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END OF SECTION
SECTION 210500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings 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. Mechanical sleeve seals.
3. Sleeves.
4. Escutcheons.
5. Coordination drawings.
6. Project record drawings.
7. Fire-suppression equipment and piping demolition.
8. Equipment installation requirements common to equipment sections.
10. Supports and anchorages.

1.3 DEFINITIONS

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

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

C. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

D. 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.

E. 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. Mechanical sleeve seals.
2. Escutcheons.
B. Welding certificates.

1.5 QUALITY ASSURANCE

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

B. Electrical Characteristics for Fire-Suppression Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. Any additional costs as a result of these modifications shall be borne by the contractor. 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. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

1.7 COORDINATION

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

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

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

D. Sequence, coordinate, and integrate installations of fire suppression materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.

E. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

F. Sequence, coordinate, and integrate removal of existing equipment and material as required to maintain services for existing building and for portions of remodeled areas at all times.

1.8 SCHEDULING AND PHASING

A. All fire suppression work shall be scheduled to meet project completion data. Fire suppression work shall be phased for projects requiring phasing of work. Install additional fittings, valves, caps as required to support phasing. Refer to phasing schedule on drawings.
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. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.

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

2.3 JOINING MATERIALS

A. Refer to individual Division 21 piping Sections for special joining materials not listed below.

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

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

2. AWWA C110, rubber, flat face, 1/8 inch 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.

2.4 MECHANICAL SLEEVE SEALS

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

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

2. Sealing Elements: EPDM or 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.
2.5 SLEEVES
A. Galvanized-Steel Sheet: 0.0239-inch 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.

2.6 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, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated or Rough brass.
C. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated.
D. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
E. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.
F. One-Piece, Floor-Plate Type: Cast-iron floor plate.
G. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.7 COORDINATION DRAWINGS
A. The Contractor shall prepare CAD generated drawings (min. ¼” scale) showing following systems/items as a minimum:
   1. Fire suppression piping routing including locations of valves, drops to sprinkler heads, risers, etc.
   2. Fire suppression equipment locations and clearances required.
B. The Contractor shall submit the CAD generated drawings to HVAC contractor for coordination with other trades. The drawings shall be submitted either in electronic format or printed copies as requested by HVAC Contractor.
C. The Contractor shall participate in coordination meetings when requested by HVAC Contractor.

2.8 PROJECT RECORD DRAWINGS
A. Drawings shall be furnished in electronic-media (CD-Rewritable type) and at least one hard copy prints.
1. Format: Same CAD program, version and operating system as the original Contract Drawings.
2. Incorporate changes and additional information previously marked on Record prints. Delete, re-draw and add details and notations where applicable.

B. Identify and date each drawing and include the designation “PROJECT RECORD DRAWINGS” or “AS-BUILT DRAWING” in a prominent location.

PART 3 - EXECUTION

3.1 FIRE-SUPPRESSION DEMOLITION
A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS
A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.
B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
E. Install piping minimum 8 inches above accessible ceilings to allow sufficient space for ceiling panel removal and service access.
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. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
g. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
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 and concrete floor and roof slabs.

P. 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 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 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.
   b. Steel Sheet Sleeves: For pipes NPS 6 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 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.

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.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems.

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

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

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 PAINTING

A. Painting of fire-suppression systems, equipment, and components is specified in Division 09 Sections "Interior Painting."

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

3.5 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.

B. Field Welding: Comply with AWS D1.1.

END OF SECTION 210500
SECTION 211313 - WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Fire-protection valves.
3. Fire-department connections.
4. Sprinklers.
5. Alarm devices.
6. Control panels.
7. Pressure gages.

1.3 DEFINITIONS

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

1.4 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.

1.5 PERFORMANCE REQUIREMENTS

A. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

   1. Contractor shall obtain fire-hydrant flow test records from authorities having jurisdiction.

C. Sprinkler system design shall be approved by Engineer and 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 According to NFPA 13 Unless Otherwise Noted:

      a. Building Service Areas: Ordinary Hazard, Group 1.
b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
c. General Business Occupancy: Light Hazard
d. General Storage Areas: Ordinary Hazard, Group 1.
e. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
f. Office and Public Areas: Light Hazard.
g. Restaurant Service Areas: Ordinary Hazard, Group 1.

3. Minimum Density for Automatic-Sprinkler Piping Design According to NFPA 13 Unless Noted Otherwise:
   a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
   c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
   d. Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500-sq. ft. area.
   e. Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500-sq. ft. area.
   f. Special Occupancy Hazard: As determined by authorities having jurisdiction.

4. Maximum Protection Area per Sprinkler According to NFPA 13 Unless Noted Otherwise:
   a. Office Spaces and Classrooms: 225 sq. ft.
   b. Storage Areas: 130 sq. ft.
   c. Mechanical Equipment Rooms: 130 sq. ft.
   d. Electrical Equipment Rooms: 130 sq. ft.
   e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:
   a. Light-Hazard Occupancies: 100 gpm for 30 minutes.
   b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.
   c. Extra-Hazard Occupancies: 500 gpm for 90 to 120 minutes.

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

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 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 minimum ¼” scale, on CAD generated drawings. Refer to Section “Common Work Results for Fire Suppression”.

E. Qualification Data: For qualified Installer.

F. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by the Engineer, including hydraulic calculations if applicable.
G. Welding certificates.

H. Fire-hydrant flow test report.

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:

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

   a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

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

C. NFPA 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. Refer to Section "Common Work Results for Fire Suppression" for details.

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, Black-Steel Pipe: ASTM A 53, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.


C. Uncoated, Steel Couplings: ASTM A 865, threaded.


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

F. Cast-Iron Flanges: ASME 16.1, Class 125.

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


I. Grooved-Joint, Steel-Pipe Appurtenances:

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

2. Pressure Rating: 175 psig minimum.

3. Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.

4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

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

2.3 PIPING JOINING MATERIALS

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

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.
2.4 LISTED FIRE-PROTECTION VALVES

A. General Requirements:
   1. Valves shall be UL listed or FM approved.
   3. Minimum Pressure Rating for High-Pressure Piping: 250 psig.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Anvil International, Inc.
   2. Crane Co.
   4. Metraflex, Inc.
   5. Milwaukee Valve Company.
   7. NIBCO INC.
   8. Potter Roemer.
   9. Reliable Automatic Sprinkler Co., Inc.
   10. Tyco Fire & Building Products LP.
   11. Victaulic Company.

C. Ball Valves:
   2. Valves NPS 1-1/2 and Smaller: Bronze body with threaded ends.
   3. Valves NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
   4. Valves NPS 3: Ductile-iron body with grooved ends.

D. Bronze Butterfly Valves:
   4. End Connections: Threaded.

E. Iron Butterfly Valves:
   3. Body Material: Cast or ductile iron.
   4. Style: Lug or wafer.
   5. End Connections: Grooved.

F. Check Valves:
   2. Pressure Rating: 250 psig minimum.
   3. Type: Swing check.
   5. End Connections: Flanged or grooved.

G. Bronze OS&Y Gate Valves:
4. End Connections: Threaded.

H. Iron OS&Y Gate Valves:
2. Pressure Rating: 250 psig minimum.
3. Body Material: Cast or ductile iron.
4. End Connections: Flanged or grooved.

I. Indicating-Type Butterfly Valves:
2. Pressure Rating: 175 psig minimum.
3. Valves NPS 2 and Smaller:
   a. Valve Type: Ball or butterfly.
   b. Body Material: Bronze.
   c. End Connections: Threaded.
4. Valves NPS 2-1/2 and Larger:
   a. Valve Type: Butterfly.
   b. Body Material: Cast or ductile iron.
   c. End Connections: Flanged, grooved, or wafer.
5. Valve Operation: Integral electrical, 115-V ac, prewired, two-circuit, supervisory switch visual indicating device.

J. NRS Gate Valves:
2. Pressure Rating: 250 psig minimum.
5. End Connections: Flanged or grooved.

2.5 SPECIALTY VALVES

A. General Requirements:
2. Pressure Rating:
   a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.
   b. High-Pressure Piping Specialty Valves: 250 psig minimum.
3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Reliable Automatic Sprinkler Co., Inc.
3. Tyco Fire & Building Products LP.
4. Victaulic Company.
5. Viking Corporation.

C. Alarm Valves:

2. Design: For horizontal or vertical installation.
3. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
4. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
5. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

D. Automatic (Ball Drip) Drain Valves:

2. Pressure Rating: 175 psig minimum.
3. Type: Automatic draining, ball check.
5. End Connections: Threaded.

2.6 HOSE CONNECTIONS

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

2. Fire-End & Croker Corporation.
3. Fire Protection Products, Inc.
5. Potter Roemer.
6. Tyco Fire & Building Products LP.
7. Wilson & Cousins Inc.
8. Zurn Plumbing Products Group; Wilkins Water Control Products Division.

B. Nonadjustable-Valve Hose Connections:

1. Standard: UL 668 hose valve for connecting fire hose.
2. Pressure Rating: 300 psig minimum.
3. Material: Brass or bronze.
4. Size: NPS 2-1/2, as indicated.
5. Inlet: Female pipe threads.
6. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching Columbia, Missouri fire-department threads.
7. Pattern: Angle or gate.

C. Roof Manifolds:

1. Standard: UL 668 hose valve for connecting fire hose.
2. Pressure Rating: 300 psig
3. Material: Brass or bronze.
4. Size: NPS 2-1/2 x 2-1/2 x 2-1/2 x 4 3-way
5. Inlet: Female pipe threads.
6. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching Columbia, Missouri fire-department threads.
7. Pattern: Angle or gate.

2.7 FIRE-DEPARTMENT CONNECTIONS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Fire-End & Croker Corporation.
   3. Fire Protection Products, Inc.
   4. GMR International Equipment Corporation.
   5. Guardian Fire Equipment, Inc.
   6. Tyco Fire & Building Products LP.
   7. Wilson & Cousins Inc.

B. Exposed-Type, Fire-Department Connection:
   2. Type: Exposed, projecting, for wall mounting.
   5. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
   6. Caps: Brass, lugged type, with gasket and chain.
   7. Escutcheon Plate: Round, brass, wall type.
   8. Outlet: Back, with pipe threads.
   9. Number of Inlets: Two or as required by local fire department.
   10. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE."
   12. Outlet Size: NPS 4 STORZ type or as required by Columbia fire department.

2.8 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:
   2. Pressure Rating: 175 psig minimum.
   4. Type: Mechanical-T and -cross fittings.
   5. Configurations: Ductile-iron housing with branch outlets.
   6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
   7. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:
   2. Pressure Rating: 175 psig minimum.
   3. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
   4. Size: Same as connected piping.
   5. Inlet and Outlet: Threaded.
C. Branch Line Testers:
   4. Size: Same as connected piping.
   5. Inlet: Threaded.
   6. Drain Outlet: Threaded and capped.
   7. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector’s Test Fittings:
   2. Pressure Rating: 175 psig minimum.
   3. Body Material: Cast- or ductile-iron housing with sight glass.
   4. Size: Same as connected piping.
   5. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:
   2. Pressure Rating: 250 psig minimum.
   4. Size: Same as connected piping.
   5. Length: Adjustable.
   6. Inlet and Outlet: Threaded.

2.9 SPRINKLERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Reliable Automatic Sprinkler Co., Inc.
   3. Tyco Fire & Building Products LP.
   4. Victaulic Company.
   5. Viking Corporation.

B. General Requirements:
   2. Type: All sprinklers shall be quick response type.
   4. Pressure Rating for High-Pressure Automatic Sprinklers: 250 psig minimum.

C. Sprinkler Finishes:
   1. Chrome plated.
   2. Bronze.
   3. Painted.

D. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
   1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

E. Sprinkler Guards:
   2. Type: Wire cage with fastening device for attaching to sprinkler.

2.10 ALARM DEVICES

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

B. Electrically Operated Alarm Bell:
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Fire-Lite Alarms, Inc.; a Honeywell company.
      b. Notifier; a Honeywell company.
      c. Potter Electric Signal Company.
   3. Type: Vibrating, metal alarm bell.
   4. Size: 6-inch minimum diameter.
   5. Finish: Red-enamel factory finish, suitable for outdoor use.

C. Water-Flow Indicators:
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ADT Security Services, Inc.
      b. McDonnell & Miller; ITT Industries.
      c. Potter Electric Signal Company.
      d. System Sensor; a Honeywell company.
      e. Viking Corporation.
      f. Watts Industries (Canada) Inc.
   4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
   5. Type: Paddle operated.
   7. Design Installation: Horizontal or vertical.

D. Pressure Switches:
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Detroit Switch, Inc.
      b. Potter Electric Signal Company.
      c. System Sensor; a Honeywell company.
      d. Tyco Fire & Building Products LP.
      e. United Electric Controls Co.
      f. Viking Corporation.
3. Type: Electrically supervised water-flow switch with retard feature.
5. Design Operation: Rising pressure signals water flow.

E. Valve Supervisory Switches:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Fire-Lite Alarms, Inc.; a Honeywell company.
   b. Kennedy Valve; a division of McWane, Inc.
   c. Potter Electric Signal Company.
   d. System Sensor; a Honeywell company.

3. Type: Electrically supervised.
5. Design: Signals that controlled valve is in other than fully open position.

F. Indicator-Post Supervisory Switches:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. System Sensor; a Honeywell company.

3. Type: Electrically supervised.
5. Design: Signals that controlled indicator-post valve is in other than fully open position.

2.11 PRESSURE GAGES

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of 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 diameter.

D. Pressure Gage Range: 0 to 250 psig.

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

2.12 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
B. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with set-screws.


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

E. Split-Casting, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with concealed hinge and set-screw.

F. Split-Plate, Stamped-Steel Escutcheons: Chrome-plated finish with concealed hinge, set-screw or spring clips.

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

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

2.13 SLEEVES

A. Cast-Iron Wall Pipe Sleeves: Cast or 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 minimum thickness; round tube closed with welded longitudinal joint.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, standard weight, zinc coated, plain ends.

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.

2.14 SLEEVE SEALS

A. Acceptable 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, to fill annular space between pipe and sleeve.

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

3.1 PREPARATION

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

B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water-service piping for service entrance to building.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping. Comply with requirements for backflow preventers in Division 22.

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.3 WATER-SUPPLY CONNECTIONS

A. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Division 22 Section "Domestic Water Piping."

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-distribution piping. Comply with requirements for backflow preventers in Division 22 Section "Domestic Water Piping Specialties."

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.4 PIPING INSTALLATION

A. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.


C. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

D. Install unions adjacent to each valve in pipes NPS 2 and smaller.

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

F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

G. Install sprinkler piping with drains for complete system drainage.

H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
I. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

J. Install alarm devices in piping systems.

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

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

M. 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 and smaller.

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

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

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

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

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

H. 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.

I. 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.

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.

3.7 SPRINKLER INSTALLATION
A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

3.8 FIRE-DEPARTMENT CONNECTION INSTALLATION
A. Install wall-type, fire-department connections.
B. Install automatic (ball drip) drain valve at each check valve for fire-department connection.
C. Install alarm bell above fire department connection.

3.9 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 or stamped steel with set-screw or spring clips.
   5. Bare Piping in Equipment Rooms: One piece, cast brass stamped steel with set-screw or spring clips.
   6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.10 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 for joint sealants in Division 07 Section “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 for joint sealants in Division 07 Section “Joint Sealants.”

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

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

J. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Galvanized-steel pipe.
   a. Extend sleeves 2 inches 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 above finished floor level. Comply with requirements for flashing in Division 07 Section “Sheet Metal Flashing and Trim.”

2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Galvanized-steel pipe.
   a. Extend sleeves 2 inches 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 above finished floor level. Comply with requirements for flashing in Division 07 Section “Sheet Metal Flashing and Trim.”

3. Sleeves for Piping Passing through Gypsum-Board Partitions:
   b. Galvanized-steel-sheet sleeves for pipes NPS 6 and larger.
   c. 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: Molded PE or Galvanized-steel pipe.

5. Sleeves for Piping Passing through Exterior Concrete Walls:
   b. Cast-iron wall-pipe sleeves for pipes NPS 6 and larger.
   c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.

6. Sleeves for Piping Passing through Interior Concrete Walls:
   b. Galvanized-steel-sheet sleeves for pipes NPS 6 and larger.

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

3.11 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, minimum two rows 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. All bolts shall be accessible from inside of building.

3.12 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."

3.13 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. Coordinate with fire-alarm tests. Operate as required.
   6. 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.

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

3.15 PIPING SCHEDULE
A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded or 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 and smaller, shall be one of the following:
   1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 and larger, shall be one of the following:
1. Standard-weight, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.16 SPRINKLER SCHEDULE

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

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Concealed sprinklers.
3. Wall Mounting: Concealed sidewall sprinklers.
4. Spaces Subject to Freezing: Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as indicated.
5. Special Applications: Extended-coverage, flow-control, sprinklers where indicated.

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

1. Concealed Sprinklers: Rough brass, with factory-painted cover plate color as directed by Architect.
2. Upright and Pendent Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 211313
SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings 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. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
7. Grout.
8. Coordination drawings.
10. Trenchings, excavating and backfilling.
11. Plumbing demolition.
12. Equipment installation requirements common to equipment sections.
13. Painting and finishing.

1.3 DEFINITIONS

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

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

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

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

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

1.4 SUBMITTALS

A. Product Data: For the following:

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

1.5 QUALITY ASSURANCE

A. 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. Any additional costs as a result of these modifications shall be borne by the Contractor. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

B. Plumbing work to comply with International Plumbing Code (IPC) as listed on Drawings and General Conditions.

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. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

1.7 COORDINATION

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

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

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

D. Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.

E. Coordinate connection of plumbing systems with exterior underground utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

F. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

G. Sequence, coordinate, and integrate removal of existing equipment and material as required to maintain services for existing building and for portions of remodeled areas at all times.
1.8 SCHEDULING AND PHASING

A. All plumbing work shall be scheduled to meet project completion date. Plumbing work shall be phased for projects requiring phasing of work. Install additional fittings, valves, caps as required to support phasing. Refer to phasing schedule on drawings.

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. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 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.

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

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

2.4 TRANSITION FITTINGS

A. Acceptable Manufacturers:

3. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
4. JCM Industries.
5. Smith-Blair, Inc.
6. Viking Johnson.

B. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

### 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. Acceptable Manufacturers:

1. Capitol Manufacturing Co.
2. Calpico, Inc.
3. Epco Sales, Inc.
5. Lochinvar Corp.;

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

E. Dielectric-Flange Kits: 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.

1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

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

### 2.6 MECHANICAL SLEEVE SEALS

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

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

2. Sealing Elements: EPDM or 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 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-Profile Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated or rough brass.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated.

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, 28-day compressive strength.

2.10 COORDINATION DRAWINGS

A. The contractor shall prepare CAD generated drawings (min. ¼” scale) showing following systems/items as a minimum:
   1. Plumbing piping routing including locations of valves, drops to fixtures, risers, etc.
2. Plumbing equipment locations and clearances required.

B. The contractor shall submit the CAD generated drawings to mechanical contractor for coordination with other trades. The drawings shall be submitted either in electronic format or printed copies as requested by HVAC Contractor.

C. The contractor shall participate in coordination meetings when requested by HVAC Contractor.

2.11 PROJECT RECORD DRAWINGS

A. Drawings shall be furnished in electronic-media (CD-Rewritable type) and at least one hard copy prints.

1. Format: Same CAD program, version and operating system as the original Contract Drawings.
2. Incorporate changes and additional information previously marked on Record prints. Delete, re-draw and add details and notations where applicable.

B. Identify and date each drawing and include the designation “PROJECT RECORD DRAWING” or “AS-BUILT DRAWING” in a prominent location.

PART 3 - EXECUTION

3.1 TRENCHING, EXCAVATING AND BACKFILLING

A. Excavate to required dimensions and depth. The trench excavation shall be in open cut from surface and shall be minimum width necessary to permit the placing of the pipe as required. Excess excavation shall be backfilled with crusher run rock. Such rocks shall be placed at the Contractor’s expense. Lines shall be used to lay out trenches.

B. All excavations shall be properly protected by the necessary bracing and timbers, to prevent any cave-ins or injury to adjacent improvements. The sides of the excavations shall be securely held by bracing or sheathing, which bracing or sheathing shall not be removed until the level of the backfill has reached the point where such removal can be safely carried out. Where adjacent improvements might be injured by the removal of such bracing, the braces shall be left in place to prevent such injury. The thickness of the sheathing and dimensions of the brass braces, shoes and miscellaneous supports to be used by the Contractor shall be of the type required to properly protect the sides of the trench and to prevent injurious cave-ins or erosions.

C. The Contractor shall do all pumping and bailing necessary to keep all excavations free of water and shall provide for the uninterrupted flow of the surface water adjacent to the line of the work during the progress of the work. The Contractor shall inspect the ground where excavation is required to ascertain the structure of the soil. Additional consideration will not be allowed for encountering rock, stone, old foundations or other unfavorable excavating conditions.

D. The Contractor shall replace all existing walks, roads, street pavements, curbs, retaining walls, steps and miscellaneous work removed or damaged in connection with the utility service installation, whether or not the improvement is shown on the drawings. Such repairs shall be done to the satisfaction of the Architect. All street cuts shall be repaired in a manner meeting the approval of the Owner.

E. In cases where existing water, sewer, electric, steam or other pipes are encountered, they shall not be displaced or disturbed unless necessary, in which case they shall promptly be replaced in good condition. All water, sewer, steam or electric lines damaged or disturbed in the construction shall be replaced or repaired at the Contractor’s expense, unless, in the opinion of the Architect, such damage was caused through no fault of the Contractor.
F. Contractor shall provide all temporary bridges, steel plates, barricades, lanterns, and such other signs and signals by day as shall be necessary to warn the public of and protect the public from the dangers caused by excavations and other obstructions, day and night.

G. The backfilling of trenches shall be carried out as rapidly as the testing and acceptance of the finished sections of the installation will permit. The trench shall be backfilled in layers of not to exceed eight inches (8") with good selected clean earth, thoroughly tamped with mechanical tamper to a 95% optimum compaction. Density shall be tested by an approved laboratory, using a standard method. Tests shall be made for each 2 ft. depth on the basis of one test per 1000 sq. ft. of fill area. Last 12" of backfill (except under streets, drives, and walks) shall be made with good clean top soil. Contractor shall obtain and pay for tests. Submit five (5) copies of tests for approval. Note: Broken stones, cinders, wood and rubbish are not acceptable for backfilling. Backfill all street cuts in a manner meeting the approval of the Architect.

H. In spaces between walls and line of excavation, fill with thin layers of selected clean earth; thoroughly tamp in eight inches (8") thick layers and bring up to a finished level of established grades. All wood and foreign materials shall be removed from excavation prior to backfilling.

I. After backfilling, all surplus excavated materials shall be removed from the property.

J. The work shall be executed so that existing culverts, walks, retaining walls, steps, fences or any permanent structure along and adjacent to the new work are properly protected. Any damage occurring to these structures shall be repaired by the Contractor at his own expense.

K. The Contractor shall make a field inspection of the location along which the underground piping is to be constructed, and note all obstructions and improvements at the surface and overhead which may affect the method of operation in the construction of these lines. Such overhead wires and underground pipes or conduits which may exist, or which may be encountered, shall be protected by the Contractor during this construction. Any expense or inconvenience caused by their existence and the necessary protection for utilities adjacent thereto shall be considered as covered and included in the contract, without additional cost to the Owner.

3.2 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 minimum 8 inches above accessible ceilings to allow sufficient space for ceiling panel removal and service access. In general install piping tight to slab, beams, joists and structural members if possible.

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. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
   g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type.
   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 and concrete floor and roof slabs.

P. 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 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 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.
   b. Steel Sheet Sleeves: For pipes NPS 6 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 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.

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

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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

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

S. 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.

T. Verify final equipment locations for roughing-in.

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

V. Draining and Refilling of Systems: Provide all shutoff valves, drain valves, pipe, fittings, and miscellaneous material required to drain each existing system as required for new work. After new work is completed, tested, and found tight, refill each system as required. Time for shutting down existing system for draining shall be coordinated with all other work and with Owner’s representative. Cost for all chemicals and additives for refill shall be borne by the Contractor.

3.3 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. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
3.4 PIPING CONNECTIONS

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

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

3.5 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 plumbing 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.

3.6 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in Division 09 Sections "Interior Painting."

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

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

B. Field Welding: Comply with AWS D1.1.

3.8 GROUTING

A. Mix and install grout for plumbing 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 around anchors.

G. Cure placed grout.

END OF SECTION 220500
SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes general requirements for single-phase and 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 plumbing equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated. All motors shall meet minimum ASHRAE energy efficiency requirements.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Motors ½ HP and Larger: Three phase, unless shown otherwise.

B. Motors Smaller than ½ HP: Single phase, unless shown otherwise.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.
G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designed speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

H. Enclosure: Open dripproof.

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: Separate winding for each speed.


F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F unless otherwise noted.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

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 220513
SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

B. Related Sections:
   1. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.

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.

C. Product Certificates: For each type of thermometer and gage, signed by product manufacturer.

PART 2 - PRODUCTS

2.1 DIRECT-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2.Marsh Bellofram.
   3. Trerice, H. O. Co.
   4. Weiss Instruments, Inc.
   5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
B. Case: Dry or liquid-filled type, drawn steel or cast aluminum 4-1/2-inch diameter.

C. Element: Bourdon tube or other type of pressure element.

D. Movement: Mechanical, connecting element and pointer.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red or other dark-color metal.

G. Window: Glass or plastic.

H. Ring: Metal.

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

J. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

K. 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 BIMETALLIC-ACTUATED DIAL THERMOMETERS

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

2. Eugene Ernst Products Co.
3. Marsh Bellofram.
4. Palmer - Wahl Instruments Inc.
5. Trerice, H. O. Co.
6. Weiss Instruments, Inc.
7. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.

C. Case: Dry or liquid-filled type, stainless steel with 5-inch diameter.

D. Element: Bimetal coil.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red or other dark-color metal.

G. Window: Glass or plastic.

H. Ring: Stainless steel.

I. Connector: Adjustable angle type.

J. Stem: Metal, for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.
2.3 PRESSURE GAGES

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

1. AMETEK, Inc.; U.S. Gauge Div.
3. Ernst Gage Co.
5. Palmer - Wahl Instruments Inc.
6. Trerice, H. O. Co.
7. Weiss Instruments, Inc.
8. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

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

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

C. Pressure-Gage Fittings:

1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install thermometers in the inlet and outlet of each domestic water heater.

B. Install vapor or bimetallic-actuated dial thermometers at suction and discharge of each pump.

C. Provide the following temperature ranges for thermometers:

1. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.

B. Install pressure gages at suction and discharge of each pump.

C. Install pressure gage after the building backflow preventer.
D. Install pressure gage after the water meter.

E. Install pressure gages after the branch or isolation valve on each floor for both the hot and cold water piping.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

C. Install needle-valve and snubber fitting in piping for each pressure gage.

D. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.

E. Adjust faces of thermometers and gages to proper angle for best visibility.

END OF SECTION 220519
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze angle valves.
2. Brass ball valves.
3. Bronze ball valves.
5. Iron, grooved-end butterfly valves.
8. Iron, grooved-end swing check valves.
10. Iron gate valves.
13. Chainwheels.

B. Related Sections:

1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
3. Division 33 water distribution piping Sections for general-duty and specialty valves for site construction piping.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: 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 B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 and NSF-372 (lead free) for valve materials for potable water service.

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 valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than 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 and larger.
   2. Handwheel: For valves other than quarter-turn types.
   3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
   4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every ten (10) plug valves, for each size square plug-valve head.
5. 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 stem extensions and the following features:
   1. Gate Valves: With rising stem.
   2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

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 ANGLE VALVES

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Crane Co., Crane Valve Group
   2. Hammond Valve.
   4. NIBCO Inc.

B. Class 125, Bronze Angle Valves with Bronze Disc:
   1. Description:
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig.
      d. Ends: Threaded.
      e. Stem and Disc: Bronze.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron.

C. Class 150, Bronze Angle Valves with Bronze Disc:
   1. Description:
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 300 psig.
      d. Ends: Threaded.
      e. Stem and Disc: Bronze.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron.
2.3  **BRONZE BALL VALVES**

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

1. American Valve, Inc.
2. Conbraco Industries, Inc.; Apollo Valves.
3. Crane Co.; Crane Valve Group; Crane Valves.
5. Milwaukee Valve Company.
6. NIBCO INC.
7. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

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

1. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Lead Free Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

2.4  **IRON, SINGLE-FLANGE BUTTERFLY VALVES**

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

2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
4. DeZurik Water Controls.
5. Hammond Valve.
7. NIBCO INC.
9. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:

1. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Nickel-plated or -coated ductile iron.
2.5 IRON, GROOVED-END BUTTERFLY VALVES

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

1. Crane Co.; Crane Valve Group; Stockham Division.
2. Hammond Valve.
3. Kennedy Valve; a division of McWane, Inc.
4. NIBCO Inc.
5. Tyco Fire Products LP; Grinnell Mechanical Products.

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

1. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 175 psig.
   c. Body Material: Coated, ductile iron.
   e. Disc: Aluminum bronze disc.
   f. Seal: EPDM.

2.6 BRONZE SWING CHECK VALVES

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

1. American Valve, Inc.
2. Crane Co.; Crane Valve Group; Crane Valves.
3. Crane Co.; Crane Valve Group; Jenkins Valves.
4. Crane Co.; Crane Valve Group; Stockham Division.
5. Hammond Valve.
7. NIBCO Inc.
8. Powell Valves.
9. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

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

1. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 200 psig.
   c. Body Design: Horizontal flow.
   e. Ends: Threaded.
   f. Disc: Bronze.

C. Class 150, Bronze Swing Check Valves with Bronze Disc:

1. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 300 psig.
   c. Body Design: Horizontal flow.
2.7 IRON SWING CHECK VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
5. Milwaukee Valve Company.
6. NIBCO Inc.
7. Powell Valves.
8. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

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

   1. Description:
      a. Standard: MSS SP-71, Type I.
      b. CWP Rating: 200 psig.
      c. Body Design: Clear or full waterway.
      d. Body Material: ASTM A 126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Gasket: Asbestos free.

2.8 IRON, GROOVED-END SWING CHECK VALVES

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

   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International, Inc.
      b. Tyco Fire Products LP; Grinnell Mechanical Products.
      c. Victaulic Company.

   2. Description:
      a. CWP Rating: 300 psig.
      c. Seal: EPDM.
      d. Disc: Spring-operated, ductile iron or stainless steel.

2.9 IRON, CENTER-GUIDED CHECK VALVES

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

   1. Anvil International, Inc.
   2. DFT Inc.
   3. Hammond Valve.
4. Metraflex, Inc.
5. Milwaukee Valve Company.
7. NIBCO INC.
9. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Description:

   b. CWP Rating: 200 psig.
   d. Style: Compact wafer.
   e. Seat: Bronze.

C. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Description:

   b. CWP Rating: 300 psig.
   d. Style: Compact wafer.
   e. Seat: Bronze.

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

1. Description:

   b. CWP Rating: 200 psig.
   d. Style: Compact wafer.
   e. Seat: EPDM or NBR.

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

1. Description:

   b. CWP Rating: 300 psig.
   d. Style: Compact wafer.
   e. Seat: EPDM or NBR.

2.10 BRONZE GATE VALVES

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

1. American Valve, Inc.
2. Crane Co.; Crane Valve Group; Crane Valves.
3. Crane Co.; Crane Valve Group; Jenkins Valves.
4. Crane Co.; Crane Valve Group; Stockham Division.
5. Hammond Valve.
7. NIBCO Inc.
8. Powell Valves.
9. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, NRS Bronze Gate Valves:

1. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

C. Class 125, RS Bronze Gate Valves:

1. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

D. Class 150, NRS Bronze Gate Valves:

1. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

E. Class 150, RS Bronze Gate Valves:

1. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.
2.11 IRON GATE VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
5. Milwaukee Valve Company.
6. NIBCO Inc.
7. Powell Valves.
8. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, NRS, Iron Gate Valves:

1. Description:
   a. Standard: MSS SP-70, Type I.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Disc: Solid wedge.
   g. Packing and Gasket: Asbestos free.

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

1. Description:
   a. Standard: MSS SP-70, Type I.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Disc: Solid wedge.
   g. Packing and Gasket: Asbestos free.

D. Class 250, NRS, Iron Gate Valves:

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

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

1. Description:
   a. Standard: MSS SP-70, Type I.
   b. CWP Rating: 500 psig.
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
2.12 BRONZE GLOBE VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Stockham Division.
3. Hammond Valve.
5. NIBCO Inc.
6. Powell Valves.
7. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, Bronze Globe Valves with Bronze Disc:

1. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

C. Class 125, Bronze Globe Valves with Nonmetallic Disc:

1. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

D. Class 150, Bronze Globe Valves with Nonmetallic Disc:

1. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.
2.13 IRON GLOBE VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
5. Milwaukee Valve Company.
6. NIBCO Inc.
7. Powell Valves.
8. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, Iron Globe Valves:

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

C. Class 250, Iron Globe Valves:

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

2.14 CHAINWHEELS

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

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron of type and size required for valve. Include zinc coating.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

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

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

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

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

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for valves 6 inches and larger and more than 96 inches above floor. Extend chains to 60 inches 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 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, gate, or plug valves.
3. Throttling Service: Globe or angle, ball, or butterfly valves.
4. Pump-Discharge Check Valves:
   a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.

c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.

B. Pressure ratings for valves shall not be less than as required by system pressures.

C. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

D. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 and Larger: Flanged ends.
3. For Steel Piping, NPS 2 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: Valve ends may be grooved.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 125 or Class 150, bronze or nonmetallic disc.
3. Ball Valves: Two piece, full port, bronze with brass, bronze, stainless-steel trim.
4. Bronze Swing Check Valves: Class 125 or Class 150, bronze or nonmetallic disc.
5. Bronze Globe Valves: Class 125 or Class 150, bronze or nonmetallic disc.

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

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
3. Iron, Grooved-End Butterfly Valves: 175 CWP.
4. Iron Swing Check Valves: Class 125, metal seats.
5. Iron, Grooved-End Swing Check Valves: 300 CWP.
6. Iron, Center-Guided Check Valves: Class 125 or Class 150, compact-wafer, metal or resilient seat.
7. Iron Gate Valves: Class 125, NRS or OS&Y.

3.6 SANITARY-WASTE AND STORM-DRAINAGE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Angle Valves: Class 125 or Class 150, bronze or nonmetallic disc.
2. Ball Valves: Two piece, full port, brass or bronze with brass, bronze, stainless-steel trim.
3. Bronze Swing Check Valves: Class 125 or Class 150, bronze or nonmetallic disc.

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

1. Iron Swing Check Valves: Class 125, metal seats.
2. Iron, Grooved-End Swing Check Valves: 300 CWP.
3. Iron Gate Valves: Class 125, NRS or OS&Y.

END OF SECTION 220523
SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

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

1.2 SUMMARY
A. 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. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Pipe positioning systems.
   8. Equipment supports.

B. Related Sections include the following:
   1. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.

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.

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.
   4. Pipe positioning systems.

B. Welding certificates.
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. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the 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. Acceptable Manufacturers:

2. Carpenter & Paterson, Inc.
3. Empire Industries, Inc.
5. Grinnell Corp.
6. GS Metals Corp.
8. 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. Acceptable Manufacturers:

2. GS Metals Corp.
4. Thomas & Betts Corporation.
5. 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 minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Acceptable Manufacturers:

1. Carpenter & Paterson, Inc.
2. PHS Industries, Inc.
3. Pipe Shields, Inc.
5. 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. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated 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. Acceptable Manufacturers:

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

2.7 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
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, 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.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
   4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
   5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
   6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
   7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 8.
   8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 8.
   9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 2.
  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.
  11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
  12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
  13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.

15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.

16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.

17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 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, from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

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 for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

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.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

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.
   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 mechanical-expansion anchors instead of building attachments where required in concrete construction.

O. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.
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 A36/A36M, 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 mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer’s written instructions.

F. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so 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 B31.9 (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 B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.

5. Insert Material: Length at least as long as protective shield.

6. 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.

3.5 ADJUSTING

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

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

3.6 PAINTING

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

   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 220529
SECTION 220548 – VIBRATION ISOLATION OF PLUMBING

PART 1 - GENERAL

1.1 SCOPE:

A. Certain systems and components of the project are intentionally designed to avoid vibration problems. Vibration isolation systems are more critical than “standard construction.” The Contractor is cautioned not to overlook these specific components in favor of “standard construction practices” in any pricing, submittal, or construction procedure.

1. Mount rotating and/or reciprocating equipment, ductwork, and piping on vibration isolators as noted in these Documents. Select, install and adjust isolators to prevent the transmission of objectionable vibration and noise to the building structure.

1.2 RELATED WORK:

A. Perform vibration isolation work in this contract, including work described in other Divisions to meet the product and execution requirements of this Section.

1. Division 1 – General Requirements.

2. Section 018636 – Ambient Noise Levels.

3. Division 3 – Concrete.

4. All Division 22 specifications relating to vibration isolated equipment and materials.

5. Section 260548 – Vibration Isolation of Electrical Systems.

1.3 QUALITY ASSURANCE:

A. Provide vibration isolators and equipment bases for Divisions 14, 21, 22, 23, 26, 27 from the product line of a single manufacturer whenever possible unless approved by the project Acoustics Consultant. Isolators not supplied by the primary vibration isolator manufacturer shall be rejected.

B. The vibration isolator manufacturer's representative shall determine isolator sizes and mountings, and shall provide field supervision and inspection to assure proper installation, adjustment and performance. Representative shall alert the Engineer and project Acoustics Consultant to any isolator selections, which may experience resonance with the approved equipment and upgrade any isolators that are found to resonate with the supported equipment. The Contractor shall include in his bid vibration isolation system elements as recommended by the manufacturer's representative to make a complete, correct, and safe installation. Supply and install any incidental materials needed, even if not explicitly specified or shown in the Construction Documents, without claim for additional payment.

C. Skilled workers who are experienced in the necessary crafts to meet the requirements of this Section shall perform the work.

1.4 SEISMIC RESTRAINT:

A. Seismic Certification: A licensed professional engineer experienced in the design of seismic restraints for
flexibly mounted equipment, in the employ of the vibration isolation manufacturer, shall certify and stamp the shop drawings stating that all requirements of state and local codes have been met regarding seismic restraint of all resiliently mounted equipment. Provide calculations and analysis showing compliance with the applicable codes.

1.5 UNACCEPTABLE TYPES:

A. Do not use Mason models C, CI or CS, Amber-Booth models XL or XK, Kinetics models SL or SM or equivalent on this project in any location.

1.6 SUBMITTALS:

A. Vibration Isolation Mounts and Hangers: In a single consolidated submittal, provide catalog datasheets, shop drawings and other documents as necessary to indicate equipment unit number, isolator type, supported weight, scheduled deflection, proposed deflection under operating load, spring free height, spring operating height, spring solid height (at coil bind), and spring diameter for each isolator. Submit calculations and analysis showing compliance with the applicable codes. Use the format below to summarize isolator characteristics for submittal review by the Engineer and project Acoustics Consultant. Submittals will be reviewed for compliance and accuracy of data provided.

C. SAMPLE SUBMITTAL FORMAT: MOUNT/HANGER PAD

<table>
<thead>
<tr>
<th>Supported Equipment</th>
<th>P-1</th>
<th>SP-1</th>
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</thead>
<tbody>
<tr>
<td>Isolator Type</td>
<td>Mason SLRS-B2-680</td>
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<tr>
<td>Supported Weight</td>
<td>1750 LB</td>
<td>320 LB</td>
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<tr>
<td>Lowest Speed</td>
<td>1500 RPM</td>
<td></td>
</tr>
<tr>
<td>Scheduled Deflection</td>
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<td>0.07 inch</td>
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<tr>
<td>Operating Deflection</td>
<td>1.6 inch</td>
<td>0.11 inch</td>
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<tr>
<td>Spring (Pad) Free Height</td>
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<tr>
<td>Operating Height</td>
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<td>0.64 inch</td>
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<tr>
<td>Solid Height</td>
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</tr>
<tr>
<td>Spring Diameter</td>
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</tr>
<tr>
<td>Pad Support Area</td>
<td>-</td>
<td>16 sq. in.</td>
</tr>
<tr>
<td>Remarks</td>
<td>Bridge bearing quality neoprene, 30 durometer</td>
<td></td>
</tr>
</tbody>
</table>

D. Equipment Bases: Provide detailed drawings for steel bases, sub-bases, and rails showing all steel work, reinforcing method of isolator attachment, and location of equipment attachment bolts.

E. Concrete Inertia Bases: Provide shop drawings showing all steel work, required concrete, and method of isolator attachment, and location of equipment attachment bolts.

F. Shop Drawings: Submit shop drawings and manufacturer's installation instructions for thrust restraints and sway braces wherever they are required. Submit shop drawings for piping isolation details where Type A pads are used; see Paragraph 3.11: Piping Isolation.

G. Inspection Report: Upon completion of the installation and after the system is put into operation, the manufacturer's representative shall make a final inspection and submit his report to the Architects and Engineers in writing certifying the correctness of installation and compliance with approved submittal data. The contractor shall allow for the cost of this service in his bid.
1.7 DRAWINGS ARE SCHEMATIC ONLY:
   A. Choose the size and number of mounts and hangers to meet these specifications. Provide brackets, rails, bases, braces, snubbers, etc. as needed for a complete and correct installation.

1.8 STANDARDS:
   A. American Association of State Highway and Transportation Officials Standard Specifications for Highway Bridges (AASHTO), Highway Bridge Specification. See Table B requirements for physical properties of bridge-bearing quality neoprene.

1.9 ALTERNATE SYSTEM:
   A. In equipment rooms with substantial isolation hanger requirements (such as chiller and pump rooms), contractor may submit the following alternate system for approval. Provide a rigid secondary structural frame from which all equipment, piping, ductwork, conduit, and other attachments may be resiliently supported. Support the equipment, piping, ductwork, conduit, and other attachments in accordance with the rest of this specification. The mechanical contractor will size the frame. Show load estimates for the frame and equipment.

PART 2 - PRODUCTS

2.1 SPRING REQUIREMENTS:
   A. Steel springs and neoprene elements shall have static deflections under operating load equal to or greater than deflections shown in this specification section. Submittals based on rated deflection will be disapproved.
   B. All steel springs as installed shall have a minimum additional travel to solid (coil bind) equal to 50% of the deflection under operating load.
   C. Spring diameter shall be no less than 80% of the compressed height of the spring at operational load.
   D. Steel springs shall not be welded to other elements of the isolator unless specifically noted in the submittal and approved by the project Acoustics Consultant.
   E. Steel springs shall not take a permanent set when compressed to coil bind.
   F. Steel springs shall be color coded to allow positive identification after installation.

2.2 ELASTOMER REQUIREMENTS:
   A. All elastomeric (neoprene) components shall be selected for maximum hardness of 40 durometer, shore A rating, where possible. In no case shall hardness exceed 50 durometer. Use bridge-bearing quality neoprene meeting AASHTO Highway Bridge Specifications in all elastomeric components where installed in irretrievable locations and as noted elsewhere in the documents.

2.3 CORROSION RESISTANCE:
   A. All isolators and associated hardware shall be designed or treated for resistance to corrosion. Steel components shall be PVC coated, or phosphated and painted with industrial grade enamel. All nuts, bolts
and washers shall be zinc electroplated. Structural steel bases and exposed steel components of concrete inertia bases shall be cleaned of welding slag and primed with zinc-chromate or metal etching primer. A finish coat of industrial grade enamel shall be applied over the primer.

1. All isolators exposed to the weather such as roof exhaust fan shall have steel parts PVC coated, hot-dip galvanized or zinc-electroplated plus coating of Neoprene or Bitumastic paint. Aluminum components for outdoor installation shall be etched and painted with industrial grade enamel. Nuts, bolts, and washers may be zinc-electroplated.

2.4 VIBRATION CONTROL MANUFACTURERS:

A. Manufacturers will be approved providing mounting systems are in strict accordance with design intent as specified herein:


2. Kinetics Noise Control, Dublin, Ohio.


B. Since manufacturers’ products vary, specific models listed in this Specification may not be approved if they do not meet all requirements in this section. Model designations listed herein are intended only as a guide.

2.5 EQUIPMENT SET ON FLOORS AND HOUSEKEEPING PADS:

A. If any of the isolated equipment is to be set directly on the floor or a housekeeping pad, provide Mason “Super-W” or approved equal neoprene pads under the unit. For units supported by load-bearing sleepers, neoprene pads (with load-distributing steel shims, if necessary) must be provided to the extent specified by the pad manufacturer's representative or engineer. Pads must meet requirements of Paragraph 2.7: TYPE A - ELASTOMERIC PADS.

2.6 EQUIPMENT BOLTED TO FLOORS OR HOUSEKEEPING PADS:

A. Bolts or snubbers used to keep the pads securely in place must be sleeved or grommeted with neoprene and secured with a neoprene washer to prevent rigid metal-to-metal contact. If the mounting base plate is to be bolted to the structure or framework rigidly connected to the structure, Mason HLB neoprene bushings and Mason HLW neoprene washers shall be used between each bolt and the isolator base plate to prevent mechanical short circuit. These additional neoprene washers and bushings may be omitted only if the base plate and friction pad incorporate neoprene elements that eliminate rigid contact between bolts and the base plate. Bolt holes shall be properly sized to allow for bushings. The hold down bolt shall incorporate steel washers to distribute load evenly over neoprene washers. Neoprene bushings and washers must meet conditions of Paragraph 2.22: ELASTOMERIC GROMMETS.

2.7 TYPE A ELASTOMERIC PADS:

A. Elastomeric pads shall be 5/16 inch minimum thickness waffled or ribbed neoprene pads Mason model W or SW, Amber-Booth model NR, Kinetics model NP or approved equal. Where multiple layers are specified or are required to provide the specified deflection, pads shall be interleaved with 16 gauge steel shim plates, Mason model WSW, Amber-Booth model SP-NR style E or approved equal. Size pads for deflection as required in Table 1. Maximum pad deflection is 20% of unloaded height, except bridge-bearing quality pads, which have maximum deflection of 15% of unloaded height. Provide load distributing top plates if needed for uniform loading. Provide pads of sufficient thickness to achieve the specified minimum deflection. Cork shall not be used in elastomeric pad assemblies. Neoprene shall meet
conditions of Paragraph 2.2: ELASTOMER REQUIREMENTS.

2.8  TYPE B NEOPRENE-IN-SHEAR FLOOR MOUNT ISOLATORS:

A. Neoprene-in-shear floor mount isolators shall have steel bottom plates with bolt holes for bolting to foundations, a threaded steel insert at top of the mounting for attaching equipment, and friction surfaces both top and bottom. All metal surfaces shall be neoprene covered to resist corrosion. Mounts shall be double deflection and designed for deflection as required in Table 1 of this specification. Maximum mount deflection is 0.35 inches at rated load. Neoprene shall meet conditions of Paragraph 2.2: ELASTOMER REQUIREMENTS. Isolators shall be Mason model ND, Amber-Booth model RVD, Kinetics model RD or approved equal.

2.9  TYPE D OPEN SPRING FLOOR MOUNT ISOLATORS:

A. Open spring floor mount isolators shall be freestanding and laterally stable with no housing, and shall have leveling adjustment bolts, which shall be rigidly connected to the equipment. Size and select isolators for deflection as required in Table 1 in this specification. Provide with 1/4" minimum elastomeric friction pad Type A between the base plate and the support. Pad shall meet conditions of Paragraph 2.2: ELASTOMER REQUIREMENTS. Vibration isolator vendor shall size elastomeric pads and associated load distributing shim plates to achieve deflection equal to 10 - 20% of the vertical thickness of the pads. Isolators shall be Mason model SLF, Amber-Booth model SW, Kinetics model FDS or approved equal.

2.10 TYPE E RESTRAINED OPEN SPRING FLOOR MOUNT ISOLATORS:

A. Restrained open spring floor mount isolators for equipment with operating weight greater than installed weight shall have built-in adjustable limit stops to prevent equipment from rising when weight is removed. Isolators shall be as Type D above plus height limiting studs and adjustable nuts, with 1/2" minimum clearance around the studs. Size and select isolators for deflection as required in Table 1 of this specification. Isolators shall be Mason model SLR, Amber-Booth model CT, Kinetics model FLS or approved equal.

2.11 TYPE F ELASTOMERIC HANGERS:

A. Elastomeric hangers shall be a neoprene-in-shear element mounted in a hanger box. The neoprene element shall be molded with a rod isolation bushing that prevents the rod from contacting the hanger box. Size and select isolators for deflection as required in Table 1 of this specification. Isolators shall be Mason model HD, WHD, Amber-Booth model BRD, Kinetics model RH or approved equal.

2.12 TYPE G SPRING AND NEOPRENE-IN-SERIES ISOLATOR HANGERS:

A. Spring and neoprene-in-series isolator hangers shall contain a steel spring and elastomeric element in series. Size and select isolators for deflection as required in Table 1 of this specification. Neoprene elements shall be molded with a rod isolation bushing that passes through the hanger box that prevents the rod from contacting the hanger box. The diameters of the spring and the hole in the mounting box shall allow for 15-degree misalignment from vertical before mechanical short circuit occurs. Isolators shall be Mason model 30N, Amber-Booth model BSRA, Kinetics model SRH or approved equal.

2.13 TYPE H PRECOMPRESSED SPRING AND NEOPRENE-IN-SERIES HANGERS:

A. Precompressed spring and neoprene-in-series hangers shall be equal to Type G including 15-degree misalignment capability. Size and select isolators for deflection as required in Table 1 of this specification. Isolator shall be pre-compressed to the rated deflection to allow installation at a fixed elevation. Hangers
shall have a release mechanism to free the spring after installation and the hanger is subjected to its full load. Deflection shall be indicated by means of a scale. Isolators shall be Mason model PC30N, Amber-Booth model PBSRA or approved equal.

2.14 TYPE K SWAY BRACES:
A. Sway braces shall be in sets of two or more and shall consist of aircraft cable, neoprene elements, or neoprene and spring assemblies. Braces shall keep the equipment stable without restricting the free motion of the vibration isolators. Submit shop drawings for approval prior to installation.

2.15 TYPE L INERTIA BASES:
A. Concrete inertia bases shall be formed of stone-aggregate concrete (150 lbs./cu. ft.) and appropriate steel reinforcing cast between perimeter structural steel channels.
B. Inertia bases shall be built to form a rigid base, which will not twist, deform, deflect, or crack in any manner that would negatively affect the operation of the supported equipment or the vibration isolation mounts. Inertia bases shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure.
C. The vibration isolator manufacturer shall supply the steel frame and reinforcement. The General Contractor may provide concrete.
D. Inertia base shall weigh a minimum of two times the weight of the supported equipment, and shall be a minimum of 6” thick. Spacing between isolators supporting the inertia base shall be a maximum of ten times the thickness of the inertia base. Bases shall have a minimum operating clearance of 2” above floor or housekeeping pad. Use height saving brackets as required to maintain proper clearances

2.16 TYPE M STEEL BASES:
A. Steel bases shall consist of structural steel sections sized, spaced, and connected to form a rigid frame which will not twist, rack, deform, or deflect in any manner to negatively affect the operation of the supported equipment or the vibration isolation mounts. Bases shall be adequately sized to support basic equipment and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. Steel bases shall be at least 6” thick. Spacing between isolators supporting the steel base shall be a maximum of ten times the thickness of the base. Bases shall have a minimum operating clearance of 2” above floor or housekeeping pad. Bases shall include side-mounting brackets for attachment to vibration isolators.

2.17 TYPE N STEEL RAILS:
A. Steel rail bases shall consist of structural steel sections sized to provide a rigid beam which will not twist, deform, or deflect in any manner which will negatively affect the operation of the supported equipment or the vibration isolation mounts. Rails shall include end-mounting brackets for attachments of vibration isolators. Rails shall have a minimum operating clearance of 2” above the floor or housekeeping pad.

2.18 TYPE P CAPTIVE NEOPRENE WALL MOUNT ISOLATORS:
A. Captive neoprene wall mount isolators shall be Mason model RBA, RCA, Kinetics model RQ, or approved equal.
2.19 TYPE R RISER SPRING ISOLATOR SUPPORTS:
A. Riser spring isolators shall meet requirements specified in Paragraph 2.1. Isolators shall be Kinetics FDS or FRS or approved equal.

2.20 TYPE S RISER NEOPRENE ISOLATOR SUPPORTS:
A. Riser neoprene isolators shall have all-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions. In no case shall hardness exceed 60 durometer. Isolators shall be Kinetics KPA, Mason ADA or approved equal.

2.21 FLEXIBLE NEOPRENE PIPING CONNECTORS:
A. Flexible neoprene piping connectors shall be twin spherical type (flanged), or single sphere type (threaded), manufactured of Kevlar cord with a Peroxide-cured EPDM cover. Connectors shall be able to accept elongation, compression and axial and transverse movement. Connectors shall be selected to suit the system temperature, pressure and fluid type. No rods or cables shall be used to control extension of the connector unless required due to temperature and pressure requirements. Any control rods must be separated from isolator with complete neoprene grommets (not just washers) as described in Paragraph 2.22: ELASTOMERIC GROMMETS. Connectors shall be Mason “Safeflex” model SFDEJ, SFDCR, SFU or approved equal. Straight wall connectors are not acceptable.

2.22 ELASTOMERIC GROMMETS:
A. Elastomeric grommets may be a combination of neoprene washer and bushing, Mason models HLW and HLB or approved equal. Otherwise they shall be E.A.R. (Indianapolis, Indiana) Isodamp, C-1000, ring bushing and washer combination or approved equal. Elastomer shall be 40 durometer maximum. Grommets shall be formed to prevent bolts from directly contacting the secured item.

2.23 FLEXIBLE CONDUIT:
A. Refer to Section 260548: Vibration Isolation of Electrical Systems.

2.24 BUILDING ISOLATION JOINTS:
A. Use a flexible piping connection, a flexible conduit, or a flexible conduit connector at every location where a pipe or conduit crosses a building expansion or isolation joint.

2.25 VIBRATION ISOLATION SELECTION TABLE (TABLE 1):
A. Vibration isolation for all equipment shall be provided in accordance with following Table 1 except as otherwise noted in Section 3 of this section. If floor span is greater than 30 feet, the project Acoustics Consultant must be contacted for advice prior to placement of any orders. References in Notes column refer to paragraphs in Part 3 of this specification section.
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<tr>
<th>Equipment Type</th>
<th>Horsepower &amp; Other</th>
<th>RPM</th>
<th>Slab on Grade</th>
<th>Up to 20' Floor Span</th>
<th>20-30' Floor Span</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Base Isolator or Hanger</td>
<td>Base Isolator or Hanger</td>
<td>Base Isolator or Hanger</td>
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<tr>
<td></td>
<td></td>
<td></td>
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<td>Min. Defl. (in.)</td>
<td>Min. Defl. (in.)</td>
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<td>Up to 10</td>
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<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Base-Mounted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Large Reciprocating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
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<td>Pumps</td>
<td></td>
<td>HP</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Close-Coupled</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Up to 7.5</td>
<td>All</td>
<td>M/N</td>
<td>B</td>
<td>0.25</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>10 and up</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Inline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 25</td>
<td>All</td>
<td>None</td>
<td>D</td>
<td>0.75</td>
<td>None</td>
<td>D</td>
</tr>
<tr>
<td>30 and up</td>
<td>All</td>
<td>None</td>
<td>D</td>
<td>1.50</td>
<td>None</td>
<td>D</td>
</tr>
<tr>
<td>End Suction &amp; Split Case</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 40</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>50 to 125</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>150 and up</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Sump</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>All</td>
<td>None</td>
<td>A</td>
<td>0.11</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

**PART 3 - EXECUTION**

**3.1 GENERAL:**

A. Resiliently mount equipment and piping on or suspended from approved foundations and supports, with isolation mounts, hangers, and/or pads as specified herein and as shown on drawings. Install seismic restraints in strict conformance with the certified shop drawings. Select locations of isolation equipment for ease of inspection and adjustment as well as for proper operation. Contractor shall cooperate with the Architect and project Acoustics Consultant to replace, at no additional cost to the Owner, any isolators that
3.2 MOUNTS AND HANGERS:

A. Align vibration isolators squarely above or below mounting points of the supported equipment.

B. For equipment with bases, locate isolators on the sides of the base that are parallel to the equipment shaft.

C. If a housekeeping pad is provided, isolator base plates shall rest entirely on the pad.

D. Position vibration isolation hangers as high as possible in the hanger rod assembly but not in contact with the building structure. Provide 1” minimum to 3” maximum clearance between hanger housing and structure above. Provide side clearance for hanger housings to allow a full 360-degree rotation about the rod axis without contacting any object.

E. Parallel pipes may be hung together on a trapeze that is isolated from the structure. Isolator deflections must equal the greatest deflection for those pipes if isolated individually. Do not mix isolated and non-isolated pipes on the same trapeze.

F. Limit stops shall be out of contact during normal operation.

G. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

H. To simplify installation, Contractor may elect to use Type E isolators instead of Type D isolators, and/or Type H isolators instead of Type G isolators.

3.3 CONCRETE INERTIA BASES:

A. Inertia bases and required steel reinforcing under this section. Pour dense aggregate concrete (150 lbs./cu. ft.) within structural frames under the supervision of the contractor responsible for the work of this section.

3.4 FLOOR CLEARANCES:

A. For floor-mounted equipment, provide a minimum operating clearance of 2” between the bottom of the equipment or inertia base and the floor or housekeeping pad. Check to ensure that this space is completely clear after installation is complete. Provide height saving brackets as needed. Where housekeeping pads are provided, coordinate isolator locations with size of housekeeping pads especially where outboard mounts are used with height saving brackets.

3.5 DEFLECTIONS:

A. Design vibration isolation systems to have deflections equal or greater than indicated on drawings and in Table 1 of this specification section. Where multiple deflection requirements apply to a single isolator, the greater deflection shall prevail. Isolators supporting equipment with center of gravity that is asymmetrical in plan shall be selected for nearly equal deflection under actual load. Vibration isolation manufacturer shall determine number and size of mountings. Install isolators in accordance with manufacturer’s instructions.
3.6 ISOLATED SYSTEMS SHALL BE INDEPENDENT:
   A. Do not hang or support piping, ductwork, conduit or mechanical equipment on other equipment, pipes or ductwork installed on vibration isolators. Maintain 2" clearance between isolated equipment and walls, ceilings and other equipment. Do not allow drain piping connected to vibration-isolated equipment to contact the building structure or other non-isolated systems unless it is resiliently mounted.

3.7 STABILIZE ALL ISOLATED EQUIPMENT:
   A. Provide resilient sway bracing to solid anchor points to stabilize all resiliently supported equipment and piping in accordance with all requirements of state and local codes.

3.8 TREAT ALL ISOLATION SYSTEMS FOR CORROSION RESISTANCE:
   A. Repair coatings damaged during installation.

3.9 BASE-MOUNTED PUMPS:
   A. See Table 1.
   B. Pipe between each pump and first associated flexible pipe connection shall mount on the concrete inertia base.
   C. Support inertia base with open spring floor mount isolators Type D.

3.10 FLEXIBLE PIPING CONNECTORS:
   A. Provide flexible neoprene piping connectors in all piping where it is connected to vibration-isolated equipment. Install these connectors between the equipment and the first associated pipe support or hanger, except where supports connect to an inertia base common to the equipment. Install straight-through connectors parallel to the axis of rotation of the shaft of the isolated equipment. Follow manufacturer's instructions for proper installation of flexible connectors including pre-extension of twin-sphere type. Install connectors in easily visible locations for inspection and replacement purposes.
   B. Use flexible metallic hoses instead of flexible neoprene piping connectors only where temperature and pressure conditions exceed the service limitations of neoprene type connectors.

3.11 PIPING ISOLATION:
   A. All piping connected to rotating or reciprocating equipment shall be vibration isolated according to Table 2 unless specifically excluded by the Acoustical Consultant.
   B. The installation or use of vibration isolators shall not cause any change of position of piping which will result in stresses in piping connections or misalignment of shafts or bearings. In order to meet this objective, maintain equipment and piping in a rigid position during installation. Do not transfer the load to the isolators until the installation is complete and under full operational load.
   C. As used in this section the term "Equipment Room" means any space containing pumps 3 HP or larger, chillers, air-handlers 3 tons or larger, fans handling 1200 cfm or more, boilers, or elevator equipment.
### TABLE 2: PIPING ISOLATION TABLE

<table>
<thead>
<tr>
<th>PIPING</th>
<th>SUPPORTED FROM</th>
<th>WHERE ISOLATORS ARE REQUIRED</th>
<th>ISOLATOR TYPE</th>
<th>STATIC DEFLECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping less than 12&quot; i.d. connected to equipment isolated with springs</td>
<td>CEILING</td>
<td>First three hangers</td>
<td>Type G</td>
<td>At least equal to that of the isolators supporting the equipment, up to 2&quot;.</td>
</tr>
<tr>
<td></td>
<td>FLOOR</td>
<td>First three mounts</td>
<td>Type D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VERTICAL</td>
<td>First three mounts</td>
<td>Type R</td>
<td></td>
</tr>
<tr>
<td>&quot;Piping 12&quot; i.d. or greater connected to equipment isolated with springs</td>
<td>CEILING</td>
<td>First three hangers</td>
<td>Type H</td>
<td>At least equal to that of the isolators supporting the equipment, up to 2&quot;.</td>
</tr>
<tr>
<td></td>
<td>FLOOR</td>
<td>First three mounts</td>
<td>Type E</td>
<td>Transfer load to the springs after installation is complete and fluid has been added to the circuit.</td>
</tr>
<tr>
<td></td>
<td>VERTICAL</td>
<td>First three mounts</td>
<td>Type R</td>
<td></td>
</tr>
<tr>
<td>Piping connected to equipment isolated with springs</td>
<td>CEILING</td>
<td>From (and including the)</td>
<td>Type G</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>fourth hanger to leaving</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Equipment Room or to 50</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>feet pipe length from</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>equipment, whichever is</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>greater</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FLOOR</td>
<td>From (and including the)</td>
<td>Type D</td>
<td>0.75&quot; minimum.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fourth mount to leaving</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment Room or to 50</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>feet pipe length from</td>
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<tr>
<td></td>
<td></td>
<td>equipment, whichever is</td>
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<td></td>
<td></td>
<td>greater</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VERTICAL</td>
<td>From (and including the)</td>
<td>Type S</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>fourth mount to leaving</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Equipment Room or to 50</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>feet pipe length from</td>
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<tr>
<td></td>
<td></td>
<td>equipment, whichever is</td>
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<tr>
<td></td>
<td></td>
<td>greater</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping connected to equipment isolated with pads or neoprene mounts</td>
<td>CEILING</td>
<td>Within Equipment Room or</td>
<td>Type F</td>
<td>At least equal to that of the pads or neoprene mounts supporting the equipment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>within 50 feet pipe length</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>from equipment, whichever is</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>greater</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FLOOR</td>
<td>Within Equipment Room or</td>
<td>Type B</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>within 50 feet pipe length</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>from equipment, whichever is</td>
<td></td>
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<td></td>
<td></td>
<td>greater</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VERTICAL</td>
<td>Within Equipment Room or</td>
<td>Type S</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>within 50 feet pipe length</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>from equipment, whichever is</td>
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<td></td>
<td></td>
<td>greater</td>
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<td></td>
</tr>
</tbody>
</table>

### 3.12 ACOUSTICALLY SEALED PENETRATIONS:

**A.** Provide wood blocking or sleeves of 22 gauge minimum steel, grouted rigidly in place, for all duct, pipe, and conduit penetrations through all walls, floors, and ceilings of mechanical equipment rooms, machine rooms, electrical equipment rooms, elevator equipment rooms, and all spaces called out in Section 018636 as well as where noted on drawings. Make inside dimension of sleeve or blocking 1/2" to 3/4" greater than outside dimension of penetrating item on all sides. Pack annular space to full depth of...
penetration with clean fiberglass batt or blanket material flush to ends of sleeve or block. Seal full perimeter of both ends of sleeve or block with liberal bead of acoustical sealant to be airtight.

3.13 AIR COMPRESSORS:
A. Bolt and grout air compressors and refrigerated air dryers to a concrete inertia base Type L, mounted on open spring floor mount isolators Type D with 2” minimum deflection.

3.14 AIR COMPRESSOR FLEXIBLE CONNECTORS:
A. Install flexible stainless steel metal pipe connectors in two planes 90 degrees to each other in discharge piping from compressor. Flexible connectors shall have a burst pressure of four times operating pressure. Furnish pipe sizes through 2” I.D. with hex male nipple fittings, and furnish pipe sizes 2-1/2” I.D. and larger with fixed steel flanges both sides.

3.15 AIR SEPARATORS AND EXPANSION TANKS:
A. Where vibration isolated piping is connected to an expansion tank or air separator, make connection with a flexible connector.

3.16 FLEXIBLE CONDUIT:
A. Use to isolate vibration from all equipment requiring vibration isolation per this specification section. Flexible conduit shall be a minimum length of 12” with 25% greater length than the separation between the isolated equipment and the termination of rigid conduit. Install the flexible conduit to be slack and not to exceed the manufacturer's minimum recommended bending radius. For conduit sizes greater than 2” diameter, use pre-manufactured flexible conduit connectors instead of flexible conduit. Refer to Section 260548: Vibration Isolation for Electrical Systems for further information.

3.17 IN-LINE PUMPS:
A. See Table 1.
B. Install neoprene double sphere pipe connectors on suction and discharge.

END OF SECTION 220548
SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

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

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

1.3 SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
   C. Valve numbering scheme.
   D. 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. Plastic Labels for Equipment:
      1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
      4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.


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

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

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

2.2 PIPE LABELS

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

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

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

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

   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

   2. Lettering Size: At least 1-1/2 inches high.

2.3 STENCILS

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

   1. Stencil Material: Fiberboard or metal.

   2. Stencil Paint: Exterior, gloss, 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.

2.4 VALVE TAGS

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

   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

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

1. Valve-tag schedule shall be included in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "Interior Painting".

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.

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

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

D. Pipe Label Color Schedule:

1. Domestic Water Piping:
   a. Background Color: Blue.

2. Sanitary Waste and Storm Drainage Piping:
   a. Background Color: Black.
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 and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

2. Valve-Tag Color:
   b. Hot Water: Natural.

3. Letter Color:
   b. Hot Water: Black.

END OF SECTION 220553
SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Insulation Materials:
      a. Flexible elastomeric.
      b. Molded Close Cell.
   2. Insulating cements.
   3. Adhesives.
   5. Lagging adhesives.
   7. Factory-applied jackets.
   8. Field-applied jackets.
   10. Securements.
   11. Corner angles.
B. Related Sections include the following:
   1. Division 23 Section "HVAC Insulation."

1.3 SUBMITTALS
A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).
B. LEED Submittal:
   1. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
C. Shop Drawings:
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   3. Detail removable insulation at piping specialties, equipment connections, and access panels.
   4. Detail application of field-applied jackets.
1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

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

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products of one of the following:
      
      a. Aeroflex USA Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. NOMACO Insulation.

   2. Thermal Conductivity: Not exceeding 0.25 BTU-in/hour sq. ft. °F at 75°F mean temperature.


   1. Acceptable Manufacturers: Subject to compliance with requirements provide product by IFS Corporation; Truebro.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      
      a. Aeroflex USA Inc.
      b. Armacell LLC.
      c. Foster Products Corporation, H. B. Fuller Company.
      d. RBX Corporation.

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

C. PVC Jacket Adhesive: Compatible with PVC jacket.

   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      
      a. Dow Chemical Company (The).
      c. P.I.C. Plastics, Inc.
      d. Speedline Corporation.

   2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. Childers Products, Division of ITW.
3. ITW TACC, Division of Illinois Tool Works.
4. Marathon Industries, Inc.
5. Mon-Eco Industries, Inc.

C. Vapor-Barrier Mastic: Water or solvent based; suitable for indoor and outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.05 perm at 43-mi dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
2. Service Temperature Range: Minus 20 to plus 200 deg F.
3. Solids Content: 63 percent by volume and 73 percent by weight.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Childers Products, Division of ITW.
   b. Foster Products Corporation, H. B. Fuller Company.
   c. Marathon Industries, Inc.
   d. Mon-Eco Industries, Inc.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
4. Service Temperature Range: Minus 50 to plus 180 deg F.
2.5 SEALANTS

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

1. Childers Products, Division of ITW.
3. Marathon Industries, Inc.
4. Mon-Eco Industries, Inc.
5. Pittsburgh Corning Corporation.

B. Joint Sealants for Cellular-Glass:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

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

2.6 FACTORY-APPLIED JACKETS

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

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

2.7 FIELD-APPLIED JACKETS

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

B. Metal Jacket:

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

   a. Childers Products, Division of ITW.
   b. PABCO Metals Corporation.
   c. RPR Products, Inc.
   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   e. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 SECUREMENTS

A. Bands:
   1. Stainless Steel: ASTM A 167 or ASTM A 240, Type 304; 0.015 inch thick, 1/2 inch wide with wing or closed seal.
   2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing or closed seal.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel or aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
      a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer’s recommended coverage rate and wet and dry film thicknesses.

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

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   5. Handholes.
   6. Cleanouts.

3.4 PENETRATIONS

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

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

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Division 07 Section "Penetration Firestopping" and fire-resistant joint sealers.

F. Insulation Installation at Floor Penetrations:

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

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

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

3.6 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
   4. Secure insulation to flanges and seal seams with manufacturers' recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.
   2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
   5.

3.7 FINISHES

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

B. Do not field paint aluminum or stainless-steel jackets.
3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one (1) location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

2. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three (3) locations of straight pipe, locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor’s option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.10 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. NPS ½” through 6”: Insulation shall be the following:

   a. Flexible elastomeric: 1/2 inch thick.

B. Stormwater and Overflow:

1. All Pipe Sizes (vertical and horizontal): Insulation shall be the following:

   a. Flexible elastomeric: 1/2 inch thick.

C. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be the following:

   a. Flexible Elastomeric: 1/2 inch thick.

D. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
1. All Pipe Sizes: Insulation shall be the following:
   a. Molded Closed Cell: 1/2 inch thick.

E. Condensate, Drinking Fountain Waste and Equipment Drain Water below 60 Deg F:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 3/4 inch thick.

F. Floor Drains/Floor Sinks Bodies and Traps Located in Mechanical Rooms, and Sanitary Drain Piping from these drains/sinks, up to main risers:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 3/4 inch thick.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Equipment, Concealed:
   1. None.

D. Equipment, Exposed:
   1. None.

E. Piping, Concealed:
   1. None.

F. Piping, Exposed in mechanical room piping that is within 6 ft. of the floor:
   1. Aluminum, Smooth: 0.016 inch thick.

END OF SECTION 220700
SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
   2. Specialty valves.
   3. Flexible connectors.
   4. Escutcheons.
   5. Sleeves and sleeve seals.
   6. Wall penetration systems.

1.3 SUBMITTALS
A. Product Data: For the following products:
   1. Specialty valves.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Flexible connectors.
   5. Water meters.
   7. Escutcheons.
   8. Sleeves and sleeve seals.
   9. Water penetration systems.

B. Field quality-control reports.

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

B. Comply with NSF 61 for potable domestic water piping and components.

1.5 PROJECT CONDITIONS
A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   1. Notify Architect no fewer than seven (7) days in advance of proposed interruption of water service.
   2. Do not proceed with interruption of water service without Architect's written permission.
PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L 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. Grooved-Joint Copper-Tube Appurtenances:
      a. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Anvil International.
         2) Shurjoint Piping Products.
         3) Victaulic Company.
      b. Copper Grooved-End Fittings: ASTM B 75 copper tube or ASTM B 584 bronze castings.
      c. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

6. Copper Pressure-Seal-Joint Fittings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Elkhart Products Corporation.
      2) NIBCO Inc.
      3) Viega.

   b. Fittings for NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
   c. Fittings for NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end.

2.3 PIPING JOINING MATERIALS

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

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

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

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

1. Calpico, Inc.
2. Capitol Manufacturing Company.
3. Central Plastics Company.
4. EPCO Sales, Inc.
6. Lochinvar Corp.
7. Victaulic
8. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
9. Zurn Plumbing Products Group; Wilkins Water Control Products.

C. Dielectric Flanges:

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

D. Dielectric-Flange Kits:

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

E. Dielectric Couplings:

1. Description:
   a. Galvanized-steel coupling.
   b. Pressure Rating: 300 psig at 225 deg F.
   c. End Connections: Female threaded.
   d. Lining: Inert and noncorrosive, thermoplastic.

F. Dielectric Nipples:

1. Description:
   a. Electroplated steel nipple complying with ASTM F 1545 (Victaulic Style 47).
   b. Pressure Rating: 300 psig at 225 deg F.
   c. End Connections: Male threaded or grooved.
   d. Lining: Inert and noncorrosive, propylene.
2.5 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.

2.6 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 minimum thickness; round tube closed with welded longitudinal joint or ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.

C. 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.

2.7 SLEEVE SEALS

A. Acceptable 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.

2.8 WALL PENETRATION SYSTEMS

A. 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.

2.9 GROUT
B. Characteristics: Nonshrink; recommended for interior and exterior applications.
C. Design Mix: 5000-psi, 28-day compressive strength.
D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EARTHWORK
A. Comply with requirements in Section "Common Work Results for Plumbing" 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 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.
C. Install shutoff valve immediately upstream of each dielectric fitting.
D. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
E. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
F. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
H. Install piping adjacent to equipment and specialties to allow service and maintenance.
I. Install piping to permit valve servicing.
J. 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.

K. Install piping free of sags and bends.

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

M. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

N. Install thermometers on inlet and outlet piping from each water heater. 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 for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

H. 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 and smaller. Use butterfly or gate valves for piping NPS 2-1/2 and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."
   1. Hose-End Drain Valves: At low points in water mains, risers, and branches.

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 and Smaller: Fitting-type waterways.
   2. NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

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 and Smaller: Use dielectric couplings.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.

1. Vertical Piping: MSS Type 8 or 42, clamps.

2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet If Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

4. Base of Vertical Piping: MSS Type 52, spring hangers.

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

C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.

E. Install supports for vertical copper tubing every 10 feet.

F. Install supports for vertical steel piping every 15 feet.
G. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.8 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. Use flanges instead of unions for NPS 2-1/2 and larger.

3.9 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, 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.

3.10 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 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 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 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:
      b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.
      c. 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.
      b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
      c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
      d. 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.
      b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.

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.
3.11 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.

3.12 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.

3.13 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.

3.14 FIELD QUALITY CONTROL
A. Perform tests and inspections.
B. Piping Inspections:
1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
   a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
C. Piping Tests:
1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and for corrective action required.

D. Domestic water piping will be considered defective if it does not pass tests and inspections.
E. Prepare test and inspection reports.

3.15 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.

3.16 CLEANING
A. Clean and disinfect potable and 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 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. Flush at 10 ft/sec to comply with NFPA standards.
   b. Fill and isolate system according to either of the following:
      1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
      2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
   c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
   d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
B. Prepare and submit reports of purging and disinfecting activities.
C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.
3.17 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. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper solder-joint fittings; and brazed or soldered joints.

E. Aboveground domestic water piping, NPS 2-1/2 and larger, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper solder-joint fittings; and brazed or soldered joints.
   2. Hard copper tube, ASTM B 88, Type L; grooved-joint copper-tube appurtenances; and grooved joints.
   3. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

3.18 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
   2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.

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 221116
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1. Vacuum breakers.
2. Backflow preventers.
4. Temperature-actuated water mixing valves.
5. Strainers.
6. Hose bibbs.
7. Wall hydrants.
8. Drain valves.
10. Air vents.

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 "Drinking Fountains and Water Coolers" for water filters for water coolers.

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

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

B. 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:
   2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Conbraco Industries, Inc.
   2. FEBCO; SPX Valves & Controls.
   4. Toro Company (The); Irrigation Div.
   7. Zurn Industries, LLC; Wilkins Div.

B. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   2. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   4. Inlet and Outlet Connections: Threaded.
   5. Finish: Chrome plated.

C. Hose-Connection Vacuum Breakers:
   2. Body: Bronze, nonremovable, with manual drain.
   4. Finish: Chrome or nickel plated.

2.2 BACKFLOW PREVENTERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Conbraco Industries, Inc.
   2. FEBCO; SPX Valves & Controls.
   3. McDonald, A.Y. Mfg Co.
   6. Zurn Industries, LLC; Wilkins Div.

B. Intermediate Atmospheric-Vent Backflow Preventers:
   1. Standard: ASSE 1012.
   2. Operation: Continuous-pressure applications.
   5. End Connections: Union, solder joint.
6. Finish: Chrome plated.

C. Reduced-Pressure-Principle Backflow Preventers:

2. Operation: Continuous-pressure applications.
3. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
4. Size: To match pipe size.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

D. Double-Check Backflow-Prevention Assemblies:

2. Operation: Continuous-pressure applications, unless otherwise indicated.
3. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
4. Size: To match pipe size.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

E. Hose-Connection Backflow Preventers:

2. Operation: Up to 10-foot head of water back pressure.
3. Inlet Size: NPS 1/2 or NPS 3/4.
5. Capacity: At least 3-gpm flow.

F. Backflow-Preventer Test Kits:

1. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.3 HOSE BIBBS

A. Hose Bibbs:

4. Supply Connections: NPS 1/2 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.4 WALL HYDRANTS

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

1. Josam Company.
3. Tyler Pipe; Wade Div.
4. Watts Drainage Products Inc.
5. Woodford Manufacturing Company.
6. Zurn Industries, LLC; Light Commercial Operation.
7. Zurn Industries, LLC; Specification Drainage Operation.

B. Vacuum Breaker Wall Hydrants:

1. Standard: ASSE 1019, Type A or Type B.
2. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
3. Classification: Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
5. Operation: Loose key.
6. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
7. Inlet: NPS 1/2 or NPS 3/4.

2.5 DRAIN VALVES

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

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

2.6 WATER HAMMER ARRESTERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AMTROL, Inc.
2. Josam Company.
5. Tyler Pipe; Wade Div.
6. Watts Drainage Products Inc.
7. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Water Hammer Arresters:
   
   2. Type: Metal bellows.
   3. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

   1. Locate backflow preventers in same room as connected equipment or system.
   2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
   3. Do not install bypass piping around backflow preventers.

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

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

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

3.2 CONNECTIONS

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

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

   1. Pressure vacuum breakers.
   2. Intermediate atmospheric-vent backflow preventers.
   3. Reduced-pressure-principle backflow preventers.
5. Water pressure-reducing 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 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

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

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

3.5 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 221119
SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes the following for soil, waste, and vent piping inside the building:
   1. Pipe, tube, and fittings.

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

1.4 SUBMITTALS
A. Product Data: For pipe, tube, fittings, and couplings.
B. Field quality-control inspection and test reports.

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

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

2.5 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 1785, drain, waste, and vent.
B. PVC Socket Fittings: ASTM D 1785, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
C. Adhesive Primer: ASTM F 656.
   1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
D. Solvent Cement: ASTM D 2564.
   1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
   1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
   2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
   3. Unshielded, Nonpressure Transition Couplings:
      a. Manufacturers: 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) Fernco Inc.
3) Mission Rubber Company; a division of MCP Industries, Inc.
4) Plastic Oddities; a division of Diverse Corporate Technologies, Inc.

c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

d. Sleeve Materials:
   2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
   3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

4. Shielded, Nonpressure Transition Couplings:
   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:
      2) Mission Rubber Company; a division of MCP Industries, Inc.

c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

PART 3 - EXECUTION

3.1 EXCAVATION
A. Refer to Section "Common Work Results for Plumbing" 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 and smaller shall be any of the following:
   1. Hubless cast-iron soil pipe and fittings heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
C. Aboveground, vent piping NPS 4 and smaller shall be any of the following:
   1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
D. Underground, soil, waste, and vent piping shall be any of the following:
   1. Cast iron, bell and spigot type, for first 15'-0" of floor drain waste outlet piping serving floor drains capable of receiving liquids in temperatures greater than 120 deg F. Floor drains include but are not limited to kitchen areas, mechanical rooms and dishwashing areas.
   2. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints for all other piping.
3.3 PIPING INSTALLATION

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

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

C. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

D. Install underground, steel, force-main piping.

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 and smaller; 1 percent downward in direction of flow for piping NPS 4 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:


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

M. 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 caulked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum caulked 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.

3.5 SPECIALTY PIPE FITTING INSTALLATION

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

3.6 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.
   1. Install gate or full-port ball valve for piping NPS 2 and smaller.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
   1. Horizontal Piping: Horizontal backwater valves.
   2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
   3. Install backwater valves in accessible locations.
   4. Backwater valves are specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.7 HANGER AND SUPPORT INSTALLATION

A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
   1. Vertical Piping: MSS Type 8 or Type 42, clamps.
   2. Install individual, straight, horizontal piping runs according to the following:
a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install supports according to Division 22 Section “Hangers and Supports for Plumbing Piping and Equipment.”

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

D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.

F. Install supports for vertical cast-iron soil piping every 15 feet.

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.

H. Install supports for vertical steel piping every 15 feet.

3.8 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 and larger.
3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

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

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 60 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.10 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 221316
SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:
   1. Metal 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 "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities for grease interceptors.

B. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

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

1.5 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 METAL CLEANOUTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Josam Company; Blucher-Josam Div.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.

B. Exposed Metal Cleanouts:

1. Standard: ASME A112.36.2M for cast iron/ASME A112.3.1 for stainless steel for cleanout test tee.
2. Size: Same as connected drainage piping
3. Body Material: As required to match connected piping.
4. Closure: Raised-head, brass or cast-iron plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Metal Floor Cleanouts:

1. Standard: ASME A112.36.2M for heavy-duty, adjustable housing cleanout.
2. Size: Same as connected branch.
3. Type: Heavy-duty, adjustable housing.
4. Body or Ferrule: Cast iron.
5. Clamping Device: Required.
7. Closure: Brass plug with straight threads and gasket.
8. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Shape: Round.
11. Top Loading Classification: Heavy Duty.
12. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
14. Size: Same as connected branch.
15. Housing: Stainless steel.
17. Riser: Stainless-steel drainage pipe fitting to cleanout.

D. Cast-Iron Wall Cleanouts:

1. Standard: ASME A112.36.2M. Include wall access.
2. Size: Same as connected drainage piping.
3. Body: As required to match connected piping.
4. Closure: Raised-head, brass or cast-iron plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 FLOOR DRAINS

A. Floor Drains:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Tyler Pipe; Wade Div.
   d. Watts Industries, Inc.
   e. Zum Industries, LLC.

2. Standard: ASME A112.6.3.
4. Seepage Flange: Required.
5. Clamping Device: Required.
6. Outlet: Bottom or Side.
10. Top or Strainer Material: Gray iron/Nickel bronze/Stainless steel.
12. Top Shape: Round.
13. Dimensions of Top or Strainer: Minimum 8 inch diameter.
16. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet. Trap-seal primer valve connection where shown on drawings.
17. Trap Material: Cast iron.
19. Trap Features: Cleanout.

2.3 FLOOR SINKS

A. Floor Sinks:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Tyler Pipe, Wade Div.
   d. Watts Industries, Inc.
   e. Zurn Industries, LLC.

2. Standard: ASME A112.3.1.
4. Seepage Flange: Required.
5. Outlet: Bottom or side.
6. Exposed Surfaces and Interior Lining: Acid-resistant enamel.
7. Sediment Bucket: Required.
8. Interior Dome Strainer: Required.
9. Top of Body and Strainer Finish: Nickel bronze or gray iron.
10. Top Shape: Square.
11. Dimensions of Top or Strainer: Minimum 12” x 12” with 8” sump and ½ grate.
12. Top Loading Classification: Light duty.
13. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap seal primer valve connection.

2.4 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Acorn Engineering Company; Elmdor/Stoneman Div.
   b. Thaler Metal Industries Ltd.
B. Description: Manufactured assembly made of 4.0-lb/sq. ft. thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.


2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

2. Size: Same as connected soil, waste, or vent stack.
3. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Special Coating: Corrosion resistant on interior of fittings.

2.6 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:

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

B. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

C. Sleeve Flashing Device:

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

D. 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.

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

F. **Frost-Resistant Vent Terminals:**

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

### 2.7 FLASHING MATERIALS

#### A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:

- General Use: 4.0-lb/sq. ft. thickness.
- Vent Pipe Flashing: 3.0-lb/sq. ft. thickness.
- Burning: 6-lb/sq. ft., 0.0938-inch thickness.

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

- General Applications: 12 oz./sq. ft.
- Vent Pipe Flashing: 8 oz./sq. ft.

#### C. Fasteners: Metal compatible with material and substrate being fastened.

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

#### E. Solder: ASTM B 32, lead-free alloy.

#### F. 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.** Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. **Locate at each change in direction of piping greater than 45 degrees.**
3. **Locate at minimum intervals of 50 feet.**
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 or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
   b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
   c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

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 conductors and stacks at floor penetrations.

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

J. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

K. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

L. Install vent caps on each vent pipe passing through roof.

M. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

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

O. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

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.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thicker.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

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

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

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

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

3.5 FLOOR DRAINS SCHEDULE

A. Floor Drains Schedule:

1. Unfinished Areas on Grade:
   
   b. Top of Body and Strainer Finish: Gray iron.
   c. Strainer Material: Gray iron.
   d. Top Loading Classification: Extra heavy duty.
   e. Integral Tray and Cleanout: Required.
   f. Backwater Valve: Required.

2. Unfinished Areas above Ground:
b. Top of Body and Strainer Finish: Gray iron.
c. Top Loading Classification: Extra heavy duty.
d. Strainer Material: Gray iron.
e. Integral Trap and Cleanout: Required.

3. Finished Areas on Grade.

b. Top of Body and Strainer: Nickel bronze.
c. Top Loading Classifications: Light duty.
d. Integral Trap and Cleanout: Required.
e. Backwater Valve: Required.

4. Finished Areas above Grade:

c. Top Loading Classification: Light duty.

5. Mechanical Rooms on Grade:

b. Top of Body and Strainer Finish: Gray iron.
c. Top Loading Classification: Extra heavy duty.
d. Strainer Material: Gray iron.
e. Trap and Cleanout: Required.
f. Backwater Valve: Required.
g. Sediment Bucket: Aluminum.
h. Drain with 9” deep sump.

6. Mechanical Rooms above Grade:

b. Top of Body and Strainer Finish: Gray iron.
c. Top Loading Classification: Extra heavy duty.
d. Strainer Material: Gray iron.
e. Sediment Bucket: Aluminum.
f. Drain with 9” deep sump.

7. Funnel Floor Drains: Same as floor drains specified above, but with elongated 8x3 funnel.

END OF SECTION 221319
SECTION 221413 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes the following storm drainage piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.
B. Related Sections include the following:
   1. Division 22 Section "Sump Pumps".

1.3 PERFORMANCE REQUIREMENTS
A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water.
   2. Storm Drainage, Force-Main Piping: 50 psig.

1.4 SUBMITTALS
A. Product Data: For pipe, tube, fittings, and couplings.
B. Field quality-control inspection and test reports.

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

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. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the 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.
B. Gaskets: ASTM C 564, rubber.
C. Caiking 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.
   2. 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.

2.5 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 1785, drain, waste, and vent.
B. PVC Socket Fittings: ASTM D 1785, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
C. Adhesive Primer: ASTM F 656.
   1. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
D. Solvent Cement: ASTM D 2564.
   1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Sleeve Materials:
      b. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
      c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

C. Rigid, Unshielded, Nonpressure Pipe 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.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Section "Common Work Results for Plumbing" 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 storm drainage piping NPS 6 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 coupled joints.
3. Dissimilar Pipe-Material Couplings: Flexible, Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Aboveground, storm drainage piping NPS 8 and larger shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and coupled joints.
3. Dissimilar Pipe-Material Couplings: Flexible, Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

D. Underground storm drainage piping shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Dissimilar Pipe-Material Couplings: Flexible, Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

3.3 PIPING INSTALLATION

A. Storm sewer and drainage piping outside the building are specified in Division 33 Section "Storm Utility Drainage Piping".

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

C. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section "Storm Drainage Piping Specialties".

D. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
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 system at each service pipe penetration through foundation wall. Make installation watertight.

G. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook", Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings".

H. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

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

J. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:
   1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

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

L. 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."


E. Plastic, Nonpressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.
3.5 HANGER AND SUPPORT INSTALLATION

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

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs: According to the following:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

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

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

D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6: 60 inches with 3/4-inch rod.
5. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

F. Install supports for vertical cast-iron soil piping every 15 feet.

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.

H. Install supports for vertical steel piping every 15 feet.

I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.

J. Install supports for vertical copper tubing every 10 feet.

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

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

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.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

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

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Test Procedure: Test storm drainage piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

3.8 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 221413
SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes the following storm drainage piping specialties:
      1. Metal cleanouts.
      2. Through-penetration firestop assemblies.
      3. Roof drains.
      4. Miscellaneous storm drainage piping specialties.
      5. Flashing materials.
   B. Related Sections include the following:
      1. Division 22 Section "Sanitary Waste Piping Specialties" for backwater valves, floor drains, trench drains and channel drainage systems connected to sanitary sewer.

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

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

1.5 COORDINATION
   A. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 METAL CLEANOUTS
   A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Josam Company.
      3. Tyler Pipe; Wade Div.
      4. Watts Drainage Products Inc.
      5. Zum Industries, LLC.
B. Exposed Metal Cleanouts:

1. Standard: ASME A112.36.2M for cast iron/ASME A112.3.1 for stainless steel for cleanout test tee.
2. Size: Same as connected drainage piping
3. Body Material: As required to match connected piping.
4. Closure: Brass or cast-iron plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Metal Floor Cleanouts:

1. Standard: ASME A112.36.2M for heavy-duty, adjustable housing cleanout.
2. Size: Same as connected branch.
3. Type: Heavy-duty, adjustable housing.
4. Body or Ferrule: Cast iron.
5. Clamping Device: Required.
7. Closure: Brass plug with straight threads and gasket.
8. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Shape: Round.
11. Top Loading Classification: Heavy Duty.
12. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
14. Size: Same as connected branch.
15. Housing: Stainless steel.
17. Riser: Stainless-steel drainage pipe fitting to cleanout.

D. Cast-Iron Wall Cleanouts:

1. Standard: ASME A112.36.2M. Include wall access.
2. Size: Same as connected pipe.
3. Body: As required to match connected piping.
4. Closure: Brass or cast-iron plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

2. Size: Same as connected pipe.
3. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Special Coating: Corrosion resistant on interior of fittings.

2.3 ROOF DRAINS

A. Metal Roof Drains:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2.4 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Boots:
   1. Description: Manufactured, ASTM A 48/A 48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 outlet; and shop-applied bituminous coating.
   2. Size: Inlet size to match downspout.
   3. Description: ASTM A 74, Service class, hub-and-spigot, cast-iron soil pipe.
   4. Size: Same as or larger than connected downspout.

B. Conductor Nozzles:
   1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
   2. Size: Same as connected conductor.

2.5 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft. thickness.

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

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

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

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

F. 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. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.

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 through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.

F. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07.
   1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   2. Position roof drains for easy access and maintenance.

G. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

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

I. Install manufactured, gray-iron downspout boots at grade with top 6 inches above grade. Secure to building wall.

J. Install cast-iron soil pipe downspout boots at grade with top of hub 6 inches above grade.

K. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

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

3.2 CONNECTIONS

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

3.3 FLASHING INSTALLATION

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

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

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

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

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

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

END OF SECTION 221423
SECTION 221429 - SUMP PUMPS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes the following sump pumps and accessories, inside the building, for building storm drainage systems:
      1. Submersible sump pumps.
      2. Sump pump basins and pits.

1.3 SUBMITTALS
   A. Product Data: For each type and size of sump pump specified. Include certified performance curves with operating points plotted on curves, and rated capacities of selected models, furnished specialties, and accessories.
   B. Shop Drawings: Diagram power, signal, and control wiring.
   C. Operation and Maintenance Data: For each sump pump to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
   A. Product Options: Drawings indicate size, profiles, and dimensional requirements of sump pumps and are based on the specific system indicated. Refer to Division 01 Section “Product Requirements.”
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

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

1.6 COORDINATION
   A. Coordinate size and location of concrete bases and pits. Concrete, reinforcement, and formwork requirements are specified in Division 03.
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 SUBMERSIBLE SUMP PUMPS

A. Acceptable Manufacturers:

2. Zoeller.

B. Description: Factory-assembled and -tested, simplex/duplex, single-stage, centrifugal, end-suction, submersible, direct-connected sump pumps complying with UL 778 and HI 1.1-1.2 and HI 1.3 for submersible sump pumps.

C. Casing: Cast iron; with cast-iron inlet strainer, legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.

D. Impeller: ASTM A 48; statically and dynamically balanced, semiopen nonclog design, overhung, single suction, keyed and secured to shaft.

E. Casing: Stainless steel; with stainless-steel inlet strainer, legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange suitable for piping connection.

F. Impeller: Stainless steel or other corrosion-resistant material.

G. Casing and Impeller: Cast-iron casing with metal inlet strainer and brass, bronze, or cast-iron impeller.

H. Pump and Motor Shaft: Stainless steel/Steel, with factory-sealed, grease-lubricated ball bearings and double-mechanical seals.

I. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection; three-conductor waterproof power cable of length required, and with grounding plug and cable-sealing assembly for connection at pump. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

1. Moisture-Sensing Probe: Internal moisture sensor with moisture alarm.

J. Pump Discharge Piping: Factory or field fabricated.

K. Basin/Pit Cover: Cast iron or steel with bituminous coating and strong enough to support controls. See Part 2 "Sump Pump Basins/Pits" Article for other requirements.

L. Controls: NEMA 250, Type 1 enclosure, pedestal mounted unless wall mounting is indicated; with two mechanical-float or micropressure switches in NEMA 250, Type 6 enclosures; mounting rod; and electric cables.

M. Capacity and Characteristics as shown on drawings.
1. Alternator Control Required: Yes for duplex pumps.

2.3 SUMP PUMP PITS

A. Description: Concrete pit with sump, pipe connections, curb frame, and separate cover.

B. Curb Frame and Cover:

1. Curb Frame Material: Galvanized steel or steel with bituminous coating.
   a. Pattern: Z-cross-section shape with raised outer rim of height matching cover, for recessed mounting having installed cover flush with top of floor slab.

2. Cover: Fabricate with openings having gaskets, seals, and bushings, for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
   a. Material: Cast iron or steel with bituminous coating.
   b. Reinforcement: Steel or cast iron, capable of supporting foot traffic for pits installed in foot-traffic areas.

C. Capacity and Characteristics as shown on drawings:

2.4 FLEXIBLE CONNECTORS

A. Acceptable Manufacturers:

1. Flex-Hose Co., Inc.
2. Flex-Weld, Inc.
3. Hyspan Precision Products, Inc.
4. Metraflex, Inc.

B. Description: 125-psig minimum working-pressure rating and ends matching pump connection:

1. Bronze Flexible Connectors: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze welded to tubing.
2. Stainless-Steel Flexible Connectors: Corrugated, stainless-steel inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to tubing.

2.5 BUILDING AUTOMATION SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:

1. On-off status of each pump.
2. Alarm status.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.
3.2 CONCRETE
A. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 SUMP PUMP INSTALLATION
A. Excavating, trenching, and backfilling are specified in Section "Common Work Results for Plumbing".
B. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.
C. Set submersible sump pumps on basin or pit floor. Make direct connections to storm drainage piping.
D. Construct sump pump pits and connect to drainage piping. Set pit curb frame recessed in and anchored to concrete. Fasten pit cover to pit curb flange. Install cover so top surface is flush with finished floor.
E. Support piping so weight of piping is not supported by pumps.

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

3.5 STARTUP SERVICE
A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify bearing lubrication.
   3. Disconnect couplings and check motors for proper direction of rotation.
   4. Verify that each pump is free to rotate by hand. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   5. Verify that pump controls are correct for required application.
B. Start pumps without exceeding safe motor power:
   1. Start motors.
   2. Open discharge valves slowly.
   3. Check general mechanical operation of pumps and motors.
C. Test and adjust controls and safeties.

D. Remove and replace damaged and malfunctioning components.

1. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.
2. Set field-adjustable switches and circuit-breaker trip ranges as indicated, or if not indicated, for normal operation.

END OF SECTION 221429
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PART 1 - GENERAL

1.1 SCOPE:
   A. Install pipe lagging where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.
      1. Locations include but not limited to:
         a. Main roof drain piping above Large Instrumental Rehearsal. Does not include overflow.
   B. Reference Details on AC drawings.

1.2 RELATED WORK:
   A. Section 22 - Piping.

1.3 QUALITY ASSURANCE:
   A. Use skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

1.4 SUBMITTALS:
   A. Submit catalog cut sheets for loaded vinyl coverings indicating surface weight, and catalog cut sheets for glass fiber board duct wrap indicating density and physical form. Submit samples if requested by the Architect or Engineer.

1.5 STANDARDS:
   C. ASTM E413-04 Standard Classification for Rating Sound Insulation
PART 2 - PRODUCTS

2.1 EXTERNAL PIPE LAGGING (MASS LOADED VINYL):

A. The loaded vinyl barrier shall be constructed of a 0.10" thick mass loaded, limp vinyl sheet bonded to a thin layer of reinforced aluminum foil on one side. The barrier shall have a nominal density of 1 lb. per sq. ft. per layer minimum. See Section 3.1 for amount of acceptable layers.

B. Glass fiber pipe wrap shall be semi rigid, preformed type, 2" minimum thickness, 1-1/2 lbs. per cu. ft. minimum density. Valves, joints and other fittings shall be wrapped with premolded glass fiber of equivalent characteristics as for pipe.

C. Minimum sound transmission loss tested in accordance with ASTM E90 shall be:

<table>
<thead>
<tr>
<th>Vinyl Density</th>
<th>Octave Band Center Frequency (Hertz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>125</td>
</tr>
<tr>
<td>1 lb / ft²</td>
<td>13</td>
</tr>
</tbody>
</table>

D. Loaded vinyl shall be factory fabricated standard or custom products of the following manufacturers or approved equal. Products may be supplied by more than one manufacturer.

   Model KNM

2. Sound Seal – Agawam, MA; website: www.soundseal.com
   Industrial Noise Control Model B-10

3. Acoustical Surfaces – Chaska, MN; website: www.acousticalsurfaces.com
   Noise S.T.O.P. Vinyl Barrier

PART 3 - EXECUTION

3.1 EXTERNAL PIPE LAGGING (MASS LOADED VINYL):

A. Cover entire pipe with 2" minimum thickness glass fiber wrap. Fill all void with clean glass fiber scrap. Apply over this wrap an airtight cover of loaded vinyl with surface weight of 1 pound per square foot per layer minimum. Provide 2 layers minimum. Aggregate weight should be 2 pounds per square foot. Exception: Cover exterior piping exposed to the elements with an all-weather jacket. Do not connect the cover rigidly to the pipe or hangers. Overlap longitudinal seams in loaded vinyl 2" minimum and tape with cloth backed tape. Overlap edge seams 1" minimum and tape with cloth backed tape or seal with acoustical sealant. Extend ends of cover to structural penetration and tape. Seal airtight with acoustical sealant.

END OF SECTION 233355
SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:
   1. Faucets for lavatories and sinks.
   2. Flushometers.
   3. Toilet seats.
   4. Protective shielding guards.
   5. Fixture supports.
   7. Urinals.
   8. Lavatories.

B. Related Sections include the following:
   1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
   2. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
   3. Division 22 Section "Emergency Plumbing Fixtures."
   4. Division 22 Section "Drinking Fountains and Water Coolers."

1.3 DEFINITIONS

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.
D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.
E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.
F. FRP: Fiberglass-reinforced plastic.
G. PMMA: Polymethyl methacrylate (acrylic) plastic.
H. PVC: Polyvinyl chloride plastic.

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. LEED Submittal:

1. Product Data for Credit WE: Documentation indicating flow and water consumption requirements.

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

D. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

E. 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:

2. Vitreous-China Fixtures: ASME A112.19.2M.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Faucets: ASME A112.18.1.

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 (1) year from date of final acceptance by Owner.

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 Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed but not less than 2.
2. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than six of each type.
PART 2 - PRODUCTS

2.1 FAUCETS

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

1. American Standard Companies, Inc.
2. Bradley Corporation.
3. Chicago Faucets.
4. Delta Faucet Company.
5. Eljer.
6. Kohler Co.
7. Moen, Inc.
10. T & S Brass and Bronze Works, Inc.
11. Zurn Industries, LLC; Commercial Brass Operation.

B. Description: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.

2. Finish: Polished chrome plate.
3. Maximum Flow Rate: 0.5 gpm unless rated otherwise.

2.2 FLUSHOMETERS

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

1. Sloan Valve Company.
2. Zurn Industries, LLC; Commercial Brass Operation.

B. Description: Flushometer for urinal or water-closet-type fixture. Include brass body with corrosion-resistant internal components, control stop with check valve, vacuum breaker, sensor operated battery powered copper or brass tubing, and polished chrome-plated finish on exposed parts.

2.3 TOILET SEATS

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

1. American Standard Companies, Inc.
3. Church Seats.
4. Eljer.
5. Kohler Co.
6. Olsonite Corp.
8. Zurn Industries, LLC; Commercial Fixtures.

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

1. Material: Molded, solid plastic with antimicrobial agent.
2. Configuration: Open front with cover.
4. Hinge Type: stainless steel, self-sustaining, external check.
5. Color: White, unless noted otherwise.

2.4 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Insul-Tect Products Co.; a Subsidiary of MVG Molded Products.
   b. McGuire Manufacturing Co., Inc.
   c. TRUEBRO, Inc.
   d. Zum Industries, LLC; Tubular Brass Plumbing Products Operation.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. TRUEBRO, Inc.
   b. Sloan Valve Co.

2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

2.5 FIXTURE SUPPORTS

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

1. Josam Company.
3. Tyler Pipe; Wade Div.

B. Water-Closet Supports:

1. Description: Combination carrier designed for mounting height of wall-mounting or floor 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. Support shall be designed to withstand minimum 300 lbs. weight on fixture.

C. Urinal Supports:

1. Description: Type for wall-mounting, urinal-type fixture. Include steel uprights with feet.
D.  Lavatory Supports:

1. Description: Type for wall-mounting, lavatory-type fixture. Include steel uprights with feet.

2.6 WATER CLOSETS

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

1. American Standard Companies, Inc.
2. Kohler Co.

B. Description: Wall/Floor-mounting, back/floor-outlet, vitreous-china fixture designed for operation. Minimum 300 lbs. weight capacity. Fixture shall be ADA compatible where specified.

1. Bowl Type: Elongated with siphon-jet design.
2. Design Consumption: Maximum 1.26 gal./flush.
3. Color: White, unless noted otherwise.

2.7 URINALS

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

1. American Standard Companies, Inc.
2. Kohler Co.

B. Description: Wall -mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation. Fixture shall be ADA compatible where specified.

1. Design Consumption: 0.125 gal./flush unless noted otherwise.
2. Color: White, unless noted otherwise.

2.8 LAVATORIES

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

1. American Standard Companies, Inc.
2. Kohler Co.

B. Description: Wall or Counter -mounting, vitreous-china fixture.

1. Color: White, unless noted otherwise.

2.9 COMMERCIAL SINKS

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

1. American Standard Co., Inc.
2. Elkay Manufacturing Co.
4. Kohler Co.
5. Marlo Manufacturing.

B. Description: Counter-mounting/Wall mounting, stainless-steel commercial sink fixture.

1. Material: 18 gauge, type 304. Stainless steel with satin finish.
2. Type: Self-rimming for counter mounting, with back-splash for wall mounting.
3. Number of Compartment: As shown on drawings.

2.10 JANITOR’S SINKS

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

1. Acorn Engineering Company.
2. Crane Plumbing, L.L.C./Fiat Products.
3. Florestone Products Co., Inc.
4. Precast Terrazzo Enterprises, Inc.
5. Stern-Williams Co., Inc.
6. Zum Industries, LLC; Light Commercial Operation.

B. Description: Flush-to-wall, floor-mounting, precast terrazzo fixture with stainless steel rim guard.

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 floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

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

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

I. 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."

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install toilet seats on water closets.

L. 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.

M. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

N. 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.

O. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

P. 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."

Q. Set shower receptors and janitor's sinks in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."

R. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.3 CONNECTIONS

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

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
3.4 FIELD QUALITY CONTROL

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

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
B. Operate and adjust disposers/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.

END OF SECTION 224000
SECTION 224700 - DRINKING FOUNTAINS AND WATER COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following drinking fountains and water coolers and related components:
   1. Pressure water coolers.
   2. Fixture supports.

1.3 DEFINITIONS

A. Accessible Drinking Fountain or Water Cooler: Fixture that can be approached and used by people with disabilities.
B. Cast Polymer: Dense, cast-filled-polymer plastic.
C. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.
D. Fitting: Device that controls flow of water into or out of fixture.
E. Fixture: Drinking fountain or water cooler unless one is specifically indicated.
F. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.4 SUBMITTALS

A. Product Data: For each fixture indicated. Include rated capacities, furnished specialties, and accessories.
B. Shop Drawings: Diagram power, signal, and control wiring.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For fixtures 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.
C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.


F. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

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

1. Elkay Manufacturing Co.
2. Halsey Taylor.
3. Haws Corporation

B. Description: Accessible, ARI 1010, Type PB, pressure with bubbler, Style W, wall-mounting water cooler for adult/child-mounting height.

2. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
5. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
6. Drain(s): Grid with NPS 1-1/4 minimum horizontal waste and trap complying with ASME A112.18.1.
7. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
   a. Electrical Characteristics: Minimum 1/6 hp; 120-V ac; single phase; 60 Hz.
8. Support: Type I/II, water cooler carrier. Refer to "Fixture Supports" Article.

2.2 FIXTURE SUPPORTS

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

1. Josam Co.
3. Tyler Pipe; Wade Div.
4. Watts Drainage Products Inc.
5. Zurn Plumbing Products Group.
B. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.

1. Type I: Hanger-type carrier with two vertical uprights.
2. Type II: Bilevel, hanger-type carrier with three vertical uprights.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.

B. Examine walls and floors for suitable conditions where fixtures are to be installed.

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

3.2 APPLICATIONS

A. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.

B. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.3 INSTALLATION

A. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.

B. Install fixtures level and plumb.

C. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

D. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

E. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

F. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.4 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."

3.5 FIELD QUALITY CONTROL

A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
   1. Remove and replace malfunctioning units and retest as specified above.
   2. Report test results in writing.

3.6 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust water cooler temperature settings.

3.7 CLEANING

A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 224700
SECTION 230500 - COMMON WORK RESULTS 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 the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
7. Grout.
8. Coordination drawings.
9. Project Record Drawings.
10. HVAC demolition.
11. Equipment installation requirements common to equipment sections.
12. Painting and finishing.
13. Concrete bases.

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. 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. Any additional costs as a result of these modifications shall be borne by the contractor. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

D. HVAC work to comply with International Mechanical Code (IMC) as listed on Drawings and General Conditions.

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. Sequence, coordinate, and integrate installations of HVAC materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.

E. Coordinate connection of HVAC systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

F. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

G. Sequence, coordinate, and integrate removal of existing equipment and material as required to maintain services for existing building and for portions of remodeled areas at all times.

1.8 SCHEDULING AND PHASING

A. All HVAC work shall be scheduled to meet project completion date. HVAC work shall be phased for projects requiring phasing of work. Install additional fittings, valves, caps, and dampers as required to support phasing. Refer to phasing schedule on drawings.

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. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 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.

2.3 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

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

   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
2. AWWA C110, rubber, flat face, 1/8 inch 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. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

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

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

2.4 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. Acceptable Manufacturers:
   1. Capitol Manufacturing Co.
   2. Capico Inc.
   3. Epco Sales, Inc.

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

E. Dielectric-Flange Kits: 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.

   1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

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

2.5 MECHANICAL SLEEVE SEALS

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

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

2. Sealing Elements: EPDM or 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.

2.6 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch 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.

2.7 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, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated or rough brass.
D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.
E. One-Piece, Floor-Plate Type: Cast-iron floor plate.
F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.8 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

2. Design Mix: 5000-psi, 28-day compressive strength.
2.9 COORDINATION DRAWINGS

A. The contractor shall prepare CAD generated overall coordination drawings (min ¼” scale) to coordinate HVAC systems installation with other trades. Following systems/items shall be indicated and co-coordinated, but not limited to, with each other based on input from installers of these systems:

1. Ceiling layout.
2. Sheet metal ductwork including locations of boxes, diffusers, grilles/registers, duct risers, fire/smoke dampers, etc.
3. HVAC piping routing including locations of valves, expansion loops, risers, etc.
4. Fire suppression piping mains, sprinkler heads, flow switches, etc.
5. Plumbing piping routing including locations of valves, drops to fixtures, risers, etc.
6. Electrical systems including locations of light fixtures, routing of main feeders/conduits larger than 3” dia., routing of cable tray, etc.

B. Contractor shall obtain information of other systems from General Contractor, Electrical Contractor, Fire Suppression Contractor, Plumbing Contractor and others as required for incorporation in the coordination drawings.

C. Contractor shall arrange coordination meeting with other contractors, whose systems need coordination, to resolve conflicts.

2.10 PROJECT RECORD DRAWINGS

A. Drawings shall be furnished in electronic-media (CD-Rewritable type) and at least one hard copy prints.

1. Format: Same CAD program, version and operating system as the original Contract Drawings.
2. Incorporate changes and additional information previously marked on Record prints. Delete, re-draw and add details and notations where applicable.

B. Identify and date each drawing and include the designation “PROJECT RECORD DRAWING” or “AS-BUILT DRAWING” in a prominent location.

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 minimum 8 inches above accessible ceilings to allow sufficient space for ceiling panel removal and service access.

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. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
   g. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
   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 and concrete floor and roof slabs.

P. 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 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 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.
   b. Steel Sheet Sleeves: For pipes NPS 6 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 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.
Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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

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

S. 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.

T. Verify final equipment locations for roughing-in.

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

V. Draining and Refilling of Systems: Provide all shutoff valves, drain valves, pipe, fittings, and miscellaneous material required to drain each existing system as required for new work. After new work is completed, tested, and found tight, refill each system as required. Time for shutting down existing system for draining shall be coordinated with all other work and with Owner’s representative. Fill glycol system with type and percentage solutions as directed by Owner.

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 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. 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."

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 larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete".
8. Concrete base for pumps shall be a minimum of 5x the pump weight.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

B. 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 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes 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. All motor shall meet minimum ASHRAE energy efficiency requirements.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Motors ½ HP and Larger: Three phase, unless shown otherwise.

B. Motors Smaller than ½ HP: Single phase, unless shown otherwise.

C. Frequency Rating: 60 Hz/

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
F. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

G. 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.

H. Enclosure: Open drip-proof.

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: Separate winding for each speed.


F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F unless otherwise noted.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Motors under 100 hp – Provide shaft grounding ring on either the drive end or non-drive end of the motor in accordance with manufacturer’s recommendations.
6. Motors 100 hp and above – Provide ceramic bearing or bearing journal on non-drive end of the motor and shaft grounding ring on the opposite end in accordance with manufacturer’s recommendations.

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
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SECTION 230516 - EXPANSION LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pipe bends and loops.
2. Alignment guides and anchors.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

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

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Welding certificates.
C. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.
D. Maintenance Data: For pipe expansion joints to include in maintenance manuals.
1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
   2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

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

      a. Adsco Manufacturing, LLC.
      b. Flex-Hose Co., Inc.
      c. Flexicraft Industries.
      d. Hyspan Precision Products, Inc.
      e. Metraflex, Inc.
      f. Piping Technology & Products, Inc.
      g. Senior Flexonics, Inc.; Pathway Division.

2.2 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.

   2. Expansion Plug: Zinc-coated steel.

E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.

   1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

F. Concrete: Portland cement mix, 3000 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.
PART 3 - EXECUTION

3.1 PIPE BEND AND LOOP INSTALLATION

A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Attach pipe bends and loops to anchors.


2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.2 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least four pipe fittings, including tee in main.

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

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

3.3 ALIGNMENT-GUIDE INSTALLATION

A. Install guides on piping adjoining pipe expansion fittings and loops.

B. Attach guides to pipe and secure to building structure.

3.4 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

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

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints or compensators are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION 230516
SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes meters and gages for mechanical systems and water meters installed inside the building.
B. Related Sections include the following:
   1. Mechanical equipment Sections that specify meters and gages as part of factory-fabricated equipment.

1.3 SUBMITTALS
A. Product Data: Include scale range, ratings, and calibrated performance curves for each meter, gage, fitting, specialty, and accessory specified.
B. Shop Drawings: Include schedule indicating manufacturer's number, scale range, fittings, and location for each meter and gage.
C. Product Certificates: Signed by manufacturers of meters and gages certifying accuracies under specified operating conditions and compliance with specified requirements.
D. Shop Drawings: For brackets for duct-mounting thermometers.
E. Maintenance Data: For meters and gages to include in maintenance manuals specified in Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Dial Type Thermometers:
      b. Ernst Gage Co.
      c. Marsh Bellofram.
      d. Trerice: H. O. Trerice Co.
      e. Weiss Instruments, Inc.
   2. Pressure Gages:
3. Pitot-Tube-Type Flow Elements:
   a. Dieterich Standard Co.
   b. Preso Meters Corp.
   c. Taco, Inc.

4. Water Meter:
   a. Badgermeter.

2.2 THERMOMETERS, GENERAL

A. Scale Range: Temperature ranges for services listed are as follows:
   1. Domestic Hot Water: 30 to 240 deg F, with 2-degree scale divisions.
   2. Hot Water: 30 to 300 deg F, with 2-degree scale divisions.
   3. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions.
   4. Steam and Condensate: 50 to 400 deg F, with 5-degree scale divisions.

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

2.3 DIAL TYPE THERMOMETERS

A. Description: ASTM E 1.

B. Case: Die cast and aluminum finished in baked-epoxy enamel, glass front, spring secured, minimum 2" diameter, maximum 5" diameter, accurate to within 1% of full scale.

C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

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

E. Scale: Satin-faced nonreflective aluminum with permanently etched markings.

F. Stem: Copper-plated steel, aluminum, or brass for separable socket; of length to suit installation.

2.4 SEPARABLE SOCKETS

A. Description: Fitting with protective socket for installation in threaded pipe fitting to hold fixed thermometer stem.
   2. Extension-Neck Length: Nominal thickness of 2 inches (50 mm), but not less than thickness of insulation. Omit extension neck for sockets for piping not insulated.
   3. Insertion Length: To extend to one-third of diameter of pipe.
   4. Cap: Threaded, with chain permanently fastened to socket.
5. Heat-Transfer Fluid: Oil or graphite.

2.5 THERMOMETER WELLS

A. Description: Fitting with protective well for installation in threaded pipe fitting to hold test thermometer.

1. Material: Steel, for use in steel piping.
2. Extension-Neck Length: Nominal thickness of 2 inches (50 mm), but not less than thickness of insulation. Omit extension neck for wells for piping not insulated.
3. Insertion Length: To extend to one-third of diameter of pipe.
4. Cap: Threaded, with chain permanently fastened to socket.
5. Heat-Transfer Fluid: Oil or graphite.

2.6 DUCT THERMOMETER SUPPORT FLANGES

A. Description: Flanged-fitting bracket for mounting in hole of duct, with threaded end for attaching thermometer.

1. Extension-Neck Length: Nominal thickness of 2 inches (50 mm), but not less than thickness of exterior insulation.
2. Insertion-Neck Length: Nominal thickness of 2 inches (50 mm), but not less than thickness of insulation lining.

2.7 PRESSURE GAGES

A. Description: ASME B40.1, phosphor-bronze bourdon-tube type with bottom connection; dry type, unless liquid-filled-case type is indicated.

B. Case: Drawn steel, brass, or aluminum with 4-1/2-inch- (115-mm-) diameter, glass lens.

C. Connector: Brass, NPS 1/4 (DN8).

D. Scale: White-coated aluminum with permanently etched markings.

E. Accuracy: Grade A, plus or minus 1 percent of middle 50 percent of scale.

F. Range: Comply with the following:

1. Vacuum: 30 inches Hg of vacuum to 15 psig of pressure (100 kPa of vacuum to 103 kPa of pressure).
2. Fluids under Pressure: Two times the operating pressure.

2.8 PRESSURE-GAGE FITTINGS

A. Valves: NPS 1/4 (DN8) brass or stainless-steel needle type.

B. Syphons: NPS 1/4 (DN8) coil of brass tubing with threaded ends.

C. Snubbers: ASME B40.5, NPS 1/4 (DN8) brass bushing with corrosion-resistant porous-metal disc of material suitable for system fluid and working pressure.
PART 3 - EXECUTION

3.1 METER AND GAGE INSTALLATION, GENERAL

A. Install meters, gages, and accessories according to manufacturer's written instructions for applications where used.

3.2 THERMOMETER INSTALLATION

A. Install thermometers and adjust vertical and tilted positions.

B. Install in the following locations:
   1. Inlet and outlet of each hydronic coil in air-handling units systems.
   2. Chilled water supply and return mains at building entrance.

C. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.
   1. Install with socket extending to one-third of diameter of pipe.
   2. Fill sockets with oil or graphite and secure caps.

D. Install thermometer wells in vertical position in piping tees where test thermometers are indicated.
   1. Install with stem extending to one-third of diameter of pipe.
   2. Fill wells with oil or graphite and secure caps.

3.3 PRESSURE-GAGE INSTALLATION

A. Install pressure gages in piping tees with pressure-gage valve located on pipe at most readable position.

B. Install dry-type pressure gages in the following locations:
   1. Discharge of each water pressure-reducing valve.
   2. Inlet and outlet of domestic water heaters.
   3. Supply and return header of chilled water system.

C. Install liquid-filled-type pressure gages at suction and discharge of each pump.

D. Install pressure-gage needle valve and snubber in piping to pressure gages.
   1. Exception: Install syphon instead of snubber in piping to steam pressure gages.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:
   1. Install meters and gages adjacent to machines and equipment to allow service and maintenance.
   2. Connect flow-measuring-system elements to meters.
   3. Connect flowmeter transmitters to meters.
   4. Connect thermal-energy-flowmeter transmitters to meters.
B. Make electrical connections to power supply and electrically operated meters and devices.

C. Install electrical connections for power and devices.

D. Electrical power, wiring, and connections are specified in Division 26 Sections.

3.5 ADJUSTING AND CLEANING

A. Calibrate meters according to manufacturer's written instructions, after installation.

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

C. Clean windows of meters and gages and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION 230519
SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes general duty valves common to several mechanical piping systems.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Special purpose valves are specified in Division 23 piping system Sections.
2. Valve tags and charts are specified in Division 23 Section "Mechanical Identification."

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each valve type. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.

C. Maintenance data for valves to include in the operation and maintenance manual specified in Division 1. Include detailed manufacturer's instructions on adjusting, servicing, disassembling, and repairing.

1.4 QUALITY ASSURANCE

A. Single-Source Responsibility: Comply with the requirements specified in Division 1 Section "Materials and Equipment," under "Source Limitations" Paragraph.

B. ASME Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

C. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set globe and gate 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 indoors and maintain valve temperature higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Ball Valves:
   a. Conbraco Industries, Inc.; Apollo Division.
   b. Milwaukee Valve Company, Inc.
   c. NIBCO Inc.
   d. Stockham Valves & Fittings, Inc.

2. Butterfly Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Grinnell Corp.
   c. Keystone Valve USA, Inc.
   d. Milwaukee Valve Company, Inc.
   e. NIBCO Inc.
   f. Stockham Valves & Fittings, Inc.

3. Swing Check Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Milwaukee Valve Company, Inc.
   c. NIBCO Inc.
   d. Stockham Valves & Fittings, Inc.

4. Lift Check Valves:
   a. Bonney Forge.

5. Globe Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Milwaukee Valve Company, Inc.
   c. NIBCO Inc.
   d. Stockham Valves & Fittings, Inc.

2.2 BASIC, COMMON FEATURES

A. Pressure and Temperature Ratings: As indicated in the "Application Schedule" of Part 3 of this Section and as required to suit system pressures and temperatures.
B. Sizes: Same size as upstream pipe, unless otherwise indicated.

C. Operators: Use specified operators and handwheels, except provide the following special operator features:

1. Handwheels: For valves other than quarter turn.
2. Lever Handles: For quarter-turn valves 6 inches (DN150) and smaller, except for plug valves, which shall have square heads. Furnish Owner with 1 wrench for every 10 plug valves.
3. Chain-Wheel Operators: For valves 4 inches (DN100) and larger, installed 96 inches (2400 mm) or higher above finished floor elevation.
4. Gear-Drive Operators: For quarter-turn valves 8 inches (DN200) 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.


1. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F (450 deg C) for gate, globe, and check valves; below 421 deg F (216 deg C) for ball valves.

2.3 BALL VALVES

A. Chilled Water and Hot Water - Ball Valves: MSS SP-110, 150 lb., 2" and smaller, ASTM B 584 bronze body and bonnet, 2-piece construction; stainless steel ball, full port blowout proof; stainless steel stem; Teflon seats and seals; soldered end connections, NIBCO T-595-Y, NIBCO S-595-Y or equal:

3. Memory Stop: For operator handles.

2.4 GLOBE VALVES

A. Chilled Water and Hot Water - Globe Valves, 3 Inches (DN65) and Smaller: MSS  SP-80; Class 125, 200-psi (1380-kPa) CWP, or Class 150, 300-psi (2070-kPa) CWP; ASTM B 62 cast-bronze body and screwed bonnet, rubber, bronze, or Teflon disc, silicon bronze-alloy stem, Teflon-impregnated packing with bronze nut, threaded or soldered end connections; and with aluminum or malleable-iron handwheel.

2.5 BUTTERFLY VALVES

A. Chilled Water and Hot Water - Butterfly Valves: MSS SP-67, 200-psi (1380-kPa) CWP, 150 psi maximum pressure differential, ASTM A 126 cast-iron full lug body and bonnet, extended neck, 316 stainless-steel stem, field-replaceable EPDM sleeve and stem seals, Grinnell Series 8000 or equal:

1. Disc Type: Aluminum bronze.
2. Operator for Sizes 2 Inches (DN50) to 5 Inches (DN150): Lever handle with latch lock with memory.
3. Operator for Sizes 6 Inches (DN200) to 24 Inches (DN600): Gear operator with position indicator with chain 6'-0" A.F.F.
4. Operator for Sizes 6 Inches (DN200) and Larger, 96 Inches (2400 mm) or Higher above Floor: Chain-wheel operator with chain 6'-0" A.F.F.

2.6 CHECK VALVES

A. Swing Check Valves, 2 Inches (DN65) and Smaller: 150 lb.; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, soldered connections, NIBCO T-433 or equal.

B. Swing Check Valves, 2-1/2 Inches (DN80) and Larger: MSS SP-71, Class 125, 200-psi (1380-kPa) CWP, ASTM A 126 cast-iron body and bolted cap, horizontal-swing bronze disc, flanged end connections, NIBCO F-918 or equal.

C. Lift Check Valves (Pump Discharge): Class 800, forged steel ball type check valve, with bolted bonnet, male-female joint, spiral wound gasket made in F316L/graphite. Valves shall conform to MS-SP-118 and ASME B16.34 and shall be tested according to API 598.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. 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.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. 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.

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

3.2 INSTALLATION

A. Install valves as indicated, according to manufacturer's written instructions.

B. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

C. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

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

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.
G. For chain-wheel operators, extend chains to 60 inches (1500 mm) above finished floor elevation.

H. Installation of Check Valves: Install for proper direction of flow as follows:
   1. Swing Check Valves: Horizontal position with hinge pin level.
   2. Lift Check Valve: With stem upright and plumb.

3.3 SOLDERED CONNECTIONS
   A. Cut tube square and to exact lengths.
   B. 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.
   C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.
   D. Open gate and globe valves to fully open position.
   E. Remove the cap and disc holder of swing check valves having composition discs.
   F. 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.
   G. Apply heat evenly to outside of valve around joint until solder melts on 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.

3.4 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.

3.5 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.
3.6 VALVE END SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2-1/2 Inches (DN65) and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
2. Steel Pipe Sizes, 2-1/2 Inches (DN65) and Smaller: Threaded or grooved end.
3. Steel Pipe Sizes, 3 Inches (DN80) and Larger: Grooved end or flanged.

3.7 APPLICATION SCHEDULE

A. General Application: Use gate, ball, and butterfly valves for shutoff duty; lubricated plug cocks, and balancing valves for throttling duty, and butterfly valves on pump discharge. Refer to piping system Specification Sections for specific valve applications and arrangements.

B. Heating and Chilled Water Systems: Use the following valve types:

1. Ball Valves (up to and including 2"):
2. Butterfly Valves 3" and Larger:
3. Bronze Swing Check: Class 150, with composition seat.
5. Balancing valves: Bell and Gossett CBV or Armstrong Flowsetter ΔP type

C. Low-Pressure Steam Systems (Inside Building): Use the following valve types:

1. Gate Valves (2" and smaller): 150 lb., rising stem.
2. Gate Valves (steam supply 3" and larger): 150 lbs, OS&Y.
3. Globe Valves: Class 150, bronze body with Teflon disc (ahead of pressure gauges).

3.8 ADJUSTING

A. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

END OF SECTION 230523
SECTION 230529 - 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. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Equipment supports.

B. Related Sections include the following:
   1. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
   2. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
   3. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
   4. Division 23 Section(s) "Metal Ducts" and "Nonmetal 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. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."
4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
5. ASME Boiler and Pressure Vessel Code: Section IX.

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

2. Carpenter & Paterson, Inc.
3. Empire Industries, Inc.
5. Grinnell Corp.
6. GS Metals Corp.
8. 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. Acceptable Manufacturers:
   2. GS Metals Corp.
   4. Thomas & Betts Corporation.
   5. 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-minimum, compressive-strength insulation insert encased in sheet metal shield.
B. Acceptable Manufacturers:
   1. Carpenter & Paterson, Inc.
   2. PHS Industries, Inc.
   3. Pipe Shields, Inc.
   5. 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. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate.
E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS
A. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated 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. Acceptable Manufacturers:
2.7 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

1. Acceptable Manufacturers:
   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

   2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   3. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

   1. Bases: One or more plastic.
   2. Vertical Members: Two or more protective-coated-steel channels.
   3. Horizontal Member: Protective-coated-steel channel.

2.8 EQUIPMENT SUPPORTS

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

2.9 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, 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.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 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, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

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 for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

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-joint construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
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.
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 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 mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.


I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

N. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood 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.

3.6 PAINTING
A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
B. 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 230529
SECTION 230548 – VIBRATION ISOLATION OF HVAC

PART 1 - GENERAL

1.1 SCOPE:

A. Certain systems and components of the project are intentionally designed to avoid vibration problems. Vibration isolation systems are more critical than “standard construction.” The Contractor is cautioned not to overlook these specific components in favor of “standard construction practices” in any pricing, submittal, or construction procedure.

1. Mount rotating and/or reciprocating equipment, ductwork, and piping on vibration isolators as noted in these Documents. Select, install and adjust isolators to prevent the transmission of objectionable vibration and noise to the building structure.

1.2 RELATED WORK:

A. Perform vibration isolation work in this contract, including work described in other Divisions to meet the product and execution requirements of this Section.

1. Division 1 – General Requirements.
2. Section 018636 – Ambient Noise Levels.
3. Division 3 – Concrete.
4. All Division 23 specifications relating to vibration isolated equipment and materials.
5. Section 260548 – Vibration Isolation of Electrical Systems.

1.3 QUALITY ASSURANCE:

A. Provide vibration isolators and equipment bases for Divisions 14, 21, 22, 23, 26, 27 from the product line of a single manufacturer whenever possible unless approved by the project Acoustics Consultant. Isolators not supplied by the primary vibration isolator manufacturer shall be rejected.

B. The vibration isolator manufacturer’s representative shall determine isolator sizes and mountings, and shall provide field supervision and inspection to assure proper installation, adjustment and performance. Representative shall alert the Engineer and project Acoustics Consultant to any isolator selections, which may experience resonance with the approved equipment and upgrade any isolators that are found to resonate with the supported equipment. The Contractor shall include in his bid vibration isolation system elements as recommended by the manufacturer's representative to make a complete, correct, and safe installation. Supply and install any incidental materials needed, even if not explicitly specified or shown in the Construction Documents, without claim for additional payment.

C. Skilled workers who are experienced in the necessary crafts to meet the requirements of this Section shall perform the work.
1.4 SEISMIC RESTRAINT:

A. Seismic Certification: A licensed professional engineer experienced in the design of seismic restraints for flexibly mounted equipment, in the employ of the vibration isolation manufacturer, shall certify and stamp the shop drawings stating that all requirements of state and local codes have been met regarding seismic restraint of all resiliently mounted equipment. Provide calculations and analysis showing compliance with the applicable codes.

1.5 UNACCEPTABLE TYPES:

A. Do not use Mason models C, CI or CS, Amber-Booth models XL or XK, Kinetics models SL or SM or equivalent on this project in any location.

1.6 SUBMITTALS:

A. Vibration Isolation Mounts and Hangers: In a single consolidated submittal, provide catalog datasheets, shop drawings and other documents as necessary to indicate equipment unit number, isolator type, supported weight, scheduled deflection, proposed deflection under operating load, spring free height, spring operating height, spring solid height (at coil bind), and spring diameter for each isolator. Submittals based upon rated deflection will be rejected. Indicate the weight and lowest rotational or reciprocal speed of each piece of isolated equipment. Indicate bridge bearing quality neoprene components and neoprene durometer where provided. Use the format below to summarize isolator characteristics for submittal review by the Engineer and project Acoustics Consultant. Submittals will be reviewed for compliance and a Review/Comment sheet returned to the Architect and Engineer for their use.

B. Elastomeric Pads: For pads supporting equipment (not piping), submit calculations showing supported weight, required deflection, pad support area, load per square inch, operating deflection, unloaded pad height (not including shims and top plate) and percent deflection. Indicate bridge-bearing quality neoprene where provided.

C. SAMPLE SUBMITTAL FORMAT: MOUNT/HANGER PAD

<table>
<thead>
<tr>
<th>Supported Equipment</th>
<th>Isolator Type</th>
<th>Supported Weight</th>
<th>Lowest Speed</th>
<th>Scheduled Deflection</th>
<th>Operating Deflection</th>
<th>Spring (Pad) Free Height</th>
<th>Operating Height</th>
<th>Solid Height</th>
<th>Spring Diameter</th>
<th>Pad Support Area</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-1</td>
<td>Mason SLRS-B2-680</td>
<td>1750 LB</td>
<td>1500 RPM</td>
<td>1.5 inch</td>
<td>1.6 inch</td>
<td>4.125 inch</td>
<td>2.525 inch</td>
<td>1.125 inch</td>
<td>2.875 inch</td>
<td>16 sq. in.</td>
<td>Bridge bearing quality neoprene, 30 durometer</td>
</tr>
</tbody>
</table>

D. Equipment Bases: Provide detailed drawings for steel bases, sub-bases, and rails showing all steel work, reinforcing method of isolator attachment, and location of equipment attachment bolts.

E. Concrete Inertia Bases: Provide shop drawings showing all steel work, required concrete, and method of isolator attachment, and location of equipment attachment bolts.

F. Shop Drawings: Submit shop drawings and manufacturer's installation instructions for thrust restraints and sway braces wherever they are required. Submit shop drawings for piping isolation details where Type A
Pads are used; see Paragraph 3.17: Piping Isolation.

G. Inspection Report: Upon completion of the installation and after the system is put into operation, the manufacturer's representative shall make a final inspection and submit his report to the Architects and Engineers in writing certifying the correctness of installation and compliance with approved submittal data. The contractor shall allow for the cost of this service in his bid.

1.7 DRAWINGS ARE SCHEMATIC ONLY:

A. Choose the size and number of mounts and hangers to meet these specifications. Provide brackets, rails, bases, braces, snubbers, etc. as needed for a complete and correct installation.

1.8 STANDARDS:

A. American Association of State Highway and Transportation Officials Standard Specifications for Highway Bridges (AASHTO), Highway Bridge Specification. See Table B requirements for physical properties of bridge-bearing quality neoprene.

1.9 ALTERNATE SYSTEM:

A. In equipment rooms with substantial isolation hanger requirements (such as chiller and pump rooms), contractor may submit the following alternate system for approval. Provide a rigid secondary structural frame from which all equipment, piping, ductwork, conduit, and other attachments may be resiliently supported. Support the equipment, piping, ductwork, conduit, and other attachments in accordance with the rest of this specification. The mechanical contractor will size the frame. Show load estimates for the frame and equipment.

PART 2 - PRODUCTS

2.1 SPRING REQUIREMENTS:

A. Steel springs and neoprene elements shall have static deflections under operating load equal to or greater than deflections shown in this specification section. Submittals based on rated deflection will be disapproved.

B. All steel springs as installed shall have a minimum additional travel to solid (coil bind) equal to 50% of the deflection under operating load.

C. Spring diameter shall be no less than 80% of the compressed height of the spring at operational load.

D. Steel springs shall not be welded to other elements of the isolator unless specifically noted in the submittal and approved by the project Acoustics Consultant.

E. Steel springs shall not take a permanent set when compressed to coil bind.

F. Steel springs shall be color coded to allow positive identification after installation.

2.2 ELASTOMER REQUIREMENTS:

A. All elastomeric (neoprene) components shall be selected for maximum hardness of 40 durometer, shore A rating, where possible. In no case shall hardness exceed 50 durometer. Use bridge-bearing quality.
neoprene meeting AASHTO Highway Bridge Specifications in all elastomeric components where installed in irretrievable locations and as noted elsewhere in the documents.

2.3 CORROSION RESISTANCE:

A. All isolators and associated hardware shall be designed or treated for resistance to corrosion. Steel components shall be PVC coated, or phosphated and painted with industrial grade enamel. All nuts, bolts and washers shall be zinc electroplated. Structural steel bases and exposed steel components of concrete inertia bases shall be cleaned of welding slag and primed with zinc-chromate or metal etching primer. A finish coat of industrial grade enamel shall be applied over the primer.

1. All isolators exposed to the weather shall have steel parts PVC coated, hot-dip galvanized or zinc-electroplated plus coating of Neoprene or Bitumastic paint. Aluminum components for outdoor installation shall be etched and painted with industrial grade enamel. Nuts, bolts, and washers may be zinc-electroplated.

2.4 VIBRATION CONTROL MANUFACTURERS:

A. Manufacturers will be approved providing mounting systems are in strict accordance with design intent as specified herein:

2. Kinetics Noise Control, Dublin, Ohio.

B. Since manufacturers’ products vary, specific models listed in this Specification may not be approved if they do not meet all requirements in this section. Model designations listed herein are intended only as a guide.

2.5 EQUIPMENT SET ON FLOORS AND HOUSEKEEPING PADS:

A. If any of the isolated equipment is to be set directly on the floor or a housekeeping pad, provide Mason "Super-W" or approved equal neoprene pads under the unit. For units supported by load-bearing sleepers, neoprene pads (with load-distributing steel shims, if necessary) must be provided to the extent specified by the pad manufacturer’s representative or engineer. Pads must meet requirements of Paragraph 2.7: TYPE A - ELASTOMERIC PADS.

2.6 EQUIPMENT BOLTED TO FLOORS OR HOUSEKEEPING PADS:

A. Bolts or snubbers used to keep the pads securely in place must be sleeved or grommeted with neoprene and secured with a neoprene washer to prevent rigid metal-to-metal contact. If the mounting base plate is to be bolted to the structure or framework rigidly connected to the structure, Mason HLB neoprene bushings and Mason HLW neoprene washers shall be used between each bolt and the isolator base plate to prevent mechanical short circuit. These additional neoprene washers and bushings may be omitted only if the base plate and friction pad incorporate neoprene elements that eliminate rigid contact between bolts and the base plate. Bolt holes shall be properly sized to allow for bushings. The hold down bolt shall incorporate steel washers to distribute load evenly over neoprene washers. Neoprene bushings and washers must meet conditions of Paragraph 2.24: ELASTOMERIC GROMMETS.

2.7 TYPE A ELASTOMERIC PADS:
A. Elastomeric pads shall be 5/16 inch minimum thickness waffled or ribbed neoprene pads Mason model W or SW, Amber-Booth model NR, Kinetics model NP or approved equal. Where multiple layers are specified or are required to provide the specified deflection, pads shall be interleaved with 16 gauge steel shim plates, Mason model WSW, Amber-Booth model SP-NR style E or approved equal. Size pads for deflection as required in Table 1. Maximum pad deflection is 20% of unloaded height, except bridge-bearing quality pads, which have maximum deflection of 15% of unloaded height. Provide load distributing top plates if needed for uniform loading. Provide pads of sufficient thickness to achieve the specified minimum deflection. Cork shall not be used in elastomeric pad assemblies. Neoprene shall meet conditions of Paragraph 2.2: ELASTOMER REQUIREMENTS.

2.8 TYPE B NEOPRENE-IN-SHEAR FLOOR MOUNT ISOLATORS:

A. Neoprene-in-shear floor mount isolators shall have steel bottom plates with bolt holes for bolting to foundations, a threaded steel insert at top of the mounting for attaching equipment, and friction surfaces both top and bottom. All metal surfaces shall be neoprene covered to resist corrosion. Mounts shall be double deflection and designed for deflection as required in Table 1 of this specification. Maximum mount deflection is 0.35 inches at rated load. Neoprene shall meet conditions of Paragraph 2.2: ELASTOMER REQUIREMENTS. Isolators shall be Mason model ND, Amber-Booth model RVD, Kinetics model RD or approved equal.

2.9 TYPE D OPEN SPRING FLOOR MOUNT ISOLATORS:

A. Open spring floor mount isolators shall be freestanding and laterally stable with no housing, and shall have leveling adjustment bolts, which shall be rigidly connected to the equipment. Size and select isolators for deflection as required in Table 1 in this specification. Provide with 1/4” minimum elastomeric friction pad Type A between the base plate and the support. Pad shall meet conditions of Paragraph 2.2: ELASTOMER REQUIREMENTS. Vibration isolator vendor shall size elastomeric pads and associated load distributing shim plates to achieve deflection equal to 10 - 20% of the vertical thickness of the pads. Isolators shall be Mason model SLF, Amber-Booth model SW, Kinetics model FDS or approved equal.

2.10 TYPE E RESTRAINED OPEN SPRING FLOOR MOUNT ISOLATORS:

A. Restrained open spring floor mount isolators for equipment with operating weight greater than installed weight shall have built-in adjustable limit stops to prevent equipment from rising when weight is removed. Isolators shall be as Type D above plus height limiting studs and adjustable nuts, with 1/2” minimum clearance around the studs. Size and select isolators for deflection as required in Table 1 of this specification. Isolators shall be Mason model SLR, Amber-Booth model CT, Kinetics model FLS or approved equal.

2.11 TYPE F ELASTOMERIC HANGERS:

A. Elastomeric hangers shall be a neoprene-in-shear element mounted in a hanger box. The neoprene element shall be molded with a rod isolation bushing that prevents the rod from contacting the hanger box. Size and select isolators for deflection as required in Table 1 of this specification. Isolators shall be Mason model HD, WHD, Amber-Booth model BRD, Kinetics model RH or approved equal.

2.12 TYPE G SPRING AND NEOPRENE-IN-SERIES ISOLATOR HANGERS:

A. Spring and neoprene-in-series isolator hangers shall contain a steel spring and elastomeric element in series. Size and select isolators for deflection as required in Table 1 of this specification. Neoprene elements shall be molded with a rod isolation bushing that passes through the hanger box that prevents the rod from contacting the hanger box. The diameters of the spring and the hole in the mounting box shall allow for 15-degree misalignment from vertical before mechanical short circuit occurs. Isolators shall
be Mason model 30N, Amber-Booth model BSRA, Kinetics model SRH or approved equal.

2.13 TYPE H PRECOMPRESSED SPRING AND NEOPRENE-IN-SERIES HANGERS:

A. Precompressed spring and neoprene-in-series hangers shall be equal to Type G including 15-degree misalignment capability. Size and select isolators for deflection as required in Table 1 of this specification. Isolator shall be pre-compressed to the rated deflection to allow installation at a fixed elevation. Hangers shall have a release mechanism to free the spring after installation and the hanger is subjected to its full load. Deflection shall be indicated by means of a scale. Isolators shall be Mason model PC30N, Amber-Booth model PBSRA or approved equal.

2.14 TYPE J THRUST RESTRAINTS:

A. Thrust restraints shall be in sets of two or more, and shall be springs in series with neoprene. Deflection shall be equal to deflection of isolators supporting the unit being restrained. Provide thrust restraints complete with rods and adjustment nuts, plus angle brackets and backing plates for attachment to the unit being restrained and anchor supports. Thrust restraints shall be Mason model WB or approved equal.

2.15 TYPE K SWAY BRACES:

A. Sway braces shall be in sets of two or more and shall consist of aircraft cable, neoprene elements, or neoprene and spring assemblies. Braces shall keep the equipment stable without restricting the free motion of the vibration isolators. Submit shop drawings for approval prior to installation.

2.16 TYPE L INERTIA BASES:

A. Concrete inertia bases shall be formed of stone-aggregate concrete (150 lbs./cu. ft.) and appropriate steel reinforcing cast between perimeter structural steel channels.

B. Inertia bases shall be built to form a rigid base, which will not twist, deform, deflect, or crack in any manner that would negatively affect the operation of the supported equipment or the vibration isolation mounts. Inertia bases shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure.

C. The vibration isolator manufacturer shall supply the steel frame and reinforcement. The General Contractor may provide concrete.

D. Inertia base shall weigh a minimum of two times the weight of the supported equipment, and shall be a minimum of 6” thick. Spacing between isolators supporting the inertia base shall be a maximum of ten times the thickness of the inertia base. Bases shall have a minimum operating clearance of 2” above floor or housekeeping pad. Use height saving brackets as required to maintain proper clearances.

2.17 TYPE M STEEL BASES:

A. Steel bases shall consist of structural steel sections sized, spaced, and connected to form a rigid frame which will not twist, rack, deform, or deflect in any manner to negatively affect the operation of the supported equipment or the vibration isolation mounts. Bases shall be adequately sized to support basic equipment and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. Steel bases shall be at least 6” thick. Spacing between isolators supporting the steel base shall be a maximum of ten times the thickness of the base. Bases shall have a minimum operating clearance of 2” above floor or housekeeping pad. Bases shall include side-mounting
brackets for attachment to vibration isolators.

2.18 TYPE N STEEL RAILS:
A. Steel rail bases shall consist of structural steel sections sized to provide a rigid beam which will not twist, deform, or deflect in any manner which will negatively affect the operation of the supported equipment or the vibration isolation mounts. Rails shall include end-mounting brackets for attachments of vibration isolators. Rails shall have a minimum operating clearance of 2” above the floor or housekeeping pad.

2.19 TYPE P CAPTIVE NEOPRENE WALL MOUNT ISOLATORS:
A. Captive neoprene wall mount isolators shall be Mason model RBA, RCA, Kinetics model RQ, or approved equal.

2.20 TYPE Q ROOF ISOLATION CURBS:
A. Roof isolation curbs shall be Mason model RSC or approved equal. Curb must provide continuous support for equipment and be constructed to resiliently resist wind and seismic forces. Construction of curb must not enable rigid connection between vibrating equipment and building structure. Curb construction must be water-resistant and equipped with flashing to prevent water infiltration. Seismic restraint calculations must be provided for all connections of equipment to the structure.

2.21 TYPE R Riser Spring Isolator SupportS:
A. Riser spring isolators shall meet requirements specified in Paragraph 2.1. Isolators shall be Kinetics FDS or FRS or approved equal.

2.22 TYPE S RISER NEOPRENE ISOLATOR SUPPORTS:
A. Riser neoprene isolators shall have all-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions. In no case shall hardness exceed 60 durometer. Isolators shall be Kinetics KPA, Mason ADA or approved equal.

2.23 FLEXIBLE NEOPRENE PIPING CONNECTORS:
A. Flexible neoprene piping connectors shall be twin spherical type (flanged), or single sphere type (threaded), manufactured of Kevlar cord with a Peroxide-cured EPDM cover. Connectors shall be able to accept elongation, compression and axial and transverse movement. Connectors shall be selected to suit the system temperature, pressure and fluid type. No rods or cables shall be used to control extension of the connector unless required due to temperature and pressure requirements. Any control rods must be separated from isolator with complete neoprene grommets (not just washers) as described in Paragraph 2.24: ELASTOMERIC GROMMETS. Connectors shall be Mason "Safeflex" model SFDEJ, SFDCR, SFU or approved equal. Straight wall connectors are not acceptable.

2.24 ELASTOMERIC GROMMETS:
A. Elastomeric grommets may be a combination of neoprene washer and bushing, Mason models HLW and HLB or approved equal. Otherwise they shall be E.A.R. (Indianapolis, Indiana) Isodamp, C-1000, ring
bushing and washer combination or approved equal. Elastomer shall be 40 durometer maximum. Grommets shall be formed to prevent bolts from directly contacting the secured item.

2.25 FLEXIBLE DUCTWORK CONNECTORS:
A. Flexible ductwork connectors shall be prefabricated, closely woven 30 ounce glass fabric, coated on both sides with neoprene and secured by double lock seams to 26 gauge minimum galvanized steel connectors on ends. Connectors shall be not less than 6" long. Material shall be UL approved and similar to "Ventglas" manufactured by Ventfabs, Inc. or approved equal.

2.26 FLEXIBLE CONDUIT:
A. Refer to Section 260548: Vibration Isolation of Electrical Systems.

2.27 VIBRATION ISOLATION SELECTION TABLE (TABLE 1):
A. Vibration isolation for all equipment shall be provided in accordance with following Table 1 except as otherwise noted in Section 3 of this section. If floor span is greater than 30 feet, the project Acoustics Consultant must be contacted for advice prior to placement of any orders. References in Notes column refer to paragraphs in Part 3 of this specification section.
### TABLE 1: VIBRATION ISOLATION SELECTION TABLE

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Horsepower &amp; Other</th>
<th>RPM</th>
<th>Slab on Grade</th>
<th>Up to 20’ Floor Span</th>
<th>20-30’ Floor Span</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Base Isolator or Hanger</td>
<td>Base Isolator or Hanger</td>
<td>Base Isolator or Hanger</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Min. Defl. (in.)</td>
<td>Min. Defl. (in.)</td>
<td>Min. Defl. (in.)</td>
</tr>
<tr>
<td>Air Compressors/ Vacuum Pumps</td>
<td>HP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank-Mounted Horizontal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 10</td>
<td>All</td>
<td>None</td>
<td>D</td>
<td>0.75</td>
<td>None</td>
<td>D</td>
</tr>
<tr>
<td>15 and up</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Tank-Mounted Vertical</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>All</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Base-Mounted</td>
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<td></td>
<td></td>
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<td>All</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
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<tr>
<td>Large Reciprocating</td>
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<td></td>
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<td></td>
<td></td>
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<td>D</td>
<td>0.75</td>
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<td>D</td>
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<td>Pumps</td>
<td>HP</td>
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</tr>
<tr>
<td>Close-Coupled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 7.5</td>
<td>All</td>
<td>M/N</td>
<td>B</td>
<td>0.25</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>10 and up</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Inline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 25</td>
<td>All</td>
<td>None</td>
<td>D</td>
<td>G</td>
<td>0.75</td>
<td>None</td>
</tr>
<tr>
<td>30 and up</td>
<td>All</td>
<td>None</td>
<td>D</td>
<td>G</td>
<td>1.50</td>
<td>None</td>
</tr>
<tr>
<td>End Suction &amp; Split Case</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 40</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
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<td>D</td>
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<td>50 to 125</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>150 and up</td>
<td>All</td>
<td>L</td>
<td>D</td>
<td>0.75</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Axial Fans, Fan Heads, Cabinet Fans, Fan Sections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 22 in. dia.</td>
<td>All</td>
<td>All</td>
<td>None</td>
<td>D/G</td>
<td>0.75</td>
<td>None</td>
</tr>
<tr>
<td>≤ 2” s.p.</td>
<td>&lt;300</td>
<td>M/N</td>
<td>D/G</td>
<td>2.50</td>
<td>L</td>
<td>D/G</td>
</tr>
<tr>
<td>≤ 2” s.p.</td>
<td>301-500</td>
<td>M/N</td>
<td>D/G</td>
<td>0.75</td>
<td>M/N</td>
<td>D/G</td>
</tr>
<tr>
<td>≤ 2” s.p.</td>
<td>&gt;500</td>
<td>M/N</td>
<td>D/G</td>
<td>0.75</td>
<td>M/N</td>
<td>D/G</td>
</tr>
<tr>
<td>&gt; 2” s.p.</td>
<td>&lt;300</td>
<td>L</td>
<td>D/G</td>
<td>2.50</td>
<td>L</td>
<td>D/G</td>
</tr>
<tr>
<td>&gt; 2” s.p.</td>
<td>301-500</td>
<td>L</td>
<td>D/G</td>
<td>1.50</td>
<td>L</td>
<td>D/G</td>
</tr>
<tr>
<td>&gt; 2” s.p.</td>
<td>&gt;500</td>
<td>L</td>
<td>D/G</td>
<td>0.75</td>
<td>L</td>
<td>D/G</td>
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</table>
### Centrifugal Fans (not including Smoke Evacuation or Emergency Stair Pressurization Fans)

<table>
<thead>
<tr>
<th>Diameter</th>
<th>M/N</th>
<th>D/G</th>
<th>M/N</th>
<th>D/G</th>
<th>M/N</th>
<th>D/G</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 22 in. dia.</td>
<td>All</td>
<td>M/N</td>
<td>0.75</td>
<td>M/N</td>
<td>0.75</td>
<td>M/N</td>
<td>0.75</td>
</tr>
<tr>
<td>≥ 24 in. dia.</td>
<td>≤ 40</td>
<td>M/N</td>
<td>2.50</td>
<td>M/N</td>
<td>3.50</td>
<td>M/N</td>
<td>3.50</td>
</tr>
<tr>
<td>≥ 24 in. dia.</td>
<td>&gt; 40</td>
<td>M/N</td>
<td>1.50</td>
<td>M/N</td>
<td>1.50</td>
<td>M/N</td>
<td>2.50</td>
</tr>
</tbody>
</table>

### Propeller Fans

- **Wall Mounted**
  - Diameter: ≤ 22 in.
    - M/N: 0.75
    - D/G: 0.75
  - Diameter: ≥ 24 in.
    - M/N: 0.75
    - D/G: 0.75

- **Roof Mounted**
  - Diameter: ≤ 22 in.
    - M/N: 0.75
    - D/G: 0.75
  - Diameter: ≥ 24 in.
    - M/N: 0.75
    - D/G: 0.75

### Heat Pumps

<table>
<thead>
<tr>
<th>Diameter</th>
<th>M/N</th>
<th>D/G</th>
<th>M/N</th>
<th>D/G</th>
<th>M/N</th>
<th>D/G</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 22 in. dia.</td>
<td>All</td>
<td>M/N</td>
<td>0.75</td>
<td>M/N</td>
<td>0.75</td>
<td>M/N</td>
<td>0.75</td>
</tr>
<tr>
<td>≥ 24 in. dia.</td>
<td>≤ 40</td>
<td>M/N</td>
<td>2.50</td>
<td>M/N</td>
<td>3.50</td>
<td>M/N</td>
<td>3.50</td>
</tr>
<tr>
<td>≥ 24 in. dia.</td>
<td>&gt; 40</td>
<td>M/N</td>
<td>1.50</td>
<td>M/N</td>
<td>1.50</td>
<td>M/N</td>
<td>2.50</td>
</tr>
</tbody>
</table>

### Condensing Units

<table>
<thead>
<tr>
<th>Diameter</th>
<th>M/N</th>
<th>D/G</th>
<th>M/N</th>
<th>D/G</th>
<th>M/N</th>
<th>D/G</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 22 in. dia.</td>
<td>All</td>
<td>A/B</td>
<td>0.11</td>
<td>E</td>
<td>0.75</td>
<td>E</td>
<td>1.50</td>
</tr>
<tr>
<td>≥ 24 in. dia.</td>
<td>≤ 40</td>
<td>M/N</td>
<td>1.50</td>
<td>M/N</td>
<td>1.50</td>
<td>M/N</td>
<td>1.50</td>
</tr>
<tr>
<td>≥ 24 in. dia.</td>
<td>&gt; 40</td>
<td>M/N</td>
<td>0.75</td>
<td>M/N</td>
<td>0.75</td>
<td>M/N</td>
<td>0.75</td>
</tr>
</tbody>
</table>

### Air Handling Unit

<table>
<thead>
<tr>
<th>Unit</th>
<th>M or N</th>
<th>D</th>
<th>M or N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal fans</td>
<td>A</td>
<td>0.15</td>
<td>A</td>
<td>0.15</td>
</tr>
</tbody>
</table>

### Rotating Equipment (Small Fans, Fan-Powered Boxes, Fan Coil Units, Unit Heaters)

<table>
<thead>
<tr>
<th>Cfm</th>
<th>M/N</th>
<th>D/G</th>
<th>M/N</th>
<th>D/G</th>
<th>M/N</th>
<th>D/G</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 600 cfm</td>
<td>All</td>
<td>D/G</td>
<td>0.50</td>
<td>D/G</td>
<td>0.50</td>
<td>D/G</td>
<td>0.50</td>
</tr>
<tr>
<td>&gt; 600 cfm</td>
<td>All</td>
<td>D/G</td>
<td>0.75</td>
<td>D/G</td>
<td>0.75</td>
<td>D/G</td>
<td>0.75</td>
</tr>
</tbody>
</table>
PART 3 - EXECUTION

3.1 GENERAL:

A. Resiliently mount equipment, ductwork, piping and other equipment on or suspended from approved foundations and supports, with isolation mounts, hangers, and/or pads as specified herein and as shown on drawings. Install seismic restraints in strict conformance with the certified shop drawings. Select locations of isolation equipment for ease of inspection and adjustment as well as for proper operation. Contractor shall cooperate with the Architect and project Acoustics Consultant to replace, at no additional cost to the Owner, any isolators that need to be upgraded from what is shown on the drawings if equipment operation results in resonance with building natural frequencies.

3.2 MOUNTS AND HANGERS:

A. Align vibration isolators squarely above or below mounting points of the supported equipment.

B. For equipment with bases, locate isolators on the sides of the base that are parallel to the equipment shaft.

C. If a housekeeping pad is provided, isolator base plates shall rest entirely on the pad.

D. Position vibration isolation hangers as high as possible in the hanger rod assembly but not in contact with the building structure. Provide 1" minimum to 3" maximum clearance between hanger housing and structure above. Provide side clearance for hanger housings to allow a full 360-degree rotation about the rod axis without contacting any object.

E. Parallel pipes may be hung together on a trapeze that is isolated from the structure. Isolator deflections must equal the greatest deflection for those pipes if isolated individually. Do not mix isolated and non-isolated pipes on the same trapeze.

F. Limit stops shall be out of contact during normal operation.

G. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

H. To simplify installation, Contractor may elect to use Type E isolators instead of Type D isolators, and/or Type H isolators instead of Type G isolators.
3.3 CONCRETE INERTIA BASES:

A. Inertia bases and required steel reinforcing under this section. Pour dense aggregate concrete (150 lbs./cu. ft.) within structural frames under the supervision of the contractor responsible for the work of this section.

3.4 FLOOR CLEARANCES:

A. For floor-mounted equipment, provide a minimum operating clearance of 2” between the bottom of the equipment or inertia base and the floor or housekeeping pad. Check to ensure that this space is completely clear after installation is complete. Provide height saving brackets as needed. Where housekeeping pads are provided, coordinate isolator locations with size of housekeeping pads especially where outboard mounts are used with height saving brackets.

3.5 DEFLECTIONS:

A. Design vibration isolation systems to have deflections equal or greater than indicated on drawings and in Table 1 of this specification section. Where multiple deflection requirements apply to a single isolator, the greater deflection shall prevail. Isolators supporting equipment with center of gravity that is asymmetrical in plan shall be selected for nearly equal deflection under actual load. Vibration isolation manufacturer shall determine number and size of mountings. Install isolators in accordance with manufacturer’s instructions.

3.6 THRUST RESTRAINTS:

A. Maximum motion shall be 1/4” under start-up or shut-down conditions for each floor or ceiling supported piece of equipment. Restrain greater motions by approved thrust restraints, Type J, attached at the centerline of the thrust, and arranged symmetrically on the unit. Anchor the restraints to fixed supports of stiffness greater than the thrust to be countered and not to resiliently supported ductwork. Adjust according to manufacturer's instructions. Submit shop drawings and manufacturer's installation instructions for thrust restraints for approval prior to installation.

3.7 ISOLATED SYSTEMS SHALL BE INDEPENDENT:

A. Do not hang or support piping, ductwork, conduit or mechanical equipment on other equipment, pipes or ductwork installed on vibration isolators. Maintain 2” clearance between isolated equipment and walls, ceilings and other equipment. Do not allow drain piping connected to vibration-isolated equipment to contact the building structure or other non-isolated systems unless it is resiliently mounted.

3.8 STABILIZE ALL ISOLATED EQUIPMENT:

A. Provide resilient sway bracing to solid anchor points to stabilize all resiliently supported equipment and piping in accordance with all requirements of state and local codes.
3.9 TREAT ALL ISOLATION SYSTEMS FOR CORROSION RESISTANCE:
   A. Repair coatings damaged during installation.

3.10 CUSTOM AIR HANDLING UNITS:
   A. Mount entire unit on open spring floor mount isolators Type D. Where units are furnished with internal structural frames and external lugs are of suitable strength and rigidity, mount isolators directly to unit. Otherwise furnish additional structural frames and install isolators to maintain cabinet integrity and bearing alignment. Provide Mason “Super-W” or approved equal neoprene pads under the internal fans. Secure piping connections with a flexible connector as described in Paragraph 3.16: FLEXIBLE PIPING CONNECTORS. Provide thrust restraints in accordance with Paragraph 3.6: THRUST RESTRAINTS if required.

3.11 EQUIPMENT MOUNTED ON ISOLATION ROOF CURBS:
   A. Equipment mounted on isolation roof curbs shall be installed on seismically rated vibration isolation roof curb per manufacturer’s installation instructions. All duct connections must be made with flexible connectors per Paragraphs 2.23: FLEXIBLE NEOPRENE PIPING CONNECTORS and 3.20: FLEXIBLE PIPING CONNECTORS.

3.12 DX UNIT REFRIGERANT LINES:
   A. Install flexible stainless steel metal pipe connectors in two planes 90 degrees to each other in refrigerant lines. Flexible connectors shall have a burst pressure of four times operating pressure. Furnish pipe sizes through 2” I.D. with hex male nipple fittings, and furnish pipe sizes 2-1/2” I.D. and larger with fixed steel flanges both sides.

3.13 CEILING SUPPORTED FANS, FAN-POWERED BOXES, FAN COILS, UNIT HEATERS:
   A. See Table 1.
   B. If equipment to be mounted is not furnished with integral structural frames and external mounting lugs of suitable strength and rigidity to prevent excessive flexing during operation, provide structural sub-base to support equipment and to which hangers shall be attached.
   C. Provide thrust restraints Type J in accordance with Paragraph 3.6: THRUST RESTRAINTS.
   D. Provide flexible duct connections in accordance with Paragraph 3.20: FLEXIBLE DUCT CONNECTORS.
   E. Provide flexible piping connectors in all piping connected to vibration-isolated equipment. Install these connectors between the equipment and the first associated pipe support or hanger.

3.14 CURB-MOUNTED ROOFTOP FANS:
   A. Supply with factory installed neoprene vibration isolators separating the motor, drive assembly and impeller from the base. Allow no rigid short circuit of these isolators through bolting, rigid conduit or other components of the curb-mounted assembly. Provide thrust restraints Type J in accordance with Paragraph 3.6: THRUST RESTRAINTS.
B. Mount curb-mounted rooftop fans on isolation bases Type Q.

3.15 BASE-MOUNTED PUMPS:

A. See Table 1.

B. Pipe between each pump and first associated flexible pipe connection shall mount on the concrete inertia base.

C. Support inertia base with open spring floor mount isolators Type D.

3.16 FLEXIBLE PIPING CONNECTORS:

A. Provide flexible neoprene piping connectors in all piping where it is connected to vibration-isolated equipment. Install these connectors between the equipment and the first associated pipe support or hanger, except where supports connect to an inertia base common to the equipment. Install straight-through connectors parallel to the axis of rotation of the shaft of the isolated equipment. Follow manufacturer's instructions for proper installation of flexible connectors including pre-extension of twin-sphere type. Install connectors in easily visible locations for inspection and replacement purposes.

B. Use flexible metallic hoses instead of flexible neoprene piping connectors only where temperature and pressure conditions exceed the service limitations of neoprene type connectors.

3.17 PIPING ISOLATION:

A. All piping connected to rotating or reciprocating equipment shall be vibration isolated according to Table 2 unless specifically excluded by the Acoustical Consultant.

B. The installation or use of vibration isolators shall not cause any change of position of piping which will result in stresses in piping connections or misalignment of shafts or bearings. In order to meet this objective, maintain equipment and piping in a rigid position during installation. Do not transfer the load to the isolators until the installation is complete and under full operational load.

C. As used in this section the term "Equipment Room" means any space containing pumps 3 HP or larger, chillers, air-handlers 3 tons or larger, fans handling 1200 cfm or more, boilers, or elevator equipment.
### TABLE 2: PIPING ISOLATION TABLE

<table>
<thead>
<tr>
<th>PIPING</th>
<th>SUPPORTED FROM</th>
<th>WHERE ISOLATORS ARE REQUIRED</th>
<th>ISOLATOR TYPE</th>
<th>STATIC DEFLECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping less than 12” i.d. connected to equipment isolated with springs</td>
<td>CEILING</td>
<td>First three hangers</td>
<td>Type G</td>
<td>At least equal to that of the isolators supporting the equipment, up to 2”.</td>
</tr>
<tr>
<td></td>
<td>FLOOR</td>
<td>First three mounts</td>
<td>Type D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VERTICAL</td>
<td>First three mounts</td>
<td>Type R</td>
<td></td>
</tr>
<tr>
<td>&quot;Piping 12” i.d. or greater connected to equipment isolated with springs</td>
<td>CEILING</td>
<td>First three hangers</td>
<td>Type H</td>
<td>At least equal to that of the isolators supporting the equipment, up to 2”. Transfer load to the springs after installation is complete and fluid has been added to the circuit.</td>
</tr>
<tr>
<td></td>
<td>FLOOR</td>
<td>First three mounts</td>
<td>Type E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VERTICAL</td>
<td>First three mounts</td>
<td>Type R</td>
<td></td>
</tr>
<tr>
<td>Piping connected to equipment isolated with springs</td>
<td>CEILING</td>
<td>From (and including the) fourth hanger to leaving Equipment Room or to 50 feet pipe length from equipment, whichever is greater</td>
<td>Type G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FLOOR</td>
<td>From (and including the) fourth mount to leaving Equipment Room or to 50 feet pipe length from equipment, whichever is greater</td>
<td>Type D</td>
<td>0.75” minimum.</td>
</tr>
<tr>
<td></td>
<td>VERTICAL</td>
<td>From (and including the) fourth mount to leaving Equipment Room or to 50 feet pipe length from equipment, whichever is greater</td>
<td>Type S</td>
<td></td>
</tr>
<tr>
<td>Piping connected to equipment isolated with pads or neoprene mounts</td>
<td>CEILING</td>
<td>Within Equipment Room or within 50 feet pipe length from equipment, whichever is greater</td>
<td>Type F</td>
<td>At least equal to that of the pads or neoprene mounts supporting the equipment.</td>
</tr>
<tr>
<td></td>
<td>FLOOR</td>
<td>Within Equipment Room or within 50 feet pipe length from equipment, whichever is greater</td>
<td>Type B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VERTICAL</td>
<td>Within Equipment Room or within 50 feet pipe length from equipment, whichever is greater</td>
<td>Type S</td>
<td></td>
</tr>
</tbody>
</table>

### 3.18 ACOUSTICALLY SEALED PENETRATIONS:

A. Provide wood blocking or sleeves of 22 gauge minimum steel, grouted rigidly in place, for all duct, pipe, and conduit penetrations through all walls, floors, and ceilings of mechanical equipment rooms, machine rooms, electrical equipment rooms, elevator equipment rooms, and all spaces called out in Section 018636 as well as where noted on drawings. Make inside dimension of sleeve or blocking 1/2” to 3/4” greater than outside dimension of penetrating item on all sides. Pack annular space to full depth of...
penetration with clean fiberglass batt or blanket material flush to ends of sleeve or block. Seal full perimeter of both ends of sleeve or block with liberal bead of acoustical sealant to be airtight.

3.19 FLEXIBLE DUCT CONNECTORS:

A. Install at all duct connections to fan units unless noted otherwise. Install between the fan unit and the first duct support. Use a flexible connector where ductwork crosses a building expansion or isolation joint. Maintain 3" minimum separation between mated duct segments. Seal joints and seams airtight.

3.20 DUCTWORK ISOLATION:

A. All ductwork shall be vibration isolated in accordance with Table 3.

B. Provide flexible duct connections in accordance with Paragraph 3.20: FLEXIBLE DUCT CONNECTORS.

C. Ductwork lagging (shown on the drawings) shall be supported with separate framing and should not be supported by the duct hangers.

D. As used in this section the term "Equipment Room" shall mean any space containing pumps 3 HP and larger, chillers, air-handlers 3 tons and larger, fans 1200 cfm or more, boilers, or elevator equipment.
TABLE 3: DUCTWORK ISOLATION TABLE

<table>
<thead>
<tr>
<th>DUCTWORK</th>
<th>SUPPORTED FROM</th>
<th>WHERE ISOLATORS ARE REQUIRED</th>
<th>ISOLATOR TYPE</th>
<th>STATIC DEFLECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductwork connected to equipment isolated with</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>springs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEILING</td>
<td>First three hangers</td>
<td>Type G</td>
<td></td>
<td>At least equal to that of the isolators supporting the equipment, up to 2”.</td>
</tr>
<tr>
<td>FLOOR</td>
<td>First three mounts</td>
<td>Type D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VERTICAL</td>
<td>First three mounts</td>
<td>Type R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large or heavy-gage ductwork connected to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>equipment isolated with springs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEILING</td>
<td>First three hangers</td>
<td>Type H</td>
<td></td>
<td>At least equal to that of the isolators supporting the equipment, up to 2”.</td>
</tr>
<tr>
<td>FLOOR</td>
<td>First three mounts</td>
<td>Type E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VERTICAL</td>
<td>First three mounts</td>
<td>Type R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ductwork connected to equipment isolated with</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>springs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEILING</td>
<td>From (and including the) fourth hanger to leaving Equipment Room or to 50 feet duct length from equipment, whichever is greater</td>
<td>Type F</td>
<td>0.20” minimum.</td>
<td></td>
</tr>
<tr>
<td>FLOOR</td>
<td>From (and including the) fourth mount to leaving Equipment Room or to 50 feet duct length from equipment, whichever is greater</td>
<td>Type B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VERTICAL</td>
<td>From (and including the) fourth mount to leaving Equipment Room or to 50 feet duct length from equipment, whichever is greater</td>
<td>Type S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ductwork connected to equipment isolated with</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pads or neoprene mounts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEILING</td>
<td>Within Equipment Room or within 50 feet duct length from equipment, whichever is greater</td>
<td>Type F</td>
<td>Equal to that of the pads or neoprene mounts supporting the equipment</td>
<td></td>
</tr>
<tr>
<td>FLOOR</td>
<td>Within Equipment Room or within 50 feet duct length from equipment, whichever is greater</td>
<td>Type B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VERTICAL</td>
<td>Within Equipment Room or within 50 feet duct length from equipment, whichever is greater</td>
<td>Type S</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.21 CENTRIFUGAL FANS (NOT INCLUDING SMOKE EVACUATION OR EMERGENCY STAIR PRESSURIZATION FANS):

A. See Table 1.
B. Provide thrust restraints Type J as scheduled or required to limit motion to 1/4" maximum under fan operating, start-up and shut-down conditions.

3.22 AIR SEPARATORS AND EXPANSION TANKS:

A. Where vibration isolated piping is connected to an expansion tank or air separator, make connection with a flexible connector.

3.23 FLOOR AND WALL MOUNTED FAN COIL UNITS:

A. Isolate floor-mounted fan coil units on Type A elastomeric pads. Piping connections must satisfy requirements of Paragraph 3.16: FLEXIBLE PIPING CONNECTORS.

3.24 FLEXIBLE CONDUIT:

A. Use to isolate vibration from all equipment requiring vibration isolation per this specification section. Flexible conduit shall be a minimum length of 12" with 25% greater length than the separation between the isolated equipment and the termination of rigid conduit. Install the flexible conduit to be slack and not to exceed the manufacturer's minimum recommended bending radius. For conduit sizes greater than 2" diameter, use pre-manufactured flexible conduit connectors instead of flexible conduit. Refer to Section 260548: Vibration Isolation for Electrical Systems for further information.

3.25 IN-LINE PUMPS:

A. See Table 1.

B. Install neoprene double sphere pipe connectors on suction and discharge.

3.26 CONDENSATE DRAIN LINES:

A. Condensate drain lines shall not connect rigidly to structure. Place a section of flexible transparent tubing in the drain line between the connection to the equipment and the point of connection to structure.

END OF SECTION 230548
SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

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

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

1.3 SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
   C. Valve numbering scheme.
   D. 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 minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/2 inch and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
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 thick, and having predrilled holes for attachment hardware.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
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 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 thick, and having predrilled holes for attachment hardware.


C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

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

F. Minimum Letter Size: 1/2 inch and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.


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

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

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

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

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

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


C. Background Color: Black.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

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

F. Minimum Letter Size: 1/2 inch and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.


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

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Fiberboard or metal.
   2. Stencil Paint: Exterior, gloss, 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.
2.6 VALVE TAGS

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

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

2.7 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.
   2. Fasteners: Reinforced grommet and wire or string.
   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. Piping Color-Coding: Painting of piping is specified in Division 09 Section "Interior Painting."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.
   1. Identification Paint: Use for contrasting background.
C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

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

D. In general follow Pipe Label Color Schedule as shown below, unless the Owner has different schedule standards in which case the Owner's schedule shall be followed:

1. Chilled-Water Piping:
   a. Background Color: Blue.

2. Heating Water Piping:
   a. Background Color: Orange.

3. Low-Pressure Steam Piping:
   a. Background Color: Yellow.

3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated or self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system. Reduce intervals to 25 feet in areas of congested piping and equipment, within mechanical rooms, etc.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
   c. Low-Pressure Steam: 1-1/2 inches, round.
   d. High-Pressure Steam: 1-1/2 inches, round.
   e. Steam Condensate: 1-1/2 inches, round.

2. Valve-Tag Color:
   b. Hot Water: Natural.
   c. Low-Pressure Steam: Natural.
   d. High-Pressure Steam: Natural.
   e. Steam Condensate: Natural.

3. Letter Color:
   b. Hot Water: Black.
   c. Low-Pressure Steam: Black.
   d. High-Pressure Steam: Black.
   e. Steam Condensate: Black.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.
SECTION 230593 - TESTING, ADJUSTING AND BALANCING FOR HVAC PIPING

PART 1 - GENERAL

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

1.2 DESCRIPTION OF WORK
   A. This scope of services specified the requirements and procedures for mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results. The test and balance work will be performed by the Owner’s personnel. It is the Contractor’s responsibility to assist as outlined below.

   B. Test, adjust and balance the following mechanical systems which are shown in the construction documents.

      1. Supply air systems, all pressure ranges, including variable volume and constant volume systems.
      2. Return air systems.
      3. Exhaust air systems.
      4. Hydronic systems.
      5. Steam distribution systems.
      6. Cooling towers.
      7. Verify temperature control system operation.

   C. The contractor’s responsibilities are as follows:

      1. Notify the Owner’s Representative fourteen (14) days prior to the schedule date for balancing the system.
      2. Schedule a two (2) week allowance for the testing and balancing firm to complete the testing and balancing work when scheduling completion of all work required of the Contractor by the contract documents.
      3. Cooperate with the testing and balancing firm and shall make all necessary preparations for the TAB efforts.
      4. Complete the following work prior to requesting the TAB effort.

         a. Clean and flush all piping systems.
         b. Leak test and make tight all piping systems.
         c. Fill all piping systems with clean water.
         d. Clean and seal all ductwork systems.
         e. Service and tag all equipment.
         f. Set and align all motors and drives.
         g. Start up and prove all equipment and systems.
         h. Make preliminary settings on all control devices and have all systems operational.
         i. Operate all systems successfully for twenty-four (24) hours minimum.

      5. Lubricate all motors and bearings.
      6. Check fan belt tension.
      7. Check fan rotation.
      8. Patch insulation, ductwork and housing, using materials identical to those removed.
      9. Seal ducts and piping, and test for and repair leaks.
     10. Seal insulation to re-establish integrity of the vapor barrier.
11. Attend a coordination meeting prior to the balancing of the system and a coordination meeting following the balancing of the system.
12. Provide a complete set of as-built drawings prior to the TAB effort.
13. Provide craftsmen of the proper trade to work with the TAB firm to make adjustments and installation changes as required.
14. Change out fan sheaves when and if required by the TAB firm.
15. Dedicate the resources to accommodate all changes identified by the test and balance firm in a timely manner.
16. If a significant rebalance (Owner’s determination) of the HVAC system is required due to the Contractor’s failure to properly install and check out the HVAC system, the cost of rebalancing the system shall be borne by the Contractor.

1.3 PRE-BALANCING CONFERENCE

A. Prior to beginning of the testing, adjusting and balancing procedures, a conference with the Owner’s Representative, Engineer and the Test and Balance Agency’s representative will be held. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting and balancing.

1.4 SEQUENCING AND SCHEDULING OF SERVICES

A. Test, adjust and balance the air conditioning systems during summer season and heating systems during winter season. This includes at least a period of operation at outside conditions within 5 deg. F wet bulb temperature of maximum summer design condition, and within 10 deg. F dry bulb temperature of minimum winter design conditions. Take final temperature readings during seasonal operation.

PART 2 - PRODUCTS (Not applicable)

PART 3 - EXECUTION (Not applicable)

END OF SECTION 230593
SECTION 230594 – AMBIENT NOISE LEVELS

PART 1 - GENERAL

1.1 SUMMARY:

A. This section specifies ambient noise levels allowable when spaces are unoccupied while mechanical, electrical, conveying and other equipment is operating. Refer to drawings and other sections of these specifications for vibration isolation and noise control systems and requirements.

1.2 REQUIREMENTS:

A. Provide equipment and materials and install systems in a manner that conforms to the requirements of the contract documents. As required to meet scheduled ambient noise levels, contractor shall replace unapproved product substitutions and defective or improperly installed materials before the end of the warranty period.

1.3 DEFINITIONS:

A. This document and other specifications will use the term acoustically sensitive for rooms with criteria between RC-25 and RC-34 and the term acoustically critical for rooms with criteria below RC-25. For rooms or spaces that are specified as having a range of criteria, the lowest number of the range will dictate whether a room is critical or sensitive.

1.4 LIGHTING SYSTEMS:

A. Luminaire components including lamp, housing, ballasts, and wiring shall operate silently and inaudibly at all points of operation between and including 0-100% power in acoustically sensitive/critical spaces.

PART 2 - PRODUCTS (Not Applicable)
PART 3 - EXECUTION

3.1 CRITERIA:

A. This building has been designed to meet specified ambient noise levels for the following room types:

<table>
<thead>
<tr>
<th>Room Type</th>
<th>RC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Performance &amp; Choral</td>
<td>15-19</td>
</tr>
<tr>
<td>Recording Studio</td>
<td>15-19</td>
</tr>
<tr>
<td>Live Room</td>
<td>15-19</td>
</tr>
<tr>
<td>Isolation Room</td>
<td>15-19</td>
</tr>
<tr>
<td>Large Instrument Rehearsal</td>
<td>25-29</td>
</tr>
<tr>
<td>Medium Classroom</td>
<td>25-29</td>
</tr>
<tr>
<td>Composition/Piano Lab</td>
<td>25-29</td>
</tr>
<tr>
<td>Faculty Studios</td>
<td>25-29</td>
</tr>
<tr>
<td>Percussion Practice Room</td>
<td>25-29</td>
</tr>
<tr>
<td>Chamber Practice</td>
<td>25-29</td>
</tr>
<tr>
<td>Practice Room</td>
<td>25-29</td>
</tr>
<tr>
<td>Office</td>
<td>30-34</td>
</tr>
<tr>
<td>Lobby</td>
<td>35-44</td>
</tr>
</tbody>
</table>

3.2 STANDARDS:

A. The maximum Room Criteria (RC) levels acceptable in the octave bands 16 Hz to 4000 Hz shall be as specified in the 2003 ASHRAE Handbook, HVAC Applications, Chapter 47. In addition, the maximum RC-15 and RC-20 noise levels acceptable in the octave bands 16 Hz to 4000 Hz shall be as follows:

<table>
<thead>
<tr>
<th>63Hz</th>
<th>125Hz</th>
<th>250Hz</th>
<th>500Hz</th>
<th>1kHz</th>
<th>2kHz</th>
<th>4kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC-15</td>
<td>43</td>
<td>35</td>
<td>28</td>
<td>21</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>RC-20</td>
<td>45</td>
<td>38</td>
<td>31</td>
<td>25</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>RC-25</td>
<td>45</td>
<td>40</td>
<td>35</td>
<td>30</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>RC-30</td>
<td>50</td>
<td>45</td>
<td>40</td>
<td>35</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>RC-35</td>
<td>55</td>
<td>50</td>
<td>45</td>
<td>40</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>RC-40</td>
<td>60</td>
<td>55</td>
<td>50</td>
<td>45</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>RC-45</td>
<td>65</td>
<td>60</td>
<td>55</td>
<td>50</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>RC-50</td>
<td>70</td>
<td>65</td>
<td>60</td>
<td>55</td>
<td>50</td>
<td>45</td>
</tr>
</tbody>
</table>

3.3 TESTS:

A. Following substantial completion, the project Acoustics Consultant will observe and measure noise levels. The measurements will be taken at normal locations of people and/or audio microphones.

END OF SECTION 230594
SECTION 23 06 90 - EQUIPMENT SOUND LEVEL LIMITS

PART 1 - GENERAL

1.1 SUMMARY

A. Sound levels for all air handlers, VAV terminals, fan coils, fans, chillers, cooling towers, other fan-powered devices, and other noise-generating equipment shall be within the scheduled limits. Equipment on this project is stringently designed to avoid noise problems. Sound level specifications are more exacting than for "standard construction". The Contractor is cautioned not to overlook these specific requirements in favor of "standard construction practices" in any pricing, submittal or construction procedure.

1.2 RELATED WORK

A. Section 23 34 00 – HVAC Fans.
B. Section 23 36 00 – Air Terminal Units.
C. Section 23 37 00 – Air Outlets and Inlets.
D. All Division 23 specifications for equipment containing fans or compressors.

1.3 SUBMITTALS

A. Submit fan sound power level data in decibels (re 10-12 W) for unit discharge, unit inlet and unit casing radiation, for octave bands of center frequency 63 to 8,000 Hz, inclusive. Where mechanical air volume control is provided as part of the unit casing (inlet vanes, disks, etc), levels shall be submitted for units with the volume control device, at maximum, minimum and one intermediate point on the system curve.
B. Submit actual test data for the units to be furnished for this project, or actual test data for the configurations used to develop the submitted levels (values interpolated from units closest to the design point of operation).
C. Submit a description of the acoustics test facility, the test setup and the number and type of fans tested to develop the sound power database.
D. Submit the fan curve and the design point of fan operation for each fan.
E. Submit a certification that the data were developed in accordance with accepted standards, including which standards were used and the method of data interpolation (Specific Sound Power Level Method or Generalized Sound Power Spectrum; AMCA 301-90).
F. Submit VAV terminal sound power level data in decibels (re 10-12 W) for unit discharge and unit radiated for octave bands of center frequency 125 to 4000 Hz, inclusive. VAV Terminals includes standard boxes without fans, fan-powered boxes, induction units, and air valves. Submitted levels shall represent maximum sound power levels derived from points of operation between and including minimum and maximum design air volumes and at the maximum pressure drop indicated in the contract documents.
G. Diffusers, Registers, and Grilles

1. Submit NC ratings for all devices using the required submittal format shown below. Calculate NC ratings from laboratory certified octave band sound power level data, developed in accordance with
ASHRAE Standard 70-1991. The submittal must indicate the assumed room effect used to convert from octave band sound power levels to NC ratings.

2. The submittal must show every device, reported in the following format. Any submittal of catalog charts without detailed project-specific information in the required format will be rejected.

3. **SAMPLE SUBMITTAL FORMAT:**

```
Air Outlet/Inlet Device Tag          Room Name #100, SA-4
CFM                               500
Device Size                       24x24
Neck size (where appl.)           14"
Model Number                      TMSA
NC rating of device               NC-20
Assumed room effect               8 dB
RC from Section 01 86 36 –        25
Ambient Noise Levels              
Accessories included              integral balancing damper, air straighteners, etc.
```

### 1.4 STANDARDS


B. Alternately, inlet and discharge levels for ducted fans may be taken in accordance with ASHRAE Standard 68 (AMCA 330); Laboratory Method of Testing to Determine the Sound Power in a Duct, 1997.

C. Tests shall be conducted in an AMCA certified acoustics laboratory.

D. Fan sound power level data development shall comply with AMCA Standard 301, Methods for Calculating Fan Sound Ratings from Laboratory Tests Data, 1990.

E. Sound power level data for VAV terminals shall be certified in accordance with ARI 880-1998 - Air Terminals.

F. Values based upon the ASHRAE Handbook estimation method, the Wells plenum calculation, or any other estimation method, are not acceptable.

### 1.5 TERMINOLOGY

A. Unit shall mean the entire device, including fans, casing, plenums, integral silencers, etc.; as distinguished from bare fans (no casing).

B. Discharge and inlet sound power levels shall be as measured at the cabinet outlet/inlet based upon supply and return fan performance or VAV terminal performance. Reported levels shall include the effects of plenums, acoustical lining, and outlet/inlet location in the cabinet, as applicable. Units tested with ducted outlets/inlets shall be adjusted for end reflection effects.

C. Cabinet sound power levels shall be total unit casing radiated sound.

### 1.6 GUARANTEE

A. Manufacturer shall certify that the units operated at the design parameters shall generate sound not exceeding the sound power/pressure levels scheduled. If the units are determined to operate in excess of
the specified limits, the Manufacturer shall correct the condition at no expense to the Owner and shall pay any expenses incurred in review by the Architect or project Acoustics Consultant.

PART 2 - SCHEDULES

2.1 SOUND POWER LEVEL LIMITS

<table>
<thead>
<tr>
<th>Octave Band (Hz)</th>
<th>AHU-1 Discharge</th>
<th>AHU-1 Inlet</th>
<th>AHU-1 Outside/Exhaust</th>
<th>AHU-1 Radiated</th>
<th>Exhaust Fan Inlet</th>
<th>Exhaust Fan Radiated</th>
<th>VAV Boxes Discharge</th>
<th>VAV Boxes Radiated</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>84</td>
<td>85</td>
<td>83</td>
<td>79</td>
<td>Shall not exceed basis of design Greenheck</td>
<td>Shall not exceed basis of design Greenheck</td>
<td>Shall not exceed basis of design Titus DESV</td>
<td>Shall not exceed basis of design Titus DESV</td>
</tr>
<tr>
<td>125</td>
<td>82</td>
<td>84</td>
<td>80</td>
<td>72</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>250</td>
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<td>87</td>
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<td>500</td>
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</tr>
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<td>4000</td>
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<td>82</td>
<td>60</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8000</td>
<td>86</td>
<td>87</td>
<td>84</td>
<td>53</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2 DIFFUSERS, REGISTERS, AND GRILLES

A. For spaces listed in Section 230594: AMBIENT NOISE LEVELS the NC ratings for diffusers, registers and grilles shall not be greater than the lowest RC listed minus 3 decibels, where an 8-decibel room effect is assumed. Where a 10-decibel room effect is used, the NC rating shall not be greater than the lowest RC minus 5 decibels. Diffusers, registers, and grilles shall not have integral dampers for spaces listed in Section 230594: AMBIENT NOISE LEVELS.

PART 3 - EXECUTION

3.1 REMEDIES

A. Replace equipment or provide noise reduction accessories (attenuators, plenums, lining, etc.) as necessary to achieve allowable sound power/pressure levels. These remedies shall be reviewed by the project Acoustics Consultant prior to implementation.

END OF SECTION 230690
SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Insulation Materials:
   a. Flexible elastomeric.
   b. Mineral fiber.

2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
7. Sealants.
8. Factory-applied jackets.
10. Field-applied cloths.
11. Field-applied jackets.
12. Tapes.
13. Securements.

B. Related Sections:

1. Division 22 Section "Plumbing Insulation."

1.3 SUBMITTALS

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

B. LEED Submittal:

1. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

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

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

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

   a. Aeroflex USA Inc.; Aerocel.
b. Armacell LLC; AP Armaflex.
c. NOMACO Insulation.

2. Thermal Conductivity: Not exceeding 0.25 BTU-in/hour °F at 75°F mean temperature.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.
   b. Johns Manville.
   c. Knauf Insulation.
   d. Manson Insulation Inc.
   e. Owens Corning Fiberglas Corp.

2. Density: 1.9 lbs/cu. ft.
3. Thermal Conductivity: Not exceeding 0.25 BTU-in/hour sq. ft. °F at 75°F mean temperature.

H. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.
   b. Johns Manville.
   c. Knauf Insulation.
   d. Owens Corning Fiberglas Corp.

2. Density: 3.0 lbs/cu. ft.
3. Thermal Conductivity: Not exceeding 0.30 BTU-in/hour sq. ft. °F at 100°F mean temperature.

I. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.
   b. Johns Manville.
   c. Knauf Insulation.
   d. Manson Insulation Inc.
   e. Owens Corning Fiberglas Corp.

2. Density: 3.0 lbs/cu. ft.
3. Thermal Conductivity: Not exceeding 0.23 BTU-in/hour sq. ft. °F at 75°F mean temperature.

J. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

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

2. INSULATING CEMENTS


2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide one of the following:
   a. Aeroflex USA Inc.
b. Armacell LCC.
c. Foster Products Corporation, H. B. Fuller Company.
d. RBX Corporation.

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

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. 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).


1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW.
   b. Foster Products Corporation, H. B. Fuller Company.
   c. ITW TACC, Division of Illinois Tool Works.
   d. Marathon Industries, Inc.
   e. Mon-Eco Industries, Inc.

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

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Dow Chemical Company (The).
   c. P.I.C. Plastics, Inc.
   d. Speedline Corporation

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

2.4 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.
2.5 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. P.I.C. Plastics, Inc.
      c. Proto PVC Corporation.
      d. Speedline Corporation.
   2. Adhesive: As recommended by jacket material manufacturer.
   4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
   5. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Products, Division of ITW.
      b. PABCO Metals Corporation.
      c. RPR Products, Inc.
      a. Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.
      d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
      e. Factory-Fabricated Fitting Covers:
         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
2.6 TAPES

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

1. Avery Dennison Corporation, Specialty Tapes Division.
2. Compac Corp.
4. Venture Tape.

B. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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

C. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Width: 3 inches.
2. Thickness: 6.5 mils.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/linear inch.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

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

1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/linear inch.

2.7 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240, Type 304; 0.015 inch thick, 1/2 inch wide with wing or closed seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing or closed seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel or aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

PART 3 - EXECUTION

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

3.2 PREPARATION
A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
B. Surface Preparation: Clean and prepare surfaces to be insulated.

3.3 GENERAL INSTALLATION REQUIREMENTS
A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
E. Install multiple layers of insulation with longitudinal and end seams staggered.
F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
G. Keep insulation materials dry during application and finishing.
H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
I. Install insulation with least number of joints practical.
J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

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

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

3.4 PENETRATIONS

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

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

C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Comply with requirements in Division 07 Section "Penetration Firestopping" and fire-resistant joint sealers.

D. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
   d. Do not overcompress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

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

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment.
Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

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

3.8 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Do not overcompress insulation during installation.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

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

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Penetration Firestopping."

3.11 FINISHES

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

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
3.13 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return and relief air located in non-conditioned space.
4. Indoor, exposed return and relief air located in non-conditioned space, mechanical room.

B. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.14 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, rectangular, round and flat-oval, supply-air, outdoor-air, return air and relief-air duct insulation shall be one of the following:


B. Exposed rectangular, round and flat-oval, supply-air, outdoor-air, return-air and relief-air duct insulation shall be the following:


C. Exposed in Mechanical Rooms, supply-air, return-air, outdoor-air and relief-air plenum insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick.

3.15 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor equipment in paragraphs below that is not factory insulated.

C. Heat-exchanger (steam to hot water) insulation shall be one of the following:

1. Mineral-Fiber Board: 3 inches thick.

D. Chilled Water Pumps and Suction Diffusers:

1. Flexible elastomeric: 1-1/2 inches thick.
3.16 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor’s option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Drainage piping located in crawl spaces.
   2. Underground piping.
   3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.17 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.

B. Chilled Water:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Flexible Elastomeric: 1 inch thick.

C. Heating-Hot-Water Supply and Return:
   1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.
   2. NPS 1-1/2 and larger: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches thick.

D. Low Pressure Steam:
   1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inch thick.
   2. NPS 1-1/2 and larger: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches thick.

3.18 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Equipment, Heating Hot-Water Convertors:
   1. Embossed Aluminum Jacket.
C. Piping, Concealed:
   1. None.

D. Piping, Exposed to view in occupied area and within 6'-0" of finished floor:
   1. PVC Jacket.

E. Piping, Exposed in mechanical rooms and within 6'-0" of finished floor:
   1. Aluminum Jacket.

END OF SECTION 230700
SECTION 230900 - CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. University of Missouri Controls Specification.

B. This section contains requirements for electrical and digital control systems as indicated on the contract drawings.

C. Contractor is responsible for providing, installing and connecting all sensors, control valves, control dampers, electrical components and all interconnecting pneumatic tubing and electrical wiring between these devices and up to the Direct Digital Controllers (DDC).

D. DDC controllers consist of Johnson Controls METSYS controller, type NAE, DX, FEC, ION, AHU, VAV, VMA, or UNT controllers. Owner will provide Johnson Control METSYS controllers for the contractor to install.

E. After all equipment has been installed, wired and piped, Owner will be responsible for all termination connections at the DDC controller’s and for checking, testing, programming and start-up of the control system. Contractor must be on site at start-up to make any necessary hardware adjustments as required.

F. Once each mechanical system is completely operational under the new control system, contractor shall make any final connections and adjustments. For controls renovation jobs, contractor shall remove all unused sensors, operators, panels, wiring, tubing, conduit, etc.

1.2 RELATED SECTIONS

A. Drawings and general provisions of Contract, including General and Special Conditions apply to work of this section.

1.3 QUALITY ASSURANCE

A. Contractor’s Qualifications:

1. Contractor shall be regularly engaged in the installation of digital control systems and equipment, of types and sizes required. Contractor shall have a minimum of five years experience installing digital control systems. Contractor shall supply sufficient and competent supervision and personnel throughout the project in accordance with General Conditions section 3.4.1 and 3.4.4.

B. Codes and Standards:

1. Electrical Standards: Provide electrical components of control systems which have been UL-listed and labeled, and comply with NEMA standards.

2. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for control systems.

3. NFPA Compliance: Comply with NFPA 90A “Standard for the Installation of Air Conditioning and Ventilating Systems” where applicable to controls and control sequences.

4. NFPA Compliance: Comply with NFPA 70 "National Electric Code".
1.4 SUBMITTALS

A. Shop Drawings: Submit shop drawings for each control system, containing the following information:

B. Product data for each damper, valve, and control device.

C. Schematic flow diagrams of system showing fans, pumps, coils, dampers, valves, and control devices.

D. Label each control device with setting or adjustable range of control.

E. Indicate all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

F. Provide details of faces on control panels, including controls, instruments, and labeling.

G. Include written description of sequence of operation.

H. Provide wiring diagrams of contractor provided interface and I/O panels.

I. Provide field routing of proposed network bus diagrams listing all devices on bus.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Conduit and Raceway:

1. Electrical metallic Tubing: EMT and fittings shall conform to ANSI C80.3.
2. Surface Metal Raceway and Fittings: Wiremold 500, Ivory, or approved equal.
3. Flexible Metal Conduit: Indoors, per National Electric Code for connection to moving or vibrating equipment.
4. Liquidtight Flexible Conduit: Outdoors, per National Electric Code for connection to moving or vibrating equipment.

B. Control Valves: Provide factory fabricated electric control valves of type, body material, and pressure class as indicated on the drawings. Butterfly style control valves are not acceptable except for two position applications. Equip control valves with proper shutoff rating for each individual application.

1. Steam and Hot Water:
   a. Manufacturer do not allow KMC valves and actuators.
   b. Water Service Valves: Equal percentage characteristics.
   c. Steam Service Valves: Equal percentage characteristics.
   d. Single Seated Valves: Cage type trim, providing seating and guiding surfaces for plug on “top and bottom” guided plugs.
   e. Valve Trim and Stems: Polished stainless steel.
   g. Control valves should have a minimum 100 psi close-off rating for chilled water applications.

2. Hydronic Chilled Water and Heating Water:

   a. Hydronic control valves shall be pressure independent. The flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range. The control valve shall accurately control the flow from 1 to 100% full rated flow.
b. The valve bodies shall be of cast iron, steel or bronze and rated for 150 psi working pressure. All internal parts shall be stainless steel, steel, Teflon, brass or bronze.

c. Valves shall be DeltaP Valves manufactured by Flow Control Industries, Belimo P Series, Danfoss AB-QM Series, or approved equal. Belimo EV050 Series is not acceptable.

d. The valves shall have pressure taps across the valve for measuring the pressure drop across the valve. The pressure taps shall have ½-inch extensions for accessibility.

e. Control valves shall be installed with unions or flanges as necessary for easy removal and replacement.

f. Valve Tag shall include the model number, AHU being served, design flow, and maximum flow for that valve.

g. The control valves shall be delivered preset to the scheduled design flow and should be capable of reaching 110% of the design flow to allow for field adjustment for capacity changes.

C. Control Dampers: Ruskin CD-50 or approved equal.

1. Provide dampers with parallel blades for 2-position control.
2. Provide opposed blades for modulating control.
3. Dampers shall be low leakage design with blade and edge seals.
4. Provide multiple sections and operators as required by opening size and sequence of operations, as indicated on the contract drawings.

D. Electric Actuators: Johnson Controls, Bray, Belmo, TAC or approved equal, KMC actuators are not approved. Size electric actuators to operate their appropriate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified. If mixed air AHU has return air, exhaust air and outside air dampers that are not mechanically linked then static safety switch must be installed and wired to safety circuit. Spring return actuators should be provided on heat exchanger control valves or dampers or as specified on the drawings. Control signal shall be 0 to 10 VDC unless otherwise specified on drawings. Actuators with integral damper end switch are acceptable. For VAV reheat valves, actuators shall have a manual override capability to aid in system flushing, startup and balancing.

E. Air and Hot Water Electronic Temperature Sensors:

1. All electronic temperature sensors shall be compatible with Johnson METASYS systems.
2. Sensors shall be 1,000 ohm platinum, resistance temperature detectors (RTDs) with two wire connections. Duct mounted sensors shall be averaging type. Contractor may install probe type when field conditions prohibit averaging type, but must receive permission from Owner’s Representative.
3. Coordinate thermowell manufacturer with RTD manufacturer. Thermowells that are installed by the contractor, but are to have the RTD installed by owner, must be Johnson Controls Inc. series WZ-1000.

F. Electronic Temperature Sensors and Transmitters:

1. Chilled Water, Heating Hot Water, and Steam Temperature Sensors:

a. General: The RTD/Temperature Transmitter/Thermowell assembly shall come as a complete assembly from a single manufacturer. The Assembly shall be suitable for use in the accurate measurement of Chilled Tower/Dual Water temperature in a mechanical room environment.

b. Calibration: Each RTD must be match calibrated to the Transmitter via NIST traceable calibration standards. Results are to be programmed into the transmitter. Results are to be presented on report as after condition at the specified calibration points. Assembly shall not be approved for installation until Owner has received all factory calibration reports.

c. RTD:

1) RTD type: 2-wire or 3-wire 100 ohm platinum class A.
2) Outside Diameter: 0.25 inch.
3) Tolerance: +/- 0.06% Type A.
4) Stability: +/- 0.1% over one year.
5) TCR: 0.00385 (ohm/ohm/°C).
6) RTD shall be tip sensitive.
7) Resistance vs. Temperature table for the RTD must be provided to the Owner.

d. Transmitter:

1) Transmitter shall be match calibrated to the RTD and assembled as a matched pair.
2) Type: 2 wire (loop powered).
3) Input: 2 or 3 wire 100 ohm platinum class A or class B RTD.
4) Output: Output shall be a 4-20 mA signal linear to temperature.
5) Calibrated Span:
   a) Chilled Water: 30°F to 130°F.
   b) Hot Water: 100°F to 250°F.
   c) Steam: 150°F to 450°F.

6) Calibration Accuracy, including total of all errors, of the Transmitter & RTD matched pair over the entire space shall be within +/- 0.2% of the calibrated span or +/- 0.18°F, whichever is greater.

7) Supply Voltage: 24 VDC
8) Ambient Operating Temp: 32 to 122°F
9) Epoxy potted for moisture resistance.
10) Mounting: Transmitter shall be mounted in the RTD connection head.

e. Thermowell:

1) Thermowell shall be suitable for immersion in chilled/hot water and steam.
2) Thermowell shall be reduced tip.
3) Thermowell shall be one piece stainless steel machined from solid bar stock.
4) Thermowell shall have ½" NPT process connection to pipe thred-o-let.
5) Thermowell Insertion depth shall be ½ the inside pipe diameter but not to exceed 10".

f. Assembly:

1) Assembly configuration: Spring loaded RTD with thermowell-double ended hex-connection heat.
2) Connection head shall be cast aluminum with chain connecting cap to body, have ½" NPT process and ¾" NPT conduit connections, and a sealing gasket between cap and body.

g. RTD/Temperature Transmitter/Thermowell assembly shall be the following or approved equal:

1) Manufacturer: Pyromation, Inc.
2) Chilled Water: RAF-185L-S4C[length code]08-SL-8HN31, TT440-385U-S (30-130)°F with calibration SMC (40,60)°F.
3) Hot Water: RAF 185L-S4C[length code]08T2-SL-8HN31, TT440-385U-S (100-250)°F with calibration SMC (140,180)°F.
4) Steam: RAT185H-S4C[length code]08T2-SL-8HN31, TT440-385U-S (150-450)°F with calibration SMC (300,350)°F.

G. Occupant Override: Provide wall mounted occupant override button in locations shown on drawings.

H. Low Limit Controllers: Provide unit-mounted low limit controllers, of rod-and-tube type, with an adjustable set point and a manual reset. Capillary shall be of adequate length to horizontally traverse face of cooling coil every 12". Multiple low limit controllers may be required for large coils. Controller shall have an extra
set of contactors for connection to control panel for alarm status. Locate the thermostat case and bellows where the ambient temperature is always warmer that the set point.

1. Freeze Stats: Johnson Controls model A70HA-1 or approved equal.

I. Humidistats: Humidistats must be contamination resistant, capable of ± 2% RH accuracy, have field adjustable calibration and provide a linear proportional signal.

1. HD20K-T91 or equivalent.

J. Humidity High Limit:

1. Multi-function device that can function as a high limit or proportional override humidity controller, as stand-alone proportional controller, or a stand-alone two-position controller.

   a. Johnson Controls TRUERH HL-67N5-8N00P or approved equal.

K. Carbon Dioxide Sensor:

1. Wall Mount: ACI Model ESENSE-R.
2. Duct Mount: ACI Model ESENSE-D.

L. Fan/Pump Status: Status points for fan or pump motors with a VFD must be connected to the terminal strip of the VFD for status indication. Current switches: Current switches are required for fan and pump statuses that are not connected to a VFD. The switches must have an adjustable trip setpoint with LED indication and be capable of detecting broken belts or couplings. Units shall be powered by monitored line, UL listed and CE certified, and have a five year warranty.

1. Kele, Hawkeye or approved equal.

M. Relays Used for Fan and Pump Start/Stop: Must have LED indication and be mounted externally or starter enclosure or VFD.

1. Kele, RIBU1C or approved equal.

N. Power Supply Used to Provide Power to Contractor-Provided Control Devices: Shall have adjustable DC output, screw terminals, overload protection and 24 VDC and 24 VDC output.

1. Kele, DCPA-1.2 or approved equal.

O. Pressure Differential Switch:

1. Fans: NECC model DP222 or approved equal.

P. Differential Pressure Transmitter: Provide units with linear analog, 4-20 mA output proportional to differential pressure, compatible with the Johnson METASYS Systems.

1. Water: Units shall be wet/wet differential pressure capable of a bi-directional pressure range of +/- 50 psid. Accuracy shall be +/- 0.25% full scale with a compensated temperature range of 30 to 150 deg F and a maximum working pressure of 250 psig. Install transmitter in a pre-manufactured bypass valve assembly with shut-off valves, vent valves and a bypass valve, all enclosed in a NEMA 1 enclosure.

   a. Setra model 230 with Kele model BVA-5 bypass valve assembly, or approved equal.
2. Air: Units shall be capable of measuring a differential pressure of 0 to 5 in. WC. Accuracy shall be 
+/- 1.0% full scale with a compensated temperature range of 40 to 149 deg F and a maximum 
working pressure of 250 psig.

   a. Setra model 267, or approved equal.
   b. Shall be installed in control panel and piped 2/3 down the duct unless shown otherwise or 
      approved by Owner’s Representative.

Q. Building Static Pressure: Transducer shall utilize a ceramic capacitive sensing element to provide a stable 
linear output over the specified range of building static pressure. Transducer shall be housed in a wall-
mounted enclosure with LCD display. Transducer shall have the following capabilities:

   1. Input Power: 24 VAC
   2. Output: 0-10 VDC
   3. Pressure Range: -0.25 to +0.25 inches w.g.
   4. Display: 3-1/2 digit LCD, displaying pressure in inches w.g.
   5. Accuracy: +/- 1.0% combined linearity and hysteresis.
   6. Temperature Effect: 0.05% / deg C.
   7. Zero Drift (1 year): 2.0% max.
   9. Operating Environment: 0 to 140 deg F, 90% RH (non-condensing).
   10. Fittings: Brass barbs, 1/8” O.D.
   12. Outdoor Sensing Tube Enclosure: UV stabilized thermoplastic or aluminum “can” enclosure to 
       shield outdoor pressure sensing tube from wind effects.
   13. Transducer shall be Veris Industries Model PXPLX01S, equivalent from Setra, or approved equal.

R. High Static Pressure Limit Switch: Provide pressure high limit switch to open contact in fan circuit to shut 
down the supply fan when the inlet static pressure rises above the set point. Provide with an adjustable 
set point, a manual reset button, 2 SPST (normally closed) contacts, and ¼” compression fittings.

   1. Kele model AFS-460-DDS, or approved equal.

S. Airflow/Temperature Measurement Devices:

   1. Provide airflow/temperature measurement devices where indicated on the plans. Fan inlet 
      measurement devices shall not be substituted for duct or plenum measurement devices indicated 
      on the plans.
   2. The measurement device shall consist of one or more sensor probe assemblies and a single, 
      remotely mounted, microprocessor-based transmitter. Each sensor probe assembly shall contain 
      one or more independently wired sensor housings. The airflow and temperature readings 
      calculated for each sensor housing shall be equally weighted and averaged by the transmitter prior 
      to output. Pitot tubes and arrays are not acceptable. Vortex shedding flow meters are not 
      acceptable.
   3. All Sensor Probe Assemblies:

      a. Each sensor housing shall be manufactured of a U.L. listed engineered thermoplastic.
      b. Each sensor housing shall utilize two hermetically sealed, bead-in-glass thermistor probes 
         to determine airflow rate and ambient temperature. Devices that use “chip” or diode case 
         type thermistors are unacceptable. Device that do not have two (2) thermistors in each 
         sensor housing are not acceptable.
      c. Each sensor housing shall be calibrated at a minimum of 16 airflow rates and have an 
         accuracy of +/- 2% of reading over the entire operating airflow range. Each sensor housing 
         shall be calibrated to standards that are traceable to the National Institute of Standards and 
         Technology (NIST).

         1) Devices whose accuracy is the combined accuracy of the transmitter and sensor 
            probes must demonstrate that the total accuracy meets the performance 
            requirements of this specification throughout the measurement range.
d. The operating temperature range for the sensor probe assembly shall be -20°F to 160°F. The operating humidity range for the sensor probe assembly shall be 0-99% RH (non-condensing).

e. Each temperature sensor shall be calibrated at a minimum of three temperatures and have an accuracy of +/- 0.15°F over the entire operating temperature range. Each temperature sensor shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).

f. Each sensor probe assembly shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.

g. Each sensor assembly shall not require matching to the transmitter in the field.

h. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location.

4. Duct and Plenum Sensor Probe Assemblies:

a. Sensor housings shall be mounted in an extruded, gold anodized, 6063 aluminum tube probe assembly. Thermistor probes shall be mounted in sensor housings using a waterproof marine grade epoxy resin. All wires within the aluminum tube shall be Kynar coated.

b. The number of sensor housings provided for each location shall be as follows:

<table>
<thead>
<tr>
<th>Area (sq. ft.)</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2</td>
<td>4</td>
</tr>
<tr>
<td>2 to &lt;4</td>
<td>6</td>
</tr>
<tr>
<td>4 to &lt;8</td>
<td>8</td>
</tr>
<tr>
<td>8 to &lt;16</td>
<td>12</td>
</tr>
<tr>
<td>&gt;=16</td>
<td>16</td>
</tr>
</tbody>
</table>

c. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:

1) Insertion mounted through the side or top of the duct.
2) Internally mounted inside the duct or plenum.
3) Standoff mounted inside the plenum.

d. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

5. Fan Inlet Sensor Probe Assemblies:

a. Sensor housings shall be mounted on 304 stainless steel blocks.

b. Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.

c. Mounting feet shall be constructed of 304 stainless steel.

d. The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.

6. Transmitters:

a. The transmitter shall have a 16 character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics. Configuration settings and diagnostics shall be accessed through a pushbutton interface on the main circuit board. Airflow shall be field configurable to be displayed as a velocity or a volumetric rate.

b. The transmitter shall be capable of independently monitoring and averaging up to 16 individual airflow and temperature readings. The transmitter shall be capable of displaying the airflow and temperature readings of individual sensors on the LCD display.
c. The transmitter shall have a power switch and operation on 24 VDC (isolation not required). The transmitter shall use a switching power supply fused and protected from transients and power surges.

d. All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.

e. The operating temperature range for the transmitter shall be -20°F to 120°F. The transmitter shall be protected from weather and water.

f. The transmitter shall be capable of communicating with the host controls using one of the following interface options:

1) Linear Analog Output Signal: Field selectable, fuse protected and isolated, 0-10 VDC and 4-20 mA (4-wire).
2) RS-485: Field selectable BACnet-MS/TP, ModBus-RTU and Johnson Controls N2 Bus.
3) 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, ModBus-TCP and TCP/IP.
4) LonWorks Free Topology.

g. The transmitter shall have an infra-red interface capable of downloading individual sensor airflow and temperature data or uploading transmitter configuration data to a handheld PDA (Palm or Microsoft Pocket PC operating systems).

7. The measuring device shall be UL listed as an entire assembly.

8. The manufacturer’s authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer’s placement requirements.

9. Manufacturer:

a. Primary, flow elements, sensors, meters and transducers shall be EBTRON, Inc. Model GTx116-P and GTx116-F or approved equal.

b. The naming of any manufacturer does not automatically constitute acceptance of this standard product nor waive their responsibility to comply totally with all requirements of the proceeding specification.

T. Electrical Requirements: Provide electric-pneumatic switches, electrical devices, and relays that are UL-listed and of type which meet current and voltage characteristics of the project. All devices shall be of industrial commercial grade or better. Residential types will be rejected.


2. Relays: Relays shall have a LED status indicator, voltage transient suppression. Closed-Open-Auto switch, plastic enclosure, and color coded wires. Kele model RIBU1C or approved equal.

U. Magnetic Flowmeter for Chilled Water, Make Up Water:

1. The Magnetic Flowmeter flow tube and computer/transducer shall come as a complete system assembled by a single manufacturer. The flowmeter shall be suitable for use in the accurate measurement of chilled water flow, Cooling Tower Water fl, or Make Up water flow for process control and/or utility metering, in a mechanical room environment, with a Johnson Controls EMCS system.

2. The flowmeter shall consist of a pulsed DC electromagnetic coil incorporating Faraday’s Law utilizing the flowing water as the conductor. The flowmeter shall provide proper grounding for use in Schedule 40 steel pipe, Schedule 10S stainless steel pipe, or copper pipe as application requires.

3. The flowmeter element should be sized to maintain maximum accuracy over the flow range of the application while keeping flow tube velocity below 15 fps at max flow. The flowmeter element shall be the flow tube, spool piece type with a non-conductive lining and no intrusions into the flow path. The flowmeter flow tube shall be suitable for direct mounting to standard ANSI flanges.
4. The flowmeter shall have a local LCD display that indicates flow in GPM and/or total gallons from the totalizer. The flowmeter shall be programmable/configurable via local push buttons. The flowmeter computer/transducer shall be remote mounted. The flow tube shall have a direct mounted junction box for wiring connections.

5. The flowmeter shall have the capability to be calibrated in situ to verify proper operation and accuracies.

6. The flowmeter shall also meet the following specifications:

   a. Measure bi-directional flow.
   b. Zero-point stability.
   c. Flow tube can withstand a full vacuum on an intermittent basis.
   d. Normal obstructions, partially opened valves, 90° or 45° elbows, and pump discharges shall require no more than 5 pipe diameters upstream and 3 pipe diameters downstream of straight run for specified performance.
   e. Auto re-start after electrodes have lost wetness.
   f. Computer/transducers shall be interchangeable to multiple flow tubes without affecting the published accuracies of the meter.
   g. Computer/transducer internal electronic components, including power supply and output boards, shall be field interchangeable/exchangeable.
   h. Calibration: NIST Traceable, certificate provided with each meter.
   i. Electrode Pressure Rating: Equivalent to flow tube flange rating.
   j. Minimum Conductivity: 5 S/cm for fluid to be measured.
   k. Transmitter Ambient Temp.: 122°F.
   l. Flow Tube Process Temp.: 32°F to 140°F for chilled water applications.
   m. Flow Tube Process Temp.: 32°F to 140°F for make up water applications.
   n. Flow Tube Process Temp.: 32°F to 141°F for hot or dual water applications.
   o. Flow Range: +/- 0 to 30 fps.
   p. Accuracy (velocity ≤ 1.0 fps): +/- 0.5% of reading or +/- 0.005 fps.
   q. Accuracy (velocity > 1.0 fps): +/- 0.5% of reading.
   r. Analog Output: 4-20 mA, linear to flow in GPM.
   s. Analog Output Accuracy: +/- 2% of span.
   t. Repeatability: +/- 0.1%.
   u. Stability: +/- 0.1%.
   v. Ambient Temperature Effect: <1% per 100°F.
   w. Vibration Effect: 0.1% (remote mounted transducer).
   x. Low Flow Cutoff: Settable to 0.04 fps or lower.
   y. Low Flow Cutoff Analog Output: Analog output shall be 4.0 mA at flows below the low cutoff.
   z. Humidity Limits: 5-90% RH.
   aa. Power Supply: 115 VAC.
   ee. Flanges: Carbon steel, ANSI Class 150#.
   ff. Electrodes: Corrosion resistant Alloy C.
   gg. Cable Length: As required per plans.
   hh. Cable shall be capable of empty pipe detection.
   ii. All cable shall be provided by the meter manufacturer.

7. The flowmeter shall be Siemens MagFlo Mag 6000 with Mag 5100W or approved equal.

8. Bids/Submittals: All bids and/or submittals must include published specifications, specific model number configurations, and operation and maintenance manuals.

9. Warranty: All parts and components as needed for the specified operation and performance shall be covered under warranty for a period of not less than two years.

V. Ultrasound Level Transmitter for Cooling Tower Basin Water: Furnish and install, where indicated on plans, a device for measuring the tower basin water level. The level transmitter shall meet the following specifications:

1. Make: Flowline.
2. Model: EchoSpan LU83-51-01
3. Range: 8" to 26.2 feet.
4. Accuracy: 0.2% of span in air.
5. Resolution: 0.039".
6. Beam Width: 3".
7. Dead Band: 8".
8. Display Type: 6 digit LCD.
9. Display Units: Inch, cm, %.
11. Supply Voltage: 12-28 VDC.
12. Loop Resistance: 500 Ohms @ 24 VDC.
13. Signal Output: 4-20 mA two-wire.
14. Signal Invert: 4-20 mA or 20-4 mA.
15. Calibration: Push button.
16. Fail-Safety: Selectable 4 mA, 20 mA, 21 mA, 22 mA, or hold.
17. Process Temperature: -4°F to 140°F.
19. Electronics Temp: -40°F to 160°F.
20. Pressure: 30 psi @ 25°C, derated @ 1,667 psi/°C above 25°C.
23. Enclosure Material: PC/ABS FR
24. Trans Material: PVDF
25. Process Mount: 2” NPT
27. Conduit Entrance: Dual, ½” NPT.
28. Classification: General purpose.
29. CE Compliance: EN 61326 EMC
30. Level transmitter shall be Flowline EchoSpan LU83-51-01 or equivalent.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer’s instructions, roughing-in drawings and details shown on drawings.

B. Raceway: Raceway is to be installed in accordance with the National Electric Code. Use of flexible metal conduit or liquidtight flexible conduit is limited to 36" to connect from EMT to devices subject to movement. Flexible raceway is not to be used to compensate for misalignment of raceway during installation.

C. Control Wiring: Install control wiring in raceway, without splices between terminal points, color-coded. Install in a neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code.

1. Install circuits over 25-volt with color-coded No. 12 stranded wire.
2. Install electronic circuits and circuits under 25-volts with color-coded No. 18 stranded twisted shielded pair type conductor.
3. N2 communications bus wire shall be 18 AWG, plenum rated, stranded twisted shielded, 3 conductor, with blue outer casing, described as 18-03 OAS STR PLNM NEON BLU JK distributed by Windy City Wire, constructed by Cable-Tek, or approved equivalent.

   a. Metastat wiring shall be minimum 20 AWG, plenum rated, stranded, 8 conductor stranded wire.
4. FC communications bus wire shall be 22 AWG, plenum rated, stranded twisted shielded, 3 conductor, with blue outer casing, described as 22-03 OAS STR PLNM NEON BLU JK distributed by Windy City Wire, constructed by Cable-Tek, or approved equivalent.
   a. Network sensor wiring (SA Bus) shall be 22 gauge plenum rated stranded twisted wire, 4 conductor.

5. All control wiring at control panel shall be tagged and labeled during installation to assist owner in making termination connections at control panel. Label all control wires per bid documents.

D. All low voltages electrical wiring shall be run as follows:
   1. Route electrical wiring on concealed spaces and mechanical rooms whenever possible.
   2. Provide EMT conduit and fittings in mechanical rooms and where indicated on drawings.
   3. Low voltage electrical wiring routed above acoustical ceiling is not required to be in conduit, but wire must be plenum rated and properly supported to building structure.
   4. Provide surface raceway, fittings and boxes in finished areas where wiring cannot be run in concealed spaces. Route on ceiling or along walls as close to ceiling as possible. Run raceway parallel to walls. Diagonal runs are not permitted. Paint raceway and fittings to match existing conditions. Patch/repair/paint any exposed wall penetrations to match existing conditions.

E. All devices shall be mounted appropriately for the intended service and location.
   1. Adjustable thermostats shall be provided with base and covers in occupied areas and mounted 48” above finished floor to the top of the device. Tubing and/or wiring shall be concealed within the wall up to the ceiling where ever possible. Surface raceway may only be used with approval of Owners Representative. Wall mounted sensors such as CO₂, RH, and non-adjustable temperature sensors shall be mounted 54” above finished floor. Duct mounted sensors shall be provided with mounting brackets to accommodate insulation. Mounting clips for capillary tubes for averaging sensors are required.
   2. All control devices shall be tagged and labeled for future identification and servicing of control system.
   3. Preheat and mixed air discharge sensors must be of adequate length and installed with capillary tube horizontally traversing face of coil, covering entire coil every 24 inches bottom to top.
   4. All field devices must be accessible or access panels must be installed.

F. Install magnehelic pressure gage across each air handling unit filter bank. If the air handling unit has a prefilter and a final filter, two magnehelic pressure gages are required.

3.2 ADJUSTING AND START-UP

A. Start-Up: Temporary control of air handling units shall be allowed only if approved by the owner’s representative to protect finishes, etc., AHUs may be run using caution with temporary controls installed by contractor early in the startup process. All safeties including a smoke detector for shut down must be operational. Some means of discharge air control shall be utilized and provided by the contractor such as a temporary sensor and controller located and installed by the Contractor.

B. The start-up, testing, and adjusting of pneumatic and digital control systems will be conducted by Owner. Once all items are completed by the Contractor for each system, Contractor shall allow time in the construction schedule for Owner to complete commissioning of controls before project substantial completion. This task should be included in the original schedule and updated to include the allotted time necessary to complete it. As a minimum, the following items are required to be completed by the Contractor for Owner to begin controls commissioning.
   1. Process Control Network:
a. The control boards and enclosures need to be installed in the mechanical rooms.
b. The fiber optic conduit and box for the process control network needs to be installed. Once in place, Owner needs to be contacted so the length of the Owner-provided fiber cable can be determined and ordered, if required. Coordinate with Owner to schedule the pull in and termination of the fiber cable. Power should be in place at that time. (Fiber for the process control network is required to allow metering of utilities prior to turn on).

2. Heating System:
   a. Pumps, heat exchangers, steam pressure reducing station, piping, control valves, steam and/or hot water meter, feeder conduit and wire, VFDs, control panels and control wiring installed in the mechanical room. The housekeeping pads must be poured before pump operation. All must be in place in working order (pumps aligned, VFDs set up by vendor, motors checked for rotation, steam regulators set to required pressure, condensate pumps operational, heating system ready to circulate (all piping pressure tested, flushed, and insulated) with differential pressure sensors in place.

3. Cooling System:
   a. Pumps, heat exchangers, piping, control valves, chilled water meter, feeder conduit and wire, VFDs, control panels and control wiring installed in the mechanical room. The housekeeping pads must be poured before pump operation. All must be in place in working order (pumps aligned, VFDs set up by vendor, motors checked for rotation, cooling system ready to circulate (all piping pressure tested, flushed, and insulated) with differential pressure sensors in place.

4. VAVs-First Pass:
   a. Power, (FC or N2 bus), and control wire installed before owner can make first commissioning pass. First pass includes installation of VAV controller, termination of power, control and network communication wiring.

5. Air Handlers:
   a. Prior to Owner commissioning, at a minimum, the following items shall be complete. Power wiring, motor rotation check, fire/smoke dampers open, control wiring including safeties, IO cabinet, air handler cleaned, and filters installed as required. To protect the systems from dirt, outside air with no return will be used until the building is clean enough for return air operation.

6. VAVs-Second Pass:
   a. After the air handlers are running and under static pressure control and the heating water system is operating, a second pass can be made on the VAVs to download the control program and commission controllers to verify the VAV dampers, thermostat, and reheat control valves are working properly.

7. Exhaust Systems:
   a. Exhaust fans need to be operational and under control before labs can be commissioned.

8. Some balance work can be done alongside the control work as long as areas are mostly complete and all diffusers are in place.
3.3 CLOSEOUT PROCEDURES

A. Contractor shall provide complete diagrams of the control system including flow diagrams with each control device labeled, a diagram showing the termination connections, and an explanation of the control sequence. The diagram and sequences shall be framed and protected by glass and mounted next to controller.

B. Contractor shall provide as-built diagram of network bus routing listing all devices on bus, once wiring is complete prior to scope completion.

END OF SECTION 230900
SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes piping systems for hot water heating and chilled water cooling systems; makeup water for these systems; blow-down drain lines; and condensate drain piping. Piping materials and equipment specified in this Section include the following:

1. Pipes, fittings, and specialties.
2. Special-duty valves.
3. Hydronic specialties.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. General Sections "Firestopping" for materials and methods for sealing pipe penetrations through fire and smoke barriers.
2. General Section "Joint Sealants" for materials and methods for sealing pipe penetrations through exterior walls.
3. Division 23 Section "Basic Mechanical Materials and Methods" for general piping materials and installation methods.
4. Division 23 Section "Valves" for gate, globe, ball, butterfly, and check valves.
5. Division 23 Section "Meters and Gages" for thermometers, flow meters, and pressure gages.
6. Division 23 Section "Hangers and Supports" for pipe supports.
7. Division 23 Section "Mechanical Identification" for labeling and identifying hydronic systems.
8. Division 23 Section "HVAC Pumps" for pumps, motors, and accessories for hydronic systems.
9. Division 23 Section "Instrumentation and Control for HVAC" for temperature-control valves and sensors.
10. Division 23 Section "Testing, Adjusting, and Balancing" for hydronic system adjusting and balancing.

1.3 SYSTEM DESCRIPTION

A. Hydronic systems are chilled water and hot water heating, forced, recirculating systems.

B. Four-Pipe System: The 4-pipe system includes independent chilled water and hot water supply and return piping mains in a closed loop, connecting to the existing campus chilled water loop for chilled water and generation of heating hot water utilizing the campus steam loop. Hot and chilled water will be circulated to fan coil units and air handling units located in the building.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
B. Product Data including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties, accessories, and installation instructions for each hydronic specialty and special-duty valve specified.

1. Submit flow and pressure drop curves for balancing valves, based on manufacturer's testing.

C. Shop Drawings detailing pipe anchors, special pipe support assemblies, alignment guides, and expansion joints and loops.

D. Field test reports indicating and interpreting test results for compliance with performance requirements specified in Part 3 of this Section.

E. Maintenance data for hydronic specialties and special-duty valves to include in the operation and maintenance manual specified in Division 1.

1.5 QUALITY ASSURANCE

A. ASME Compliance: Comply with the following provisions:

1. ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
2. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
3. Welding Standards: Qualify welding processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications."

1.6 COORDINATION

A. Coordinate layout and installation of piping with equipment and with other installations.

B. Coordinate pipe sleeve installation for foundation wall penetrations.

C. Coordinate pipe fitting pressure classes with products specified in related Sections.

D. Coordinate size and location of concrete housekeeping pads. Cast anchor-bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

E. Coordinate installation of pipe sleeves for penetrations in exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Firestopping" for fire and smoke wall and floor assemblies.

1.7 EXTRA MATERIALS

A. Maintenance Stock: Furnish a sufficient quantity of chemicals for initial system startup and for preventive maintenance for one year from Substantial Completion.

PART 2 - PRODUCT

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Balancing Valves:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett.
   c. Nibco
   d. Tour & Anderson.

2. Pressure-Reducing Valves (Make-up water for hot and chilled water systems):
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Grinnell Supply Sales Co.
   d. ITT Hoffman; ITT Fluid Handling Div.
   e. Bell & Gossett.

3. Safety Relief Valves:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Conbraco Industries, Inc.
   d. ITT Fluid Technology Corp.; ITT McDonnell & Miller.
   e. Bell & Gossett.

4. Compression Tanks:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. ITT Fluid Technology Corp.; ITT Bell & Gossett.
   d. Taco, Inc.
   e. Bell & Gossett.

5. Air/Dirt Separators:
   a. Spirotherm.

6. Air Purgers:
   a. Amtrol.
   b. Bell & Gossett.
   c. Taco.

7. Suction Diffusers:
   a. Bell & Gossett.
   b. Armstrong.

2.2 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3 "Pipe Applications" Article for identifying where the following materials are used.

B. Steel Pipe, 2-1/2-Inch NPS (DN50) and Smaller: All steel pipe shall be ASTM A53, Grade B, Type E. Welded fittings shall be the same material as the pipe.

C. Steel Pipe, 3- to 12-Inch NPS (DN65 to DN300): All steel pipe shall be ASTM A53, Grade B, Type E. Welded fittings shall be the same material as the pipe.

1. Steel Pipe Nipples: ASTM A 106 or ASTM A 53, Schedule 40, carbon steel, seamless for 2-inch NPS (DN50) and smaller and electric-resistance welded for 2-1/2-inch NPS (DN65) and larger.
D. Steel pipe, 14- to 18-inch NPS (DN 350 to DN 450): All steel pipe shall be ASTM A53, Grade B, Type E. Welded fittings shall be the same material as the pipe.

E. Contractor may, at his option, use Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B) for hot water heating and chilled water loop piping 2-1/2” and below.

### 2.3 FITTINGS

A. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125.

B. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

C. Cast-Iron Threaded Flanges: ASME B16.1, Classes 125 and 250; raised ground face, bolt holes spot faced.

D. Wrought-Steel Fittings: ASTM A 234 (ASTM A 234M), Standard Weight.

E. Wrought-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: Cast iron with flat faced flanges, 125 lb. valves.

F. Wrought-Copper Fittings: ASME B16.22.

G. Wrought-Copper Unions: ASME B16.22.

### 2.4 JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

B. Brazing Filler Metals: AWS A5.8, Classification Bag 1 (silver).

C. Welding Materials: Comply with Section II, Part C of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

D. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

### 2.5 VALVES

A. Gate, globe, check, ball, and butterfly valves are specified in Division 15 Section "Valves."

B. Refer to Part 3 "Valve Applications" Article for specific uses and applications for each valve specified.

C. Balancing Valves (2" and Under): 200-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature, bronze body, balancing valve with combination shutoff capability. Balancing valves shall have memory stop and pressure/temperature metering taps, with wheel handle and indicator. Furnish with portable test kit. Quarter turn valves will not be acceptable.

D. Pressure-Reducing Valves: Diaphragm-operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem.
Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

E. Safety Relief Valves: Brass or bronze body with brass and rubber, wetted, internal working parts; according to ASME Boiler and Pressure Vessel Code, Section IV. See schedule on drawings for sizes.

2.6 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig (1035-kPa) working pressure, 225 deg F (107 deg C) operating temperature; ½ ball valve.

B. Pre-pressurized Expansion Tanks: Welded carbon steel for 125-psig (860-kPa) working pressure, 240 deg F (191 deg C) maximum operating temperature. Provide taps tank for tank and drain fitting; tanks shall be vertical or horizontal as indicated on drawings. Tanks shall be furnished with heavy duty butyl diaphragm and charging valve. Factory test tank with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

C. Provide steel air and dirt separators; all fittings shall be fabricated steel, rated for 150 psi design pressure and selected not to exceed 10 feet per second at the specified gpm. All units shall include an integral copper bundle of tubes to act as the turbulence suppressive coalescing medium which must completely fill the fittings internal area. Units are to remove free air and entrained air during system start up and continue to eliminate dissolved air and dirt through continual circulation and the coalescing action. Each fitting is to have a separate air and venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral float actuated brass air vent. There shall be no restrictions in the connection from the venting chamber to the vent. The fittings are to include a valve side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Unit shall have the bottom of the vessel extended for dirt separation with the system connection nozzles equidistant from the top and bottom of the vessel and include a blowdown connection and valve. Equipment shall be Spirotherm or approved equal, type “VDT” for heating system and type “VHT” for chilled water system.

D. Balancing Valves (2-1/2” and Larger): 175 psi working pressure, 250 deg F maximum operating temperature, heavy-duty, cast iron flanged, valves 2-1/2-3” size shall have brass ball with glass and carbon filled TFE seat rings. Valves 4” to 8” shall be fitted with bronze seat, replaceable bronze disc with EPDM seal insert and stainless steel stem. Valve shall have pre-set capability.

E. Y-Pattern Strainers: 125-psig (860-kPa) working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for 2-1/2-inch NPS (DN65) and larger, threaded connections for 2-inch NPS (DN50) and smaller, bolted cover, perforated Type 304 stainless-steel basket, and bottom drain connection.

F. Basket Strainers: 125-psig (860-kPa) working pressure; high-tensile cast-iron body (ASTM A 126, Class B), flanged end connections, bolted cover, perforated Type 304 stainless-steel basket, and bottom drain connection.

G. Automatic and Quick-fill Station: Furnish and install for hot water system, 1/2” Bell & Gossett or Taco relief valve on hot water system, set for 100 p.s.i. Extend line from each relief valve to nearest floor drain and turn down. Provide 1/2” Bell & Gossett or Taco pressure regulating valve with strainer for each system set to maintain not less than 10 p.s.i. at high point in each piping system. Mount each valve and strainer assembly approximately 36” above floor in accessible location. Provide 4-1/2” pressure gauge with globe valve on low pressure side of each regulating valve.

H. Suction Diffuser: Angle pattern 175-psig (1204-kPa) pressure rating, cast-iron body and end cap, pump inlet fitting; with bronze startup and stainless-steel permanent strainers; stainless-steel straightening vanes; drain plug; and factory-fabricated support.
PART 3 - EXECUTION

3.1 PIPE APPLICATIONS

A. Hot Water and Chilled Water, 2-1/2"-Inch NPS (DN50) and Smaller: Steel pipe with threaded joints or Type L drawn-temper copper tubing with soldered joints.

B. Hot and Chilled Water 3-Inch NPS (DN65) and Larger: Steel pipe with welded and flanged joints.

C. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:
   1. Shutoff Duty: Use ball (up to 2-1/2") and butterfly valves (3" and larger).

B. Install shutoff-duty valves at each branch connection to supply mains, at supply connections to each piece of equipment, and elsewhere as indicated.

C. Install balancing valves on the outlet of each heating or cooling element and elsewhere as required to facilitate system balancing.

D. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

E. Install center-guided check valves on each pump discharge and elsewhere as required to control flow direction.

F. Install safety relief valves on hot water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Pipe discharge to floor without valves. Comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

G. Install pressure-reducing valves set in quick and automatic fill system on hot water generators and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS

A. Install piping according to Division 23 Section "Common Work Results for HVAC."

B. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains at low points in mains, risers, branch lines consisting of a tee fitting, 3/4-inch NPS ball valve, and short 3/4-inch NPS threaded nipple and cap. Install manual air vents at all high points.

D. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

E. Install branch connections to mains using tee fittings in main with takeoff out top of main, except for up-feed risers with takeoff out top of main line.

F. Install unions in pipes 2-inch NPS and smaller, adjacent to each valve, at final connections of each piece of equipment, and elsewhere as indicated. Unions are not required at flanged connections.
G. Install flanges on valves, apparatus, and equipment having 2-1/2-inch NPS and larger connections.

H. Install flexible connectors at inlet and discharge connections to pumps (except in-line pumps) and other vibration-producing equipment.

I. Install strainers on supply side of each control valve, pressure-reducing valve, pressure-regulating valve, solenoid valve, in-line pump, and elsewhere as indicated. Install 3/4-inch NPS nipple and ball valve in blow-down connection of strainers 2-inch NPS and larger.

J. Provide temporary caps and covers over piping to prevent collection of dirt and debris during construction.

K. Anchor piping as required to ensure proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

A. General: Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports." Conform to requirements below for maximum spacing of supports.

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) in length.
   2. Adjustable roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal runs 20 feet (6 m) or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
   2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
   3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
   5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
   6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
   7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
   8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2 inch.
   9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8 inch.
  10. NPS 10: Maximum span, 20 feet; minimum rod size, 3/4 inch.

D. Install hangers for drawn-temp copper piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at each floor.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Division 23 Section "Common Work Results for HVAC" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping; and solvent-welded joints for PVC and CPVC piping.
3.6 HYDRONIC SPECIALTIES INSTALLATION
   A. Install manual air vents at high points in system, at heat-transfer coils, and elsewhere as required for system air venting.
   B. Install combination air/dirt separator in hot water and chilled water pump suction lines. Run piping to compression tank with a 2 percent upward slope toward tank. Install blow-down piping with ball valve; extend to nearest drain.
   C. Install shot-type chemical feeder in hot water system where indicated; in upright position with top of funnel not more than 48 inches (1200 mm) above floor. Install feeder with connections on each side of the hot water pump discharge valve. Pipe drain, with ball valve, to nearest equipment drain.

3.7 TERMINAL EQUIPMENT CONNECTIONS
   A. Piping size for supply and return shall be same size at a minimum as equipment connections. See drawings for pipe sizes of equipment connection branch piping.
   B. Install control valves in accessible locations close to equipment.
   C. Install pressure gage at coil inlet connections.

3.8 FIELD QUALITY CONTROL
   A. Testing Preparation: 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 system with clean water. Clean strainers.
      4. Isolate equipment that is not subjected to test pressure from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Flanged joints where blinds are inserted to isolate equipment need not be tested.
      5. Install relief valve set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
   B. Testing: Test hydronic piping as follows:
      1. Acceptance Testing: Perform hydrostatic tests on the hydronic piping in accordance with ANSI B 31.9 and as follows:
      2. Notify Owner’s Representative 24 hours before required testing. All tests shall be conducted in the presence of the Owner’s Representative.
      3. Flush system with clean water. Clean strainers.
      4. Minimum test pressure shall be 100 PSIG.
      5. Pressure gauge shall be min. 4" dia. Face, 0-160 PSIG, and shall be calibrated within 1 year of test date.
      6. Test pressure shall be held for 1 hour. Test pressure shall be held for 4 hours if tested with air.
      7. Prepare reports for all tests and required corrective action.
      8. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.
      9. System shall be operated for a minimum of 24 hours to demonstrate to the Owner’s Representative that system is complete and operational.
     10. Install temporary bypass at heating hot water and chilled water utility entrance points to allow flushing of systems with building pumps. After flush is approved by the owner, remove temporary bypass and cap bypass fittings.
3.9 ADJUSTING AND CLEANING

A. After completing system installation, including outlet fittings and devices, inspect finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Flush hydronic piping systems with clean water. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

C. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

3.10 COMMISSIONING

A. Fill system and perform initial chemical treatment.

B. Check expansion tanks to determine that they are not air bound and that system is completely full of water.

C. Perform these steps before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vents at high points of systems 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. Check operation of automatic bypass valves.
7. Lubricate motors and bearings.

END OF SECTION 232113
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SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following categories of HVAC pumps for hydronic systems:

1. End-suction pumps.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 23 Section "Meters and Gages for HVAC Piping" for thermometers and pressure gages, connector plugs, and devices.
2. Division 23 Section "Common Motor Requirements for HVAC Equipment" for pump motors.
3. Division 23 Section "Vibration Control" for inertia bases, isolation pads, spring supports, spring hangers, and flexible pipe connectors.
4. Division 23 Section "Instrumentation and Controls for HVAC" for interlock wiring between pumps, and between pumps and field-installed control devices.
5. Division 26 Sections for power-supply wiring, field-installed disconnects, required electrical devices, and motor controllers.

1.3 PERFORMANCE REQUIREMENTS

A. Pump Pressure Ratings: At least equal to system's maximum operating pressure at point where installed, but not less than specified.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data including certified performance curves and rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties, and accessories. Indicate pump's operating point on curves.

C. Shop drawings showing pump layout and connections. Include setting drawings with templates, directions for installation of foundation and anchor bolts, and other anchorages.

D. Wiring diagrams detailing wiring for power, signal, and control systems and differentiating between manufacturer-installed wiring and field-installed wiring.

E. Product certificates signed by manufacturers of pumps, certifying accuracies under specified operating conditions and compliance with specified requirements.
F. Maintenance data for pumps to include in the operation and maintenance manual specified in Division 1. Include startup instructions.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following:

1. ASME B31.9 "Building Services Piping" for piping materials and installation.
2. Hydraulic Institute’s "Standards for Centrifugal, Rotary & Reciprocating Pumps" for pump design, manufacture, testing, and installation.
3. UL 778 "Standard for Motor Operated Water Pumps" for construction requirements. Include UL listing and labeling.
4. NEMA MG 1 "Standard for Motors and Generators" for electric motors. Include NEMA listing and labeling.
5. NFPA 70 "National Electrical Code" for electrical components and installation.

B. Single-Source Responsibility: Obtain each category of pumps from 1 source and by a single manufacturer.

C. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of pumps and are based on the specific types and models indicated. Other manufacturers’ pumps with equal performance characteristics may be considered. Refer to Division 1 Section "Product Substitutions."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store pumps in dry location.

B. Retain shipping flange protective covers and protective coatings during storage.

C. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

D. Extended Storage Longer than 5 Days: Dry internal parts with hot air or vacuum-producing device. Coat internal parts with light oil, kerosene, or antifreeze after drying. Dismantle bearings and couplings; dry; coat with acid-free, heavy oil; tag; and store in dry location.

E. Comply with pump manufacturer's rigging instructions.

PART 2 - PRODUCT

2.1 MANUFACTURERS

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

1. Supported-Volute, Flexible Coupled, End-Suction Pumps:

   b. ITT Fluid Technology Corp.; Bell & Gossett Div., Series 1510.
   c. Peerless.

2.2 PUMPS, GENERAL

A. General: Factory assembled and tested.
B. Base-Mounted Pumps: Include pump casings that allow removal and replacement of impellers without disconnecting piping.

C. Types, Sizes, Capacities, and Characteristics: As indicated.

D. Motors: NEMA MG 1, general purpose, continuous duty, Design B, except Design C where required for high starting torque. Furnish single-, multiple-, or variable-speed motors, with type of enclosures and electrical characteristics indicated. Include built-in thermal-overload protection and grease-lubricated ball bearings. Select each motor to be nonoverloading over full range of pump performance curve.

E. Motors Indicated to Be Energy Efficient: Minimum efficiency as indicated according to IEEE 112, Test Method B. Include motors with higher efficiency than "average standard industry motors" according to IEEE 112, Test Method B, if efficiency is not indicated. Chilled water and heating hot water pumps shall be high efficiency, premium quality, inverter duty.

F. Factory Finish: Manufacturer's standard paint applied to factory-assembled and -tested units before shipping.

G. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

2.3 SEPARATELY COUPLED, END-SUCTION PUMPS

A. Description: Supported-volute, centrifugal, separately coupled, end-suction, single-stage, bronze-fitted, radially split case design; rated for 175-psig (1200-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C). Include back-pull-out design, and the following:

1. Casing: Cast iron, with flanged piping connections, drain plug in bottom of volute, and threaded gage tappings at inlet and outlet flange connections. Include integral feet or other means on volute to support weight of casing and attached piping.

2. Impeller: ASTM B 584, cast bronze, statically and dynamically balanced, closed, overhung, single suction, keyed to shaft, and secured by locking cap screw.

3. Wearing Rings: Replaceable, bronze casing ring.

4. Shaft and Sleeve: Steel shaft with bronze sleeve.

5. Seals: Mechanical type. Include carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.

6. Coupling: Woods “Dura-Flex”, capable of absorbing torsional vibration and shaft misalignment. Include flange and sleeve section that can be disassembled and removed without removing pump or motor.

7. Coupling Guard: Steel, removable, and attached to mounting frame.


9. Motor: Secured to mounting frame, with adjustable alignment.

10. Motor Controllers: Furnish pumps with motor controllers as indicated on schedule on drawings. Refer to Division 15 Section "Motor Controllers" for specifications.

11. Furnish pump with gauge tappings on suction and discharge. Provide 4-1/2" diameter pressure gauges with brass globe valves on suction and discharge of each pump.

2.4 GENERAL-DUTY VALVES

A. Refer to Division 23 Section "Valves" for general-duty gate, ball, butterfly, globe, and check valves.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting performance of pumps.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 CONCRETE

A. Install concrete inertia bases and concrete pads for pumps. Refer to Division 3 Section "Cast-in-Place Concrete" and Division 23 Section "Basic Mechanical Materials and Methods."

3.3 INSTALLATION

A. Install pumps according to manufacturer's written installation and alignment instructions.

B. Install pumps in locations indicated and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so that piping is not supported by pumps.

D. Set base-mounted pumps on concrete inertia bases. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

1. Support pump base plate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches (19 to 38 mm) between pump base and foundation for grouting.

2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust alignment of pump and motor shafts for angular and parallel alignment by 1 of 2 methods specified in the H.I.'s Standards for Centrifugal, Rotary & Reciprocating Pumps, "Instructions for Installation, Operation and Maintenance."

D. Alignment Tolerances: According to manufacturer's recommendations.
3.5 CONNECTIONS

A. General: Install shutoff valve and strainer on pump suction and cushion check valve and cutoff valve on pump discharge, except where other arrangement is indicated.

B. Connect piping to pumps as indicated. Install valves that are the same size as piping connecting to pumps.

C. Install suction and discharge pipe sizes equal to or greater than the diameter of pump nozzles, sizes as noted on drawings.

D. Install flexible connectors on suction and discharge sides of base-mounted pumps and where indicated. Install between pump casing and valves, except where other arrangement is indicated.

E. Install thermometers where indicated.

F. Install pressure gages on pump suction and discharge. Install at integral pressure gage tappings.

G. Install temperature and pressure gage connector plugs in suction and discharge piping around each pump.

H. Install electrical connections for power, controls, and devices.

I. Electrical power and control wiring and connections are specified in Division 26 Sections.

3.6 FIELD QUALITY CONTROL

A. Check suction piping connections for tightness to avoid drawing air into pumps.

B. Clean strainers.

3.7 COMMISSIONING

A. Final Checks Before Startup: Perform the following preventive maintenance operations and checks before startup:

1. Lubricate bearings.
2. Disconnect coupling and check motor for proper rotation that matches direction marked on pump casing.
3. Check that pumps are free to rotate by hand. Pumps for handling hot liquids shall be free to rotate with pump hot and cold. Do not operate pump if it is bound or even drags slightly until cause of trouble is determined and corrected.
4. Check that pump controls are correct for required application.

B. Starting procedure for pumps with shutoff power not exceeding safe motor power:

1. Prime pumps, opening suction valve, closing drains, and preparing pumps for operation.
2. Open warm-up valves of pumps handling hot liquids if pumps are not normally kept at operating temperature.
3. Open circulating line valves if pumps should not be operated against dead shutoff.
4. Start motors.
5. Open discharge valves slowly.
6. Check general mechanical operation of pumps and motors.
7. Close circulating line valves once there is sufficient flow through pumps to prevent overheating.
B. When pumps are to be started against closed check valves with discharge shutoff valves open, steps are the same, except that discharge valves are opened sometime before motors are started.

C. Remove startup strainers after flushing of system.

D. Refer to Division 23 Section “Testing, Adjusting, and Balancing” for detailed requirements for testing, adjusting, and balancing hydronic systems.

END OF SECTION 232123
SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round and flat-oval ducts and fittings.
   4. Sealants and gaskets.
   5. Hangers and supports.

B. Related Sections:
   1. 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. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.4 SUBMITTALS

A. Product Data: For each type of the following products:
   1. 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: CAD generated 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.

7. Refer to Section "Common Work Results for HVAC".

D. Field quality-control reports.

1.5 QUALITY ASSURANCE


B. 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 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

C. 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."

D. 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."

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
   2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
   3. Coat insulation with antimicrobial coating.
   4. Cover insulation with polyester film complying with UL 181, Class 1.

F. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent or solid sheet steel where indicated.

G. Formed-on Transverse Joints (Flanges): 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."

H. 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."

2.3 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. 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 in Diameter: Flanged.

D. 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 in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. 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."

2.4 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.

2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36, 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.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. 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, 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, 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 be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 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, "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 and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in 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 before external insulation is applied. Provide adequate sealing as required to meet duct leakage requirements.

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 or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "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 of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
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, for 24 inches length, that are visible through return and exhaust 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:
   1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Use a minimum leakage class 4 for rectangular ductwork and 3 for spiral ductwork. Submit a test report for each test.
   2. Maximum Allowable Leakage: Duct system leakages shall not exceed 5% of design air flows. When systems are leak tested in section, the total cumulative leakage of the system shall not exceed 5%.
   3. Test the following systems:
      a. All supply air ducts and sections from air handling unit to terminal units.
      b. All return air ducts and sections from grilles/registers to return/relief air fan.
      c. 10% of supply air ductwork downstream of boxes, but not less than two systems.
      d. Two exhaust air duct systems.
   4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
   5. Test for leaks before applying external insulation.
   6. 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.
   7. 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 new and existing 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:
   1. Underground Ducts: Concrete-encased, PVC-coated, galvanized sheet steel with thicker coating
      on duct exterior.

B. Supply Ducts:
   1. Downstream of Air Handling Units and Up to Terminal Units:
      a. Pressure Class: Positive 6-inch wg.
   2. From Terminal Units to Outlets:
      a. Pressure Class: Positive 1-inch wg.
   3. Ducts Located within Mechanical Equipment Rooms:
      a. Pressure Class: Positive 4-inch wg.

C. Return Ducts:
   1. All Ducts:
      a. Pressure Class: Negative 4-inch wg.

D. Exhaust Ducts:
   1. General Exhaust System Ducts:
      a. Pressure Class: Negative 2-inch wg.
   2. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1, Class 3 and 4) Air:
      a. Type 304, stainless-steel sheet.
         1) Exposed to View: No. 4 finish.
         2) Concealed: No. 2B finish.
      b. PVC-coated, galvanized sheet steel with thicker coating on duct interior.
      c. Pressure Class: Positive or negative 3-inch wg.

E. Outdoor-Air Ducts:
   1. All Ducts:
      a. Pressure Class: Positive or negative 1-inch wg.

F. Intermediate Reinforcement:
   1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.

G. Elbow Configuration:
1. **Rectangular Duct:** Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
   
   a. **Velocity 1000 fpm or Lower:**
      
      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.
   
   b. **Velocity 1000 to 1500 fpm:**
      
      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with 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."
   
   c. **Velocity 1500 fpm or Higher:**
      
      1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with 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. **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."

3. **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 or Lower:** 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) **Velocity 1000 to 1500 fpm:** 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) **Velocity 1500 fpm or Higher:** 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      4) **Radius-to-Diameter Ratio:** 1.5.
   
   b. **Round Elbows, 12 Inches and Smaller in Diameter:** Stamped or pleated.
   
   c. **Round Elbows, 14 Inches and Larger in Diameter:** Standing seam or Welded.

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:** Spin in.
2. Round and Flat Oval: 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." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm: Conical tap.
c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113
SECTION 233119 - HVAC CASINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings 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. Factory-fabricated, field-assembled, single- and double-wall casings for HVAC equipment.

1.3 PERFORMANCE REQUIREMENTS
   A. Static-Pressure Classes:
      1. Upstream from Fan(s): 2-inch wg.
      2. Downstream from Fan(s): 6-inch wg.
   B. Acoustical Performance:
      1. NRC: 1.09 according to ASTM C 423.
      2. STC: 40 according to ASTM E 90.
   C. Structural Performance:
      1. Casings shall be fabricated to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed 1/8 inch per foot of width.
         a. Fabricate outdoor casings to withstand wind load of 15 lbf/sq. ft. and snow load of 30 lbf/sq. ft.

1.4 SUBMITTALS
   A. Product Data: For each type of the following products:
      1. Factory-fabricated casings.
      2. Liners and adhesives.
      3. Sealants and gaskets.
   B. LEED Submittals:
      1. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment".
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation".
3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1-2004, Section 6.4.4.2.2 - "Duct Leakage Tests".
4. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1-2004, Section 7.2.4 - "Ventilation System Start-Up".
5. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

C. Shop Drawings: For HVAC casings. Include plans, elevations, sections, components, and attachments to other work.

1. Detail HVAC casing assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Sheet metal thickness(es).
3. Reinforcement and spacing.
4. Seam and joint construction.
5. Access doors including frames, hinges, and latches.
6. Filter, coil, humidifier, and other apparatus being installed in and mounted on casing.
7. Locations for access to internal components.
8. Hangers and supports including methods for building attachment, vibration isolation, seismic restraints, and casing attachment.
9. Interior lighting, including switches.

D. Welding certificates.

E. Product Certificates: For acoustically critical casings, from manufacturer.

1. Show sound-absorption coefficients in each octave band lower than those scheduled when tested according to ASTM C 423.
2. Show airborne sound transmission losses lower than those scheduled when tested according to ASTM E 90.

F. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code - Steel", for hangers and supports.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up".

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation".

1.6 COORDINATION

A. 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 Section "Cast-in-Place Concrete".
B. Coordinate sizes and locations of steel supports. Supports are specified in Division 05 Section "Metal Fabrications".

C. Coordinate installation of roof curbs, equipment supports and roof penetrations. These items are specified in Division 07 Section "Roof Accessory"s.

PART 2 - PRODUCTS

2.1 GENERAL CASING FABRICATION REQUIREMENTS

A. General Material Requirements: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible", Chapter 6, "Equipment and Casings", for acceptable materials, material thicknesses, and casing construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

1. Fabricate casings with more than 3-inch wg negative static pressure according to SMACNA’s "Rectangular Industrial Duct Construction Standards".
2. Casings with more than 2-inch wg positive static pressure may be fabricated according to SMACNA’s "Rectangular Industrial Duct Construction Standards".

B. Galvanized Sheet Steel: Comply with ASTM A 653.

1. Exterior Surface Galvanized Coating Designation: G90.
2. Interior Surface Galvanized Coating Designation:
   a. Sections Not Exposed to Moisture: G60.
   b. Sections Housing and Downstream from Cooling Coil and Humidifiers: G90 (Z275).

C. Stainless Steel: ASTM A 480, Type 304, and having a No. 2D finish.

D. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the interior sheet metal surfaces of casing in contact with the airstream. Apply untreated clear coating to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H minimum when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to UL 723; certified by an NRTL.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Sealing Requirement: SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible", Seal Class A. Seal all seams, joints, connections, and abutments to building.

G. Penetrations: Seal all penetrations airtight. Cover with escutcheons and gaskets, or fill with suitable compound so there is no exposed insulation. Provide shaft seals where fan shafts penetrate casing.

H. Access Doors: Fabricate access doors according to SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible", Figure 6-11, "Casing Access Doors - 2-inch wg (500 Pa)"; and Figure 6.12, "Casing Access Doors - 3-10-inch wg (750-2500 Pa)"; and according to pressure class of the plenum or casing section in which access doors are to be installed.
1. **Size**: Minimum 20 by 66 inches height. If height of casing is less than 72 inches, then door height shall be 6 inches less than casing height.

2. **Vision Panel**: Double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.

3. **Hinges**: Piano or butt hinges and latches, number and size according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

4. **Latches**: Minimum of two wedge-lever-type latches, operable from inside and outside.

5. **Neoprene gaskets around entire perimeters of door frames.**

6. **Doors shall open against air pressure.**

### Condensate Drain Pans:

1. Double-wall construction shall have space between walls filled with foam insulation and sealed moisture tight.

2. Intermediate drain pan or drain trough shall collect condensate from top coil for units with stacked coils or stacked eliminators.

3. **Insulation**: Polystyrene or polyurethane.

4. **Slopes shall be in a minimum of two planes to collect condensate from cooling coils (including coil piping connections and return bends), eliminators, and humidifiers when units are operating at maximum catalogued face velocity across cooling coils.**

5. **Each drain pan connection shall have a trap.** Drain traps with depth and height differential between inlet and outlet equal or greater to the design static pressure plus 2-inch wg. Include slab height in trap calculation.

### 2.2 SHOP-FABRICATED CASINGS

#### A. Single- and Double-Wall Casings

- Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

#### B. Double-Wall Casing Inner Panel

- Solid sheet steel. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

#### C. Interstitial Insulation

- Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard".
  1. **Maximum Thermal Conductivity**: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
  2. **Coat insulation with antimicrobial coating.**
  3. **Cover insulation with polyester film complying with UL 181, Class 1.**

#### D. Interstitial Insulation

- Flexible-elastomeric duct liner complying with ASTM C 534, Type II for sheet materials and with NFPA 90A or NFPA 90B.
  1. **Maximum Thermal Conductivity**: 0.25 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

#### E. Fabricate casings with standing seams and angle-iron reinforcements unless otherwise indicated.

#### F. Fabricate close-off sheets from casing to dampers, filter frames, and coils and between stacked coils. Use galvanized sheet steel of same thickness as casing and with a galvanized coating designation of G90.

#### G. Bolt close-off sheets to frame flanges and housings. Support coils on stands fabricated from galvanized-steel angles or channels.

#### H. Reinforce casings with galvanized-steel angles.
2.3 MANUFACTURED CASINGS

A. Description: Double-wall, insulated, pressurized equipment casing.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Buffalo Air Handling.
   2. CertainTeed Corp.; Insulation Group.
   3. CLEANPAK International.
   4. Industrial Noise Control, Inc.
   5. McGill AirSilence LLC.
   6. SEMCO Incorporated.

C. Double-Wall Panel Fabrication: Solid, galvanized sheet steel exterior wall and solid, galvanized sheet steel interior wall; with space between wall filled with insulation.
   1. Wall Thickness: 2 inches unless noted otherwise.
   2. Fabricate with a minimum number of joints.
   3. Weld exterior and interior walls to perimeter; to interior, longitudinal, galvanized-steel channels; and to box-end internal closures. Paint welds.
   4. Sheet metal thickness shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for static-pressure class indicated for casing.
   5. Sheet Metal Thicknesses:
      a. Exterior Wall Thickness: 0.040 inch minimum.
      b. Interior Wall Thickness: 0.034 inch minimum.
   7. Fill each panel assembly with insulating material that is noncombustible, inert, mildew resistant and vermin proof and that complies with NFPA 90A.
   8. Fabricate panels with continuous tongue-and-groove or self-locking joints effective inside and outside each panel.

D. Trim Items: Fabricate from a minimum of 0.052-inch galvanized sheet steel, furnished in standard lengths for field cutting.

2.4 CASING LINER

A. Fibrous-Glass Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corp.; Insulation Group.
      b. Johns Manville.
      c. Knauf Insulation.
      d. Owens Corning.

   2. Maximum Thermal Conductivity:
      a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
      b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
3. Antimicrobial Erosion-Resistant Coating: Apply to surface of the liner that will form the interior surface of casing to act as a moisture repellent and an erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

4. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
   a. 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. Flexible-Elastomeric Casing Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1, and with NFPA 90A or NFPA 90B.
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Aeroflex USA Inc.
      b. Armacell LLC.
      c. NOMACO Insulation.
   2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
   3. 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 80 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-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized steel, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

D. Shop or Factory Application of Casing 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 casing liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of casing 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 casings or cut and fit to ensure butted-edge overlapping.
   5. Apply adhesive coating on longitudinal seams in casings with air velocity of 2500 fpm.
   6. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
   7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from casing wall. Fabricate edge facings at the following locations:
      a. Fan discharges.
      b. Intervals of lined casing preceding unlined duct.
      c. Upstream edges of transverse joints in casings where air velocities are higher than 2500 fpm or where indicated.
8. Secure insulation between perforated sheet metal inner wall of same thickness as specified for outer wall. Use mechanical fasteners that maintain inner wall at uniform distance from outer wall without compressing insulation.

2.5 SEALANT MATERIALS

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. 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. 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).
   8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
   10. Substrate: Compatible with galvanized sheet steel or stainless steel.

C. 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. VOC: Maximum 395 g/L.
   9. 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).
   10. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
   11. Service: Indoor or outdoor.
   12. Substrate: Compatible with galvanized sheet steel or stainless steel.

D. 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).

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine concrete bases and steel supports for compliance with requirements for conditions affecting installation and performance of HVAC casings.

B. Examine casing insulation materials and liners before installation. Reject casings that are wet, moisture damaged, or mold damaged.

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

3.2 INSTALLATION

A. Install casings according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Equipment Mounting: Install HVAC casings on concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
   2. For supported casings, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Install seismic restraints on casings. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Apply sealant to joints, connections, and mountings.

E. Field-cut openings for pipe and conduit penetrations; insulate and seal according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Support casings on floor or foundation system. Secure and seal to base.

G. Support components rigidly with ties, braces, brackets, seismic restraints, and anchors of types that will maintain housing shape and prevent buckling.

H. Align casings accurately at connections, with 1/8-inch misalignment tolerance and with smooth interior surfaces.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Perform field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual".
   2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
3. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.
4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

B. HVAC casings will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 CLEANING
A. Comply with in Division 23 Section "Metal Ducts".

END OF SECTION 233119
SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Backdraft and pressure relief dampers.
   3. Fire dampers.
   4. Combination fire and smoke dampers.
   5. Flange connectors.
   6. Turning vanes.
   7. Remote damper operators.
   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.
   1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. LEED Submittal:
   1. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
   1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
      a. Special fittings.
      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.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

E. Source quality-control reports.

F. 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, but not less than two.

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.


2. Exposed-Surface Finish: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480, Type 304, and having a No. 2 finish for concealed ducts and D4 finish for exposed ducts.

D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. American Warming and Ventilating; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
5. Nailor Industries Inc.
6. Ruskin Company.
7. SEMCO Incorporated.
8. Vent Products Company, Inc.

B. Description: Gravity balanced.


D. Frame: 0.052-inch-thick, galvanized sheet steel/0.063-inch-thick extruded aluminum/0.052-inch, with welded corners and mounting flange.

E. Blades: Multiple single-piece blades, center-pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum/0.050-inch-thick aluminum sheet with sealed edges.

F. Blade Action: Parallel.

G. Blade Seals: Extruded vinyl, mechanically locked.

H. Blade Axles:

1. Material: Nonferrous metal or Galvanized steel.
2. Diameter: 0.20 inch.

I. Tie Bars and Brackets: Aluminum.

J. Return Spring: Adjustable tension.

K. Bearings: Steel ball or synthetic pivot bushings.

L. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.
   a. Sleeve Thickness: 20-gage minimum.
   b. Sleeve Length: 6 inches minimum.

6. Screen Mounting: Rear mounted.
7. Screen Material: Aluminum.
8. Screen Type: Insect.
9. 90-degree stops.
2.3 MANUAL VOLUME DAMPERS

A. Standard, Manual Volume Dampers:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. McGill AirFlow LLC.
   d. METALAIRE, Inc.
   e. Nailor Industries Inc.
   f. Ruskin Company.
   g. Vent Products Company, Inc.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:
   a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness, or 0.10 inch aluminum sheet channels.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized-steel, 0.064 inch thick, or roll-formed aluminum 0.10 inch thick.

7. Bearings:
   a. Molded synthetic or Stainless-steel sleeve.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel/Aluminum.

2.4 FIRE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
5. McGill AirFlow LLC.
6. METALAIRE, Inc.
7. Nailor Industries Inc.
8. 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 static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.052 inch thick and of length to suit application.
   2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.


2.5 COMBINATION FIRE AND SMOKE DAMPERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. Cesco Products; a division of Mestek, Inc.
   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 static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.


G. Smoke Detector: Integral, factory wired for single-point connection.

H. Blades: Roll-formed, horizontal, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Leakage: Class I.

J. Rated pressure and velocity to exceed design airflow conditions.
K. Mounting Sleeve: Factory-installed, 0.052-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.

L. Damper Motors: Modulating or two-position action.

M. 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 and breakaway torque rating of 150 in. x lbf.
   5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
   6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
   7. Electrical Connection: 24V, single phase, 60 Hz.

N. Accessories:

   1. Remote mounted momentary test switch. Provide with pushbutton and lights (red for closed damper, green for open damper).

2.6 LANGE CONNECTORS

   A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

   B. Material: Galvanized steel.

   C. Gage and Shape: Match connecting ductwork.

2.7 TURNING VANES

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

      1. Ductmate Industries, Inc.
      2. Duro Dyne Inc.
      3. METALAIRE, Inc.
      4. SEMCO Incorporated.

   B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

   C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

   D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.
2.8 DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
5. Greenheck Fan Corporation.
6. McGill AirFlow LLC.
7. Nailor Industries Inc.
8. Ventfabrics, Inc.


1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
   d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Doors close when pressures are within set-point range.
5. Hinge: Continuous piano.
7. Seal: Neoprene or foam rubber.
8. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.9 DUCT ACCESS PANEL ASSEMBLIES

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

1. Ductmate Industries, Inc.
2. Flame Gard, Inc.
3. 3M.
B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon or 0.0428-inch stainless steel.

D. Fasteners: Carbon or Stainless steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.10 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabs, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.


1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.


1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

G. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.
2.11 FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Thermaflex.

B. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
3. Temperature Range: Minus 10 to plus 160 deg F.

C. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or Nylon strap in sizes 3 through 18 inches, to suit duct size.

2.12 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.
E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. Upstream and downstream from duct filters.
   3. At outdoor-air intakes and mixed-air plenums.
   4. At drain pans and seals.
   5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links.
   7. At each change in direction and at maximum 50-foot spacing.
   8. Upstream and downstream from turning vanes.
   9. Upstream or downstream from duct silencers.
  10. Control devices requiring inspection.
  11. 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.
   2. Two-Hand Access: 12 by 6 inches.

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 and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

O. Connect flexible ducts to metal ducts with draw bands and adhesive plus sheet metal screws. Do not use flexible ducts through walls, partitions.

P. Install duct test holes where required for testing and balancing purposes.

Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

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 233300
SECTION 233355 – DUCT/PIPE LAGGING

PART 1 - GENERAL

1.1 SCOPE:

A. Install duct lagging where shown on the Mechanical Drawings, as specified herein, and as needed for a complete and proper installation.

B. Locations called out on mechanical drawings and shown with dashed line next to duct or pipe.

C. Reference Details on AC Drawings.

1.2 RELATED WORK:

A. Section 01 86 36 – Ambient Noise Levels.

B. Section 09 21 00 – Gypsum Board

C. Section 23 31 13 – Metal Ducts.

1.3 QUALITY ASSURANCE:

A. Use skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

1.4 SUBMITTALS:

A. Submit catalog cut sheets for loaded vinyl coverings indicating surface weight, and catalog cut sheets for glass fiber board duct wrap indicating density and physical form. Submit samples if requested by the Architect or Engineer.

1.5 STANDARDS:


C. ASTM E413-04 Standard Classification for Rating Sound Insulation

PART 2 - PRODUCTS

2.1 EXTERNAL DUCT/PIPE LAGGING (MASS LOADED VINYL):

A. The loaded vinyl barrier shall be constructed of a 0.10” thick mass loaded, limp vinyl sheet bonded to a thin layer of reinforced aluminum foil on one side. The barrier shall have a nominal density of 1 lb. per sq. ft. per layer minimum. See Section 3.1 for amount of acceptable layers.

B. Glass fiber duct/pipe wrap shall be semi rigid, preformed type, 1.5” minimum thickness, 1-1/2 lbs. per cu. ft. minimum density. Valves, joints and other fittings shall be wrapped with premolded glass fiber of equivalent characteristics as for pipe.

C. Minimum sound transmission loss tested in accordance with ASTM E90 shall be:

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<th>Octave Band Center Frequency (Hertz)</th>
<th>Vinyl Density</th>
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<tbody>
<tr>
<td>125</td>
<td>13</td>
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<tr>
<td>250</td>
<td>17</td>
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<td>4000</td>
<td>37</td>
</tr>
<tr>
<td>STC</td>
<td>26</td>
</tr>
</tbody>
</table>

D. Loaded vinyl shall be factory fabricated standard or custom products of the following manufacturers or approved equal. Products may be supplied by more than one manufacturer.

   Model KNM

2. Sound Seal – Agawam, MA; website: www.soundseal.com
   Industrial Noise Control Model B-10

3. Acoustical Surfaces – Chaska, MN; website: www.acousticalsurfaces.com
   Noise S.T.O.P. Vinyl Barrier

PART 3 - EXECUTION

3.1 EXTERNAL DUCT/PIPE LAGGING (MASS LOADED VINYL):

A. Cover entire pipe with 2” minimum thickness glass fiber wrap. Fill all void with clean glass fiber scrap. Apply over this wrap an airtight cover of loaded vinyl with surface weight of 1 pound per square foot per layer minimum. Provide 2 layers minimum. Aggregate weight should be 2 pounds per square foot. Exception: Cover exterior piping exposed to the elements with an all-weather jacket. Do not connect the cover rigidly to the pipe or hangers. Overlap longitudinal seams in loaded vinyl 2” minimum and tape with cloth backed tape. Overlap edge seams 1” minimum and tape with cloth backed tape or seal with acoustical sealant. Extend ends up 2 inches on wall where penetrations and seal ends airtight with acoustical sealant.

END OF SECTION 233355
SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Centrifugal roof ventilators.
   2. Ceiling-mounting ventilators.
   3. In-line centrifugal fans.
   4. Utility sets

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.
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.
   7. Fan speed controllers.

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.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Roof framing and support members relative to duct penetrations.
   2. Ceiling suspension assembly members.
   3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Field quality-control test reports.

E. 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. 

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(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. CENTRIFUGAL ROOF VENTILATORS

A. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
   2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. 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.

E. Accessories:
   1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
   2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

F. Roof Curbs: Aluminum or galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
   1. Configuration: Self-flashing without a cant strip, with mounting flange.
   2. Overall Height: 18 inches.
   5. Metal Liner: Aluminum or galvanized steel.
   6. Mounting Pedestal: Galvanized steel with removable access panel.

G. Capacities and Characteristics as indicated on drawings.

2.3 IN-LINE CENTRIFUGAL FANS

A. Description: In-line, belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

E. Accessories:
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Companion Flanges: For inlet and outlet duct connections.
   3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
   4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

F. Capacities and Characteristics as indicated on drawings.

2.4 CEILING-MOUNTING VENTILATORS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Breidert Air Products.
   5. JencoFan; Div. of Breidert Air Products.
   7. NuTone Inc.
   8. 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. Grille: Plastic or Aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

G. Accessories:
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
   4. Motion Sensor: Motion detector with adjustable shutoff timer.
   5. Filter: Washable aluminum to fit between fan and grille.
   7. Manufacturer's standard roof jack or wall cap, and transition fittings.

H. Capacities and Characteristics as indicated on drawings.
2.5 UTILITY SET FANS

A. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. Housing: Fabricated of galvanized steel with side sheets fastened with a deep lock seam or welded to scroll sheets.
   1. Housing Discharge Arrangement: Adjustable to eight standard positions.

C. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.
   1. Blade Materials: Steel or Aluminum.
   2. Blade Type: As scheduled.

D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

E. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L50 of 200,000 hours.

F. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   1. Service Factor Based on Fan Motor Size: 1.5.
   2. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   3. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

G. Accessories:
   1. Inlet and Outlet: Flanged.
   2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
   4. Access Door: Gasketed door in scroll with latch-type handles.
   5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
   6. Inlet Screens: Removable wire mesh.

H. Coatings: Epoxy/Phenolic/Powder-baked enamel as indicated.

I. Capacities and Characteristics as indicated on drawings.

2.6 MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

B. Enclosure Type: Totally enclosed, fan cooled.
2.7 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using vibration control devices. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Roof curbs shall be installed as required to maintain roof warranty.

D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

E. Support suspended units from structure using threaded steel rods. Vibration-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 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.

END OF SECTION 233423
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SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Shutoff, single-duct air terminal units.

1.3 SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.
   1. Air terminal units.
   2. Liners and adhesives.
   3. Sealants and gaskets.

B. LEED Submittal:
   1. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2010, Section 5 - "Systems and Equipment."

C. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
   3. Hangers and supports, including methods for duct and building attachment and vibration isolation.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

E. Field quality-control reports.

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

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2010, Section 5 - “Systems and Equipment” and Section 7 - “Construction and System Start-Up.”

PART 2 - PRODUCTS

2.1 TERMINAL UNIT MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carnes.
   2. METALAIRe, Inc.
   4. Titus.
   5. Tuttle & Bailey.

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Furnish and install where shown on drawings, Titus Model DESC-3000 single duct, variable volume terminals units or equivalent meeting these specifications.

B. All terminals shall have pressure independent DDC control. Control shall be rest for air flow between zero and maximum cataloged cfm. Air flow limiters will not be accepted.

C. At an inlet velocity of 2000 fpm, the differential static pressure for any size of unit shall not exceed 0.35” wg with a one-row coil, or 50” with a two-row coil.

D. Discharge sound ratings for the basic unit shall not exceed 23 NC at 1.00” static pressure.

E. The unit inlet shall be equipped with a cross-shaped flow sensor with amplifying pressure pickup points connected to central averaging chambers. The sensor shall amplify the duct velocity pressure by a factor of 1.75 and shall maintain control accuracy with the same size inlet duct in any configuration.

F. All units shall be furnished with pressure independent direct digital controls supplied and mounted by the Owner. Contractor shall provide data sheets on all components to be mounted, indicating component dimensions, mounting hardware and methods, as well as wiring and piping diagrams for each application identified by unit tag per the schedule in the drawings, to the terminal unit manufacturer.

G. The controls shall be compatible with inlet velocity sensors supplied by the terminal manufacturer. The sensor shall be multi-point center averaging type, with a minimum of four measuring ports parallel to the take-off point from the sensor. Sensors with measuring ports in series are not acceptable. The sensor must provide a minimum differential pressure signal of .03” wg at inlet velocities of 500 fpm.

H. Controls shall be field set by Owner/Balancer for the scheduled minimum and maximum flow rates. Flow measuring taps and flow curves will be supplied with each terminal for field balancing air flow. Each terminal shall be equipped with labeling showing unit location, size, and scheduled cfm.

I. The Contractor shall provide a Class II 24vac transformer and disconnect switch for DDC controlled VAV boxes. The Owner shall provide and install the damper controllers on the job.
J. The unit casing shall be 22 gauge galvanized steel, internally lined with engineered closed cell foam insulation which complies with UL 181 and NFPA 90A. Liner shall be 1-1/2" pound density closed cell foam. The liner shall be mechanically fastened to the unit casing.

K. Damper shall be heavy gauge metal, with shaft rotating in Delrin self-lubricating bearings. Shaft shall be marked on the end to indicate the damper blade position. Unit shall be designed for field conversion from normally open to normally closed, or vice versa, without relocating the actuator, changing parts or adding relays.

L. The dampers shall have a built-in stop to prevent overstroking and shall seal against a closed-cell foam gasket, to limit close-off leakage.

M. Each VAV terminal shall be furnished with hot water heating coil. Hot water coil shall be factory mounted in a casing with performance as shown in schedule on drawings. Heaters shall be furnished by the VAV terminal manufacturer as a complete assembly. Construction shall be aluminum plate fins, copper tube serpentine type with sweat connections, tested at 250 psi under water. Performance shall be based on 180 degree F. entering water temperature and 160 degrees F. leaving water temperature, maximum water pressure drop of 3 ft. water column. Coils shall have return bends factory insulated with minimum ½" thick flexible elastomeric insulation.

2.3 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Steel Cables: Galvanized steel complying with ASTM A 603.

C. 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.

D. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
3.2 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.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

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

B. Tests and Inspections:

1. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

3.6 COMMISSIONING

A. Complete installation and startup checks according to manufacturer's written instructions.

B. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.

C. Verify that controls and control enclosure are accessible.
D. Verify that control connections are complete.

E. Verify that nameplate and identification tag are visible.

F. Verify that controls respond to inputs as specified.

END OF SECTION 233600
SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Round ceiling diffusers.
2. Rectangular and square ceiling diffusers.
3. Louver face diffusers.
4. Linear bar diffusers.
5. Linear slot diffusers.
6. Linear floor diffuser plenums.
7. Adjustable bar registers and grilles.
8. Fixed face registers and grilles.

B. Related Sections:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

C. Source quality-control reports.
PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

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

1. Anemostat Products; a Mestek company.
2. Carnes.
4. METALAIRE, Inc.
5. Price Industries.
6. Titus.
7. Tuttle & Bailey.

B. Round Ceiling Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, white unless noted otherwise.
4. Face Style: Minimum three cone.
5. Mounting: To match ceiling type.

C. Rectangular and Square Ceiling Diffusers:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, white unless noted otherwise.
4. Face Size: 24 by 24 inches or 12 by 12 inches.
5. Face Style: Minimum three cone.
6. Mounting: To match ceiling type.

D. Louver Face Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, white unless noted otherwise.
4. Face Size: As indicated on drawings.
5. Mounting: To match ceiling type.
7. Accessories:
   a. Adjustable pattern vanes.
   b. Operating rod extension.

2.2 CEILING LINEAR SLOT OUTLETS

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

1. Anemostat Products; a Mestek company.
2. Carnes.
4. METALAIRE, Inc.
5. Price Industries.
6. Titus.
7. Tuttle & Bailey.

B. Linear Bar Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Aluminum or Stainless steel.
3. Finish: Baked enamel, white or natural aluminum or polished stainless steel.
4. Core Spacing Arrangement: As indicated on drawings.
5. Deflection Vanes: Extruded construction fixed louvers with removable core.
7. Mounting: Countersunk screw.
8. Accessories: Blank-off strips where shown on drawings.

C. Linear Slot Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
4. Finish - Face and Shell: Baked enamel, black.
5. Finish - Pattern Controller: Baked enamel, black.
7. Slot Width/Number of Slots/Length: As indicated on drawings.

2.3 UNDERFLOOR AIR DISTRIBUTION DIFFUSERS

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

1. Anemostat Products; a Mestek company.
2. Carnes.
4. METALAIRE, Inc.
5. Price Industries.
6. Titus.

B. Round Induction Diffusers:

2. Material: Plastic, high impact, and resistant to cart and foot traffic.
3. Color: Gray or Black.
4. Components:
   a. Diffuser core.
   b. Flow regulator.
   c. Dirt and liquid catch pan.
   d. Spacer flange.
   e. Gasketed, underfloor compression ring.

C. Linear Floor Diffuser Plenums:

1. Material: Steel.
3. Components:
   a. Aluminum diffuser core.
b. Diffuser frame.
c. Plenum, 0.034-inch steel.

2.4 REGISTERS AND GRILLES

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

1. Anemostat Products; a Mestek company.
2. Carnes.
4. METALAIRES, Inc.
5. Price Industries.
6. Titus.
7. Tuttle & Bailey.

B. Adjustable Bar Register and Grille:

1. Material: Steel or Aluminum.
2. Finish: Baked enamel, white unless noted otherwise.
3. Face Blade Arrangement: Horizontal adjustable.
6. Frame: 1 inch wide.
7. Mounting: Countersunk screw.
8. Damper Type: Adjustable opposed blade for register only.
9. Accessories:
   a. Front-blade gang operator.

C. Fixed Face Register:

1. Material: Steel or Aluminum.
2. Finish: Baked enamel, white unless noted otherwise.
5. Frame: 1 inch wide.
7. Damper Type: Adjustable opposed blade for register only.

2.5 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 233713
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SECTION 233723 - HVAC GRAVITY VENTILATORS, LOUVERS AND VENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes fixed extruded aluminum louvers and wall vents.

B. Related Sections include the following:

1. Division 23 Section "HVAC Power Ventilators" for roof-mounting exhaust fans.

1.3 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

B. Horizontal Louver: Louver with horizontal blades; i.e., the axes of the blades are horizontal.

C. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

D. Storm-Resistant Louver: Louver that provided specified wind-driven rain performance, as determined by testing according to AMCA 500-L.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Intake and relief ventilators shall be capable of withstanding the effects of gravity loads, wind loads, seismic loads, and thermal movements without permanent deformation of components, noise or metal fatigue, or permanent damage to fasteners and anchors.


C. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on a uniform pressure of 20 lbf/sq. ft., acting inward or outward.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, over stressing of components, failure of connections, or other detrimental effects.

1. Temperature Change (Range): 120 deg F ambient; 180 deg F material surfaces.
E. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer’s stock units identical to those provided, except for length and width according to AMCA 500-L.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.
   1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.
   2. Show mullion profiles and locations.

C. Product Test Reports: Based on evaluation of comprehensive tests performed according to AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain ventilators, louvers and vents through one source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

B. Product Options: Information on Drawings and in Specifications establishes requirements for system's aesthetic effects and performance characteristics. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction. Performance characteristics are indicated by criteria subject to verification by one or more methods including preconstruction testing, field testing, and in-service performance.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of intake and relief ventilators, louvers, vents and are based on the specific equipment indicated. Refer to Division 01 Section “Product Requirements.”
   1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.


1.7 COORDINATION

A. Field Measurements: Verify louver openings by field measurements before fabrication and indicate measurements on Shop Drawings.
   1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish opening dimensions and proceed with fabricating louvers without field measurements. Coordinate construction to ensure that actual opening dimensions correspond to established dimensions.
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. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653, G90 zinc coating, mill phosphatized.

D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
2. Use Phillips flat-head screws for exposed fasteners, unless otherwise indicated.
3. For fastening galvanized steel, use hot-dip-galvanized steel or 300 series stainless-steel fasteners.
4. For color-finished louvers, use fasteners with heads that match color of louvers.

E. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed, for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.3 FABRICATION, GENERAL

A. Fabricate frames, including integral bases and sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

B. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

C. Fabricate supports, anchorages, and accessories required for complete assembly.

D. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

E. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolts assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.

1. Continuous Vertical Assemblies: Fabricate units without interrupting blade-spacing pattern unless horizontal mullions are indicated.
2. Horizontal Mullions: Provide horizontal mullions at joints unless continuous vertical assemblies are indicated.
F. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.

G. Include supports, anchorages, and accessories required for complete assembly.

H. Provide vertical mullions of type and at spacings indicated, but not more than recommended by manufacturer, or 72 inches o.c., whichever is less.
   1. Full Recessed Mullions: Where indicated, provide mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.
   2. Semirecessed Mullions: Where indicated, provide mullions partly recessed behind louver blades so louver blades appear continuous. Where length of louver exceeds fabrication and handling limitations, fabricate with interlocking split mullions and close-fitting blade splices designed to permit expansion and contraction.
   3. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.
   4. Exterior Corners: Prefabricated corner units with mitered and welded blades and with fully recessed mullions at corners.

I. Provide subsills made of same material as louvers or extended sills for recessed louvers.

J. Join frame members to each other and to fixed louver blades with fillet welds concealed from view unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.4 FIXED, EXTRUDED-ALUMINUM LOUVERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ruskin Company; Tomkins PLC.
   2. Greenheck Fan Corporation.
   3. Louvers and Dampers, Inc.

B. Horizontal, Drainable-Blade Louver:
   1. Louver Depth: 4 inches.
   2. Frame and Blade Nominal Thickness: Not less than 0.080 inch for blades and 0.080 inch for frames.
   3. Mullion Type: Exposed.
   4. Louver Performance Ratings:
      a. Free Area: Not less than 54% for 48-inch- wide by 48-inch-high louver.
      b. Point of Beginning Water Penetration: Not less than 873 fpm free-area velocity.
      c. Air Performance: Not more than 0.15 inch wg static pressure drop at 873-fpm free-area velocity.
   5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.5 LOUVER SCREENS

A. General: Provide screen at each exterior louver.
1. Screen Location for Fixed Louvers: Interior face.
2. Screening Type: Bird screening except where insect screening is indicated.

B. Secure screen frames to louver frames with stainless-steel machine screws, spaced a maximum of 6 inches from each corner and at 12 inches o.c.

C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
   1. Metal: Same kind and form of metal as indicated for louver to which screens are attached.
   2. Finish: Same finish as louver frames to which louver screens are attached.
   3. Type: Rewirable frames with a driven spline or insert.

2.6 BLANK-OFF PANELS

A. Insulated, Blank-Off Panels: Laminated panels consisting of insulating core surfaced on back and front with metal sheets and attached to back of louver.
   1. Thickness: 1 inch.
   2. Metal Facing Sheets: Aluminum sheet, not less than 0.032-inch nominal thickness.
   3. Insulating Core: Rigid, glass-fiber-board insulation.
   4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer’s standard extruded-aluminum-channel frames, not less than 0.080-inch, with corners mitered and with same finish as panels.
   5. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
   6. Panel Finish: Same type of finish applied to louvers, but black color.
   7. Attach blank-off panels with sheet metal screws.

2.7 FINISHES, GENERAL

A. Comply with NAAMM’s “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.

B. Finish louvers after assembly.

2.8 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with system established by the Aluminum Association for designation aluminum finishes.

B. High-Performance Organic Coating Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers’ written instructions.
   1. Fluoropolymer Two-Coat Coating System: Manufacturer’s standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight, complying with AAMA 605.2.
      a. Color and Gloss: As selected by Architect from manufacturer’s full range of colors and glosses.

C. Finish shall match color of architectural metal attic panels.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

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

3.2 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

A. Install louvers plumb and at indicated alignment with adjacent work.

B. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

C. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 07 Section "Joint Sealants" for sealants applied during installation.

D. Label intake and relief louvers according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

E. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

F. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

G. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

H. Form closely fitted joints with exposed connections accurately located and secured.

I. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Division 07 Section "Joint Sealants" for sealants applied during louver installation.

3.4 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories.

3.5 ADJUSTING AND CLEANING

A. Adjust damper linkages for proper damper operation.
B. Clean exposed surfaces of louvers that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.

C. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

D. Restore louvers damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with factory-applied finish coating.
SECTION 237315 - MODULAR CUSTOM 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes variable-volume central-station air-handling units.

B. Related Sections: The following Sections contain requirements that relate to this Section:
   1. Division 26 Section “Variable Frequency Drives” for field-mounted alternating-current starters.

1.3 SUBMITTALS

A. General: Follow the procedures specified in Division 1 Section “Special Conditions”.

B. Product Data for each air-handling unit specified, including the following:
   1. Certified fan-performance curves with system operating conditions indicated.
   2. Certified fan-sound power ratings.
   3. Certified coil-performance ratings with system operating conditions indicated.
   4. Motor ratings and electrical characteristics plus motor and fan accessories.
   5. Material gages and finishes.
   6. Filters with performance characteristics.
   7. Dampers, including housings, linkages, and operators.

C. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

D. Wiring diagrams detailing wiring for power and control systems and differentiating between manufacturer-installed and field-installed wiring.

E. Maintenance data for air-handling units to include in the operation and maintenance manual specified in Division 1.

1.4 QUALITY ASSURANCE

A. NFPA Compliance: Air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, “Installation of Air Conditioning and Ventilating Systems”.

B. ARI Certification: Air-handling units and their components shall be factory tested according to the applicable portions of ARI 430, “Central-Station Air-Handling Units”, and shall be listed and bear the label of the Air-Conditioning and Refrigeration Institute (ARI).

C. UL and NEMA Compliance: Provide motors required as part of air-handling units that are listed and labeled by UL and comply with applicable NEMA standards.
D. Comply with NFPA 70 for components and installation.

E. Listed and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

   1. The Terms “Listed” and Labeled: As defined in the National Electrical Code, Article 100.
   2. Listing and Labeling Agency Qualifications: A “Nationally Recognized Testing Laboratory” (NRTL) as defined in OSHA Regulation 1910.7.

F. Coordination: Coordinate layout and installation of air-handling units with piping and ductwork and with other installations.

G. Warranty: Ventilation air-handling units shall have a 2-year warranty on all parts not including enthalpy wheel. Enthalpy wheel shall have a 5-year unconditional warranty on parts.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver each air-handling unit as a factory-assembled module with protective crating and covering.

B. Lift and support units with manufacturer’s designated lifting or supporting points.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate size and location of concrete housekeeping bases. Cast anchor-bolt inserts into base.

1.7 EXTRA MATERIALS

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

B. Filters: Furnish one (1) set for each air-handling unit.

C. Fan Belts: Furnish one (1) set for each air-handling unit fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

   1. Variable-Volume Air Handling Units:
      b. McQuay International.
      c. Carrier Corporation.
      d. Trane Company (The); Commercial Systems Group.
      e. Temtrol.
      f. Huntair
2.2 VARIABLE-VOLUME CENTRAL STATION AIR HANDLING UNITS

A. General Description: Factory assembled, consisting of fans, motor assemblies, coils, dampers, plenums, filters and drip pans.

B. Casing: Formed and reinforced, solid double-wall, insulated, galvanized steel panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed. The housing shall be supported by an all welded, epoxy-painted structural base with lifting lugs.

1. **Outside Casing Framing:** G90 Galvanized steel, minimum 16-gage.
2. **Outside Casing Panels:** G90 Galvanized steel, minimum 18-gage.
3. **Inside Casing:** G90 Galvanized steel, solid, minimum 20-gage.
4. **Floor Liner:** G90 Galvanized steel, solid, minimum 14-gage.

C. Casing Insulation: All panels and the floor shall be insulated with 2-inch, 1.5-pound/ft² density fiberglass insulation, complying with NFPA 90A. “Installation of Air Conditioning and Ventilating Systems”, for insulation. All connecting channels shall be insulated to prevent sweating.

D. Access Doors: Same materials and finishes as the unit casing and complete with hinges, latches, handles, and gaskets. Each door shall be provided with two (2) cam type handles and heavy-duty stainless steel piano hinges to achieve maximum sealing. A 3/8-inch bulb-type gasket complying with UL 723 shall be provided around the entire door perimeter. Door hinges shall allow a full 180-degree swing. All doors shall be air pressure closing.

1. Access doors shall be provided in the fan sections, filter sections, and blank (access) sections.

E. Base-Rail: Provide minimum 6-inch high or higher if required for condensate drain, full length base rail channel of 12-gage galvanized steel.

F. Condensate Drain Pans: Formed sections of 16G 304 stainless steel sheet complying with requirements in ASHRAE 62. Fabricate pans with slopes in two planes to collect condensate from cooling coils (including coil piping connections and return bends) and humidifiers when units are operating at maximum catalogued face velocity across cooling coil. Drain pans shall extend full length and depth of section.

1. Double-Wall Construction: Fill space between walls with 1 inch thick 6 lbs. density fiberglass insulation and seal moisture tight.
2. Drain Connections: Both ends of pan, for units wider than 95 inches. Connection shall be minimum 1-1/4 inches MPS stainless steel.
3. Units with stacked coils shall have an intermediate drain pan or drain trough to collect condensate from top coil.

2.3 FAN SECTION

A. The fan construction shall be in accordance with the class required or specified in the project fan schedule. Fan shafts shall be sized so that the first critical rotational speed is at least 125% of the maximum operating rotational speed for classes I and II, and at least 142% of the maximum rotational speed for classes III and IV.

B. The manufacturer shall certify the sound power level ratings in the eight octave bands. Sound power levels shall be in decibels referenced to 10-12 watts.

C. The fans shall have been statically and dynamically balanced by the fan manufacturer to grade G6.3 per ISO 1940-1. An IRD or PMC analyzer shall have been used to measure velocity, the final balanced reading shall not exceed 0.1 inches/second.

D. Fan inlets shall be equipped with removable fan inlet grilles, designed according to OSHA standards.
E. The fans shall be manufactured by EBM-PAPST or an approved equivalent.

F. Technical features:

a. Surface of rotor
b. Material of electronics housing
c. Material of impeller
d. Number of blades
e. Direction of blades
f. Type of protection
g. Insulation class for motors less than 4HP
h. Ins. class for motors greater than 4HP
i. Humidity class for outdoor use
j. Humidity class for indoor use
k. Max. permissible ambient motor temp.
l. Min. permissible ambient motor temp.
m. Mounting position
n. Condensate discharge holes
o. Operation mode
p. Motor bearing
q. Technical features for motors greater than 7HP
r. Technical features for motors 2.5-7HP
s. EMC interference immunity
t. EMC interference emission
u. Touch current acc. IEC 60990
v. Electrical leads
w. Motor Protection
x. Protection class
y. Product conforming to standard
F. Controls and starters are built into the motors.

G. Motors shall have a min. 1.1 service factor at nominal voltage of three phase 380-480VAC. Motors shall have Class F insulation.

H. Motors shall be ErP 2015 compliant, tested according to DIN 24163 and ISO 5801.

I. The motors shall have a built in soft-start feature.

J. The fanwall shall be equipped with an air monitoring probe. Huntair Flow-Cone or equal, which indicates airflow in Cubic Feet per Minute. The flow measuring station shall consist of a flow measuring station with static pressure tap and two total pressure tubes located at the throat of the fan inlet cone. The flow measuring station shall not obstruct the inlet of the fan and shall have no effect on fan performance (flow or static) or sound power levels. Provide (4-10ma) (0-10-volt) output control signal transmitter for use in the BAS as specified elsewhere).

K. Each fan in the fanwall system shall be furnished with a backdraft damper.

L. Fanwall Electrical:
   1. Provide a complete electrical system required to run the Fanwall Array system including all equipment, material, electrical enclosure and electrical components.
   2. Fanwall electrical designs shall be in accordance with the NEC.

M. Motor Circuit Protection:
   1. All motors in the Fanwall Array shall be provided with individual Motor Protection for thermal overload protection. All motor circuit protectors can be located in starting device enclosure or, if required by design, in a separate enclosure. Motor circuit protector enclosure must be located and mounted at a minimal distance from motors in the fanwall system. Provide remote indication by means of aux contacts wired in series.

   a. Pilot Lights: Multiple (one per fan) cover mounted pilot lights for local monitoring.

N. Fanwall Control:
   1. As required by system design, provide a single variable frequency drive to start and run all motors in the Fanwall Array, see specification section 262923. The variable frequency drive shall be sized accordingly to start and hold all motors in the fan wall. Provide service disconnect with fuses of circuit breaker. Provide individual disconnecting means for each fan.

O. Hot and Chilled Water Coil Section: Solid double-wall, insulated, galvanized steel casing for coils to match cabinet construction indicated above. Design and construct to facilities removal and replacement of coil for maintenance and to assure full airflow through coil.

   1. Coil Construction: Rigidly supported across full face, pitched to allow drainage.

      a. Fins: Aluminum, mechanically bonded to tubes, spaced at a maximum of 10 fins per inch.
      b. Tubes: Seamless copper, 5/8-inch O.D., 0.025 inch wall thickness.
      c. Headers for Water Coils: Seamless copper with connections for drain valve and air vent, and threaded piping connections.

   2. Coil-Performance Tests: Factory-test cooling coils with 315 psig air pressure under warm water, according to ARI 410, “Forced-Circulation Air-Cooling and Air-Heating Coils”.
P. Filter/Mixing Box Section: Provide solid double-wall, insulated, galvanized steel casing for filter/mixing box section to match cabinet construction indicated above, with magnehelic gauges for indicating the operating pressure drop across each filter bank (two magnehelic gauges are required for each air handling unit). Magnehelic gauges shall be installed with a manifold and valves to isolate lines to each side of the filter. Magnehelic gauges shall be Dwyer Model 2002 with air filter gauge accessory package.

1. Pre-Filters: Pre-filters shall be 2-inch-thick, high density glass micro fibers laminated to an all glass woven mesh backing with welded wire media support grid, clean airflow resistance of 0.10 inch wg at face velocity of 300 fpm and ASHRAE 52.1 filter-arrestance efficiency of 70 to 82 percent. Filters shall comply with NFPA 90A. Provide filter media holding frames arranged for flat orientation. Filter shall be Farr type 30/30 or equal by American Air Filter. All filters shall be 24 inches by 24 inches or 24 inches by 12 inches, where possible.

2. Final Filters: Final filters for supply airstream shall be 12-inch thick, cartridge type filters with filter media consisting of high density microfine glass fibers, laminated to a reinforcing backing. Filter media shall have an average efficiency of 60-65% on ASHRAE Test Standard 52.1, and it shall have a arrestance of not less than 97% on that same standard. Provide filter media holding frames arranged for flat orientation. Filter shall be Farr RIGA-FLO 15 or equal by American Air Filter. All filters shall be 24 inches by 24 inches or 24 inches by 12 inches, where possible.

3. Dampers: Provide factory-mounted low leakage airfoil blade outside and return air dampers of galvanized steel in galvanized frame. Dampers shall be fully gasketed with vinyl seals between damper blades and stainless steel end seals along end of dampers. Provide linkage between outside and return air dampers.

4. Minimum Outside Air Damper/Airflow Measurement Station: Provide separate minimum outside air damper assembly with integral airflow measurement station at filter/mixing box. Airflow measurement station shall have an accuracy of plus or minus 5% of airflow when air velocity is within 400 fpm and 2000 fpm. Minimum outside air damper with airflow measurement station shall be equal to Ruskin Model AMS50.

Q. Access Sections: Provide access sections having casings to match the cabinet construction indicated above the access door construction as specified above. Depth of access sections shall be as indicated on the Drawings.

2.4 ACCESSORIES

A. Each modular custom central-station air-handling unit shall be furnished with the following accessories:

1. The fan motor shall be wired to a junction box mounted on the exterior of the unit. Utilize liquid tight flexible conduit for connection to fan motor.
2. Each section shall be equipped with one LED light fixture. For unit wider than 95 inches, each section shall be equipped with two LED light fixtures.
3. All lights shall be wired and controlled by one light switch mounted adjacent to supply air fan access door. All wiring shall utilize EMT.

2.5 MOTORS

A. General: Refer to Division 23 Section “Motors” for general requirements.

B. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.

C. Service Factor: Minimum 1.15 for polyphase motors.

D. Starts, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine area and conditions to receive equipment, for compliance with installation tolerances and other conditions affecting performance of air-handling units.

B. Examine roughing-in of hydronic and condensate drainage piping, and electrical to verify actual locations of connections before installation.

C. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install air-handling units level and plumb, according to manufacturer’s written instructions.


B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Maintain specified filters in air handling units throughout construction to prevent dust and debris from entering interior of units.

3.3 HOUSEKEEPING BASES

A. Coordinate size of housekeeping bases with actual unit sizes provided. Construct base 4 inches larger in both directions than overall dimensions of supported unit.

B. Concrete base installation requirements are specified in Section 230500 “Common Work Results for HVAC” and Section 03300 “Cast-in-Place Concrete”.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect condensate drain pans using 1-1/4-inch NPS, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
3. Hot- and Chilled Water Piping: Conform to applicable requirements of Division 23 Section “Hydronic Piping”. Connect to supply and return coil tapings with shutoff or balancing valve and union or flange at each connection, as indicated on the Drawings.

B. Duct installation and connection requirements are specified in other Division 23 Sections. The Drawings indicate the general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.

C. Electrical: Conform to applicable requirements of Division 26 Sections.
1. Connect fan motors to wiring systems and to ground. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

2. Temperature control wiring and interlock wiring is specified in Division 23 Section “Instrumentation and Control for HVAC”.

3.5 CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

3.6 COMMISSIONING

A. Final Checks Before Startup: Perform the following before startup:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections for piping ductwork, and electrical are complete. Verify that proper thermal overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
7. Install new filters of the specified type in each air handling unit.
8. Verify that manual and automatic volume control, and fire dampers in connected ductwork 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.

C. Refer to Division 23 Section “Testing, Adjusting, and Balancing” for air-handling system testing, adjusting, and balancing requirements.

3.7 DEMONSTRATION

A. Engage the services of a factory-authorized service representative to train Owner’s maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

1. Review data in the operation and maintenance manuals. Refer to Division 1 Section “Contract Closeout”.
2. Schedule training with Owner with at least seven (7) days advance notice.

END OF SECTION 237313
SECTION 238219 - FAN COIL 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 fan-coil units and accessories.

1.3 DEFINITIONS
   A. BAS: Building automation system.

1.4 SUBMITTALS
   A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
   B. LEED Submittals:
      1. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
      2. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2010, Section 5 - "Systems and Equipment."
   C. 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.
   D. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
      1. Ceiling suspension components.
      2. Structural members to which fan-coil units will be attached.
      3. Method of attaching hangers to building structure.
      4. Size and location of initial access modules for acoustical tile.
      5. Items penetrating finished ceiling, including the following:
         a. Lighting fixtures.
         b. Air outlets and inlets.
         c. Speakers.
         d. Sprinklers.
         e. Access panels.
      6. Perimeter moldings for exposed or partially exposed cabinets.
   E. Samples for Initial Selection: For units with factory-applied color finishes.
F. Field quality-control test reports.

G. Operation and Maintenance Data: For fan-coil 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. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

H. 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.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2010, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."


1.6 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fan coil units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Two (2) years from date of final acceptance by Owner.

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. Fan-Coil-Unit Filters: Furnish one set spare filters for each filter installed.
   2. Fan Belts: Furnish one set spare fan belts for each unit installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

A. Acceptable Manufacturers:
   1. Airtherm; a Mestek Company.
   2. Carrier Corporation.
   3. Environmental Technologies, Inc.
   5. Marshall Engineered Products Co., LLC (MEPCO); Dunham-Bush, Inc.
   7. Trane.
   8. YORK International Corporation.

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: 1/2-inch thick, coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.

D. Main and Auxiliary Drain Pans: Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1-2010. Drain pans shall be removable.

E. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.

F. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color as selected by Architect.
   1. Vertical Unit Front Panels: Removable, steel, with integral stamped or extruded aluminum discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
   2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped discharge grilles.
   3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's standard colors. Return grille shall provide maintenance access to fan-coil unit.
   4. Steel recessing flanges for recessing fan-coil units into ceiling or wall.

G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.

H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

I. Fan and Motor Board: Removable.
   1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
3. Wiring Termination: Connect motor to chassis wiring with plug connection.

J. Factory, Hydronic Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
   1. Two-way, pressure independent modulating control valve for chilled-water coil. See specification section 230900 – Control Systems for additional control valve requirements.
   2. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
   3. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
   5. Risers: ASTM B 88, Type L copper pipe with hose and ball valve for system flushing.

K. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

M. Capacities and Characteristics as indicated on drawings.

2.3 DUCTED FAN-COIL UNITS

A. Acceptable Manufacturers:
   1. Carrier Corporation.
   2. Engineered Air Ltd.
   3. Environmental Technologies, Inc.
   5. Marshall Engineered Products Co., LLC (MEPCO); Dunham-Bush, Inc.
   7. Trane.
   8. YORK International Corporation.

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: 1/2-inch thick coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.

D. Drain Pans: Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1-2010.

E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panels.

F. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
   1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille.
   2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.

4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.

H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

I. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

J. Factory, Hydronic Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.

1. Two-way, pressure independent modulating control valve for chilled-water coil. See specification section 230900 – Control Systems for additional control valve requirements.
2. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
3. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig working pressure, with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.

K. Control devices and operational sequence are specified in Division 23 Section "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

M. Capacities and Characteristics as indicated on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

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

3.2 INSTALLATION

A. Install fan-coil units level and plumb.
B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.
   a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

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. 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. 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.

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

3.5 ADJUSTING

A. Adjust initial temperature set points.
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings 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. Cabinet unit heaters with centrifugal fans and hot-water heating coils.
   2. Propeller unit heaters with hot-water or steam coils.

1.3 DEFINITIONS

A. BAS: Building automation system.
B. CWP: Cold working pressure.
C. PTFE: Polytetrafluoroethylene plastic.
D. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.
B. LEED Submittal:
   1. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2010, Section 5 - "Systems and Equipment."
C. 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. Plans, elevations, sections, and details.
   2. Location and size of each field connection.
   3. Details of anchorages and attachments to structure and to supported equipment.
   4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
   5. Location and arrangement of piping valves and specialties.
   6. Location and arrangement of integral controls.
D. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Suspended ceiling components.
2. Structural members to which unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

E. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

F. Field quality-control test reports.

G. 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."


1.6 EXTRA MATERIALS

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

   1. Cabinet Unit Heater Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 CABINET UNIT HEATERS

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

   1. Hot Water:

      a. Airtherm; a Mestek Company.
      b. Carrier Corporation.
      c. Dunham-Bush, Inc.
      d. Engineered Air Ltd.
      e. International Environmental Corporation.
f. McQuay International.
g. Trane.
h. USA Coil & Air.

B. Description: A factory-assembled and -tested unit complying with ARI 440.

C. Coil Section Insulation: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.
   1. Thickness: 1/2 inch.
   2. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F mean temperature.
   3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
   4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Cabinet: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
   1. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch-thick, galvanized, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
   2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0528-inch-thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
   3. Recessing Flanges: Steel, finished to match cabinet.
   4. Control Access Door: Key operated.
   5. Base: Minimum 0.0528-inch-thick steel, finished to match cabinet, 4 inches high with leveling bolts.
   7. False Back: Minimum 0.0428-inch-thick steel, finished to match cabinet.

E. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.

F. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

G. Fan and Motor Board: Removable.
   1. Fan: Forward curved, high static, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
   2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

H. Factory, Hot-Water Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet and outlet.
   1. Two or Three-way, modulating control valve. Three-way valve packages shall include bypass line with manually adjustable balance device.
   2. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum GWP rating and blowout-proof stem.
   3. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venture, connection for portable
differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.

I. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

J. Basic Unit Controls:
   1. Wall-mounting or Unit-mounted thermostat with the following features.

K. BAS Interface Requirements:
   1. Interface shall be BAC-net or LonWorks compatible for central BAS workstation and include the following functions:
      a. Cabinet unit heater start, stop, and operating status.
      b. Occupied and unoccupied schedules.

L. Electrical Connection: Factory wire motors and controls for a single field connection.

M. Capacities and Characteristics as indicated on drawings.

2.2 PROPELLER UNIT HEATERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Airtherm; a Mestek Company.
   2. Dunham Bush Inc.
   3. Engineered Air Ltd.
   5. Modine.
   6. Trane.

B. Description: An assembly including casing, coil, fan, and motor in vertical and 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 and conical diffuser for vertical units.

I. General Coil Requirements: Test and rate hot-water or steam propeller unit heater coils according to ASHRAE 33.
J. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.

K. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

L. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Motor Type: Permanently lubricated.

M. Control Devices:
   1. Unit-mounted or Wall-mounting thermostat.

N. Capacities and Characteristics: As indicated on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
   B. Examine roughing-in for piping and electrical connections to verify actual locations before unit heater installation.
   C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants."
   B. Install cabinet unit heaters to comply with NFPA 90A.
   C. Install propeller unit heaters level and plumb.
   D. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
   E. 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."
   F. 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.
   G. Install new filters in each fan-coil unit within two weeks of Substantial Completion.
3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."

E. Comply with safety requirements in UL 1995.

F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 23 Section "Hydronic Piping."

G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

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

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

1. 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.

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

3.5 ADJUSTING

A. Adjust initial temperature set points.

END OF SECTION 238239
SECTION 238413 - HUMIDIFIERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings 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 humidifiers:

1. Evaporative Media Humidification System.

1.3 DEFINITION

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.


C. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which humidifiers will be attached.
2. Size and location of initial access modules for acoustical tile.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For humidifiers to include in 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. Comply with ARI 640, "Commercial and Industrial Humidifiers."
1.6 EXTRA MATERIALS
   A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Supply one replacement electrode cylinder with each self-contained humidifier.

1.7 COORDINATION
   A. Coordinate location and installation of humidifiers with manifolds in ducts and air-handling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   B. Acceptable Manufacturer: Condair Ltd; Nordportbogan 5, 22848 Norderstedt, Germany Ph. +49 40 85 32770, Fax +40 85 32 77 79 Email: info@condair.com Web: www.condair.com
   C. Substitutions: Not permitted.

2.2 IN-DUCT LOW PRESSURE NOZZLE AND EVAPORATIVE MEDIA HUMIDIFIER/COOLER
   A. Series: DL Series humidifiers as manufactured by NORTEX / CONDAIR. Nortex DL with Variable Frequency Drive (VFD), low pressure nozzle and evaporative media humidifier system is configured to operate on Reverse Osmosis (RO) or De-ionized (DI) Water supplied by others.
   B. General:
      1. Pre-engineered system, for air handler/duct application, uses low pressure nozzle technology to directly inject fine mist into the airstream with a ceramic evaporative media downstream for additional evaporation and mist elimination.
      2. Humidifier minimum installation length 23.6 inches; (distance from nozzle grid to ceramic media).
      3. Humidifier accepts reverse osmosis and de-ionized water.
      4. Low pressure nozzles to operate between 43.5 and 101.5 psi (3-7 bar).
      5. Evaporative media to be porous ceramic material designed for post evaporation and mist elimination.
      6. Electronic controller, which monitors the operation of the system, controls output levels and initiates self-cleaning and flush cycles to ensure hygiene operation.
      7. Humidifier powered by 200-240 volts single phase power supply.
      8. Hydraulic system to supply water to the low pressure nozzles with 31 stages of control.
      9. Duct shall contain nozzle grid, connection hoses, and ceramic media. Pumps, valves, controls, and other mechanical components shall be provided in a separate module for installation external to the air stream.
     10. Control panel includes Modbus interface for integration into building automation system, BACnet, LonWorks, available as options.
     11. Central rack for mounting the control panel and hydraulic unit shall be provided.
   C. Nozzle Grid:
1. Pre-assembled nozzle grid sections with color coded nozzle assemblies for easy connection to staging solenoid valves.
2. 316SS Low pressure nozzles with capacities of: 3.3 lb/hr (1.5 l/hr), 5.5 lb/hr (2.5 l/hr), 6.6 lb/hr (3.0 l/hr), 8.8 lb/hr (4.0 l/hr), or 11 lb/hr (5.0 l/hr).
3. Nozzles spray angle can be adjusted into four (4) positions to prevent condensing on AHU walls.
4. Threaded nozzle connections. All other connections to be push fit quick connections.

D. Evaporative Media:
1. Media: Made of porous ceramic material, absolutely free of fiberglass.
3. No tools required for media removal.
4. Rate of Evaporation: Dependent on the air volume, air temperature, and installation distance from nozzle grid.

E. Mist Eliminator:
1. Additional droplet separator required if air velocity exceeds the allowable limit.
   a. DL without additional mist eliminator allows velocities operation up to 590 fpm (3.0 m/s).
   b. DL with additional mist eliminator allows velocities operation up to 787 fpm (4.0 m/s).

F. Management System:
1. Microprocessor control using a proportional-integral method for interpreting analog signals from a humidistat and or building control systems.
2. The controller determines which stages should be activated to meet humidification loads.
3. The controller activates self-maintenance cycles. This includes controlled flushing of the water supply lines, and drain cycles to maintain cleanliness of the water loop.
4. Control panel complete with on/off switch, auto drain switch, and LCD touch screen for fault, maintenance, and operational indication.
5. System shall be bacnet MSTP compatible.

G. Control panel with backlit Touch Screen Display to have the following functionality:
1. Service indicator and LED power on.
2. Intuitive touch screen back-lit graphic display.
3. Display of relative humidity and set point.
4. Display of operating hours.
5. Capacity output.
6. Real-time data and time.
7. Error history indication.
8. Limited capacity adjustment.
9. Inlet flush and line purging.
10. Adjustable maintenance intervals and alarms.
11. Remote relay testing.
12. Modbus standard host protocol.
13. Terminal block installed for easy field connections.

H. Humidity Control Methods:
1. Humidistat/thermostat or BMS control.
2. Accepts standard modulating control signals.
3. On/Off, 24 VAC safety loop for On/Off control, air proving, and/or high limit.

I. Hydraulic Assembly:
1. Packaged Hydraulic Assembly: Shall be installed external to airstream and include all components required for circulation water including: optional pumps, Hygiene Plus Silver Ion canister, staging valves, sensors, and drainage system.

2. A maximum of 31 stage control shall be controlled by up to five (5) 24 Vdc solenoid valves.

3. VFD controlled pump in DL Type A systems.

4. Sterile filter.

5. Water jet pump to allow for draining of the nozzle supply lines.

6. The hydraulic unit shall include a Hygiene Plus canister to actively dose the supply water with silver ions as a means of bacteria control.

7. Inlet valve, pressure gauge and sensor to ensure correct supply water pressure of 43.5-101.5 psi (3-5 bar).

8. Standard conductivity sensor to monitor supply water conductivity. Control panel to trigger alarm if conductivity increases above allowable limit.

J. Aerosol Breakdown and Hygiene Control:

1. Management System capable of real-time flushing, purging and cleaning cycles via the management System control panel. In the event of no call for humidity, humidifier shall drain all water from the nozzle supply lines.

2. Humidifier Operation: Aerosol-free operation guaranteed under maximum air velocity of 787 fpm (4.0 m/s).

K. Model: NORTEC DL Low Pressure Nozzle and Evaporation Media Humidifiers/Coolers.

2.3 PRODUCTS

A. The Nortec ML RO 500 system that produces 500 L/hr (132.1 gal/hour) at 15°C (59°F) rejecting >95% of salts and minerals from main water with a 75/25% recovery ratio.

1. Units to be complete with:

   a. PLC control.
   b. Separate pump provides 4 bar (58 psi) output pressure.
   c. Reservoir tank closed with 0.2 µm breathing filter.
   d. Overflow protection.
   e. Type approved water meter for produced permeate.
   f. 5 µm filtration of the tap water.
   g. Pressure switch for protection of pump.
   h. Operational hour meter.
   i. Stopcock for RO water.
   j. Unit shall be delivered on a stainless steel frame with separate reservoir tank.
   k. Unit shall be fully assembled and tested.
   l. All components exposed to water are made of corrosion resistant material.
   m. Permeate quality must be between 5 and 30 µS/cm.

2. Incoming water quality:

   a. Water supply: Drinking Water Quality.
   b. 2.5-7 bar @ 700 l/h.
   c. Conductivity: 120-1000 µS/cm.
   d. Silt Index: Max. 3.
   e. KMnO4: Max. 10 mg/l.
   f. NTU: Max. 1.0
   g. Temperature: Max. 15°C.
   h. TDS: Max. 625 mg/l.
   i. Fe: Max. 0.2 mg/l.
   j. Free Chlorine: Max. 0,1 mg/l.
   k. Hardness: Max. 1° Dh.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

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

3.2 INSTALLATION

A. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1-2004.

B. Seal humidifier manifold duct or plenum penetrations with flange.

C. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

D. Install stainless-steel drain pan under each manifold mounted in duct.
   2. Connect to condensate trap and drainage piping.
   3. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1-2004.

E. Install manifold supply piping pitched to drain condensate back to humidifier.

F. All piping for humidifier and RO systems shall be stainless steel as recommended by the manufacturer.

G. Install drip leg upstream from steam trap a minimum of 6 inches tall for proper operation of trap.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   1. Install piping adjacent to humidifiers to allow service and maintenance.
   2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.

B. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.

C. Install piping from safety relief valves to nearest floor drain.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems".

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".
3.4 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. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

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

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

3.5 DEMONSTRATION

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

END OF SECTION 238413
SECTION 260500 - 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. Common electrical installation requirements.

1.3 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."

E. Coordinate sleeve selection and application and installation as specified in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

PART 2 - PRODUCTS

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 unless specifically noted otherwise.

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 RACEWAY AND CABLING PENETRATIONS

A. Install sleeves as specified in Division 26 Section “Sleeves and Sleeve Seals for Electrical Raceways and Cabling.”

3.3 SLEEVE-SEAL INSTALLATION

A. Install sleeve-seals as specified in Division 26 Section “Sleeves and Sleeve Seals for Electrical Raceways and Cabling.”

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical raceway and cabling installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.5 DEMONSTRATION

A. At substantial completion, contractor shall walk owner and facility maintenance personnel through the building to point out major electrical equipment locations including but not limited to:
   1. Panelboards
   2. Switchboards
   3. Disconnects
   4. Driver Locations
   5. Inverter Locations
   6. Lighting Control equipment
   7. Fire alarm equipment consisting of fire alarm control panel, annunciator, power supplies, etc.
   8. Meters
   9. Access panels

END OF SECTION 260500
SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section Includes:
      1. Copper building wire rated 600 V or less.
      2. Metal-clad cable, Type MC, rated 600 V or less.
      3. Connectors, splices, and terminations rated 600 V and less.

1.3 DEFINITIONS
   A. EPDM: Ethylene-propylene-diene terpolymer rubber
   B. NBR: Acrylonitrile-butadiene rubber
   C. RoHS: Restriction of Hazardous Substances.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product.
   B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS
   A. Field quality-control reports.

1.6 QUALITY ASSURANCE
   A. Testing Agency Qualifications: Member company of NETA.
      1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
   B. Comply with NFPA 70.
PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alcan Products Corporation; Alcan Cable Division.
   3. General Cable Corporation.
   4. Senator Wire & Cable Company.
   5. Southwire Company.

C. Standards:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. RoHS compliant.
   3. Conductor and Cable Marking: Comply with wire and cable marking according to UL’s "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8

E. Conductor Insulation:
   1. Type THHN and Type THWN-2: Comply with UL 83. (Minimum insulation rating shall be 90 deg C)

2.2 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. MC Cable only to be used for dedicated light fixture whips up to 6'-0” long or where specifically permitted on drawings.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alcan Products Corporation; Alcan Cable Division.
   3. General Cable Corporation.
   4. Senator Wire & Cable Company.
   5. Southwire Company.

D. Standards:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. Comply with UL 1569.
   3. RoHS compliant.
   4. Conductor and Cable Marking: Comply with wire and cable marking according to UL’s "Wire and Cable Marking and Application Guide."

E. Circuits:
1. **Single circuit with color-coded conductors.**

F. **Conductors:** Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

G. **Ground Conductor:** Insulated.

H. **Conductor Insulation:**
   1. **Type THHN/THWN-2:** Comply with UL 83.

I. **Armor:** Steel, interlocked.

J. **Jacket:** PVC applied over armor.

2.3 **CONNECTORS AND SPLICES**

A. **Description:** Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   1. AFC Cable Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division.
   5. Tyco Electronics Corp.

C. **Use of 3M ScotchLok connectors or push-in wire connectors (similar to WAGO push-in connectors) are not permitted. All wiring to be done with wire nut type connectors.**

**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. 12 AWG and smaller; stranded for No. 10 AWG and larger.

C. **Power-Limited Fire Alarm and Control:** Solid for No. 12 AWG and smaller.

3.2 **CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS**

A. **Service Entrance:** Type THHN/THWN-2, single conductors in raceway.

B. **Exposed Feeders:** Type THHN/THWN-2, single conductors in raceway.

C. **Feeders Concealed in Ceilings, Walls, Partitions, and Crawlsaces:** Type THHN/THWN-2, single conductors in raceway.
D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.
   1. Metal-clad cable, Type MC cable is only allowed for lighting fixture whips up to 6'-0" long. They must be dedicated whips.
   2. Refer to drawings for other specific locations where MC cable is permitted. (for difficult to reach spaces with a maximum length of 6ft. Longer lengths to be pre-approved by owner)

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

I. Class 1 Control Circuits: Type THHN/THWN-2, in raceway.

J. Class 2 Control Circuits: Type THHN/THWN-2, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.
3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors over 200 amps for compliance with requirements.

2. Perform each of the following visual and electrical tests:

   a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
   b. Test bolted connections for high resistance using one of the following:
      1) A low-resistance ohmmeter.
      2) Calibrated torque wrench.
      3) Thermographic survey.
   c. Inspect compression-applied connectors for correct cable match and indentation.
   d. Inspect for correct identification.
   e. Inspect cable jacket and condition.
   f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
   g. Continuity test on each conductor and cable.
   h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

   a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519
SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "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.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Plans showing as-built, dimensioned locations of grounding features specified in "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.
b.  Instructions for periodic testing and inspection of grounding features at test wells, ground rings, grounding connections for separately derived systems based on NETA MTS.

1)  Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2)  Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A.  Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

B.  Comply with UL 467 for grounding and bonding materials and equipment.

2.2 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.  Allen-Bradley Co
2.  Alltec Corporation
3.  Appleton Electric Co
4.  Calpipe Industries Incorporated
5.  Eric, Inc.
6.  Harger Lightning & Grounding.
7.  Lyncole XIT Grounding
8.  Mk3 Enterprises, LLC Electrical Contractor
9.  Superior Grounding Systems, INC.

2.3 CONDUCTORS

A.  Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B.  Bare Copper Conductors:
4.  Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5.  Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6.  Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7.  Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

G. Conduit Hubs: Mechanical type, terminal with threaded hub.

H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

I. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

J. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

K. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

L. Straps: Solid copper, copper lugs. Rated for 600 A.

M. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal two-piece clamp.

N. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

O. Water Pipe Clamps:

1. Mechanical type, two pieces with stainless-steel bolts.
   b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet.

B. Ground Plates: 1/4 inch (6 mm) thick, hot-dip galvanized.
PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2 AWG minimum.
   1. Bury at least 24 inches below grade.
   2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.
D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.

1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.


3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

G. 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.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Div 33 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. 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 bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

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; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

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 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building's foundation.
3. Provide provisions for extension of ground ring to the North around future building expansion. Clearly mark location of ground ring at North end of building for future extension.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
   a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
   b. Perform tests by fall-of-potential method according to IEEE 81.
4. 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.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

   1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
   2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
   3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
   4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526
SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Aluminum slotted support systems.
3. Nonmetallic slotted support systems.
4. Conduit and cable support devices.
5. Support for conductors in vertical conduit.
6. Structural steel for fabricated supports and restraints.
7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
8. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

   a. Slotted support systems, hardware, and accessories.
   b. Hangers and supports for electrical equipment and systems.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Ductwork, piping, fittings, and supports.
   3. Structural members to which hangers and supports will be attached.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Luminaires.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
      f. Projectors.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified."
   2. Component Importance Factor: 1.0.
   3. Component Amplification Factor: Per Table 13.6-1 of the ASCE 7-10.
2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Tube and 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. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.


4. Channel Width: Selected for applicable load criteria.

5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.

3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.

4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

5. Toggle Bolts: All-steel springhead type.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA 101
3. NECA 105.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

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. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.
3.3 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:
   1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.4 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Division 09 painting Sections. for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529
PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section Includes:
      1. Metal conduits, tubing, and fittings.
      2. Nonmetal conduits, tubing, and fittings.
      3. Metal wireways and auxiliary gutters.

1.3 DEFINITIONS
   A. GRC: Galvanized rigid steel conduit.
   B. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS
   A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and
      cabinets.
   B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment
details.

1.5 INFORMATIONAL SUBMITTALS
   A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and
      coordinated with each other, using input from installers of items involved:
      1. Structural members in paths of conduit groups with common supports.
      2. HVAC and plumbing items and architectural features in paths of conduit groups with common
         supports.
   B. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting
      provisions, including those for internal components, from manufacturer.
      1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled
         components or on calculation.
      2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and
         describe mounting and anchorage provisions.
      3. Detailed description of equipment anchorage devices on which the certification is based and their
         installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
7. Maverick Tube Corporation.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. FMC: Comply with UL 1; zinc-coated steel.

H. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

I. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
2. Fittings for EMT:
   a. Material: Steel.
   b. Type: compression.
3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

J. Joint Compound for IMC, or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.
2.2 NONMETALLIC CONDUITS AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Amco Corporation.
4. CANTEX Inc.
7. ElecSYS, Inc.
8. Electri-Flex Co.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company.
12. Thomas & Betts Corporation.

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ENT: Comply with NEMA TC 13 and UL 1653.

D. RNC: **Type EPC-40-PVC**, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. LFNC: Comply with UL 1660.

F. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

G. Fittings for LFNC: Comply with UL 514B.

H. Solvents and Adhesives: As recommended by conduit manufacturer.

1. Solvent cements and adhesive primers shall have a VOC content of 510 and 550g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, **Type 1** unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: **Screw-cover type** unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.
2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect. Surface metal raceway shall only be permitted where specifically indicated on the plans.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Thomas & Betts Corporation.
   c. Wiremold Company (The); Electrical Sales Division.

2. Surface metal raceway is not to be used unless there is specific owner approval for each instance. Contractor shall provide routing for approval prior to rough-in.

2.5 BOXES, ENCLOSURES, AND CABINETS

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

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
7. RACO; a Hubbell Company.
10. Spring City Electrical Manufacturing Company.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.

E. Metal Floor Boxes:

1. Material: Cast metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep or 4 inches by 2-1/8 inches by 2-1/8 inches deep depending on device configuration or as noted on drawings.

K. Gangable boxes are allowed.

L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

M. Cabinets:
   1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panelboards.
   4. Metal barriers to separate wiring of different systems and voltage.
   5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed Conduit: GRC.
   2. Concealed Conduit, Aboveground: GRC.
   3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried or concrete encased as noted on drawings.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
   5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT.
   2. Exposed, Not Subject to Severe Physical Damage: EMT.
   3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
      a. Loading dock.
      b. Mechanical rooms on walls below 8' AFF.
   4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
   6. Damp or Wet Locations: GRC.
   7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
F. Install surface raceways only where indicated on Drawings.
G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION
A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
C. Complete raceway installation before starting conductor installation.
D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
G. Conceal conduit and EMT within finished walls and ceilings unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
H. Support conduit within 12 inches of enclosures to which attached.
I. Raceways Embedded in Slabs:
   1. Only Feeders to be installed under slabs (12" below) Branch circuits are not to be run in slabs.
   2. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
   3. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   4. Arrange raceways to keep a minimum of 1 inch of concrete cover in all directions.
   5. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
   6. Change from ENT to GRC or IMC before rising above floor.
J. Stub-ups to Above Recessed Ceilings:
   1. Use EMT, IMC, or RMC for raceways.
   2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

N. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

P. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

Q. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

R. Surface Raceways:
   1. Install surface raceway with a minimum 2-inch radius control at bend points.
   2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

S. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

T. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where an underground service raceway enters a building or structure.
   3. Where otherwise required by NFPA 70.

U. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

V. Expansion-Joint Fittings:
   1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
   2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
      a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
      b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
      c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.

5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

W. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.

2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

AA. Locate boxes so that cover or plate will not span different building finishes.

BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

DD. Set metal floor boxes level and flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.

2. Install backfill as specified in Section 312000 "Earth Moving."

3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."

4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

   a. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

5. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."
3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

   A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.5 FIRESTOPPING

   A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.6 PROTECTION

   A. Protect coatings, finishes, and cabinets from damage and deterioration.

      1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
      2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533
SECTION 260536 - CABLE TRAYS FOR ELECTRICAL/COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Ladder cable tray.
2. Wire-mesh cable tray.
3. Cable tray accessories.
4. Warning signs.

B. Related Requirements:

1. Section 260536 "Cable Trays for Electrical Systems" for cable trays and accessories serving electrical systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of cable tray.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
   a. Vertical and horizontal offsets and transitions.
   b. Clearances for access above and to sides of cable trays.
   c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
   d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Delegated-Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.
1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
2. Vertical and horizontal offsets and transitions.
3. Clearances for access above and to side of cable trays.
4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.

B. Seismic Qualification Certificates: For cable trays, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.

B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
2. Component Importance Factor: 1.0.
3. Component Amplification Factor: Per Table 13.6-1 of the ASCE 7-10.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:
1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 LADDER CABLE TRAY (Located in Recording Studio Equipment Room)

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

2. Cooper B-Line, Inc.
4. GS Metals Corp.; GLOBETRAY Products.
5. MONO-SYSTEMS, Inc.
6. MPHusky.
7. PW Industries.

B. Description:

1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
2. Width: 24 inches unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 4 inches unless otherwise indicated on Drawings.
4. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.
5. Rung Spacing: 6 inches o.c.
6. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
7. Minimum Cable-Bearing Surface for Rungs: 7/8-inch (22-mm) width with radius edges.
8. No portion of the rungs shall protrude below the bottom plane of side rails.
9. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
10. Fitting Minimum Radius: 12 inches.
11. Class Designation: Comply with NEMA VE 1, Class 8A.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
14. Covers: Louvered type made of same materials and with same finishes as cable tray.

C. Materials and Finishes:

1. Steel:

   a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
   b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
   c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.

   1) Hardware: Galvanized, ASTM B 633.

2.4 WIRE-MESH CABLE TRAY

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

CABLE TRAYS FOR ELECTRICAL/COMMUNICATIONS SYSTEMS

2. Cooper B-Line, Inc.
4. GS Metals Corp.; GLOBETRAY Products.
5. MONO-SYSTEMS, Inc.
6. MPHusky.
7. PW Industries.
8. Legrand, Cablofil

B. Description:

2. Width: **18 inches** unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: **4 inches**.
4. Straight Section Lengths: **10 feet**, except where shorter lengths are required to facilitate tray assembly.
5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
6. Class Designation: Comply with NEMA VE 1, **Class (75lbs/ft) minimum**
7. Splicing Assemblies: Bolted type using serrated flange locknuts.
8. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Steel:
   a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A 1008/A 1008M, Grade 33, Type 2.
   b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
   c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
      1) Hardware: Galvanized, ASTM B 633.

2.5 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

D. Provide **cable tray liner** where passing through exposed ceilings.

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. Comply with requirements for fasteners in Section 260553 "Identification for Electrical Systems."
2.7 SOURCE QUALITY CONTROL
   
   A. Testing: Test and inspect cable trays according to **NEMA VE 1**.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

   A. Install cable trays according to **NEMA VE 2**.

   B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

   C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

   D. Remove burrs and sharp edges from cable trays.

   E. Join aluminum cable tray with splice plates; use four square neck-carriage bolts and locknuts.

   F. Fasten cable tray supports to building structure and install seismic restraints.

   G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems." **Comply with seismic-restraint details according to Section 260548.16 “Seismic Controls for Electrical Systems.”**

   H. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

   I. 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.

   J. Support bus assembly to prevent twisting from eccentric loading.

   K. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

   L. Locate and install supports according to **NEMA VE 2**. Do not install more than one cable tray splice between supports.

   M. Support wire-basket cable trays with **trapeze hangers**.

   N. Support **trapeze hangers** for wire-basket trays with 3/8-inch diameter rods.

   O. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

   P. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in **NEMA VE 2**. Space connectors and set gaps according to applicable standard.

   Q. Make changes in direction and elevation using manufacturer's recommended fittings.

   R. Make cable tray connections using manufacturer's recommended fittings.
S. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."

T. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

U. Install cable trays with enough workspace to permit access for installing cables.

V. 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.

W. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.

X. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

Y. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."

B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."

D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inches.

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

E. Tie MI cables down every 36 inches where required to provide a 2-hour fire rating and every 72 inches elsewhere.
3.4 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 260536
SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABELLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
   2. Sleeve-seal systems.

B. Related Requirements:
   1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:
   1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
   2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
D. Sleeves for Rectangular Openings:

2. Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
   b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Advance Products & Systems, Inc.
   b. CALPICO, Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.
   e. Proco Products, Inc.

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.


4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.3 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.


C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 “Joint Sealants.”

b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

END OF SECTION 260544
SECTION 260548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Restraint channel bracings.
2. Restraint cables.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.

   b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic forces required to select seismic 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 Sections for equipment mounted outdoors.

3. Seismic-Restraint Details:

   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.

   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings.
Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

1.5 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 as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. 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) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: C.

2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.

   a. Component Importance Factor: 1.0.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.168.
4. Design Spectral Response Acceleration at 1.0-Second Period: 0.093

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

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

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

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

2.6 ADHESIVE ANCHOR BOLTS
A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.
PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

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 caused by 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. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Equipment and Hanger Restraints:
   1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. 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.

E. 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.

F. 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 connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following 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.

C. Seismic controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548.16
SECTION 260548 – VIBRATION ISOLATION OF ELECTRICAL

PART 1 - GENERAL

1.1 SCOPE:

A. Install communication equipment and conduit in a manner to prevent transmission of objectionable vibration to acoustically critical/sensitive spaces. Vibration isolation includes, but is not limited to, resilient mounting of transformers, racks containing fans or transformers (dimmers, amplifiers, datacom, etc.) and use of flexible conduit.

1.2 RELATED WORK:

A. Perform vibration isolation work in this contract, including work described in other Divisions to meet the product and execution requirements of this Section.

B. Division 1 – General Requirements.

C. Section 01 86 36 – Ambient Noise Levels.

D. All Division 26 and 27 specifications relating to vibration isolated equipment and materials.

1.3 QUALITY ASSURANCE:

A. Provide vibration isolators for Divisions 14, 21, 22, 23, 26, 27 from the product line of a single manufacturer whenever possible unless approved by the project Acoustics Consultant. Isolators not supplied by the primary vibration isolator manufacturer shall be rejected.

B. The vibration isolator manufacturer's representative shall determine isolator sizes and mountings, and shall provide field supervision and inspection to assure proper installation, adjustment and performance. Representative shall alert the Engineer and project Acoustics Consultant to any isolator selections, which may experience resonance with the approved equipment and upgrade any isolators that are found to resonate with the supported equipment. The Contractor shall include in his bid vibration isolation system elements as recommended by the manufacturer's representative to make a complete, correct, and safe installation. Supply and install any incidental materials needed, even if not explicitly specified or shown in the Construction Documents, without claim for additional payment.

C. Skilled workers who are experienced in the necessary crafts to meet the requirements of this Section shall perform the work. Upon completion of the installation and after the system is put into operation, the manufacturer's representative shall make a final inspection and submit his report to the Architects and Engineers in writing certifying the correctness of installation and compliance with approved submittal data. The contractor shall allow for the cost of this service in his bid.

1.4 SEISMIC RESTRAINT:

A. Seismic Certification: A licensed professional engineer experienced in the design of seismic restraints for flexibly mounted equipment, in the employ of the vibration isolation manufacturer, shall certify and stamp the shop drawings stating that all requirements of state and local codes have been met regarding seismic restraint of all resiliently mounted equipment. Provide calculations and analysis showing compliance with the applicable codes.
1.5 SUBMITTALS:

A. In a single consolidated submittal, provide catalog datasheets, shop drawings and other documents as necessary to indicate equipment unit number, isolator type, supported weight, scheduled deflection, proposed deflection under operating load, and rated deflection for each isolator. Submittals based upon rated deflection will be rejected. Indicate bridge bearing quality neoprene components and neoprene durometer where provided. Submittals will be reviewed for compliance and a Review/Comment sheet returned to the Architect and Engineer for their use.

PART 2 - PRODUCTS

2.1 FLEXIBLE STEEL CONDUIT

A. Flexible steel conduit shall be UL-listed liquid tight flexible metal conduit as manufactured by American Brass, Columbia or approved equal.

2.2 FLEXIBLE CONDUIT CONNECTORS

A. Flexible conduit connectors for conduit sizes greater than 2” diameter shall be Crouse-Hinds type XD expansion/deflection coupling, or approved equal.

2.3 MANUFACTURERS

A. The following vibration control manufacturers will be approved providing mounting systems are in strict accordance with design intent as specified herein:

2. Kinetics Noise Control, Dublin, Ohio.

Since manufacturers’ products vary, specific models listed in this Specification may not be approved if they do not meet all requirements in this section. Model designations listed herein are intended only as a guide.

2.4 NEOPRENE VIBRATION ISOLATORS:

A. Neoprene Floor Mounts shall be Mason type ND or Kinetics type RD selected for lowest possible durometer, within rated capacities, with 0.2” minimum static deflection under actual load. Where seismic restraint is required, provide one of two options: (1) Mason type BR mounts selected for lowest possible durometer, within rated capacities, with 0.1” minimum static deflection under actual load or (2) ND or RD mounts with seismic snubbers. Refer to Paragraph 1.4.

B. Neoprene Hangers shall be Mason type HD or WHD, or Kinetics type RH, selected for lowest possible durometer, within rated capacities, with 0.2” minimum static deflection under actual load.

C. Neoprene Floor Pads shall be Mason type Super W, selected for lowest possible durometer, not exceeding 50 durometer or 15% maximum deflection, with 0.07” minimum static deflection under actual load.

D. Neoprene Wall Mounts shall be Mason type BR, RBA or RCA, or Kinetics type RQ, selected for lowest possible durometer, within rated capacities, with 0.05” minimum static deflection under actual shear load.
PART 3 - EXECUTION

A. Mount all transformers, variable frequency drives and equipment racks containing fans or transformers (dimmers, amplifiers, datacom, etc.) on neoprene floor mounts (not pads), or wall mounts. Install equipment to avoid rigid connection between isolated equipment and structure. Suspended transformers shall be attached with neoprene hangers. Where seismic restraint is required, seismic snubbers and/or cable sway braces installed shall not support static loads.

B. Mount all switchgear on neoprene floor pads Mason type Super W or equivalent. Install equipment to avoid rigid connection between isolated equipment and structure. Where seismic restraint is required, seismic snubbers and/or cable sway braces installed shall not support static loads. See Part 2.3 for more information on the isolators.

C. Use flexible conduit for all connections to vibration isolated equipment (transformers, dimmers, amplifiers, datacom, etc.). Flexible conduit shall be a minimum length of 12” with 25% greater length than the separation between the isolated equipment and the termination of rigid conduit. Install the flexible conduit to be slack and not to exceed the manufacturer’s minimum recommended bending radius. For conduit sizes greater than 2” diameter, use pre-manufactured flexible conduit connectors instead of flexible conduit.

D. For all transformers, main feed must be attached to the side or top of the transformer. Under no circumstances should the contractor connect the feed to the bottom of the transformer without obtaining written approval from the Project Acoustics Consultant.

E. Use flexible conduit or a flexible conduit connector at every location where conduit crosses a building expansion/isolation joint and where conduit first attaches to floated concrete floors, walls supported on floated concrete floors, and gypsum board barrier ceilings.

F. Resiliently mount to structure conduit connected to vibration isolated electrical equipment for a distance equal to 200 conduit diameters and for any additional extent indicated on the Drawings. Wrap conduit with 1/2” elastomeric closed-cell insulation prior to restraining with wall-mounted clamp. See conduit isolation detail on “AC” Drawings for pictorial description.

G. ACOUSTICALLY SEALED PENETRATIONS: See acoustic AC Drawing Details.

END OF SECTION 260548
PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section Includes:
      1. Color and legend requirements for raceways, conductors, and warning labels and signs.
      2. Labels.
      4. Tapes and stencils.
      5. Tags.
      7. Cable ties.
      9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
   B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.
   C. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
   A. Comply with ASME A13.1.
   B. Comply with NFPA 70.
   D. Comply with ANSI Z535.4 for safety signs and labels.
   E. Comply with NFPA 70E and Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.
F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:
   1. **Black letters on an orange field.**
   2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use 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.
      d. Neutral: White
   3. Colors for 480/277-V Circuits:
      b. Phase B: Orange.
      c. Phase C: Yellow.
      d. Neutral: Gray
   4. Color for Equipment Grounds: **Green.**
   5. Colors for Isolated Grounds: Green with white stripe.

C. Raceways and Cables Carrying Circuits at More Than 600 V:
   1. **Black letters on an orange field.**
   2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:
   1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
   2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

C. Self-Adhesive Wraparound Labels: **Preprinted**, 3-mil- thick, **vinyl** flexible label with acrylic pressure-sensitive adhesive.
   1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
   2. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: **Vinyl**, thermal, transfer-printed, 3-mil- thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
   1. Minimum Nominal Size:
      a. 1-1/2 by 6 inches for raceway and conductors.
      b. 3-1/2 by 5 inches for equipment.
      c. As required by authorities having jurisdiction.

### 2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters and that stay in place by gripping action.

### 2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

C. Floor Marking Tape: 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with **yellow and black** stripes and clear vinyl overlay.

D. Underground-Line Warning Tape:
   1. **Tape:**
      a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and **communications** utility lines.
      b. Printing on tape shall be permanent and shall not be damaged by burial operations.
      c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
   2. **Color and Printing:**
      b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
      c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE"
   3. Tape shall be Multi-layer laminate, consisting of high density polyethylene scrim coated with printed pigmented polyolefin film, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2.6 TAGS

A. Write-on Tags:
   1. Polyester Tags: \textbf{0.010 inch} thick, with corrosion-resistant grommet and cable tie for attachment.
   2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Metal-Backed Butyrate Signs:
   1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
   2. 1/4-inch grommets in corners for mounting.
   3. Nominal Size: 10 by 14 inches.

B. Laminated Acrylic or Melamine Plastic Signs:
   1. Engraved legend.
   2. Thickness:
      a. For signs up to 20 sq. in, minimum 1/16 inch.
      b. For signs larger than 20 sq. in., 1/8 inch thick.
      c. Engraved legend with \textbf{black letters on white face}.
      d. \textbf{Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting}.
      e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
   2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
   3. Temperature Range: Minus 40 to plus 185 deg F.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
   2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
   3. Temperature Range: Minus 40 to plus 185 deg F.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.


J. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.
K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "POWER/VOLTAGE."
2. "EMERGENCY POWER."
3. "FIRE ALARM SYSTEM POWER."

M. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

P. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

Q. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

R. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

S. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

T. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

U. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
2. Install underground-line warning tape for direct-buried cables and cables in ductbanks.

V. Write-on Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using cable ties appropriate for location.

W. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

X. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

Y. Cable Ties: General purpose, for attaching tags, except as listed below:
   1. Outdoors: UV-stabilized nylon.
   2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl tape applied in bands.
   1. Locate identification 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.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
   1. "EMERGENCY POWER."
   2. "POWER"
   3. "FIRE ALARM SYSTEM"

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use self-adhesive wraparound labels to identify the phase.
   1. Locate identification 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.

F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.

I. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

J. Auxiliary Electrical Systems Conductor Identification: Marker tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

K. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
L. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

M. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Metal-backed, butyrate warning signs.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
   a. Power-transfer switches.
   b. Controls with external control power connections.


P. Operating Instruction Signs: Laminated acrylic or melamine plastic signs.

Q. Emergency Operating Instruction Signs: Laminated acrylic or melamine plastic signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.

R. Equipment Identification Labels:

1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
2. Outdoor Equipment: Laminated acrylic or melamine sign.
3. Equipment to Be Labeled:
   a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of an engraved, laminated acrylic or melamine label.
   b. Enclosures and electrical cabinets.
   c. Access doors and panels for concealed electrical items.
   d. Switchgear.
   e. Switchboards.
   f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
   g. Emergency system boxes and enclosures.
   h. Enclosed switches.
   i. Enclosed circuit breakers.
   j. Enclosed controllers.
   k. Variable-speed controllers.
   l. Push-button stations.
   m. Power-transfer equipment.
   n. Contactors.
   o. Remote-controlled switches, dimmer modules, and control devices.
   p. Battery-inverter units.
   q. Battery racks.
   r. Power-generating units.
   s. Monitoring and control equipment.

END OF SECTION 260553
PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.3 DEFINITIONS
A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
C. SCCR: Short-circuit current rating.
D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS
A. Product Data: For computer software program to be used for studies.
B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
   1. Short-circuit study input data, including completed computer program input data sheets.
   2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
      a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
      b. Single-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data: For Short-Circuit Study Specialist.
B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.
1.6 QUALITY ASSURANCE

A. Studies shall use SKM Power Tools Electrical Engineering Software computer program (PTW32). Manual calculations or studies utilizing other software programs are not acceptable.

B. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE


B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, and panelboard designations.
   6. Calculated X/R ratios and equipment interrupting rating (1/2 cycle) fault currents.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short-circuit ratings.
   2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
   3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
   4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
   5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

G. Short-Circuit Study Output:
1. Short Circuit Study Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated fault-current magnitude and angle.
   c. Show calculated X/R ratio and equipment interrupting rating (1/2 cycle fault currents on electrical distribution system diagram).

2. Equipment Evaluation Report:
   a. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
   b. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
   c. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3. Electronic models of all studies performed shall be turned over to the owner in digital format and shall include the complete SKM data files for the project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Obtain all data necessary for the conduct of the study.
1. Verify completeness of data supplied on the Riser diagram. Call any discrepancies to the attention of Engineer.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
   1. To normal system low-voltage load buses where fault current is 10 kA or less.
   2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

F. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
   1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

G. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:
   1. Switchgear and switchboard bus.
   2. Medium-voltage controller.
   3. Motor-control center.
   4. Distribution panelboard.
   5. Branch circuit panelboard.
   6. Three phase branch circuits with overcurrent protective devices installed with a rating equal to or greater than 30 amps.
   7. Motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horsepower.

3.3 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.4 DEMONSTRATION

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION 260572
SECTION 260573 - 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. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1.3 DEFINITIONS
A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
C. SCCR: Short-circuit current rating.
D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS
A. Product Data: For computer software program to be used for studies.
B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
   1. Coordination-study input data, including completed computer program input data sheets.
   2. Study and equipment evaluation reports.
   3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
      a. **Submit study report for action prior to receiving final approval of the distribution equipment submittals.** If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data: For **Coordination Study Specialist.**
B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.
1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. The following parts from the Protective Device Coordination Study Report:
      1) One-line diagram.
      2) Protective device coordination study.
      3) Time-current coordination curves.
   b. Power system data.

1.7 QUALITY ASSURANCE

A. Studies shall use SKM Power Tools Electrical Engineering Software computer program (PTW32). Manual calculations or studies utilizing other software programs are not acceptable.

B. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE


B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, and panelboard designations.
D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

F. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
   a. Phase and Ground Relays:
      1) Device tag.
      2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
      3) Recommendations on improved relaying systems, if applicable.
   b. Circuit Breakers:
      1) Adjustable pickups and time delays (long time, short time, ground).
      2) Adjustable time-current characteristic.
      3) Adjustable instantaneous pickup.
      4) Recommendations on improved trip systems, if applicable.
   c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
   a. Power utility's overcurrent protective device.
   b. Medium-voltage equipment overcurrent relays.
   c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
   d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
   e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
   f. Cables and conductors damage curves.
   g. Ground-fault protective devices.
   h. Motor-starting characteristics and motor damage points.
   i. Generator short-circuit decrement curve and generator damage point.
   j. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

H. Coordination Study shall include the stamp or seal and signature of the preparing engineer, and shall be reviewed and approved by the Engineer of Record.

I. Electronic models of all studies performed shall be turned over to the owner.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Submit preliminary coordination study analysis with equipment submittals. The coordination analysis shall include but not be limited to:
   1) Service entrance equipment
      a) All overcurrent protective devices installed in service entrance panels.
   2) Feeder Circuits
      a) All three (3) phase Feeder circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
   3) Branch Circuits
      a) All three (3) phase branch circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
      b) All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horsepower.

2. Revise coordination study analysis after relevant equipment submittals have been approved. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study. Provide in both hardcopy and electronic disk format. The computer disk shall include the complete coordination file including all device curves (Use the SKM "Project-Backup" command).

3. Prior to project completion, the coordination study and arc flash hazard analysis shall be provided in both hard copy and on USB drive. The hard copy shall include time current curves (for phase and ground fault settings) for each panel and the corresponding TCC report clearly showing each device set point. The digital format shall include the complete coordination file including all device curves (Use the SKM "Project-Backup" command). The digital format shall include the complete SKM data files for the project.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

F. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:
   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

G. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

H. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

I. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

J. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

K. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Motor-control centers.

L. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the riser diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of
performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
17. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
   c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
   d. Generator thermal-damage curve.
   e. Ratings, types, and settings of utility company's overcurrent protective devices.
   f. Special overcurrent protective device settings or types stipulated by utility company.
   g. Time-current-characteristic curves of devices indicated to be coordinated.
   h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
   i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
   j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.

3.4 FIELD ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
SECTION 260574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH 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. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.

2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

   a. Submit initial study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Specialist.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.
1.6  CLOSEOUT SUBMITTALS

   A.  Operation and Maintenance Data:
      1.  Maintenance procedures according to requirements in NFPA 70E shall be provided in the 
          equipment manuals.
      2.  Operation and Maintenance Procedures: In addition to items specified in Section 017823 
          "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel 
          that comply with requirements in NFPA 70E.

1.7  QUALITY ASSURANCE

       calculations or studies utilizing other software programs are not acceptable.

   B.  Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, 
       analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. 
       All elements of the study shall be performed under the direct supervision and control of this professional 
       engineer.

PART 2 - PRODUCTS

2.1  COMPUTER SOFTWARE

       1.  Do not use the "Use Equipment Specific Arc Flash Equation in Protective Device Library" method 
           for arc flash calculations in the SKM software.

   B.  Comply with IEEE 1584 and NFPA 70E.

   C.  Analytical features of device coordination study computer software program shall have the capability to 
       calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2  ARC-FLASH STUDY REPORT CONTENT

   A.  Executive summary.

   B.  Study descriptions, purpose, basis and scope.

   C.  One-line diagram, showing the following:
       1.  Protective device designations and ampere ratings.
       2.  Cable size and lengths.
       3.  Transformer kilovolt ampere (kVA) and voltage ratings.
       4.  Motor and generator designations and kVA ratings.
       5.  Switchgear, switchboard, motor-control center and panelboard designations.

   D.  Study Input Data: As described in "Power System Data" Article.

   E.  Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study 
       Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

   F.  Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination 
       Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."
G. Arc-Flash Study Output:
   1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated symmetrical fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. No AC Decrement (NACD) ratio.
      e. Equivalent impedance.
      f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
      g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:
   1. Arcing fault magnitude.
   2. Protective device clearing time.
   3. Duration of arc.
   5. Working distance.
   6. Incident energy.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a waterproof, 3.5-by-5-inch self-adhesive, machine printed, equipment label for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
   1. Location designation.
   2. Nominal voltage.
   3. Flash protection boundary.
   5. Incident energy.
   7. Proper level of PPE (Personal Protective Equipment)
   8. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings. Submit sample of label for Owner Approval prior to installation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance.
   1. Submit preliminary arc flash hazard analysis with equipment submittals.
      a. The coordination and arc flash hazard analysis shall included but not be limited to:
         1) Service entrance equipment
            a) All overcurrent protective devices installed in service entrance panels.
2) Feeder Circuits
   a) All three (3) phase Feeder circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.

3) Branch Circuits.
   a) All three (3) phase branch circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
   b) All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horsepower.

2. Revise arc flash hazard analysis after relevant equipment submittals have been approved and as installed feeder lengths verified. Overcurrent protective devices that have not been submitted and approved prior to study may not be used in study. Provide in both hardcopy and electronic disk format. The computer disk shall include the complete coordination file including all device curves (Use the SKM “Project-Backup” command).

3. Prior to project completion, the coordination study and arc flash hazard analysis shall be provided in both hard copy and on USB drive. The hard copy shall include time current curves (for phase and ground fault settings) for each panel and the corresponding TCC report clearly showing each device set point. The digital format shall include the complete coordination file including all device curves (Use the SKM “Project-Backup” command). The digital format shall include the complete SKM data files for the project.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:
   1. Short-Circuit Study Output: As specified in Section 260572 “Overcurrent Protective Device Short-Circuit Study.”
   2. Protective Device Coordination Study Report Contents: As specified in Section 260573 “Overcurrent Protective Device Coordination Study.”

C. Calculate maximum and minimum contributions of fault-current size.
   1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
   2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
   1. Identify any location other than the Service Entrance Main with a HCR>2 and provide recommendations for improvement.

E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.
   1. Switchgear and switchboard bus.
      a. All overcurrent protective devices installed in service entrance panels.
   2. Motor-control center.
      a. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horsepower.
   3. Distribution panelboard.
   5. Three phase branch circuits with overcurrent protective devices installed with a rating equal to or greater than 30 amps.
   6. Motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horsepower.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
   1. Fault contribution from induction motors should not be considered beyond three to five cycles.
   2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
   1. When the circuit breaker is in a separate enclosure.
   2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

J. Arc flash hazard analysis shall include the stamp or seal and signature of the preparing engineer, and shall be reviewed and approved by the Engineer of Record.

K. Electronic models of all studies performed shall be turned over to the owner.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
   1. Verify completeness of data supplied on the riser diagram on Drawings. Call discrepancies to the attention of Architect.
   2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
   3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
   1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
   2. Obtain electrical power utility impedance at the service.
   3. Power sources and ties.
   4. Short-circuit current at each system bus, three phase and line-to-ground.
   5. Full-load current of all loads.
   6. Voltage level at each bus.
   7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
   8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
   9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
   10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
   11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
   12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
   13. Motor horsepower and NEMA MG 1 code letter designation.
14. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

3.4 LABELING

A. Apply one owner approved arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards, disconnects and transformers.

END OF SECTION 260574
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings 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. Photoelectric switches.
      2. Indoor occupancy and vacancy sensors.
      4. Digital timer light switches.
      5. Outdoor motion sensors.
   B. Related Requirements:
      1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product.
   B. Shop Drawings:
      1. Show installation details for the following:
         a. Occupancy sensors.
         b. Vacancy sensors.
      2. Interconnection diagrams showing field-installed wiring.
      3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS
   A. Field quality-control reports.
   B. Sample Warranty: For manufacturer's warranties.

1.5 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.
1.6 WARRANTY

A. Manufacturer’s Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Faulty operation of lighting control devices.

2. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DIGITAL TIME SWITCHES

A. Basis of Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following Manufacturers:

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Lightolier Controls; a Genlyte Company
5. Watt Stopper (The).
6. Hubbell

B. Digital time switch
   1. The digital time switch shall be programmable to turn lights off after a preset time.
   2. Time switch shall be a completely self-contained control system that replaces the standard toggle switch. It shall have a ground wire and ground strap for safety. Switching mechanism shall be a latching air gap relay.
   3. Zero Crossing Circuitry shall be used to increase the relay life, protect from the effects of inrush current, and increase the switch’s longevity.
   4. Time switch shall be compatible with all LED, electronic ballasts, ELV, MLV and motor loads. Triac and other harmonic generating devices shall not be allowed.
   5. Time switch shall operate at universal voltages of 100-300 VAC; 50/60 Hz.
   6. Time switch shall have no minimum load requirement and shall be capable of controlling 0 to 800 watt incandescent, fluorescent @ 100/120 VAC, 50/60 Hz.
   7. Time scroll feature shall allow manual overriding of the preset time-out period. Selecting time scroll UP shall allow time-out period to scroll up throughout the timer possibilities to the maximum. Time scroll DN (down) shall allow time-out period to scroll down to minimum.
   8. Time switch shall have the option for a one second light flash warning at five minutes before the timer runs out and twice when the countdown reaches one minute (when used to control lighting loads).
   9. Time switch shall have the option for a beep warning that shall sound every five seconds once the timer runs out and twice when the countdown reaches one minute (when used to control lighting loads).
   10. Time switch shall have manual feature for timer reset where pressing the ON/OFF switch for more than 2 seconds resets the timer to the programmed time-out period.
   11. Time switch shall have an electroluminescent backlit Liquid Crystal Display that shows the timer’s countdown.
   12. Time switch shall fit behind a decorator style faceplate. The calibration switch for setting time-out, time scroll, one second light flash, and beep warning shall be concealed to prevent tampering of adjustments and hardware.
   13. Time-out period shall be adjustable in increments of 5 minutes from 5 minutes to 1 hour, and in increments of 15 minutes from 1 hour to 12 hours.
   14. Time switch shall be capable of operating as an ON/OFF switch.
   15. For ease of installation and cleaner wiring, the switch shall utilize terminal style wiring.
   16. The time switch shall not protrude more than 1/8” from the wall and should blend in aesthetically.
   17. For safety, the time switch shall have a 100% OFF override switch with no leakage current to the load.
18. For safety, in the event there is an open circuit in the AC line such as a ballast or lamp failure, the time switch shall automatically switch to OFF mode.
19. To ensure quality and reliability, time switch shall be manufactured by an ISO 9002 certified manufacturing facility and shall have a defect rate of less than 1/3 of 1%.
20. Time switch shall have 5 year warranty and shall be UL and CUL listed.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. NSi Industries LLC; TORK Products.
4. Tyco Electronics; ALR Brand.
5. Lithonia Lighting; Acuity Lighting Group, Inc.
7. Square D; Schneider Electric
8. TORK
9. Watt Stopper (The).

B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lux), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
3. Time Delay: Fifteen second minimum, to prevent false operation.
5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.3 DIGITAL OCCUPANCY CONTROL SYSTEM

A. Basis of design product: Subject to compliance with requirements, provide Wattstopper Digital Lighting Management (DLM) system as indicated on Drawings:
1. Contractor may submit prior to bid comparable products for pre-approval. Substitutions will not be entertained after submittal of bid.

B. Digital Ceiling mounted occupancy sensor system.
1. Ceiling mounted passive infrared (PIR), ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor. Furnish the Company’s system which accommodates the square-foot coverage requirements for each area controlled, utilizing room controllers, digital occupancy sensors and accessories which suit the lighting and electrical system parameters.
2. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:
   a. Digital calibration and pushbutton programming for the following variables:
      1) Sensitivity – 0-100% in 10% increments
      2) Time delay – 1-30 minutes in 1 minute increments
      3) Test mode – Five second time delay
      4) Detection technology – PIR, Ultrasonic or Dual Technology activation and/or re-activation.
      5) Walk-through mode
      6) Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.
   b. One or two RJ-45 port(s) for connection to DLM local network.
c. Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool and control by remote personal controls.

d. Device Status LEDs including:
   1) PIR Detection
   2) Ultrasonic detection
   3) Configuration mode
   4) Load binding

e. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.


3. Units shall not have any dip switches or potentiometers for field settings.

4. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.

5. WattStopper product numbers: LMPX, LMDX, LMPC, LMUC, LMDC

C. DIGITAL WALL SWITCHES

1. Low voltage momentary pushbutton switches in 1, 2, 3, 4, 5 and 8 button configuration; available in white, light almond, ivory, grey and black; compatible with wall plates with decorator opening. Wall switches shall include the following features:
   a. Two-way infrared (IR) transceiver for use with personal and configuration remote controls.
   b. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
   c. Red configuration LED on each switch that blinks to indicate data transmission.
   d. Blue Load/Scene Status LED on each switch button with the following characteristics:
      1) Bi-level LED
      2) Dim locator level indicates power to switch
      3) Bright status level indicates that load or scene is active
   e. Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.

2. Two RJ-45 ports for connection to DLM local network.

3. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required to achieve multi-way switching.

4. The following switch attributes may be changed or selected using a wireless configuration tool:
   a. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
   b. Individual button function may be configured to Toggle, On only or Off only.
   c. Individual scenes may be locked to prevent unauthorized change.
   d. Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
   e. Ramp rate may be adjusted for each dimmer switch.
   f. Switch buttons may be bound to any load on a room controller and are not load type dependant; each button may be bound to multiple loads.


D. ROOM CONTROLLERS

1. Room Controllers automatically bind the room loads to the connected devices in the space without commissioning or the use of any tools. Room Controllers shall be provided to match the room lighting load and control requirements. The controllers will be simple to install and will not have, dip switches, potentiometers or require special configuration. The control units will include the following features:
   a. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.
   b. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf unit without requiring any configuration or setup.
   c. Device Status LEDs to indicate:
      1) Data transmission
      2) Device has power
3) Status for each load
4) Configuration status
d. Quick installation features including:
   1) Standard junction box mounting
   2) Quick low voltage connections using standard RJ-45 patch cable
e. Plenum rated
f. Manual override and LED indication for each load
g. Dual voltage (120/277 VAC, 60 Hz)
h. Zero cross circuitry for each load.

2. On/Off Room Controllers shall include:
a. One or two relay configuration
b. Efficient 150 mA switching power supply
c. Three RJ-45 DLM local network ports
d. Discrete model listed for connection to receptacles, for occupancy-based control of plug loads within the space.
e. One relay configuration only
   1) Automatic-ON/OFF configuration
f. WattStopper product numbers: LMRC-101, LMRC-102, LMPL-101

3. On/Off/Dimming enhanced Room Controllers shall include:
a. Real time current monitoring
b. One, two or three relay configuration
c. Efficient 250 mA switching power supply
d. Four RJ-45 DLM local network ports.
e. One 0-10 volt analog output per relay for control of compatible ballasts and LED drivers.
f. The following dimming attributes may be changed or selected using a wireless configuration tool:
   1) Establish preset level for each load from 0-100%
   2) Set high and low trim for each load
   3) Set lamp burn in time for each load up to 100 hours
g. Discrete model listed for connection to receptacles, for occupancy-based control of plug loads within the space.
   1) One relay configuration only
   2) Automatic-ON/OFF configuration
h. WattStopper product numbers: LMRC-211, LRMC-212, LRMC-213, LMPL-201, LMRC-311, LMRC-312, LMRC-313.

E. ISOLATED RELAY INTERFACE
1. Output interface for integration of third party systems
2. Single pole double throw isolated relay
3. Status LED for isolated relay
4. Over current protection
5. Two RJ45 ports with hinged dust cover
6. UL 2043 plenum rated
7. Watt Stopper product number: LMRL-100

F. DIGITAL INTERFACE
1. Operating voltage 24VDC from DLM network
2. Maximum current consumption 15Ma
3. DLM local network connection: 2 RJ45 ports
4. Terminal block for connection to third party system. RS-232 Data Wiring.
5. Baud rate configurable to 9600, 19200, 38400, 57600 or 115200
6. WattStopper product number: LMDI-100

G. ROOM NETWORK (DLM Local Network)
1. The DLM local network is a free topology lighting control physical connection and communication protocol designed to control a small area of a building. Digital room devices connect to the network using CAT 5e cables with RJ-45 connectors which provide both data and power to room devices. Features of the DLM local network include:
a. Plug n' Go automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy-efficient sequence of operation based upon the device attached.
b. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
c. Push n' Learn configuration to change the automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.
d. Two-way infrared communications for control by handheld remotes, and configuration by a handheld tool including adjusting load parameters, sensor configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.

H. CONFIGURATIONS TOOLS
1. A configuration tool facilitates optional customization of DLM local networks, and is used to set up open loop daylighting sensors. A wireless configuration tool features infrared communications, while PC software connects to each local network via a USB interface.
2. Features and functionality of the wireless configuration tool shall include:
   a. Two-way infrared (IR) communication with DLM IR-enabled devices within a range of approximately 30 feet.
   b. High visibility organic LED (OLED) display, pushbutton user interface and menu-driven operation.
   c. Read, modify and send parameters for occupancy sensors, room controllers and buttons on digital wall switches.
   d. Save up to nine occupancy sensor setting profiles, and apply profiles to selected sensors.
   e. Temporarily adjust light level of any load(s) on the local network, and incorporate those levels in scene setting.
3. WattStopper Product Numbers: LMCT-100, LMCI-100/LMCS-100

2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS
A. Basis of Design Product: Subject to compliance with requirements provide product as indicated on Drawings or pre-approved comparable product by one of the following:
   1. Bryant Electric; a Hubbell company.
   2. Cooper Industries, Inc.
   3. Hubbell Building Automation, Inc.
   5. Lightolier Controls.
   6. Lithonia Lighting; Acuity Lighting Group, Inc.
   7. Lutron Electronics Co., Inc.
   8. Sensor Switch, Inc.
   9. Square D; a brand of Schneider Electric.
   10. Watt Stopper.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
   3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor Tag 'MS':
   1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft.
   2. Sensing Technology: Dual technology - PIR and ultrasonic.
   3. Switch Type: SP.
   4. Voltage: Dual voltage, 120 and 277 V; dual-technology type.
5. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
6. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.

2.5 OUTDOOR MOTION SENSORS

A. Basis of Design Product: Subject to compliance with requirements provide product as indicated on Drawings or pre-approved comparable product by one of the following:

1. Bryant Electric; a Hubbell company.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
5. Lightolier Controls.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. Lutron Electronics Co., Inc.
8. Sensor Switch, Inc.
9. Square D; a brand of Schneider Electric.
10. Watt Stopper.


1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. **PIR** type, weatherproof. Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm). Comply with UL 773A.
3. Switch Rating:
   a. Luminaire-Mounted Sensor: **500-VA fluorescent/LED**.
   b. Separately Mounted Sensor: Dry contacts rated for 20-A **LED** load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

4. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off." With bypass switch to override the "on" function in case of sensor failure.
5. Voltage: Match the circuit voltage **Dual voltage, 120- and 277-V** type.
6. Detector Coverage:
   a. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft.
   b. Long Range: 180-degree field of view and 110-foot detection range.

7. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
8. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
10. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F, rated as "raintight" according to UL 773A.

2.6 LIGHTING CONTACTORS

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

2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
4. General Electric Company; GE Consumer & Industrial - Electrical Distribution; Total Lighting Control.
5. Square D; a brand of Schneider Electric.
6. TORK
7. Watt Stopper (The)

B. Description: Electrically operated and electrically held, combination-type lighting contactors, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.7 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Color coding of DLM System conductors shall be WHITE. Obtain pre-approval of color from owner prior to ordering.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

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

3.2 SENSOR INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.3 CONTACTOR INSTALLATION

A. Comply with NECA 1.

B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.4 WIRING INSTALLATION

A. Comply with NECA 1.


C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

F. Provide white colored cable for all lengths when making DLM System connections with CAT5e with RJ45 connectors. Contractor shall submit cable color and obtain confirmation from owner prior to ordering.

3.5 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.6 PROGRAMMING

A. On a room by room basis, after approved programming is completed and verified, the lighting control system lock-out features on switches, sensors, etc. shall be enabled to prevent accidental re-programming and to maintain programmed scenes and sequences.

B. System switches shall be configured for auto-on (and auto-off) control of associated lighting unless otherwise noted.

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.8 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.

3.9 FACTORY COMMISSIONING

A. Upon completion of the installation, the system shall be commissioned by the manufacturer's factory authorized representative who will verify a complete fully functional system.

B. The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the system startup and adjustment date.

C. After commissioning and after switches have been programmed, system lockout features shall be activated such that programming function is locked out to avoid unintentional re-setting of switches.

3.10 DEMONSTRATION

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

END OF SECTION 260923
SECTION 262200 - 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. Section Includes: Distribution, dry-type transformers rated 600 V and less, with capacities up to 1500 kVA.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.

2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformers, accessories, and components, from manufacturer.

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

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

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.
1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

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

C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.7 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. General Electric Company.
   3. Square D; Schneider Electric.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

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

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Coil Material: Aluminum.

F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.
G. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

### 2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: **Ventilated**.
   1. NEMA 250, **Type 2**: Core and coil shall be encapsulated within resin compound to seal out moisture and air.
   2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.

E. Transformer Enclosure Finish: Comply with NEMA 250.
   1. Finish Color: **Gray**.

F. Taps for Transformers 3 kVA and Smaller: **One 5 percent tap above normal full capacity**.

G. Taps for Transformers 7.5 to 24 kVA: **One 5 percent tap above and one 5 percent tap below normal full capacity**.

H. Taps for Transformers 25 kVA and Larger: **Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity**.

I. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

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.
   3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
   1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
   2. Include special terminal for grounding the shield.

M. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

N. Wall Brackets: **Wall brackets fabricated from design drawings signed and sealed by a licensed structural engineer**.
O. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and Less: 40 dBA.
2. 30 to 50 kVA: 45 dBA.
3. 51 to 150 kVA: 50 dBA.
4. 151 to 300 kVA: 55 dBA.
5. 301 to 500 kVA: 60 dBA.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 “Identification for Electrical Systems.”

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
2. Ratio tests at the rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at the rated voltage connections.
4. No load losses, and excitation current and rated voltage at the rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation Resistance Tests:
   a. High-voltage to ground.
   b. Low-voltage to ground.
   c. High-voltage to low-voltage.
9. Temperature tests.

B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

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 Section 260526 “Grounding and Bonding for Electrical Systems” have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated from design drawings signed and sealed by a licensed structural engineer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

1. Transformers shall be mounted on neoprene vibration isolation mounts of bridge-bearing quality (Kinetics Noise Control Model RD – elastomeric vibration isolators). Use flexible conduit at connections between transformers and rigid conduit.

C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

C. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
   1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
   3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

E. 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 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. 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 262200
SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Service and distribution switchboards rated 600 V and less.
   2. Surge protection devices.
   3. Disconnecting and overcurrent protective devices.
   4. Instrumentation.
   5. Control power.
   6. Accessory components and features.
   7. Identification.

1.3 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
   1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
   2. Detail enclosure types for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
   6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
   8. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Delegated Design Submittal:
   1. For arc-flash hazard study.
   2. For arc-flash labels.
1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Routine maintenance requirements for switchboards and all installed components.
      b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
      c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
   2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   3. Fuses and Fusible Devices for Fused Circuit Breakers: 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 Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
   5. 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.
   6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.
1.7 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency’s Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 104 deg F.

b. Altitude: Not exceeding 6600 feet.

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

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.

2. Indicate method of providing temporary electric service.

3. Do not proceed with interruption of electric service without Owner’s written permission.

4. Comply with NFPA 70E.

1.10 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances toworkspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: **Three** years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: **Five** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to **ASCE/SEI 7**.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.

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

2.2 SWITCHBOARDS

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. Square D; a brand of Schneider Electric.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: **Fixed, individually** mounted.
3. Sections front and rear aligned.
I. Nominal System Voltage: **480Y/277 V**.

J. Main-Bus Continuous: **3000 A**. (For School of Music Building)

K. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.

      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."

L. Indoor Enclosures: Steel, NEMA 250, **Type 1**.

M. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's **standard gray** finish over a rust-inhibiting primer on treated metal surface.

N. Barriers: Between adjacent switchboard sections.

O. Insulation and isolation for **main bus of main section and** main and vertical buses of feeder sections.

P. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

Q. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

R. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

S. Buses and Connections: Three phase, four wire unless otherwise indicated.

   1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.

   2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, **silver-plated**.

   3. Copper feeder circuit-breaker line connections.


   5. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.

   6. Disconnect Links:

      a. Isolate neutral bus from incoming neutral conductors.

      b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.

   7. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with **mechanical** connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.


T. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.3 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. Square D; a brand of Schneider Electric.

B. SPDs: Comply with UL 1449, Type 1.

C. Features and Accessories:
1. Indicator light display for protection status.
2. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
3. Surge counter.

D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V.
2. Line to Ground: 1200 V for 480Y/277 V.
3. Line to Line: 2000 V for 480Y/277 V.

F. SCCR: Equal or exceed 100 kA.

G. Nominal Rating: 20 kA.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. 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 adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.

2. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
3. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
   a. Provide GFEP Circuit breakers on all branch circuits in the main distribution panel 'MDP'
   b. The service entrance Ground Fault Equipment Circuit Breaker will coordinate with feeder circuits that have GFEP to insure that the feeder circuit will open before the GFEP can trip the main breaker.

5. MCCB Features and Accessories:

   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Ground-Fault Protection: **Integrally mounted** relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at [55] [75] percent of rated voltage.

g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

h. Auxiliary Contacts: **One SPDT switch** with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

i. Any device that can trip the breakers shall have a visible indication on the front of the switchboard.

2.5 **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 switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

2.6 **IDENTIFICATION**

A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.

   1. Nameplate: At least 0.032-inch- (0.813-mm-) thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.

B. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

PART 3 - EXECUTION

3.1 **EXAMINATION**

A. Receive, inspect, handle, and store switchboards according to **NEMA PB 2.1**.

   1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
   2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
   3. Protect from moisture, dust, dirt, and debris during storage and installation.
   4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

D. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Comply with NECA 1.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

C. Support and secure conductors within the switchboard according to NFPA 70.

D. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Acceptance Testing:
   a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
   b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.


4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

5. Perform the following infrared scan tests and inspections, and prepare reports:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
   c. Instruments and Equipment:
      1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."
3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION 262413
SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Electronic-grade panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.
B. GFCI: Ground-fault circuit interrupter.
C. GFEP: Ground-fault equipment protection.
D. MCCB: Molded-case circuit breaker.
E. SPD: Surge protective device.
F. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.
   1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
   2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details.
   2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
   3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
   4. Detail bus configuration, current, and voltage ratings.
   5. Short-circuit current rating of panelboards and overcurrent protective devices.
   6. Include evidence of NRTL listing for SPD as installed in panelboard.
   7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.
B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Keys: Two spares for each type of panelboard cabinet lock.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
B. Handle and prepare panelboards for installation according to NECA 407.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

   a. Ambient Temperature: Not exceeding minus 22 deg F to plus 104 deg 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.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Owner no fewer than two days in advance of proposed interruption of electric service.
   2. Do not proceed with interruption of electric service without Owner's written permission.
   3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
   1. Panelboard Warranty Period: 24 months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.
   1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Surface-mounted, dead-front cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 3R.
      c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4, Stainless Steel.
      d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
   2. Height: 84 inches maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.

4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.

5. Finishes:
   a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.


G. Incoming Mains:
   1. Location: Convertible between top and bottom.
   2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:
      a. Plating shall run entire length of bus.
      b. Bus shall be fully rated the entire length.

   2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
   3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
   4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
   5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
   6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.

I. Conductor Connectors: Suitable for use with conductor material and sizes.
   2. Terminations shall allow use of 75 deg C rated conductors without derating.
   3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
   4. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
   5. Ground Lugs and Bus-Configured Terminators: Two bolt Compression type, with a lug on the bar for each pole in the panelboard.
   6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
   7. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
   8. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.
K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
   1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
   2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

2.3 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   3. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
   1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker or Lugs only as indicated on drawings.


F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

G. Branch Overcurrent Protective Devices (MCCB) frame sizes 100A and larger shall be electronic trip and shall have adjustable trip settings as indicated in Section 2.6 below to allow for coordination and limiting arch flash hazard.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   3. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
C. Mains: Circuit breaker or lugs only as indicated in panelboard schedules.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 ELECTRONIC-GRADE PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   3. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1; with factory-installed, integral SPD; labeled by an NRTL for compliance with UL 67 and UL 1449 after installing SPD.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

D. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

E. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

F. SPD.
   1. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
   2. Protection modes and UL 1449 Voltage Protection Rating (VPR) for grounded wye circuits with 480Y/277 V or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
      a. Line to Neutral: 1200V for 480Y/277; 700 V for 208Y/120.
      b. Line to Ground: 1200V for 480Y/277; 800 V for 208Y/120.
      c. Neutral to Ground: 1200V for 480Y/277; 700 V for 208Y/120.
      d. Line to Line: 2000V for 480Y/277; 1200V for 208Y/120.
   3. SCCR: Equal to the SCCR of the panelboard in which installed.
   4. Inominal Rating: 20 kA.

G. Buses:
   1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
   2. Copper equipment and isolated ground buses.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   3. Square D; a brand of Schneider Electric.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Adjustable trip setting for circuit-breaker frame sizes **200 A and larger**.
   a. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long- and short-time time adjustments.
      4) Ground-fault pickup level, time delay, and I^2t response.

2. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

3. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).


5. 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. Ground-Fault Protection: **Integrally mounted** relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   e. Shunt Trip: **120-V** trip coil energized from separate circuit, set to trip at **55** percent of rated voltage.
   f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage **without intentional** time delay.
   g. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
   h. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in **on or off** position.
   i. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
   j. Any device that can trip the breakers shall have a visible indication on the front of the panel.

2.7 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

   1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.8 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. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting:
   1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
   2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim 90 inches above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.

K. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.
   2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer’s written instructions.
L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

M. Install filler plates in unused spaces.

N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

O. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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 for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Do not perform optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.

c. Instruments and Equipment:

   1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

   1. Measure loads during period of normal facility operations.
   2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
   4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416
SECTION 262500 - ENCLOSED BUS ASSEMBLIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings 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. Feeder-bus assemblies.

1.3 ACTION SUBMITTALS

A. Shop Drawings: For each type of bus assembly.

1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.

2. Indicate required clearances, method of field assembly, and location and size of each field connection.

3. Detail connections to switchgear, switchboards, transformers, and panelboards.

4. Cable and conductor terminal sizes for bus and plug-in device terminations.


B. Delegated-Design Submittal: For seismic-restraint details, signed and sealed by a qualified professional engineer.

1. Include design calculations for selecting seismic restraints.

2. Detail fabrication, including anchorages and attachments to structure and to supported equipment.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:

1. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.

2. Clearances for access above and to the side of enclosed bus assemblies.

3. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.

4. Support locations, type of support, and weight on each support.

5. Location of adjacent construction elements including luminaires, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For enclosed bus assemblies, accessories, and components.

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.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Handling, Installation, Operation, and Maintenance of Busway Rated 600 Volts or Less."

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Source Limitations: Obtain enclosed bus assemblies 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 UL 857.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design enclosed bus assemblies, plug-in devices, and components.

B. Seismic Performance: Enclosed bus assemblies, plug-in devices, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

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

2. Component Importance Factor: 1.0.

C. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 140 deg F.
2.3 ENCLOSED BUS ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Square D; Schneider Electric.
   2. General Electric Company; Electrical Distribution & Control Division.
   3. Eaton Electrical Inc.; Cutler-Hammer Products

B. Feeder-Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.
   1. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems" when mounting provisions and attachments are anchored to building structure
   2. Electrical Characteristics:
      a. Voltage: 277/480 V.
      b. Phase: Three; 4 wire.
      c. Percent of Neutral Capacity: 100.

3. Short-Circuit Interrupting Rating:
   a. For Bus Amperage of 3000: 150 symmetrical kAIC.


5. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.

6. Voltage Drop:
   a. Measure voltage drop at 30 deg C ambient with bus thermally stabilized at full rated load.
   b. Three-phase, line-to-line voltage drop less than 3.1 V per 100 feet at 40 percent power factor.

7. Ground: 50 percent capacity, integral with housing.

8. Ground: 50 percent capacity, internal bus bar of material matching bus material.

9. Enclosure: Steel or Aluminum, with manufacturer's standard finish.

10. Fittings and Accessories: Manufacturer's standard.

11. Firestop: Comply with UL 1479 firestop system, listed and labeled by an NRTL acceptable to authorities having jurisdiction for penetrations of fire-rated walls, ceilings, and floors.

12. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 feet for horizontally mounted runs and up to 16 feet for vertically mounted runs.

13. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.

C. Joints:
   1. Busway joints shall use one high-strength steel bolt with Belleville washers.
   2. Bolts shall be torque indicating type and at ground potential.
   3. Bolts shall be two-headed design to indicate when proper torque has been applied and require only a standard long handle wrench to be properly activated.
   4. Access shall be required to only one side of the busway for tightening joint bolts.
   5. Joint connection assemblies shall be removable without disturbing adjacent busway lengths.
   6. Joint connection assemblies that rely on the joint cover to provide ground continuity are unacceptable.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including luminaires, HVAC equipment, fire-suppression system, and partition assemblies.

B. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.
   1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Section 260548.16 "Seismic Controls for Electrical Systems."
   2. Support bus assembly to prevent twisting from eccentric loading.
   3. Support bus assembly with not less than 3/8-inch steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
   4. Fasten supports securely to building structure according to Section 260529 "Hangers and Supports for Electrical Systems."
   5. Bolts and nuts that are loosened for any reason after tightening to manufacturer's recommended torque setting shall be discarded and replaced with new bolts and nuts.

C. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.

D. Construct rated firestop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Section 078413 "Penetration Firestopping."

E. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

F. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

G. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

H. Comply with NECA 1.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Terminate to switchboard enclosures with matching bus assemblies according to Section 262413 "Switchboards."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment test, for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with Drawings and Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, and grounding.
   d. Verify correct connection according to single-line diagram.
   e. Inspect bolted electrical connections for high resistance using one or more of the following methods:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
      3) Perform thermographic survey.

3. Electrical Tests:
   a. Perform insulation resistance measurements through bolted connections and bus joints with low-resistance ohmmeter.
   b. Perform insulation resistance tests of each busway, phase to phase, and phase to ground.
   c. Perform a dielectric withstand voltage test on each busway, phase to ground with phases not under test grounded for one minute.
   d. Measure resistance of assembled busway sections on insulated busway and compare values with adjacent phases.
   e. Perform phasing test on each busway tie section energized by separate sources.
   f. Verify operation of busway space heaters.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

F. Enclosed bus assemblies will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.4 ADJUSTING

A. Set field-adjustable, circuit-breaker trip ranges and overload relay trip settings as indicated.

3.5 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.
3.6 PROTECTION

A. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION 262500
SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Straight-blade convenience and isolated-ground receptacles.
2. USB charger devices.
3. GFCI receptacles.
4. Twist-locking receptacles.
5. Pendant cord-connector devices.
6. Cord and plug sets.
7. Toggle switches.
8. Decorator-style convenience.
9. Wall plates.
10. Floor service outlets.
11. Poke-through assemblies.

1.3 DEFINITIONS

A. Abbreviations of Manufacturers’ Names:

1. Cooper: Cooper Wiring Devices; Division of Cooper Industries, Inc.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.
1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors are to be used:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.
3. Connector shall be at right angle. Twist type shall not be permitted.

D. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

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.

1. All convenience receptacles to be of the quick connect type to have a right angle connector feature with pre-stripped leads. Connector contacts are to be crimped and welded.
2. Products: Basis of design: Pass & Seymour, PT5362 (duplex)
   a. Subject to compliance with requirements, provide one of the following:
      1) Cooper. (Arrowlink Series)
      2) Hubbell. (Snapconnect Series)

B. Isolated-Ground, Duplex Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. All Isolated Ground receptacles to be of the quick connect type to have a right angle connector feature with pre-stripped leads. Connector contacts are to be crimped and welded.
2. Products: Basis of design: Pass & Seymour, PTIG5362 (duplex)
   a. Subject to compliance with requirements, provide one of the following:
      1) Cooper. (Arrowlink Series)
      2) Hubbell. (Snapconnect Series)
3. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
2.3 USB CHARGER DEVICES

A. Tamper-Resistant, USB Charger Receptacles: 5.1 V dc, 3.1 A for charging capability, USB Type A. Transformer is not to be “on” until USB senses Load. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1310, and FS W-C-596.
   1. Products: Basis of design: Pass & Seymour, TR5362USB (2 USB Charging Ports, 1 Nema 5-20R Duplex)
      a. Subject to compliance with requirements, provide one of the following:
         1) Cooper. TR7746 (2 USB Charging Ports, 1 Nema 5-20R Duplex)
         2) Hubbell. USB20X2 (2 USB Charging Ports, 1 Nema 5-20R Duplex)
   3. USB Receptacles: Dual, Type A.
   4. Line Voltage Receptacles: Dual, two pole, three wire, and self-grounding.

2.4 GFCI RECEPTACLES

A. General Description:
   1. 125 V, 20 A, straight blade, non-feed-through type.
   2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
   3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
   4. When ground fault protection is lost, power to the receptacle is disconnected.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
   1. All convenience receptacles to be of the quick connect type to have a right angle connector feature with pre-stripped leads. Connector contacts are to be crimped and welded.
   2. Products: Basis of design: Pass & Seymour, PT2095LA (duplex)
      a. Subject to compliance with requirements, provide one of the following:
         1) Cooper. (Arrowlink Series)
         2) Hubbell. (Snapconnect Series)

2.5 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Cooper; L520R.
      b. Hubbell; HBL2310.
      c. Leviton; 2310.
      d. Pass & Seymour; L520-R.

2.6 PENDANT CORD-CONNECTOR DEVICES

A. Description:
   1. Matching, locking-type plug and receptacle body connector.
   2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
2.7 CORD AND PLUG SETS

A. Description:
   1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

2.8 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.
   1. Switches not associated with the DLM Lighting system: All Snap switches to be of the quick connect type to have a right angle connector feature with pre-stripped leads. Connector contacts are to be crimped and welded.

B. Switches, 120/277 V, 20 A:
   1. Products: Basis of design: Pass & Seymour, PT20AC1 (single pole), PT20AC2 (two pole), PT20AC3 (three way), PT20AC4 (four way).
      a. Subject to compliance with requirements, provide one of the following:
         1) Cooper. (Arrowlink Series)
         2) Hubbell. (Snapconnect Series)

C. Pilot Light Switches, 20 A:
   1. Products: Basis of design: Pass & Seymour, PT20AC1-SL (single pole), PT20AC3-SL (three way), PT20AC4 (four way).
      a. Subject to compliance with requirements, provide one of the following:
         1) Cooper.
         2) Hubbell.
         3) Leviton.

   2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

2.9 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.
   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material for Finished Spaces: Where white devices are installed, use Smooth, high-impact thermoplastic faceplates. Where Gray devices are used, provide 0.035-inch- thick, satin-finished, Type 302 stainless steel faceplates.
   4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.10 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.
C. Service Plate: *Rectangular, die-cast aluminum* with satin finish.

D. Power Receptacle: Duplex, NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

E. Data Communication Outlet: *Blank cover with bushed cable opening to accept owner installed data outlet.*

2.11 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: *White* throughout except for *Gray* devices to be located at specialty wall colored locations as noted by Architect unless otherwise indicated or required by NFPA 70 or device listing.

2. Isolated-Ground Receptacles: *As specified above, with orange triangle on face.*

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.

3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.

4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.

2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.

4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.

6. Use a torque screwdriver when a torque is recommended or required by manufacturer.

7. When conductors larger than No. 12 AWG are installed on 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 and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACES
A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION
A. Comply with Section 260553 "Identification for Electrical Systems."
B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL
A. Test Instruments: Use instruments that comply with UL 1436.
B. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
C. Perform the following tests:
1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
D. Tests for Convenience Receptacles:
1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Test straight-blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

F. Wiring device will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

END OF SECTION 262726
SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in enclosed switches.
2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, 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. Submit in electronic format suitable for use in SKM coordination software.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "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 used on the Project. Submit in electronic format suitable for use in SKM coordination software.
4. Coordination charts and tables and related data.
1.5 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussman, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
3. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Service Entrance: Class RK1, time delay.
   2. Feeders: Class RK1, time delay.
   3. Motor Branch Circuits: Class RK1, time delay.
   4. Large Motor Branch (601-4000 A): Class L, time delay.
   5. Power Electronics Circuits: Class J, high speed.
   6. Other Branch Circuits: Class RK1, time delay.
   7. Control Transformer Circuits: Class CC, time delay, control transformer duty.
   8. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813
SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 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. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.
B. NO: Normally open.
C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, 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.
   5. Include 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. Provide in electronic format compatible with SKM Software.

B. Shop Drawings: For enclosed switches and circuit breakers.

   1. Include plans, elevations, sections, details, and attachments to other work.
   2. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.
B. 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.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
   b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and electronic format compatible with SKM Software.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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

2.2 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. 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 an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty:

2. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
3. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.4 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Three Pole, 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, Three Pole, 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. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
   4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
   5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - \(120\)-V ac.
   6. Hookstick Handle: Allows use of a hookstick to operate the handle.
   7. Lugs: Compression type, suitable for number, size, and conductor material.
   8. Service-Rated Switches: Labeled for use as service equipment.

2.5 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   3. Square D; a brand of Schneider Electric.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. MCCBs shall be equipped with a device for locking in the isolated position.

E. Lugs shall be suitable for \(90\) deg C rated wire, sized according to the \(75\) deg C temperature rating in NFPA 70.
F. Standards: Comply with UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents.

G. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I-squared t response.

H. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

I. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

J. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

K. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

L. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
12. Any device that can trip the breakers shall have a visible indication on the front of the switchboard.

M. School of Music Main Service entrance Breaker ‘SE-1’ to be provided with three phase voltage monitor module. Model SPVRB-480 as manufactured by Instrument Transformers, inc or pre-approved equal. Set to maximum 10 second delay. ‘SE-1’ to have arc reducing maintenance switch.

N. Telecom North Node Building Main Service entrance Breaker ‘SE-T1’ to be provided with three phase voltage monitor module. Model SPVRB-208 as manufactured by Instrument Transformers, inc or pre-approved equal. Set to maximum 10 second delay. ‘SE-T1’ to have arc reducing maintenance switch.

2.6 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).
C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

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

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
3.4 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.5 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:
   a. Inspect physical and mechanical condition.
   b. Inspect anchorage, alignment, grounding, and clearances.
   c. Verify that the unit is clean.
   d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
   e. Verify that fuse sizes and types match the Specifications and Drawings.
   f. Verify that each fuse has adequate mechanical support and contact integrity.
   g. Inspect bolted electrical connections for high resistance using one of the two following methods:

   1) Use a low-resistance ohmmeter.
      a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

   2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
      a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
  i. Verify correct phase barrier installation.
  j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
   d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
   e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

C. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:
   a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, grounding, and clearances.
   d. Verify that the unit is clean.
   e. Operate the circuit breaker to ensure smooth operation.
   f. Inspect bolted electrical connections for high resistance using one of the two following methods:
      1) Use a low-resistance ohmmeter.
         a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
         a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
   g. Inspect operating mechanism, contacts, and chutes in unsealed units.
   h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in
accordance with manufacturer’s published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.

e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.

g. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.

h. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.

c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

5. 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.

1. Test procedures used.

2. Include identification of each enclosed switch and circuit breaker tested and describe test results.

3. List deficiencies detected, remedial action taken, and observations after remedial action.
3.7 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study"

END OF SECTION 262816
SECTION 262913 - 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. Section includes the following enclosed controllers rated 600 V and less:
   1. Full-voltage manual.
   2. Full-voltage magnetic.
   3. Reduced-voltage magnetic.

B. Related Section:
   1. Division 26 Section "Variable-Frequency Motor Controllers" for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1.3 DEFINITIONS

A. CPT: Control power transformer.
B. MCCB: Molded-case circuit breaker.
C. MCP: Motor circuit protector.
D. N.C.: Normally closed.
E. N.O.: Normally open.
F. OCPD: Overcurrent protective device.
G. SCR: Silicon-controlled rectifier.

1.4 PERFORMANCE REQUIREMENTS

1.5 SUBMITTALS

A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
   1. Show tabulations of the following:
a. Each installed unit's type and details.
b. Factory-installed devices.
c. Nameplate legends.
d. Short-circuit current rating of integrated unit.
e. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

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

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: For enclosed controllers, 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. Field quality-control 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 installed components.
   2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
   3. Manufacturer's written instructions for setting field-adjustable overload relays.
   4. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.

G. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.6 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

C. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

1.7 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.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller.
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 minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.9 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 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.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Square D; a brand of Schneider Electric.
   c. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   d. Rockwell Automation, Inc.; Allen-Bradley brand.

2. Configuration: Nonreversing.
3. Surface mounting.

C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Square D; a brand of Schneider Electric.
   c. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   d. Rockwell Automation, Inc.; Allen-Bradley brand.

2. Configuration: Nonreversing.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 20 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; melting alloy type.
4. Surface mounting.
5. Green pilot light.
D. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Square D; a brand of Schneider Electric.
   c. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   d. Rockwell Automation, Inc.; Allen-Bradley brand.

2. Configuration: **Nonreversing**.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; melting alloy type.
4. Surface mounting.
5. Green pilot light.

E. Magnetic Controllers: Full voltage, across the line, electrically held.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Square D; a brand of Schneider Electric.
   c. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   d. Rockwell Automation, Inc.; Allen-Bradley brand.

2. Configuration: **Nonreversing**.
   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 24-V ac; obtained from integral CPT, with primary and secondary fuses, with sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
   a. CPT Spare Capacity: 50 VA.
6. Solid-State Overload Relay:
   a. Switch or dial selectable for motor running overload protection.
   b. Sensors in each phase.
   c. Class 20 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
   d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
   e. Analog communication module.
7. N.O., isolated overload alarm contact.
8. External overload reset push button.

F. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Square D; a brand of Schneider Electric.
ENCLOSED CONTROLLERS

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.

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

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

B. Seismic Bracing: Comply with requirements specified in Division 26 Section "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 each fusible-switch enclosed controller.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."

F. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified 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 nameplate.
3. Label each enclosure-mounted control and pilot device.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:
1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:
1. Inspect controllers, wiring, components, connections, and equipment installation. **Test and adjust controllers, components, and equipment.**
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify **Owner** before starting the motor(s).
5. Test each motor for proper phase rotation.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multi-pole enclosed controller 11 months after date of Substantial Completion.
   c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed controllers 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 controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING
A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

3.7 PROTECTION
A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION
A. **Train** Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION 262913
SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes AC motor Variable Frequency Drives rated 600 V and below.

1.3 PERFORMANCE REQUIREMENTS
A. Seismic Performance: VFDs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 REFERENCE STANDARDS
C. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association.

1.5 SUBMITTALS
A. See Section 01 3000– Administrative Requirements for submittal procedures.
B. Product Data: For each type and rating of VFD indicated. Include features, performance, electrical ratings, short circuit rating, operating characteristics, dimensions, shipping and operating weights, and furnished specialties and accessories.
C. Test Reports: Indicate field test and inspection procedures and test results.
D. Manufacturer’s Instructions: Indicate application conditions and limitations of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
E. Manufacturer’s Field Reports: Indicate startup inspection findings.
F. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

G. Maintenance Data: NEMA ICS 7.1. Include routine preventative maintenance schedule.

H. LEED Submittals:
   1. Product Data for Credit EA 5: For continuous metering equipment for energy consumption.

I. Shop Drawings: For each VFD indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
   1. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Each installed unit's type and details.
      b. Factory-installed devices.
      c. Enclosure types and details.
      d. Nameplate legends.
      e. Short-circuit current (withstand) rating of enclosed unit.
      f. Features, characteristics, ratings, and factory settings of each VFD and installed devices.
   2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

J. Seismic Qualification Certificates: For VFDs, 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.

K. Product Certificates: For each VFD, from manufacturer.

L. Operation and Maintenance Data: For VFDs 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 thermal-magnetic circuit breaker and MCP trip settings.
   2. Manufacturer's written instructions for setting field-adjustable overload relays.
   3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
   4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
   5. NEMA ICS 7.1: Include routine preventive maintenance schedule.
   6. NEMA ICS 7.1: Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

M. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 EXTRA MATERIALS

A. Furnish two extra of each air filter.
1.7 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum five years documented experience and with service facilities within 130 miles of Project.

D. IEEE Compliance: Fabricate and test VFD according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Products: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer’s written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than 14 deg F (minus 10 deg C) and not exceeding 104 deg F (40 deg C).
   2. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
   3. Humidity: Less than 95 percent (noncondensing).
   4. Altitude: Not exceeding 3300 feet (1005 m).

B. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Owner per requirements in the front end documents.
   2. Do not proceed with interruption of electrical systems without Owner’s written permission.
   3. Comply with NFPA 70E.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, including clearances between VFDs, and adjacent surfaces and other items.

1.10 COORDINATION

A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:
   1. Torque, speed, and horsepower requirements of the load.
   2. Ratings and characteristics of supply circuit and required control sequence.
   3. Ambient and environmental conditions of installation location.
B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Toshiba: Model Q9 or Model FS1: www.toshiba.com
   2. ABB: Model ACH550: www.abb.com
   3. Yaskawa: Model Z1000: www.yaskawa.com

B. Manufacturers other than the above are not allowed

2.2 DESCRIPTION

A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7. Select unspecified features and options in accordance with NEMA ICS 3.1.
   1. Employ microprocessor-based inverter logic isolated from power circuits.
   2. Employ pulse-width-modulated inverter system.
   3. Include a DC link reactor for reduction of harmonic distortion.
   4. The controller, and all associated components, shall be supplied by a single vendor.
   5. The controller will be operating a variable volume fan motor, or water pump motor for HVAC application.
   6. System voltage shall be indicated on front of ASD, using minimum of 1-inch high letters.

B. Enclosures: NEMA 250, Type 1, suitable for equipment application in places regularly open to the public. No disconnects in VFD cabinet. Disconnect must be in separate enclosure.

2.3 OPERATING REQUIREMENTS

A. Rated Input Voltage for motors rated below 40 HP: 200 volts, three phase, 60 Hertz, with a voltage tolerance of +/- 10% and a frequency tolerance of +/- 2 Hz.

B. Rated Output: Output frequency shall vary between 0.1 Hz and 400 Hz. Frequency resolution shall be 0.01 Hz digital and 0.03 Hz analog with an accuracy of +/-0.2% of maximum frequency at 25 degrees Celsius. Maximum voltage frequency shall be adjustable from 25 Hz to 400 Hz. Voltage boost shall be adjustable from 0% to 30% with starting frequency adjustable from 0 Hz to 10 Hz. The output current shall be 100% continuous and 110% for 60 seconds, based on NEC table 430-250 (Full-Load Current, Three-Phase Alternating Current Motors) for 200 volts or 460 volts.

C. The controller shall contain three critical frequency jump points with individual bandwidth. Upper and lower frequency limits shall be capable of being varied.

D. The PWM carrier frequency shall be adjustable from 5000 Hz to 15000 Hz.

E. The drive shall contain two separate acceleration/deceleration times (0.1 to 6000 seconds) with a choice of linear, S, or C curves. The drive shall have a standard dynamic electric braking for motors rated 30 HP or below. The drive shall restart into a rotating motor by sensing the coasting motor speed and matching that
frequency. The drive shall have adjustable soft stall (10%-150%) and adjustable electronic overload protection (10%-100%).

F. The drive shall have external fault input, be capable of re-setting faults remotely and locally.

G. Input Signal:
   1. 0 to 10 v DC
   2. 0 to 5 v DC
   3. 4 to 20 mA DC

H. Manual bypass is not required on VFD unless indicated on bid documents.

2.4 COMPONENTS

A. Display: Provide integral digital display to indicate output voltage, output frequency, and output current, output power (kw), and motor RPM.

2.5 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.
   1. Dry and Clean Indoor Locations: Type 1.
   2. Outdoor Locations: Type 3R.
   3. Other Wet or Damp Indoor Locations: Type 4.
   4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Disconnects associated with VFD's shall be in separate enclosure from VFD.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance.

B. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

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

3.2 INSTALLATION

A. Install in accordance with NEMA ICS 7.1, manufacturer's instructions, and per drawings.
   1. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Wall-Mounting Controllers: Install VFDs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not
on walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

C. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. General: Install independently mounted Variable Frequency Drive in accordance with manufacturer's written instructions.

E. Manufacturer's Field Services: Arrange and pay for the services of a factory-authorized service representative to inspect the field assembly and connection of components, and supervise the pretesting and adjustment of Variable Frequency Drives.

F. Mounting: For control equipment at walls, bolt units to wall or mount on lightweight structural steel channels bolted to the wall. For Drives not at walls, provide freestanding racks fabricated of structural steel members and lightweight slotted structural steel channels. Use feet consisting of 3/8-inch thick steel plates, 6 inches square, bolted to the floor. Use feet for welded attachment of 1-1/2-inch by 1-1/2-inch by ¼-inch vertical angle posts not over three feet on centers. Connect the posts with horizontal lightweight slotted steel channels and bolt the control equipment to the channels.

G. Comply with NECA 1.

H. When remote service disconnect is required, provide with auxiliary contacts hardwired to VFD safety circuit to shut down VFD, if disconnect is opened.

3.3 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFD with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.
4. System voltage to be indicated on front of VFD, using minimum 1” high letters.
5. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place in clear plastic holder.

B. Operating Instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFD units.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote device. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.
3.5  CONNECTIONS

A. Tighten connectors, terminals, bus joints, and mountings. Tighten field connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, comply with tightening torques specified in UL 486A.

3.6  CLEANING

A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally using methods and materials as recommended by manufacturer.

3.7  FIELD QUALITY CONTROL

A. Prior to initial energizing, provide the service of the manufacturer's field representative to prepare and start controllers.

B. Perform tests and inspections. Owner shall be provided the opportunity to witness all testing.
   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. Acceptance Testing Preparation:
   1. Pre-testing: On completing installation of the system, perform the following preparations for tests, under the supervision of the factory authorized service representative.
      a. Clean devices using manufacturer's approved methods and materials.
      b. Inspect for defects and physical damage, and nameplate compliance with current project drawings.
      c. Check tightness of electrical connections of devices with calibrated torque wrench. Use manufacturer's recommended torque values.
      d. Verify proper fuse types and ratings in fusible devices.
      e. Make insulation resistance tests of conducting parts of motor control components; and of connecting supply, feeder, and control circuits. For devices containing solid-state components, use test equipment and methods recommended by the manufacturer.
      f. Make continuity tests of circuits.
      g. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instructions.
         1) Visual and mechanical inspection: Include the following inspections and related work.
         h. Motor-Control Device Ratings and Settings: Verify that ratings and settings as installed are appropriate for final loads and final system arrangement and parameters as recommended by Division 15. Recommend final protective-device ratings and settings where differences are found. Use accepted revised ratings or settings to make the final system adjustments. Prepare and submit the load current and overload relay heater list.

D. Electrical Tests: Perform the following in accordance with manufacturer's instructions:
   1. Insulation resistance test of motor control devices conducting parts to the extent permitted by the manufacturer's instructions. Insulation resistance less than recommended by the manufacturer are unacceptable.
      a. Make adjustments for final settings of adjustable-trip devices.
      b. Test auxiliary protective features such as loss of phase, lockout, phase unbalance and undervoltage to verify operation.
      c. Check for improper voltages at terminals in Drives that have external control wiring when controller disconnect is opened. Any voltage over 30 V is unacceptable.

E. Correct deficiencies and retest motor control devices. Verify by the system tests that specified requirements are met.
F. Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible organization and person.

3.8 SERVICE AND GUARANTEE

A. General Requirements: Provide, at no additional cost to the Owner, all services, materials and equipment necessary for the successful operation of the entire system for a period of one year after completion of successful performance test. Provide necessary material required for the work. Minimize impacts on facility operations when performing scheduled adjustments and non-scheduled work.

B. Description of Work: The adjustment and repair of the system includes all computer equipment, software updates, electronic and electrical components, equipment and all sensors and control devices. Provide the manufacturer's required adjustments and all other work necessary.

C. Personnel: Provide qualified personnel to accomplish all work promptly and satisfactorily. Owner shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

D. Emergency Service: Owner will initiate service calls when a Variable Frequency Drive is not functioning properly. Qualified personnel shall be available to provide service of the complete system, including external controls. Furnish owner with a telephone number where service representative can be reached at all times. Service personnel shall be at the site within 24 hours after receiving a request for service. Restore the Variable Frequency Drive system to proper operating condition within 3 days.

E. Operating: Performance of scheduled adjustments and repair shall verify operation of the system as demonstrated by the initial performance test.

F. Systems Modifications: Provide all recommendations for system modification in writing to Owner. Do not make any system modifications, including operating parameters and control settings, without prior approval of Owner. All modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

3.9 DEMONSTRATION

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

END OF SECTION 262923
SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section includes automatic transfer switches rated 600 V and less, including the following:
      1. Bypass/isolation switches.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
      2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.
   B. Shop Drawings:
      1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
      2. Include material lists for each switch specified.
      3. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
      4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

1.4 INFORMATIONAL SUBMITTALS
   A. Qualification Data: For manufacturer-authorized service representative.
   B. Seismic Qualification Certificates: For transfer switches, accessories, and components, from manufacturer.
      1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
      3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
   C. Field quality-control reports.
1.5 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Features and operating sequences, both automatic and manual.
   b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications:

1. Member company of NETA.
   a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Construction Manager and Owner no fewer than five days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. Comply with NEMA ICS 1.

C. Comply with NFPA 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.
F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
2. Short-time withstand capability for three cycles.

H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

K. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

L. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

M. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

N. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed tape markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 “Identification for Electrical Systems.”

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via front access.

O. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Manufacturers: Basis of Design is around the GE Energy – Zenith Series ZTSCT. Contractor may submit prior to Bid for pre-approval transfer switch as manufacturer by:

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
6. Main and Neutral Lugs: Mechanical type.
7. Ground Lugs and Bus-Configured Terminators: Mechanical type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
   a. Initiation occurs without active control of generator.
   b. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
4. Failure of power source serving load initiates automatic break-before-make transfer.

E. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

H. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
   a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
   a. Generator is an existing Cummins Unit. Coordinate with existing unit for controls.

11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

   a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
   b. Push-button programming control with digital display of settings.
   c. Integral battery operation of time switch when normal control power is unavailable.

I. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency systems. Include results of test for the following conditions:

   a. Overvoltage.
   b. Undervoltage.
   c. Loss of supply voltage.
   d. Reduction of supply voltage.
   e. Alternative supply voltage or frequency is at minimum acceptable values.
   f. Temperature rise.
   g. Dielectric voltage-withstand; before and after short-circuit test.
   h. Overload.
   i. Contact opening.
   j. Endurance.
   k. Short circuit.
   l. Short-time current capability.
   m. Receptacle withstand capability.
n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.
   1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033053 "Miscellaneous Cast-in-Place Concrete."
   2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
   4. Provide workspace and clearances required by NFPA 70.

B. Identify components according to Section 260553 "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

D. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, motor controls, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

   1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

G. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."

H. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with Drawings and Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, grounding, and required clearances.
   d. Verify that the unit is clean.
   e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   f. Verify that manual transfer warnings are attached and visible.
   g. Verify tightness of all control connections.
   h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
   i. Perform manual transfer operation.
   j. Verify positive mechanical interlocking between normal and alternate sources.
   k. Perform visual and mechanical inspection of surge arresters.
   l. Inspect control power transformers.
      1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
      2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
      3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:
   a. Perform insulation-resistance tests on all control wiring with respect to ground.
   b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
   c. Verify settings and operation of control devices.
   d. Calibrate and set all relays and timers.
   e. Verify phase rotation, phasing, and synchronized operation.
   f. Perform automatic transfer tests.
   g. Verify correct operation and timing of the following functions:
      1) Normal source voltage-sensing and frequency-sensing relays.
      2) Engine start sequence.
      3) Time delay on transfer.
      4) Alternative source voltage-sensing and frequency-sensing relays.
      5) Automatic transfer operation.
      6) Interlocks and limit switch function.
      7) Time delay and retransfer on normal power restoration.
      8) Engine cool-down and shutdown feature.

   a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.
   a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
   b. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

D. Coordinate tests with tests of generator and run them concurrently.

E. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

F. Transfer switches will be considered defective if they do not pass tests and inspections.

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

H. Prepare test and inspection reports.

I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
   1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
   3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

3.4 DEMONSTRATION

A. **Engage a factory-authorized service representative to train** Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION 263600
SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings 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 lightning protection system for ordinary structures.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product.
B. Shop Drawings:
   1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
   2. Include raceway locations needed for the installation of conductors.
   3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
   4. Include roof attachment details, coordinated with roof installation.
   5. Calculations required by NFPA 780 for bonding of metal bodies.

1.4 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Lightning protection cabling attachments to roofing systems and accessories.
   2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
   3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.
B. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.
C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS
A. Maintenance Data: For lightning protection system to include in maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

B. Completion Certificate:
   1. UL Master Label Certificate.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: UL-listed installer, category OWAY.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

   a. East Coast Lightning Equipment Inc.
   b. ERICO International Corporation.
   c. Harger.
   d. Heary Bros. Lightning Protection Co. Inc.
   e. Independent Protection Co.
   f. Preferred Lightning Protection.
   g. Robbins Lightning, Inc.
   h. Thompson Lightning Protection, Inc.
   i. National Lighting Protection Corporation

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.

B. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

A. Air Terminals:

   1. Copper unless otherwise indicated.
   2. 5/8-inch diameter by 24 inches long.
   3. Rounded tip.
   4. Threaded base support.

B. Air Terminal Bracing:

   1. Galvanized steel.
   2. 1/4-inch diameter rod.

C. Class 1 Main Conductors:
1. Stranded Copper: 57,400 circular mils in diameter.

D. Secondary Conductors:
1. Stranded Copper: 26,240 circular mils in diameter.

E. Ground Loop Conductor: Tinned copper.

F. Ground Rods:
1. Material: Copper-clad steel.
3. Rods shall be not less than 120 inches long.
4. Sectional type, with integral threads.

G. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.

C. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

D. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed systems in NFPA 780.
1. Conceal Down conductors and interior conductors.
2. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed-through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
3. Install conduit where necessary to comply with conductor concealment requirements.
4. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer’s written instructions.
5. Route Down conductors on the North side of the building such that they will be protected from damage during future expansion of building to the North. Make connections to ground ring such that they will not be affected by the future North expansion of the building.

E. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.
1. Bury ground ring not less than 24 inches from building foundation.
2. Bond ground terminals to the ground loop.
3. Bond grounded building systems to the ground loop conductor within 12 feet of grade level.
4. Design North end of building Lightning protection so that it can be modified for a future building expansion to the North.
3.2 CONNECTIONS

A. Connections in earth or concrete, shall be done by exothermic welds listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: bolted connectors, exothermic weld, or crimp.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   1. Perform inspections as required to obtain a UL Master Label for system.

B. Prepare test and inspection reports and certificates.

END OF SECTION 264113
SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings 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 LED luminaires:
B. Related Requirements:
   1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS
A. CCT: Correlated color temperature.
B. CRI: Color Rendering Index.
C. Fixture: See "Luminaire."
D. IP: International Protection or Ingress Protection Rating.
E. LED: Light-emitting diode.
F. Lumen: Measured output of lamp and luminaire, or both.
G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaires.
   4. Include emergency lighting units, including batteries and chargers.
   5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
   6. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project. IES LM-79 and IES LM-80.
      a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
B. Shop Drawings: For nonstandard or custom luminaires.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Luminaires.
   2. Suspended ceiling components.
   3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
   4. Structural members to which equipment and/or luminaires will be attached.
   5. Initial access modules for acoustical tile, including size and locations.
   6. Items penetrating finished ceiling, including the following:
      a. Other luminaires.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
      f. Ceiling-mounted projectors.
   7. Moldings.
   8. Accoustical Panels

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Certificates: For luminaires, 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.

D. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For each type of luminaire.

F. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Diffusers and Lenses: **One for every 100** of each type and rating installed. Furnish at least one of each type.
   2. Globes and Guards: **One for every 20** of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: **Five** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to **ASCE 7**.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

   1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified."

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. Standards:
1. UL Listing: Listed for damp location.
2. Recessed luminaires shall comply with NEMA LE 4.
3. User Replaceable Lamps:
   a. Bulb shape complying with ANSI C78.79.
   b. Lamp base complying with ANSI C81.61 or IEC 60061-1].

C. CRI of minimum 80. CCT of 3500 K.

D. Rated lamp life of 50,000 hours to L70.

E. Lamps dimmable from 100 percent to 0 percent of maximum light output.

F. Internal driver.
   1. Provide remote driver for fixtures in Large RR, Traditional Performance Space, Isolation Rooms
      and Live Room/Jazz Combo Rehearsal as noted on the drawings.

G. Nominal Operating Voltage: 277 V ac or as noted on the drawings.
   1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

H. Housings:
   1. Extruded-aluminum housing and heat sink.
   2. powder-coat painted finish or as noted in Luminaire Schedule.

2.3 LUMINAIRE TYPES
A. Refer to Luminaire Schedule on the Drawings for each Luminaire Type.
   1. Contractor may submit substitution request for equal products to those listed in the
      Luminaire schedule prior to bid for evaluation. If approved, formal approval will be issued.
      No substitutions will be entertained and/or permitted after bid date.

2.4 MATERIALS
A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating
   conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames,
   lenses, diffusers, and other components from falling accidentally during relamping and when secured in
   operating position.

C. Diffusers and Globes:
   1. prismatic acrylic
   2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and
      other changes due to aging, exposure to heat, and UV radiation.
   3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they
   will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
1. Label shall include the following lamp characteristics:
   a. "USE ONLY" and include specific lamp type.
   b. Lamp diameter, shape, size, wattage, and coating.
   c. CCT and CRI for all luminaires.

2.5 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.


D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:
1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:
1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:
1. Attached to a minimum 20 gauge backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:
1. Ceiling mount with two 5/32-inch-diameter aircraft cable supports adjustable to 120 inches in length.

H. Suspended Luminaire Support:
1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:
1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION
A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL
A. Perform the following tests and inspections:
1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265119
SECTION 265219 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Emergency lighting units.
   2. Exit signs.
   3. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color Rendering Index.
C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
D. Fixture: See "Luminaire" Paragraph.
E. Lumen: Measured output of lamp and luminaire, or both.
F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
   1. Include data on features, accessories, and finishes.
   2. Include physical description of the unit and dimensions.
   3. Battery and charger for light units.
   4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
   5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.
      a. Manufacturers’ Certified Data: Photometric data certified by manufacturer’s laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
B. Shop Drawings: For nonstandard or custom luminaires.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
C. Product Schedule:
   1. For emergency lighting units. **Use same designations indicated on Drawings.**
   2. For exit signs. **Use same designations indicated on Drawings.**

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing laboratory providing photometric data for luminaires.

B. Product Certificates: For each type of luminaire.

C. Seismic Qualification Data: For luminaires, 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.
   4. Provide seismic qualification certificate for each piece of equipment.

D. Product Test Reports: For each luminaire for tests performed by **manufacturer and witnessed by a qualified testing agency.**

E. Sample Warranty: For manufacturer's **special** warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.
   1. Provide a list of all lamp types used on Project; use ANSI and manufacturers’ codes.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five year(s) from date of Substantial Completion.
B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Power Unit Batteries: Five years from date of Substantial Completion. Full warranty shall apply for first year and prorated warranty for the remaining four years.
2. Warranty Period for Self-Powered Exit Sign Batteries: Five years from date of Substantial Completion. Full warranty shall apply for the entire warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified."

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

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

B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for fluorescent luminaires.

F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.

G. Bulb Shape: Complying with ANSI C79.1.

2.3 EMERGENCY LIGHTING

A. Refer to Luminaire Schedule on the Drawings for each Luminaire Type.

1. Contractor may submit substitution request for equal products to those listed in the Luminaire schedule prior to bid for evaluation. If approved, formal approval will be issued. No substitutions will be entertained and/or permitted after bid date.

B. General Requirements for Emergency Lighting Units: Self-contained units.

C. Emergency Lighting Unit:

1. Wall with universal junction box adaptor.
2. UV stable thermoplastic housing, rated for damp locations.
3. Two LED lamp heads.
4. Internal emergency power unit.
5. Self-Diagnostics
D. Remote Emergency Lighting Units:
1. Wall with universal junction box adaptor.
2. UV stable thermoplastic housing, rated for damp locations.
3. Two LED lamp heads.
4. External emergency power unit.

2.4 EXIT SIGNS

A. Refer to Luminaire Schedule on the Drawings for each Luminaire Type.
1. Contractor may submit substitution request for equal products to those listed in the Luminaire schedule prior to bid for evaluation. If approved, formal approval will be issued. No substitutions will be entertained and/or permitted after bid date.

B. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
1. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
3. Master/Remote Sign Configurations:
   a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply battery for power connection to remote unit.
   b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.
4. Self-Diagnostics

2.5 MATERIALS

A. Metal Parts:
1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:
1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:
1. Clear, UV-stabilized acrylic.
2. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Conduit: Electrical metallic tubing, minimum 3/4 inch in diameter.

2.6 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
2.7 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.


PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:
   1. Sized and rated for luminaire and emergency power unit weight.
   2. Able to maintain luminaire position when testing emergency power unit.
   3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
   4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:
   1. Attached to a minimum 20-gage backing plate attached to wall structural members.
   2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
   4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service:

1. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.
   a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 265219
SECTION 265619 - LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
   2. Luminaire supports.
   3. Luminaire-mounted photoelectric relays.

B. Related Requirements:
   1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
   2. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color rendering index.
C. Fixture: See "Luminaire."
D. IP: International Protection or Ingress Protection Rating.
E. Lumen: Measured output of lamp and luminaire, or both.
F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaire.
   4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
   5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project. IES LM-79 and IES LM-80.
a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.

6. Wiring diagrams for power, control, and signal wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing laboratory providing photometric data for luminaires.

B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

D. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and photoelectric relays to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.9 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

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

   a. Structural failures, including luminaire support components.
   b. Faulty operation of luminaires and accessories.
   c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: 5 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified."

2.2 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. UL Compliance: Comply with UL 1598 and listed for wet location.

D. Lamp base complying with ANSI C81.61 or IEC 60061-1.

E. Bulb shape complying with ANSI C79.1.

F. CRI of 80. CCT of 3000 K.
G. L70 lamp life of 50,000 hours.

H. Lamps dimmable from 100 percent to 0 percent of maximum light output.

I. Internal driver.

J. Nominal Operating Voltage: 277 V ac or as noted on drawings.

K. In-line Fusing: Separate in-line fuse for each luminaire.

L. Lamp Rating: Lamp marked for outdoor use.

M. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

A. Refer to Luminaire Schedule on the Drawings for each Luminaire Type.

1. Contractor may submit substitution request for equal products to those listed in the Luminaire schedule prior to bid for evaluation. If approved, formal approval will be issued. No substitutions will be entertained and/or permitted after bid date.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.
H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:
   a. "USE ONLY" and include specific lamp type.
   b. Lamp diameter, shape, size, wattage and coating.
   c. CCT and CRI for all luminaires.

2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, and canopy ceilings and overhang ceilings for suitable conditions where luminaires will be installed.

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

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:
   1. Sized and rated for luminaire weight.
   2. Able to maintain luminaire position after cleaning and relamping.
   3. Support luminaires without causing deflection of finished surface.
   4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:
   1. Attached to structural members in walls.


H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 BOLLARD LUMINAIRE INSTALLATION:

A. Align units for optimum directional alignment of light distribution.

   1. Install on concrete base with top 6 inches (or as noted on drawings) above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.5 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 6 inches (or as noted on drawings) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.6 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.
3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

3.10 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265619
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SECTION 270500 - 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.

1.3 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."

E. Coordinate sleeve selection and application and installation as specified in Division 27 Section "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

PART 2 - PRODUCTS

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. Install sleeves as specified in Division 27 Section “Sleeves and Sleeve Seals for Communications Pathways and Cabling.”

3.3 SLEEVE-SEAL INSTALLATION

A. Install sleeve-seals as specified in Division 27 Section “Sleeves and Sleeve Seals for Communications Pathways and Cabling.”

3.4 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 270500
SECTION 270544 - SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLES

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
   2. Sleeve-seal systems.
B. Related Requirements:
   1. Division 07 Section "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product.
B. LEED Submittals:
   1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 SLEEVES
A. Wall Sleeves:
   2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
   1. Use EZ-PATH Smoke and Acoustical Pathways as noted on drawings (or pre-approved equal)
C. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
D. Sleeves for Rectangular Openings:
   2. Minimum Metal Thickness:
a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Advance Products & Systems, Inc.
      b. CALPICO, Inc.
      c. Metraflex Company (The).
      d. Pipeline Seal and Insulator, Inc.
      e. Proco Products, Inc.
   2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   3. Pressure Plates: Carbon steel.
   4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Presealed Systems.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
   C. Design Mix: 5000-psi, 28-day compressive strength.
   D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.
B. Comply with NEMA VE 2 for cable tray and cable penetrations.
C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."

b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed.

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.

5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
   1. Where noted on drawings, use the EZ-Path smoke and acoustical pathways. (Or pre-approved equal)
   2. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
   3. Seal space outside of sleeves unless penetration arrangement requires rectangular sleeved opening.

E. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.
SECTION 270548 – VIBRATION ISOLATION OF COMMUNICATION SYSTEMS

PART 1 - GENERAL

1.1 SCOPE:
A. Install communication equipment and conduit in a manner to prevent transmission of objectionable vibration to acoustically critical/sensitive spaces. Vibration isolation includes, but is not limited to, resilient mounting of transformers, racks containing fans or transformers (dimmers, amplifiers, datacom, etc.) and use of flexible conduit.

1.2 RELATED WORK:
A. Perform vibration isolation work in this contract, including work described in other Divisions to meet the product and execution requirements of this Section.
B. Division 1 – General Requirements.
C. Section 01 86 36 – Ambient Noise Levels.
D. All Division 26 and 27 specifications relating to vibration isolated equipment and materials.

1.3 QUALITY ASSURANCE:
A. Provide vibration isolators for Divisions 14, 21, 22, 23, 26, 27 from the product line of a single manufacturer whenever possible unless approved by the project Acoustics Consultant. Isolators not supplied by the primary vibration isolator manufacturer shall be rejected.
B. The vibration isolator manufacturer’s representative shall determine isolator sizes and mountings, and shall provide field supervision and inspection to assure proper installation, adjustment and performance. Representative shall alert the Engineer and project Acoustics Consultant to any isolator selections, which may experience resonance with the approved equipment and upgrade any isolators that are found to resonate with the supported equipment. The Contractor shall include in his bid vibration isolation system elements as recommended by the manufacturer’s representative to make a complete, correct, and safe installation. Supply and install any incidental materials needed, even if not explicitly specified or shown in the Construction Documents, without claim for additional payment.
C. Skilled workers who are experienced in the necessary crafts to meet the requirements of this Section shall perform the work. Upon completion of the installation and after the system is put into operation, the manufacturer’s representative shall make a final inspection and submit his report to the Architects and Engineers in writing certifying the correctness of installation and compliance with approved submittal data. The contractor shall allow for the cost of this service in his bid.

1.4 SEISMIC RESTRAINT:
A. Seismic Certification: A licensed professional engineer experienced in the design of seismic restraints for flexibly mounted equipment, in the employ of the vibration isolation manufacturer, shall certify and stamp the shop drawings stating that all requirements of state and local codes have been met regarding seismic restraint of all resiliently mounted equipment. Provide calculations and analysis showing compliance with the applicable codes.
1.5 SUBMITTALS:

A. In a single consolidated submittal, provide catalog datasheets, shop drawings and other documents as necessary to indicate equipment unit number, isolator type, supported weight, scheduled deflection, proposed deflection under operating load, and rated deflection for each isolator. Submittals based upon rated deflection will be rejected. Indicate bridge bearing quality neoprene components and neoprene durometer where provided. Submittals will be reviewed for compliance and a Review/Comment sheet returned to the Architect and Engineer for their use.

PART 2 - PRODUCTS

2.1 FLEXIBLE STEEL CONDUIT

A. Flexible steel conduit shall be UL-listed liquid tight flexible metal conduit as manufactured by American Brass, Columbia or approved equal.

2.2 FLEXIBLE CONDUIT CONNECTORS

A. Flexible conduit connectors for conduit sizes greater than 2” diameter shall be Crouse-Hinds type XD expansion/deflection coupling, or approved equal.

2.3 MANUFACTURERS

A. The following vibration control manufacturers will be approved providing mounting systems are in strict accordance with design intent as specified herein:

2. Kinetics Noise Control, Dublin, Ohio.

Since manufacturers’ products vary, specific models listed in this Specification may not be approved if they do not meet all requirements in this section. Model designations listed herein are intended only as a guide.

2.4 NEOPRENE VIBRATION ISOLATORS:

A. Neoprene Floor Mounts shall be Mason type ND or Kinetics type RD selected for lowest possible durometer, within rated capacities, with 0.2” minimum static deflection under actual load. Where seismic restraint is required, provide one of two options: (1) Mason type BR mounts selected for lowest possible durometer, within rated capacities, with 0.1” minimum static deflection under actual load or (2) ND or RD mounts with seismic snubbers. Refer to Paragraph 1.4.

B. Neoprene Hangers shall be Mason type HD or WHD, or Kinetics type RH, selected for lowest possible durometer, within rated capacities, with 0.2” minimum static deflection under actual load.

C. Neoprene Floor Pads shall be Mason type Super W, selected for lowest possible durometer, not exceeding 50 durometer or 15% maximum deflection, with 0.07” minimum static deflection under actual load.

D. Neoprene Wall Mounts shall be Mason type BR, RBA or RCA, or Kinetics type RQ, selected for lowest possible durometer, within rated capacities, with 0.05” minimum static deflection under actual shear load.
PART 3 - EXECUTION

A. Mount all transformers and equipment racks containing fans or transformers (dimmers, amplifiers, datacom, etc.) on neoprene floor mounts, or wall mounts (not pads). Install equipment to avoid rigid connection between isolated equipment and structure. Suspended transformers shall be attached with neoprene hangers. Where seismic restraint is required, seismic snubbers and/or cable sway braces installed shall not support static loads.

B. Use flexible conduit for all connections to vibration isolated equipment (transformers, dimmers, amplifiers, datacom, etc.). Flexible conduit shall be a minimum length of 12" with 25% greater length than the separation between the isolated equipment and the termination of rigid conduit. Install the flexible conduit to be slack and not to exceed the manufacturer's minimum recommended bending radius. For conduit sizes greater than 2” diameter, use pre-manufactured flexible conduit connectors instead of flexible conduit.

C. For all transformers, main feed must be attached to the side or top of the transformer. Under no circumstances should the contractor connect the feed to the bottom of the transformer without obtaining written approval from the Project Acoustics Consultant.

D. Use flexible conduit or a flexible conduit connector at every location where conduit crosses a building expansion/isolation joint and where conduit first attaches to floated concrete floors, walls supported on floated concrete floors, and gypsum board barrier ceilings.

E. ACOUSTICALLY SEALED PENETRATIONS: See acoustic AC Drawings.

END OF SECTION 270548
PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

A. Project is “University of Missouri, Columbia – School of Music New Building, Columbia, MO”. The purpose of this section is to provide the Contract Specification for the Audio-Video (AV) Systems to be installed in the School of Music new building and related ancillary spaces within the project. Spaces which include Audio-Video Systems are:

1. Large Instrumental Rehearsal Room (1)
2. Traditional Performance Space (1)
3. Composition/Piano Lab (1)
4. Music Education Classroom (1)
5. Medium Classroom (1)
6. Meeting Room (1)

1.2 RELATED DOCUMENTS

A. The Contractor shall read, review and understand all documents listed below prior to bidding or proceeding with work. The Contractor shall also refer to and understand all other related documents indicated herein.

1. This section of the Specification.
2. Division 1
   a. Applicable provisions of Division 1 shall govern all work under this section.
3. Contract
   a. In addition to the conditions and work described herein, all conditions of the Contract shall apply.
4. AV Equipment Schedule, observing:
   a. Product descriptions, manufacturers’ names and model numbers.
   b. Quantities (to be confirmed by Bidder) for base pricing.
   c. Listed additive and/or deductive alternates which, if accepted by Owner, may alter the intent of, or negate, the text of this Specification or the details of the Drawings with respect to the facility afforded by said alternates.
5. Audio-Video (AV) Systems Drawings: AV Systems drawings including schematics, elevations, sections and details designated as “AV”.
6. Other Drawings:
   a. Related Architectural Drawings; for reference only.
   b. Related Electrical Drawings; for reference only. Drawings with prefix “EA” identify electrical rough-in including conduit, junction and pull boxes, et cetera, for use with the audio-video systems. Power requirements for the audio-video systems are shown on drawings with “E” prefix. Work described by “EA” and “E” drawings is not included in this Section.
   c. Other, as appropriate; for reference only.
1.3 DEFINITIONS

A. “ADA” - Americans with Disabilities Act.

B. “Ancillary Equipment Rack” - The moveable equipment rack with equipment serving the main mixing console.

C. “Architect” or “Architect of Record” – BNIM Architects, 2460 East Pershing Road, Suite 100, Jackson County, Kansas City, MO 64108, ph: 816-783-1500, fax: 816-783-1501.

D. “ASITG” - Audio System Isolated Technical Ground.

E. “Audio Video Panel” - Input/Output panel for audio connectors and/or video connectors. (Single-use connector panels shown on drawings are, in some instances, identified according to use.)

F. “AV” – Audio-Video.

G. “AVC” – Audio-Video Systems Contractor.

H. “AVP” - Used herein and on Drawings to abbreviate Audio Video Panel.

I. “Bid” - Herein, used interchangeably with “proposal.”

J. “Center Cluster or Center Loudspeaker” - Loudspeakers at center of proscenium.

K. “Contract” - Used herein, refers to the Audio-Video Systems prime contract or subcontract.

L. “Contractor” – Audio-Video Systems Contractor.

M. “Control Booth” - Synonymous with “Control Room”. Unless otherwise noted, references that which is made part of the particular space being described.


O. “Dedicated Movable Equipment” - Equipment furnished for a specific facility and not considered part of an AV equipment pool.

P. “Delay” - When referring to audio signal, same as “electronic delay.”

Q. “DSP” - Digital Signal Processor.

R. “EC” - Electrical Contractor.

S. “EE” - Electrical Engineer.

T. “Facility-Wide” - For purposes of the Project, inclusive of the performance spaces and ancillary and technical support spaces.

U. “Floor Box” – Audio/Video/Power floor boxes.

V. “Furnish” - Supply, to Owner’s representative, all equipment, parts or materials not requiring installation. Such equipment, parts and material may be supplied loose but must be appropriately packaged. Excludes test equipment, et cetera, “furnished” for use during system testing.

W. “GC” - General Contractor.
X. “He,” “Him,” “His,” et cetera - Third-person singular used without preference or regard to gender.

Y. “ICT” - Information Communication Technology.

Z. “IT” – Information Technology.

AA. “IHMP” - In House Mix Position.

BB. “Incidental” - A minor item or expense associated with this work that a reasonable person would believe to be included without requiring explicit description.

CC. “IR” - Infrared.

DD. “Jack” - A receptacle used to make electrical low-voltage signal connections via a cord-mounted plug.

EE. “Left Cluster” - Loudspeakers at house-left with respect to audience members’ view of stage.

FF. “MDF” – Master Distribution Facility (IT Head-End).

GG. “MIAGP” - Main Isolated Audio Ground Point (within audio equipment racks).

HH. “Mobile Equipment” - Generally, equipment on wheels. Considered part of an AV equipment pool furnished as part of these systems.

II. “Mobile Rack” - See “Ancillary Equipment Rack”.

JJ. “Movable Equipment” - Generally, equipment that may be employed at various positions but requiring infrequent repositioning, or, requiring more effort to reposition than “Portable Equipment”. Considered part of an AV equipment pool furnished as part of these systems.

KK. “N/A” – Not Applicable.

LL. “N.I.C.” - Not included in AV Systems Contract.

MM. “Normalled” - Connected through a patchbay so that no patch cable is required to make the subject connection. Unless otherwise noted, insertion of patch cable breaks “normal”.

NN. “Others” - Persons or contractors other than the Audio-Video Systems contractor responsible for the work described by this section of the overall project Specification.

OO. “Portable Equipment” - Generally, equipment that may be readily carried, repositioned or deployed by one person.

PP. “Proposal” - Herein, used interchangeably with “bid,” or, “tender.”

QQ. “Provide” - Unless otherwise indicated, requires contractor to furnish and install.

RR. “RGBx” - refers to both RGBHV and RGBS video.

SS. “Right Cluster” - Loudspeakers at house-right with respect to audience members’ view of stage.

TT. “Shop Drawings” – Drawings used by technicians offsite and onsite of the project for assembly and installation of the equipment.

UU. “Terminate” - Provide end-of-line impedance matching if specifically indicated, otherwise, synonymous with “connect” or “land”.

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VV. “Volume” - Sometimes used in lieu of “level” or “sound pressure level” when the former may be confused with elevation or height and when the latter is cumbersome.

WW. “Work” - When used as a noun, refers to the overall materials and labor required by the Contract to be provided or furnished.

1.4 SCOPE OF WORK

A. Complete System

1. Provide all described systems complete and working, according to the detailed information contained in the Contract Documents, the omission of minor details notwithstanding.

2. All system components should be connected and tested in the shop prior to delivery and installation at the project site. Any system functions or equipment which do not work properly during this test must be communicated in writing to the Consultant. Repair or replace equipment which is broken, damaged or failing to meet manufacturer’s specifications; and retest entire system for proper functioning.

B. Test all AV cable and terminations to ensure compliance with criteria contained in this specification and applicable industry standards.

1. The thorough testing of the AV cable installation, including terminations is required. Such testing will quantify the quality of the cable installation. To such degree that the cable installation and terminations do not meet the project’s stated requirement, the Contractor will be required to repair or replace, at no cost to the Owner, the poorly performing cable or terminations. The Contractor will also bear any additional expenses for having the cable or terminations re-tested.

2. Provide the test results to Consultant as detailed in this specification.

C. Contractor shall provide the following in accordance with Specifications and Drawings:

1. Submittals as described hereinafter. Furnish catalog sheets, color and material samples for approval only upon request by Owners’ Representatives. Do not furnish catalog sheets except for equipment for which authorization to substitute is requested.

2. Verification of dimensions and other conditions at project site.

3. Verification that any component required by this Section, if suspended or mounted overhead, bears appropriate approval by a structural engineer of hanging or mounting hardware integral and/or attached to that component.

4. Verification that all hardware, rigging or structural elements, as provided by others, bear appropriate structural engineering approval prior to components required by this Section being suspending from or mounting to said elements.

5. AV equipment, accessories and mounting hardware.

6. Control equipment and accessories.


8. Within each of the audio Digital Signal Processor systems, create system equipment, and connection, functional diagrams (a.k.a., “maps”) including remote-control accommodations based on the systems described herein. Such maps shall be well-labeled, neatly organized and ready for operation at the time of Acceptance Testing. Submit design with Shop Drawings.

9. Installation, configuring and programming of any software systems purchased through this contract.

10. Cabling, wiring connectors, connector panels and accessories.

11. Equipment racks and associated accessories.

12. Power distribution within equipment racks made part of this work, ready for power connection by the Electrical Contractor.
13. Incidentals necessary for a complete working system.
14. Initial testing and adjustments, demonstration of system for approval, participation in acceptance tests, final adjustments as required.
15. Record Documents.
17. Instruction of operating personnel and video record of training sessions.
18. Maintenance services for one year following acceptance of system.

D. Special Insurance

1. Provide insurance fully covering all equipment against loss and damage during shipment, storage, installation, testing, adjustment and demonstration.

E. Not in this Scope of Work

1. Related work specified elsewhere or provided by Owner, including:
   a. All conduits/containment, cable trays, junction boxes, pull boxes, outlet boxes, floor boxes, and in-ceiling loudspeaker backboxes when not integral with loudspeaker devices.
   b. All project AC power, including but not limited to:
      1) Dedicated Audio-Video AC power system.
      2) AC power to individual equipment racks from dedicated AC power system.
      3) AC power receptacles not within equipment racks but dedicated for audio-video systems use and served by the dedicated AC power system.
   c. Audio System Isolated Technical Ground (ASITG) conductors from Main Building Technical Ground Points to Main Isolated Audio Ground Points (MIAGP) in AV equipment racks.
   d. All architectural millwork required in support of the AV systems.

1.5 BIDING

A. Bids shall include specified equipment and pre-approved alternates.

B. The information included in the Quality Insurance section below shall be included in the bid proposal.

1.6 ASSURANCE OF MOST UP-TO-DATE EQUIPMENT

A. It is a project requirement that all AV equipment be each manufacturer’s most recent models, especially as includes the introduction or integration of new technology, according to the following guidelines.

1. Prior to ordering, the Contractor must verify that the equipment being purchased represents the manufacturer’s most recent products within each product category.
2. The Owner shall have 14 days to respond to any equipment changes which would be made due to such recent technology becoming available.
1.7 OWNER’S RIGHT TO SUBSTITUTE OR DELETE EQUIPMENT

A. Substitutions to or deletions of the specified equipment, as may be requested by the Owner or Owner’s Representative, shall be allowed without cost penalty to the Owner prior to equipment being ordered by the Contractor, according to the following guidelines:

1. The pricing of requested substitutions which are more or less expensive than the originally specified equipment will follow the provisions for Pricing of Changes, listed below.
2. Substitution requests from the Owner or Owner’s Representative which are made following approval of the specified equipment and after purchasing by the Contractor are subject to the provisions for Pricing of Changes.

1.8 PRICING OF CHANGES

A. Changes to the required equipment prior to the ordering of the equipment, as may be requested and approved by the Owner or Owner’s Representative, shall be priced as follows:

1. Such changes must be made at no cost penalty to the owner based on the Dealer Cost of each equipment item.
2. Do the degree that the changes of equipment require additional engineering time, the Contractor may submit for additional engineering amounts at the change-order labor rate for the project.

B. Changes to the required equipment following the ordering of equipment, as may be requested and approved by the Owner or Owner’s Representative, shall be priced as follows:

1. When a manufacturer does not provide a Manufacturer’s Suggested Retail Price (MSRP) or List Price, additions shall be at no more than 33% above wholesale or dealer cost based on the manufacturer’s wholesale or dealer price list, according to the quantities required, and without regard for additional discounts afforded to preferred dealers by manufacturers. Conversely, deletions shall be at no less than 120% of wholesale.
2. When a manufacturer does provide an MSRP or List Price, equipment additions shall be at no more than 90% of MSRP or no more than 33% above wholesale, as described above, whichever is less. Conversely, credited deletions shall be at no less than 80% of MSRP or 30% above wholesale, whichever is more.
3. Additions, as approved by the Owner or Owner’s Representative, to the required labor shall be priced at no more than the rate quoted on the bid form and therefore made part of the contract. Price conversely for credited deletions.
4. Include change-order labor rate with bid for this project.

1.9 SUBMITTALS

A. The Contractor will provide all requested submittals in a timely manner according to the descriptions below, and the following list. Submittals must be approved prior to the commencement of purchasing or installation pursuant to the information contained within the submittal.

1. Within Four Weeks of Contract Award:
   a. Milestone Dates
   b. Project Personnel
   c. Conduit/Containment Verification

   1) The statement must verify all conduit systems including those serving the AV systems in the base package and alternates, regardless the acceptance of the alternates as part of the final installation.
2. Prior to Equipment Purchase
   a. Equipment list including manufacturer, model number and quantity arranged by room and/or system.
   b. Shop Drawings (see definition herein).

3. Prior to Equipment Installation
   a. Rigging and Mounting Drawings.
   b. DSP files.
   c. Integrated control system simulation files for the touch panel.

4. Prior to AV Commissioning (Checkout)
   a. Written notice of installation completion.
   b. Initial Testing and Adjustment Documentation.

5. Prior to Completion
   a. Notification of completion of Punch List.
   b. Outline of training sessions.
   c. Operating and Maintenance Manuals.
   d. As-Built Drawings.

B. Form

1. Submit all materials for review as described below, referenced to the Specification paragraph number (where applicable).
2. Submit two copies for AV review (photocopies and electronic copies are acceptable).
3. Submit all major drawings on sheets of one size, preferably the project standard size.
4. Where materials are presented on sheets 11” x 17” or smaller, organize into three-ring binders which include:
   a. Dividers or tabs between logical sections
   b. Project name and binder title labels on face and edge of binders

5. Submit all minor drawings on sheets of one size.
6. Contractor material submitted electronically shall be stored in CD or DVD. Arrange folders on submittal disks with a naming convention that makes clear the contents of files which, otherwise, have no distinguishable names.
7. Contractor drawings submitted electronically shall be plotted to PDF format and at the standard sheet size for the project. Thus, if the recipient chooses to plot to paper at 1:1 ratios, the drawing will fit properly on this sheet size. (This paragraph intends to assure that drawings are well defined and readable, whether viewed electronically or on paper.)
8. On submittal drawings, maintain 3/32” minimum lettering height wherever possible. Submittals with text less than 1/16” in height may be rejected.
9. Partial Submittals may be rejected.

C. Documents

1. Provide the following documents for review by Owner’s Representatives after award of Contract and prior to purchase, fabrication, assembly and installation of equipment and materials:
   a. Milestones: Provide schedule of work with milestones for following tasks:
      1) Submittals complete
      2) Shop fabrication complete
3) Shop testing
4) Shipment to site
5) Installation
6) Field testing
7) Training

b. First Event Date:

1) The scheduled project completion date will be provided to Contractor prior to making the contract. As of this date systems should be usable and substantially complete.
2) At the discretion of the Owner, Final Acceptance Testing and correction of “punch list” items may extend beyond the date for substantial completion. Contractor will be advised as to any changes in expected date of completion.

c. Personnel:

1) Provide, in writing within two weeks after award of Contract, names, mailing address, phone numbers with extensions, email addresses and paging service numbers (if available) of following project personnel:

   a) Administrative Project Manager
   b) Technical Project Manager
   c) Service and Installation Manager(s)
   d) Field Foreman

d. Conduit Verification:

1) Within four weeks after award of Contract, submit:

   a) Statement confirming that Contractor has reviewed the conduit system as shown in electrical section of building construction documents and, where applicable, as built.
   b) Notification to Consultant, General Contractor, Architect and Electrical Contractor of deficiencies or inadequacies, if any, in conduit system design or installation. If none, so indicate.

e. Shop Drawings:

1) Provide the following Shop and Field drawings for review and approval prior to purchase, fabrication or assembly of equipment:

   a) System functional diagrams showing all wire-tag numbers or nomenclature to be used in the assembly shop or in the field.
   b) System conduit plan or riser drawing showing wire type and wire fill including quantity of each wire type.
   c) Detailed system schematic wiring diagrams showing all wire-tag numbers or nomenclature to be used in the assembly shop or in the field. (To be provided for all wiring that cannot be accurately represented by one-line functional diagrams.)
   d) Audio Digital Signal Processor functional diagrams in computer file format.
   e) Integrated remote control system operational computer file and printed screen shots for the user-interface.
   f) Patchbay layouts referenced to system functional diagrams.
g) Equipment rack layouts.
h) Shop drawings of all custom ("bespoke") assemblies such as racks, panels, et cetera.
i) Physical arrangement and circuiting of AC power distribution within AV equipment racks.
j) Shop drawings detailing cable management and including:
   (1) Wire type and physical arrangement of ducts, trays, harness bars, et cetera.
   (2) Major wire routes in racks according to signal groups.
   (3) Transition at junction boxes and equipment racks.

k) Mounting and installation details of AV equipment requiring integration with cabinetry or architectural elements.
l) Catalog sheets as required by this Specification and for products where Contractor has choice allowed by this Specification.

f. Rigging and Mounting Drawings

1) Details, stamped and signed by an engineer licensed in the State of Missouri, of all equipment mounting methods and materials provided by the Scope of Work, wherein failure of method or materials used for mounting or hanging permanently installed equipment could result in serious personal injury.

2) Details provided by or requiring approval by licensed engineer may include: method of attachment to building structure or attachment and/or suspension points; method of attachment to supported equipment; all suspension materials; a materials list including specifications of all suspension materials; calculations used to determine loads and strengths of suspension materials; other as deemed necessary by the engineer.

3) In the absence of submitted approved, stamped and signed mounting and hanging details, the Owner reserves the right to acquire such engineering approval at the expense of the Contractor. Owner will notify Contractor of such intent. Contractor shall remedy within two weeks or Owner may proceed without Contractor approval and without relieving Contractor from any other obligations set forth by Contract.

g. Samples

1) Color and finish samples as required by this Specification and, additionally, as may be requested by Owners’ representatives. In the absence of specific requests for the Owner’s representatives, minimally, submit samples of…

   a) …each wall plate/panel finishes type and color combination.
   b) …each round, ceiling or wall-mounted, loudspeaker grille type.

h. Catalog sheets as required by this Specification and for products where Contractor has choice allowed by this Specification. (Reiterating: DO NOT submit the catalogue sheets for listed equipment.)

i. Initial Testing and Adjustment Documentation

1) Submit at least two weeks prior to final acceptance testing.
2) Preliminary performance test results.
D. Requests for Substitutions

1. Substitutions requested by Contractor before and/or after the Contract award shall be in accordance with the requirements of the Contract, this Specification Section, and, as applicable, the General Conditions. In any case, requests for substitutions, before and/or after the Contract award, must be in writing. Contractor shall receive authorization in writing from the Owner or Owner’s representative prior to implementing substitutions.

2. Prior to purchase, fabrication or assembly of related equipment, provide:

   a. A list of all requested substitutions granted during or since the bidding and contract negotiation process, including the date granted and name of grantor. Written verification of granted substitutions may be required.
   b. A list of requested substitutions pending acceptance.
   c. Documentation in support of requested substitutions pending acceptance.

3. Contractors shall submit bids based upon the specified items. Contractors wishing to submit pre-approved substitutes based on cost savings to the Owner shall do so as voluntary deduct alternates with their bids.

E. Approvals

1. Do not proceed with the Work until approvals required by the Contract, this Specification Section and, as applicable, the General Conditions are granted by Owner’s Representatives, specifically, the Architect/Engineer and the Consultant.

2. Receive written approval and editorial review from Architect and Owner prior to publication of any references, articles, and/or acknowledgments regarding this project.

1.10 RECORD DOCUMENTS

A. Operating and Maintenance Data Manuals:

1. Submit one paper set of Operating and Maintenance Data Manuals bound in heavy duty locking binders with steel hinges. Binders shall include heavy duty dividers and contain the following sections:

   a. Table of contents.
   b. Updated system functional descriptions.
   c. List of provided equipment, material, accessories, and loose items including quantities.
   d. Manufacturers’ descriptions and specifications sheets arranged alphabetically by manufacturer and then by model number.
   e. Complete instructions including:

      1) System-specific operating instructions written by the contractor to instruct current and future users on how to run the system whether or not they have had the benefit of site training or oral history.
      2) Equipment-specific operating instructions including manufacturers’ operating manuals arranged alphabetically by manufacturer and then by model number.
      3) Tabular, graphic, photographic or software record of settings and adjustments of semi-fixed controls.

   f. Test reports.
   g. Key Schedule. (i.e., a list of physical keys relating specifically to this project).
   h. Copies of the un-compiled source codes for the integrated control system, if any.
Project Manual for:

CP170621 - School of Music New Building

CP172801 - General Site: School of Music Extended Utilities

Audio-Video Systems (For Reference Only)

i. Copies of warranty amendment letters.

j. Copy of this Specification.

2. Submit three copies of the above on CD or DVD media. Include all of the above except for, or with the addition of, the following:

a. Do not provide a “Table of Contents”. Instead, organize data in folders with clear organization and readily understood file names (e.g.: “Equipment\[manufacturer's name]\[model number]\”; “Software\Remote Controls\[room name]\[control system name]”, et cetera).

b. Provide software settings and data files for all computer-controlled equipment.

c. Include DVD(s) shot during all Employer training sessions as recorded and edited by the Contractor.

d. Provide, in “pdf” format, manufacturers’ catalogue sheet for each piece of equipment.

B. System “As Built” Drawings:

1. Upon completion of the project and final acceptance of the installation, update original drawings to accurately reflect the as-built conditions of all required modifications, executed change orders or other field conditions.

2. Provide three copies of the following “As Built” drawings, in pdf format, on CD:

   a. System functional block diagrams.
   
   b. Detailed wiring diagrams including wire tag numbers and wire color codes.
   
   c. AV panel elevations.
   
   d. Patchbay layouts.
   
   e. Rack layouts.
   
   f. Terminal block layouts.
   
   g. Circuiting of AC power distribution within AV equipment racks.
   
   h. AC power sequence layouts.
   
   i. Conduit diagrams.
   
   j. Conduit-fill schedule diagrams.
   
   k. Other relevant drawings as appropriate.

3. Provide two paper copies of the above “As Built” drawings on Project’s standard drawing size or reduced to sheets no smaller than 11”x17”. Maintain 3/32” minimum lettering height wherever possible and allow no lettering less than 1/16” in height.

C. Posted Operating and Maintenance Instructions:

1. Provide and post at each equipment rack location and equipment backboard, mounted behind glass or acrylic plastic, a bond-paper xerographic (not blue-line) reproduction of the following:

   a. Instructions indicating the method and/or sequence for powering the system on and off.
   
   b. System block diagram, System block diagram. If large paper is used, fold and store in protective envelope in the back of equipment rack at the Rack Room. Provide heavy-duty envelope(s), as required.
D. Infrastructure Testing Manuals

1. Submit, as recorded media, one Infrastructure Testing Data Manual containing the following sections:
   a. Table of contents.
      1) Logical section breakdown of testing conducted.
   b. Test reports.

2. Submit three copies of the above on CD or DVD media.

E. AV System Training Video Recordings

1. Make a video recording of all training sessions and provide two copies on DVD media to the Owner.

F. Software Passwords:

1. Software Password Schedule (i.e., a spreadsheet listing the manufacturer, model number and location in the Facility of each piece of audio-video systems equipment, the software for which is password-protected).

2. Provide three copies of software passwords as unprotected .pdf files on CD or DVD media.

3. Provide to Owner's Representative as a secure document separate from Operating and Maintenance Manuals and As-Built Drawings.

G. Source Code Files

1. The Contractor shall provide to the Owner, at the conclusion of acceptance testing, any system source codes, touch panel source material and audio processor files.

2. All electronic files become the property of the Owner and shall be fully functional and able to be modified.

3. Provide three copies of the source code files on CD or DVD media.

1.11 QUALITY ASSURANCE

A. Contractor Qualifications

1. AV Contractors (or their subcontractors) submitting proposals on any work covered by the Audio-Video Systems Contract Documents for the construction of the project shall be recognized contractors engaged in the types of work covered under said Contract Documents. Said Contractor (or their subcontractors) must possess sufficient technical, operational, and financial resources to perform and complete the contract, and shall furnish evidence thereof on request and prior to contract award.

2. To qualify as the AV Contractor, a contracting firm shall have been, for at least the past five years, in the business of providing systems comparable to those described by the Audio-Video Systems Contract Documents. Submit with proposal, documentation verifying the AV contractor’s experience in fabricating and installing audio-video systems of similar scope and size to that of this project. Contractors not having the requisite applicable experience may be disqualified.
3. To qualify as the AV Contractor, a contracting firm shall have factory-trained programmer(s) of the specified integrated control system and the specified audio digital signal processor on staff. Contractors without certified programmer(s) on staff shall contract independent programmer(s) with said training. Submit with proposal, documentation indicating compliance and include name(s) of programmer(s). When using independent programmer(s), the Contractor shall complete the installation with acknowledged programmer(s) or provide a written notification and proposed alternative to the Consultant, Owner’s Representatives or Architect for approval.

4. To qualify as a Contractor, a contracting firm shall maintain facilities, test equipment and trained technicians for fabricating, installing, and servicing the equipment specified, and have done so for at least the past five years. Said service facility shall be fully staffed with qualified personnel. Contractor shall maintain a parts inventory and stock of "loaner" or rental equipment sufficient to provide, within 24 hours of notification, any necessary in-warranty or out-of-warranty service or equipment replacement to prevent loss of use of the System due to equipment failure.

5. To qualify as a Contractor, a contractor shall be an experienced user, and be able to provide, at request of consultant, at least one each during Initial Testing and Acceptance Testing, of test equipment items listed below. Alternatively, professional-grade test-equipment which combines the functions of the individual pieces of equipment listed may be used in the testing procedures. Kits, "home-built" and other nonprofessional test equipment shall not be acceptable.

a. 1/3-Octave Real Time Analyzer
b. Distortion Analyzer (Tektronix, Hewlett Packard, Audio Precision, B&K or Neutrik)
c. Low Distortion Audio Oscillator
d. Precision Sound Level Meter
e. Impedance Bridge
f. Oscilloscope
g. Random Noise Generator
h. Digital Volt-Meter
i. TEF 20, SIM System or SIA Smaart Live version 4 or later
j. Waveform Monitor
k. Vectorscope
l. Function Generator
m. Video Signal Analyzer, e.g. Tektronix VM700T
n. Video Test Generator with RGBHV, component video, SDI/HD-SDI, DVI and HDMI outputs.

B. Contractor Responsibilities and Miscellaneous Understandings at Time of Proposal:

1. The Contractor shall verify correctness and completeness of materials lists and model numbers prior to bidding and shall assume responsibility for correctness of quantities. If a conflict exists between system drawings and/or written descriptions and/or itemized equipment lists, or if mathematical errors within the Specification result in low equipment totals, the Contractor shall provide the higher quantity unless directed by the Architect or Consultant to do otherwise.

2. A Contractor intending to utilize the services of another company or person in fulfillment of the Specification shall include, with the Bid Submittals, copies of the intended written contract between that other person or company and the bidding firm. The Contractor shall utilize only employees of his firm for the fabrication and installation of the systems specified unless participation by others has been indicated by the Contractor and accepted by the Architect as part of the Bid. In any case, the Contractor shall be wholly and singly responsible for all details of the Contract Documents.
3. The Contractor shall submit a complete, concise, and unambiguous bid document inclusive of all design, materials, equipment, technical and non-technical installation labor, specialized tools and test equipment, system warranty and documentation and any and all applicable taxes, fees and permits.

4. The Contractor shall submit, with the bid document for the base package, pricing in separate line items for each alternate.

5. Provide a Letter of Qualifications with the Proposal according to the following guidelines:

   a. Send letter to Architect.
   b. List the AV Contractor’s name, address, email address, telephone and fax numbers, number of employees, date of establishment as a business, date of incorporation (if applicable) and contractor’s license number (if applicable).
   c. List at least two previously completed systems of similar scope and complexity completed within the previous seven years. Provide names, addresses, and phone numbers of Owner, Consultant (if any), Construction Manager, and Architect contact for each project listed.
   d. List and profile experience and training (formal and factory) of proposed:
      1) Technical Project Manager.
      2) Service and Installation Manager(s)
      3) Field Foreman.
      4) Analysis equipment owned and maintained by Subcontractor.
   e. List subcontracting intent (including testing services):
      1) List, for each subcontractor, name, address, email address, telephone and fax numbers, number of employees, date of establishment as a business, date of incorporation (if applicable) and contractor’s license number (if applicable).
      2) Proposed subcontractor scopes of work.
      3) List and profile experience of each subcontractor in designated scopes.

6. Authorization to Contact References

   a. By bidding this work, the bidding contractor agrees that the Architect/Owner/Consultant may contact any reference provided by the bidding contractor for the purposes of verifying the information provided.

7. Letter of Qualification shall be signed, with name and title printed below signature, by a corporate officer or owner of the contracting company.

8. Pre-Bid Questions and Site Visits

   a. Pre-bid questions shall be addressed to the Owner’s representative(s) in writing. Verbal instructions to either bid or perform the Work in a manner which does not comply with the Contract Documents do not bind the Owner or Subcontractor.

C. Field Personnel

   1. When such training is available, Technical Project Manager and Field Foreman shall be factory trained in installation and adjustment of specified equipment prior to commencement of installation.
   2. Maintain the same individual in charge of work throughout execution unless illness, loss of personnel, or other circumstance(s) beyond the control of the Contractor intervenes. Immediately inform Architect, Consultant, GC, EC, ICT Contractor and Owner’s Representative, by fax or email, of change of individual in charge.
D. Coordination

1. Coordinate work of this Section with work of other Project Manual sections and associated trades.
2. Specific references, herein, requiring coordination of certain work shall not obviate responsibility for other required coordination.

E. Contractor shall

1. Verify correctness of Equipment Schedule with regard to quantities and model numbers.
2. Verify dimensions and other relevant conditions at Site prior to installation.
3. Review conduit system as shown in electrical section of building construction documents and, where applicable, as built.
   a. Notify Consultant, Architect, GC, and EC within four weeks after award of contract of deficiencies or inadequacies in conduit system design.
4. Notify Consultant, prior to submitting shop drawings, conflicts and/or deficiencies in the system diagrams, equipment, and system description.
5. Notify appropriate parties of conflicts in timely manner.
6. Work cooperatively with other trades to resolve conflicts.
7. Furnish specified Submittals in a timely fashion.
8. Meet requirements and milestones of project schedule.
9. Use equipment in the manner specified.
10. To the greatest extent possible, assemble and wire equipment racks off-site.
11. "Burn-in" or "Break-in" electronic equipment for 72 hours minimum.
12. Replace failed equipment.
13. Repair or replace with approved alternate, new components found not to meet manufacturers' specifications, when such failure has an adverse effect on the installation.
15. Following manufacturer's instruction for installation and testing procedures of the equipment.

F. Standards and Codes

1. Comply with local, state and federal codes and applicable National Electrical Code, American National Standards Institute and Underwriters' Laboratories, Inc. standards.
2. All equipment, material, accessories, and loose items furnished shall be new and shall conform to applicable requirements of the above-mentioned agencies.
3. If required by local authorities, provide certificates and labels indicating compliance with above-mentioned codes and standards where applicable.

G. Testing

1. Submit preliminary performance test data at least of two week prior to final testing.
2. Equipment shall be operated under standard conditions as recommended by manufacturer during performance testing.
3. Final Acceptance Testing shall be performed in presence of Owner's Representative to demonstrate acceptability of project as installed.
4. Repair conditions caused by defective workmanship.
5. Replace defective material and equipment.
6. Re-testing may be required to demonstrate compliance with Drawings and Specification.
1.12 WARRANTY AND TECHNICAL SUPPORT

A. One year warranty

1. Contractor shall warrant the system against failure resulting from defects in material or workmanship for a period of one year from final acceptance by Owner.
2. If the manufacturer of any equipment used in these systems provides less than a one-year warranty for that equipment, Contractor shall assume warranty responsibility for the balance of the one-year period not covered by the manufacturer.
3. Within warranty period, Contractor shall make necessary repairs and replacements at the convenience of and at no cost to Owner. Within warranty period, provide prompt replacement of defective materials and repair of faulty workmanship at no cost to the owner.
4. Paint, exterior finishes, fuses and lamps are excluded from guarantee except when damage or failure results from defective materials covered by guarantee.

B. On-site service

1. Provide, at no cost to Owner, maintenance service during above mentioned warranty period. At minimum, this service shall include a visit to the site, one visit six months prior to expiration of the warranty period and one visit two to four weeks prior to expiration of the warranty period, for checking AV systems and equipment. Perform standard maintenance and effect any warranty service requirements revealed during these visits. (No limitation of warranty service is intended by these instructions).
2. During warranty period, Contactor shall answer all service calls within one business-day.
3. Provide on-site service within 24 hours of notice by Owner if instructions from Contractor to Owner fail to correct system-critical faults within two hours of notice by Owner.
4. Provide on-site service within 72 hours for faults determined by the Owner to be not system-critical. Alternatively, at the discretion of the Owner, components to be removed and replaced by Owner may be transported via common carrier shipments.

C. Extended Warranty Option

1. If Owner accepts any Extended Warranty Option, fulfill the requirements of the Extended Warranty as described for original one-year warranty and according to any agreed-to special terms.

1.13 SYSTEM DESCRIPTION

A. General

1. This System Description supplements other information in this Specification, AV System Drawings, AV Equipment Schedule, and related architectural, electrical and other drawings. The Work shall include, but not be limited to, the systems, system elements, components and related cabling infrastructure, panels and hardware described in this System Description.
2. Provide new audio and video equipment interfaced with new conduit and power systems (the latter two systems by others)
3. Install owner-furnished equipment, if any, interfacing with the new systems and the conduit and power systems.
4. Provide installed cabling and connector panels (AVPs & JBs) for connectivity to support the program requirements described for each space.
5. Provide programming for the integrated control system and all DSP based systems.
6. Coordinate with the university IT personnel for assigning the IP address for the related AV systems equipment.
B. Base Package

1. General programmatic requirements, where applicable:
   a. Provide a sound-reinforcement and playback system that will serve the following types of program material:
      1) Speech reinforcement of announcements, narration and presentations.
      2) Program playback to provide prerecorded accompaniment for lectures, presentations or performances.
      3) Live music reinforcement for performances requiring amplification.
   b. Provide the following subsystems:
      1) Hearing Assistance System to provide a wireless amplification system for the hearing impaired in compliance with the Americans with Disabilities Act.
   c. Provide installed cabling and connector panels (AVPs & JBs) for connectivity to support the program requirements described above and the following:
      1) Microphone and audio tie-lines to facilitate audio connections throughout the performance spaces.
      2) AV Data (Cat 6 F/UTP) patching to route AV and data signals throughout the performance spaces, and to connect to the facility-wide data network.

2. Large Instrumental Rehearsal Room (130)
   a. Audio System
      1) Microphone and Accessories
         a) Provide a pair of microphones to support archival recordings for rehearsals, as well as input to the Hearing Assistance System. Mount the microphones on the dedicated junction boxes at the ceiling reflector.
         b) Provide a dual channel microphone preamplifier for the ceiling microphones.
         c) Provide two channels of 2-way microphone splitter with Jensen isolation transformer for the ceiling microphones. The transformer isolated split outputs shall be available at the AV rack for connecting to brought-in recording equipment.
         d) Provide a single channel wireless microphone system with lavalier microphone to capture instructor’s voice for lecture capture system. Mount the antenna on equipment rack.
      2) Audio Electronics
         a) Provide an aux stereo audio inputs at the mobile lectern/podium to allow for portable equipment (N.I.C.) to be connected to the system.
         b) Provide a USB audio interface to support lecture capture and live streaming.

         (1) The lecture capture and live streaming software will be provided, installed and configured by Owner.
         (2) Coordinate with owner Representatives for configuring the audio interface.
(3) Provide a stereo audio interface inputs at the AV rack to allow sending audio to live streaming from a brought-in mixer.

c) Main Digital Signal Processing (DSP) System

(1) Provide programmable Digital Signal Processing System to serve the various systems with independent gain controls, signal delays, cross-over filtering, equalization, and level control for each loudspeaker group as indicated on the drawings, as required for system tuning. The various systems are as follow:

(a) Main Loudspeaker System
(b) Surround Loudspeakers
(c) Subwoofer
(d) Lecture Capture System
(e) Skype Audio Calls
(f) Hearing Assistance System

(2) Include automatic gain control (AGC) for the wireless microphone in DSP programming.

(3) Include a mixer to mix voice from the instructor and audio program played during the classes to send to the lecture capture software via the external USB audio interface.

(4) Configure the DSP to use its built-in USB interface for Skype calls from the installed O.F.E. Mac mini.

(5) The audio system shall be temporarily and automatically muted or disabled upon activation of fire alarm system, if required.

(6) Refer to “Main Systems and Equipment” section for programming and other requirements.

d) Loudspeaker System

(1) Main Loudspeakers

(a) Provide a main loudspeaker system that consists of two single-cabinet, full-range, self-powered loudspeakers to provide even coverage of sound pressure level for the room.

(b) Mount the loudspeakers to the wall with wall brackets. Coordinate with other trades for structure support.

b. Video System

1) Video Electronics

a) Provide, in the mobile lectern/podium, a Blu-ray DVD player to support playback of pre-recorded materials for lecturers and presentations.

b) Provide aux HDMI inputs at the mobile lectern/podium to allow for portable equipment (N.I.C.) to be connected to the system.

(c) Coordinate with Owner Representatives to install an O.F.E. Mac mini in the wall-mounted pivoting rack.

d) Provide a HDMI signal extender for connecting the O.F.E. computer monitor on the mobile lectern/podium to the Mac mini.
e) Provide a webcam and a USB signal extender to support lecture capture and Skype video calls. Mount the webcam on the computer monitor. The lecture capture software will be provided, installed and configured by Owner.

f) Provide a HD PTZ camera at the rear of the room for live streaming, video recording and monitoring. The streaming software will be provided, installed and configured by Owner.

g) Provide a HDMI signal extender and a HDMI capture device for the PTZ camera to support live streaming. Coordinate with Owner Representatives for configuration.

h) Provide, at the mobile lectern/podium, an HDMI switcher for selecting playback sources.

(1) The switcher shall be HDCP compliant.
(2) The switcher shall be able to manage EDID communication between devices automatically.
(3) The switcher shall have a built-in DXLink output.
(4) Configure the switcher so that the output aspect ratio follows the aspect ratio of the input source.

i) Provide, at the wall-mounted pivoting rack, an AV presentation switcher/scaler for selecting playback sources and to convert video signals to the native resolution of the specified video projector.

(1) The switcher shall be HDCP compliant.
(2) The switcher shall be able to manage EDID communication between devices automatically.
(3) The switcher shall have built-in DXLink inputs and outputs.
(4) Configure the switcher so that the audio from HDMI inputs are de-embedded, and output stereo analog audio to the main DSP.
(5) Configure the switcher so that the audio switching follows the video switching.
(6) Configure the switcher output resolution and scanning frequency for maximum picture quality of the projector.
(7) Configure the switcher so that the output aspect ratio follows the aspect ratio of the input source.
(8) The switch shall have built-in control system for controlling other AV equipment.

j) Coordinate with other trade and Owner Representatives for mounting equipment to the mobile lectern/podium provided by others.

c. Integrated Control System

1) Provide an integrated control system capable of controlling all basic functions of audio and video equipment, including but not limited to: projector, projection screen, Blu-ray DVD player, presentation switchers, DSP and power sequencer for the audio and video systems, as well as room lighting system, curtains and window shades.
2) Provide a touch panel user interface on the mobile lectern/podium.

   a) The panel shall have control function for the following:

      (1) System power on/off
      (2) Projector power on/off
      (3) Projection screen up/down
      (4) Playback source selection
      (5) Blu-ray DVD player controls
      (6) PTZ camera controls
      (7) Volume and mute controls of the source equipment
      (8) Master volume and mute controls of the audio
      (9) Streaming audio feeds control (mute/unmute DSP outputs to the audio interface)
      (10) Room lighting on/off and dimming
      (11) Window shades up/down
      (12) Curtains deploy/store

   b) Coordinate with the Owner Representatives regarding the University standard requirements of the control page design that are appropriate for the systems.

   c) Coordinate with other trades for connecting and configuring controls of the room lighting system, window shades and curtains.

   d) Use animation and graphics where are appropriate to create a clear and professional look and feel to the interface. Design all control pages such that the necessary signal routing to implement the various functions is transparent to the user.

   e) All control functions available on the manufacturer's standard handheld remote control should be available in some form via the integrated touch panel control system.

   f) Use device control feedback whenever possible to give the user visual feedback that the control signal has been received and processed by the device.

   g) Provide all touch panel layouts to Consultant for review prior to installing to the system.

   h) Provide all touch panel layouts to Owner’s Representatives for review prior to the opening event.

   i) The touch panel programming will be reviewed after the Owner has used the room long enough to be more familiar with the systems and may require modification.

   j) Design the control system with opening page that requires users to enter a User ID or some form of password unless directed by the Owner’s Representatives otherwise.

   k) Provide a “Help” tab that is always available to presenters. It shall include contact information of an AV Technician or help desk and an IT Technician. Coordinate with Owner’s Representatives.

   l) Other functions as deemed appropriate through the Submittal process made part of this work.

3) Provide PoE+ Ethernet switches for control system communication, connecting selected equipment to the campus network and to supply power for the touch panel.
d. Sub-Systems

1) Hearing Assistance System
   a) Provide wireless, radio frequency Hearing Assistance Systems for the spaces.
   b) Provide receivers in quantity to comply with the Americans with Disabilities Act.
   c) Configure the system to use the channel that has the clearest audio for the area served.
   d) Configure the system so that each space uses different channel.
   e) Mount the antenna on the equipment rack.

e. Power Sequencing System

1) Provide an AC power sequencing system, as noted on the drawings and the equipment schedule, to control the turn-on and turn-off sequence of audio and video electronics to avoid damage and disturbance due to power transients.

2) Provide remotely controllable power modules that are integrated into the connection panels for the main loudspeakers, surround loudspeakers and subwoofer, and controlled by the AC power sequencer. Coordinate with EC for installation.

3) The system shall turn on power according to the following order:
   a) Source equipment
   b) Mixing and routing equipment
   c) DSP system
   d) Amplifiers and main loudspeakers

4) The system shall turn off power the reversed order.

5) The following equipment shall be excluded from the power sequencing system:
   a) Integrated Control System
   b) DSP's
   c) Ethernet switches

6) Submit drawing showing power sequence design for approval by Consultant.

7) Provide a fan-less uninterruptable power supply (UPS) for the following:
   a) DSP's
   b) Ethernet switches

3. Traditional Performance Space (132)

a. Audio System

1) Microphone and Accessories
   a) Provide a pair of microphones to support archival recordings for rehearsals, as well as input to the Hearing Assistance System. Mount the microphones on the dedicated junction boxes at the ceiling.
   b) Provide a dual channel microphone preamplifier for the ceiling microphones.
   c) Provide two channels of 2-way microphone splitter with Jensen isolation transformer for the ceiling microphones. The transformer isolated split
outputs shall be available at the rear of the room for connecting to brought-in recording equipment.

d) Provide a single channel wireless microphone system with lavaliere microphone to capture instructor’s voice for lecture capture system. Mount the antenna on equipment rack.

2) Audio Electronics

a) Provide an aux stereo audio inputs at the mobile lectern/podium to allow for portable equipment (N.I.C.) to be connected to the system.

b) Provide a USB audio interface to support lecture capture and live streaming.

1) The lecture capture and live streaming software will be provided, installed and configured by Owner.

2) Coordinate with owner Representatives for configuring the audio interface.

3) Provide a stereo audio interface inputs at the rear of the room to allow sending audio to live streaming from a brought-in mixer.

c) Main Digital Signal Processing (DSP) System

1) Provide programmable Digital Signal Processing System to serve the various systems with independent gain controls, signal delays, cross-over filtering, equalization, and level control for each loudspeaker group as indicated on the drawings, as required for system tuning. The various systems are as follow:

(a) Main Loudspeaker System
(b) Surround Loudspeakers
(c) Subwoofer
(d) Lecture Capture System
(e) Skype Audio Calls
(f) Hearing Assistance System

2) Include automatic gain control (AGC) for the wireless microphone in DSP programming.

3) Include a mixer to mix voice from the instructor and audio program played during the classes to send to the lecture capture software via the external USB audio interface.

4) Configure the DSP to use its built-in USB interface for Skype calls from the installed O.F.E. Mac mini.

5) The audio system shall be temporarily and automatically muted or disabled upon activation of fire alarm system, if required.

6) Refer to “Main Systems and Equipment” section for programming and other requirements.

d) Loudspeaker System

1) Main Loudspeakers

(a) Provide a main loudspeaker system that consists of two single-cabinet, full-rage, self-powered loudspeakers to
provide even coverage of sound pressure level for the room.

(b) Rig the loudspeakers from the Unistrut at the ceiling. Coordinate with other trades for structure support.

b. Video System

1) Video Electronics

a) Provide, in the mobile lectern/podium, a Blu-ray DVD player to support playback of pre-recorded materials for lecturers and presentations.
b) Provide a desktop document camera to support lectures.
c) Provide aux HDMI inputs at the mobile lectern/podium to allow for portable equipment (N.I.C.) to be connected to the system.
d) Coordinate with Owner Representatives to install an O.F.E. Mac mini in the wall-mounted pivoting rack.
e) Provide a HDMI signal extender for connecting the O.F.E. computer monitor on the mobile lectern/podium to the Mac mini.
f) Provide a webcam and a USB signal extender to support lecture capture and Skype video calls. Mount the webcam on the computer monitor. The lecture capture software will be provided, installed and configured by Owner.
g) Provide a HD PTZ camera at the rear of the room for live streaming, video recording and monitoring. The streaming software will be provided, installed and configured by Owner.
h) Provide a HDMI signal extender and a HDMI capture device for the PTZ camera to support live streaming. Coordinate with Owner Representatives for configuration.
i) Provide, at the mobile lectern/podium, an HDMI switcher for selecting playback sources.

(1) The switcher shall be HDCP compliant.
(2) The switcher shall be able to manage EDID communication between devices automatically.
(3) The switcher shall have a built-in DXLink output.
(4) Configure the switcher so that the output aspect ratio follows the aspect ratio of the input source.

j) Provide, at the wall-mounted pivoting rack, an AV presentation switcher/scaler for selecting playback sources and to convert video signals to the native resolution of the specified video projector.

(1) The switcher shall be HDCP compliant.
(2) The switcher shall be able to manage EDID communication between devices automatically.
(3) The switcher shall have built-in DXLink inputs and outputs.
(4) Configure the switcher so that the audio from HDMI inputs are de-embedded, and output stereo analog audio to the main DSP.
(5) Configure the switcher so that the audio switching follows the video switching.
(6) Configure the switcher output resolution and scanning frequency for maximum picture quality of the projector.
(7) Configure the switcher so that the output aspect ratio follows the aspect ratio of the input source.
8) The switch shall have built-in control system for controlling other AV equipment.

k) Provide an DXLink receiver at the projector to receive the video signal from the AV presentation switcher/scaler.

l) Coordinate with other trade and Owner Representatives for mounting equipment to the mobile lectern/podium provided by others.

2) Video Projection and Control

a) Provide a video projector, as specified in the Equipment Schedule, mounted to the ceiling of the adjacent Storage, to support rehearsals, lectures and performances. The projector shall...

1) ...be a lamp-free projector with laser illumination system.
2) ...have 1-chip DLP color system.
3) ...have native resolution of 1920x1080 or 1920x1200.
4) ...be capable of 7,500 ANSI lumens minimum output brightness.
5) ...have at least 10,000:1 contrast ratios with dynamic black.
6) ...be compatible with the following video signals:
   a) NTSC.
   b) HDTV formats of 1080p, 1080i, 720p, 480p and 480i.
   c) Computer video signals up to 1920x1200.
7) ...have HDMI input that is HDCP compliant.
8) ...have vertical lens shift and image flip functions that allow the projector to be used for ceiling mount rear projection application.
9) ...can be remotely controlled via Ethernet and RS-232 protocol.

b) Provide projector lenses according to Equipment Schedule. Verify correct lens model for throw distance and projected image size prior to purchase of lenses.

c) Prior to Acceptance Testing, adjust the video projector settings to optimize the image quality.

d) Provide a motorized front projection screen at the location as shown on drawings. Rig the screen from the Unistrut at the ceiling. Coordinate with other trades for structure support.

e) Controls of the projector and projection screen shall be via the integrated control system.

c. Integrated Control System

1) Provide an integrated control system capable of controlling all basic functions of audio and video equipment, including but not limited to: projector, projection screen, Blu-ray DVD player, presentation switchers, DSP and power sequencer for the audio and video systems, as well as room lighting system, curtains and window shades.

2) Provide a touch panel user interface on the mobile lectern/podium.

a) The panel shall have control function for the following:

1) System power on/off
2) Projector power on/off
(3) Projection screen up/down
(4) Playback source selection
(5) Blu-ray DVD player controls
(6) PTZ camera controls
(7) Volume and mute controls of the source equipment
(8) Mute volume and mute controls of the audio
(9) Streaming audio feeds control (mute/unmute DSP outputs to the audio interface)
(10) Room lighting on/off and dimming
(11) Window shades up/down
(12) Curtains deploy/store

b) Coordinate with the Owner Representatives regarding the University standard requirements of the control page design that are appropriate for the systems.
c) Coordinate with other trades for connecting and configuring controls of the room lighting system, window shades and curtains.
d) Use animation and graphics where are appropriate to create a clear and professional look and feel to the interface. Design all control pages such that the necessary signal routing to implement the various functions is transparent to the user.
e) All control functions available on the manufacturer’s standard handheld remote control should be available in some form via the integrated touch panel control system.
f) Use device control feedback whenever possible to give the user visual feedback that the control signal has been received and processed by the device.
g) Provide all touch panel layouts to Consultant for review prior to installing to the system.
h) Provide all touch panel layouts to Owner’s Representatives for review prior to the opening event.
i) The touch panel programming will be reviewed after the Owner has used the room long enough to be more familiar with the systems and may require modification.
j) Design the control system with opening page that requires users to enter a User ID or some form of password unless directed by the Owner’s Representatives otherwise.
k) Provide a “Help” tab that is always available to presenters. It shall include contact information of an AV Technician or help desk and an IT Technician. Coordinate with Owner’s Representatives.
l) Other functions as deemed appropriate through the Submittal process made part of this work.

3) Provide PoE+ Ethernet switches for control system communication, connecting selected equipment to the campus network and to supply power for the touch panel.

d. Sub-Systems

1) Hearing Assistance System

a) Provide wireless, radio frequency Hearing Assistance Systems for the spaces.
b) Provide receivers in quantity to comply with the Americans with Disabilities Act.
c) Configure the system to use the channel that has the clearest audio for the area served.
d) Configure the system so that each space uses different channel.
e) Mount the antenna on the equipment rack.

e. Power Sequencing System

1) Provide an AC power sequencing system, as noted on the drawings and the equipment schedule, to control the turn-on and turn-off sequence of audio and video electronics to avoid damage and disturbance due to power transients.

2) Provide remotely controllable power modules that are integrated into the connection panels for the main loudspeakers, surround loudspeakers and subwoofer, and controlled by the AC power sequencer. Coordinate with EC for installation.

3) The system shall turn on power according to the following order:

   a) Source equipment
   b) Mixing and routing equipment
   c) DSP system
   d) Amplifiers and main loudspeakers

4) The system shall turn off power the reversed order.

5) The following equipment shall be excluded from the power sequencing system:

   a) Integrated Control System
   b) DSP’s
   c) Ethernet switches

6) Submit drawing showing power sequence design for approval by Consultant.

7) Provide a fan-less uninterruptable power supply (UPS) for the following:

   a) DSP’s
   b) Ethernet switches

4. Composition / Piano Lab (380)

a. Audio System

1) Microphone and Accessories

   a) Provide a microphone at ceiling to support lecture capture, as well as input to the Hearing Assistance System.

2) Audio Electronics

   a) Provide an aux stereo audio inputs at the mobile lectern/podium to allow for portable equipment (N.I.C.) to be connected to the system.
   b) Provide a USB audio interface to support lecture capture.

   (1) The lecture capture software will be provided, installed and configured by Owner.
   (2) Coordinate with owner Representatives for configuring the audio interface.
c) Music Lab System

(1) The music lab system shall be provided and installed by others.
(2) Coordinate with Owner Representatives to connect the music lab system to the DSP.

d) Main Digital Signal Processing (DSP) System

(1) Provide programmable Digital Signal Processing System to serve the various systems with independent gain controls, signal delays, cross-over filtering, equalization, and level control for each loudspeaker group as indicated on the drawings, as required for system tuning. The various systems are as follow:

(a) Main Loudspeaker System
(b) Lecture Capture System
(c) Skype Audio Calls
(d) Hearing Assistance System

(2) Include automatic gain control (AGC) for the wireless microphone in DSP programming.
(3) Include a mixer to mix voice from the instructor and audio program played during the classes to send to the lecture capture software via the external USB audio interface.
(4) Configure the DSP to use its built-in USB interface for Skype calls from the installed O.F.E. Mac mini.
(5) The audio system shall be temporarily and automatically muted or disabled upon activation of fire alarm system, if required.
(6) Refer to "Main Systems and Equipment" section for programming and other requirements.

e) Loudspeaker System

(1) Main Loudspeakers

(a) Provide a main loudspeaker system that consists of two single-cabinet, full-range, self-powered loudspeakers to provide even coverage of sound pressure level for the room.
(b) Mount the loudspeakers to the front wall with wall brackets. Coordinate with other trades for structure support.

b. Video System

1) Video Electronics

a) Provide, in the mobile lectern/podium, a Blu-ray DVD player to support playback of pre-recorded materials for lecturers and presentations.

b) Provide a desktop document camera to support lectures.

c) Provide aux computer and HDMI inputs at the mobile lectern/podium to allow for portable equipment (N.I.C.) to be connected to the system.

d) Provide a webcam to support lecture capture and Skype video calls. Mount the webcam on the O.F.E. iMac monitor. The lecture capture software will be provided, installed and configured by Owner.
e) Provide, at the mobile lectern/podium, an AV presentation switcher/scaler for selecting playback sources and to convert video signals to the native resolution of the specified video projector.

(1) The switcher shall be HDCP compliant.
(2) The switcher shall be able to manage EDID communication between devices automatically.
(3) The switcher shall have a built-in DXLink output.
(4) Configure the switcher so that the audio from HDMI inputs are de-embedded, and output stereo analog audio to the main DSP.
(5) Configure the switcher so that the audio switching follows the video switching.
(6) Configure the switcher output resolution and scanning frequency for maximum picture quality of the projector.
(7) Configure the switcher so that the output aspect ratio follows the aspect ratio of the input source.
(8) The switch shall have built-in control system for controlling other AV equipment.

f) Provide an DXLink receiver at the projector to receive the video signal from the AV presentation switcher/scaler.

g) Coordinate with other trade and Owner Representatives for mounting equipment to the mobile lectern/podium provided by others.

2) Video Projection and Control

a) Provide a video projector, as specified in the Equipment Schedule, mounted to the ceiling of the adjacent Storage, to support rehearsals, lectures and performances. The projector shall...

(1) …be Epson Pro G series projector that is MU’s standard/preferred equipment.
(2) …have 3-chip LCD color system.
(3) …have native resolution of 1920x1080 or higher.
(4) …be capable of 5,500 ANSI lumens or higher output brightness.
(5) …be compatible with the following video signals:
   (a) HDTV formats of 1080p, 1080i, 720p, 480p and 480i.
   (b) Computer video signals up to 1920x1200.
(6) …have a HDMI input that are HDCP compliant.
(7) …have vertical lens shift and image flip functions.
(8) …can be remotely controlled via RS-232 protocol and Ethernet.

b) Prior to Acceptance Testing, adjust the video projector settings to optimize the image quality.

c) Provide a motorized front projection screen at the location as shown on drawings. Mount the screen to the ceiling. Coordinate with other trades for structure support.

d) Controls of the projector and projection screen shall be via the integrated control system.
c. Integrated Control System

1) Provide an integrated control system capable of controlling all basic functions of audio and video equipment, including but not limited to: projector, projection screen, Blu-ray DVD player, presentation switcher, DSP and power sequencer for the audio and video systems, as well as room lighting system and window shades.

2) Provide a touch panel user interface on the mobile lectern/podium.
   a) The panel shall have control function for the following:
      
      (1) System power on/off
      (2) Projector power on/off
      (3) Projection screen up/down
      (4) Playback source selection
      (5) Blu-ray DVD player controls
      (6) Volume and mute controls of the source equipment
      (7) Master volume and mute controls of the audio
      (8) Room lighting on/off and dimming
      (9) Window shades up/down

   b) Coordinate with the Owner Representatives regarding the University standard requirements of the control page design that are appropriate for the systems.

c) Coordinate with other trades for connecting and configuring controls of the room lighting system and window shades.

d) Use animation and graphics where are appropriate to create a clear and professional look and feel to the interface. Design all control pages such that the necessary signal routing to implement the various functions is transparent to the user.

e) All control functions available on the manufacturer's standard handheld remote control should be available in some form via the integrated touch panel control system.

f) Use device control feedback whenever possible to give the user visual feedback that the control signal has been received and processed by the device.

g) Provide all touch panel layouts to Consultant for review prior to installing to the system.

h) Provide all touch panel layouts to Owner’s Representatives for review prior to the opening event.

i) The touch panel programming will be reviewed after the Owner has used the room long enough to be more familiar with the systems and may require modification.

j) Design the control system with opening page that requires users to enter a User ID or some form of password unless directed by the Owner’s Representatives otherwise.

k) Provide a “Help” tab that is always available to presenters. It shall include contact information of an AV Technician or help desk and an IT Technician. Coordinate with Owner’s Representatives.

l) Other functions as deemed appropriate through the Submittal process made part of this work.

3) Provide a PoE+ Ethernet switch for control system communication, connecting selected equipment to the campus network and to supply power for the touch panel.
d. Sub-Systems

1) Hearing Assistance System
   a) Provide wireless, radio frequency Hearing Assistance Systems for the room.
   b) Provide receivers in quantity to comply with the Americans with Disabilities Act.
   c) Configure the system to use the channel that has the clearest audio for the area served.
   d) Configure the system so that each space within the project uses different channel.
   e) Mount the antenna on the dedicated wall panel.

e. Power Sequencing System

1) Provide an AC power sequencing system, as noted on the drawings and the equipment schedule, to control the turn-on and turn-off sequence of audio and video electronics to avoid damage and disturbance due to power transients.
2) Provide remotely controllable power modules that are integrated into the connection panels for the main loudspeakers, and controlled by the AC power sequencer. Coordinate with EC for installation.
3) The system shall turn on power according to the following order:
   a) Source equipment
   b) Mixing and routing equipment
   c) DSP system
   d) Amplifiers and main loudspeakers
4) The system shall turn off power the reversed order.
5) The following equipment shall be excluded from the power sequencing system:
   a) Integrated Control System
   b) DSP’s
   c) Ethernet switches
6) Submit drawing showing power sequence design for approval by Consultant.

5. Music Education Classroom (383) and Medium Classroom (385)

a. Audio System

1) Microphone and Accessories
   a) Provide a microphone at ceiling to support lecture capture, as well as input to the Hearing Assistance System.

2) Audio Electronics
   a) Provide an aux stereo audio inputs at the mobile lectern/podium to allow for portable equipment (N.I.C.) to be connected to the system.
b) Provide a USB audio interface to support lecture capture.

(1) The lecture capture software will be provided, installed and configured by Owner.
(2) Coordinate with owner Representatives for configuring the audio interface.

c) Main Digital Signal Processing (DSP) System

(1) Provide programmable Digital Signal Processing System to serve the various systems with independent gain controls, signal delays, cross-over filtering, equalization, and level control for each loudspeaker group as indicated on the drawings, as required for system tuning. The various systems are as follow:

(a) Main Loudspeaker System
(b) Lecture Capture System
(c) Skype Audio Calls
(d) Hearing Assistance System

(2) Include automatic gain control (AGC) for the wireless microphone in DSP programming.
(3) Include a mixer to mix voice from the instructor and audio program played during the classes to send to the lecture capture software via the external USB audio interface.
(4) Configure the DSP to use its built-in USB interface for Skype calls from the installed O.F.E. Mac mini.
(5) The audio system shall be temporarily and automatically muted or disabled upon activation of fire alarm system, if required.
(6) Refer to "Main Systems and Equipment" section for programming and other requirements.

d) Loudspeaker System

(1) Main Loudspeakers

(a) Provide a main loudspeaker system that consists of two single-cabinet, full-range, self-powered loudspeakers to provide even coverage of sound pressure level for the room.
(b) Mount the loudspeakers to the front wall with wall brackets. Coordinate with other trades for structure support.

b. Video System

1) Video Electronics

a) Provide, in the mobile lectern/podium, a Blu-ray DVD player to support playback of pre-recorded materials for lecturers and presentations.
b) Provide a desktop document camera to support lectures.
c) Provide aux computer and HDMI inputs at the mobile lectern/podium to allow for portable equipment (N.I.C.) to be connected to the system.
d) Coordinate with Owner Representatives to install an O.F.E. Mac mini in the mobile lectern/podium.
e) Provide a webcam to support lecture capture and Skype video calls. Mount the webcam on the computer monitor. The lecture capture software will be provided, installed and configured by Owner.

f) Provide, at the mobile lectern/podium, an AV presentation switcher/scaler for selecting playback sources and to convert video signals to the native resolution of the specified video projector.

   (1) The switcher shall be HDCP compliant.
   (2) The switcher shall be able to manage EDID communication between devices automatically.
   (3) The switcher shall have a built-in DXLink output.
   (4) Configure the switcher so that the audio from HDMI inputs are de-embedded, and output stereo analog audio to the main DSP.
   (5) Configure the switcher so that the audio switching follows the video switching.
   (6) Configure the switcher output resolution and scanning frequency for maximum picture quality of the projector.
   (7) Configure the switcher so that the output aspect ratio follows the aspect ratio of the input source.
   (8) The switcher shall have built-in control system for controlling other AV equipment.

g) Provide an DXLink receiver at the projector to receive the video signal from the AV presentation switcher/scaler.

h) Coordinate with other trade and Owner Representatives for mounting equipment to the mobile lectern/podium provided by others.

2) Video Projection and Control

a) Provide a video projector, as specified in the Equipment Schedule, mounted to the ceiling of the adjacent Storage, to support rehearsals, lectures and performances. The projector shall...

   (1) …be Epson Pro G series projector that is MU’s standard/preferred equipment.
   (2) …have 3-chip LCD color system.
   (3) …have native resolution of 1920x1080 or higher.
   (4) …be capable of 5,500 ANSI lumens or higher output brightness.
   (5) …be compatible with the following video signals:

      (a) HDTV formats of 1080p, 1080i, 720p, 480p and 480i.
      (b) Computer video signals up to 1920x1200.

   (6) …have a HDMI input that are HDCP compliant.
   (7) …have vertical lens shift and image flip functions.
   (8) …can be remotely controlled via RS-232 protocol and Ethernet.

b) Prior to Acceptance Testing, adjust the video projector settings to optimize the image quality.

c) Provide a motorized front projection screen at the location as shown on drawings. Mount the screen to the ceiling. Coordinate with other trades for structure support.

d) Controls of the projector and projection screen shall be via the integrated control system.
c. Integrated Control System

1) Provide an integrated control system capable of controlling all basic functions of audio and video equipment, including but not limited to: projector, projection screen, Blu-ray DVD player, presentation switcher, DSP and power sequencer for the audio and video systems, as well as room lighting system and window shades.

2) Provide a touch panel user interface on the mobile lectern/podium.

   a) The panel shall have control function for the following:

   (1) System power on/off
   (2) Projector power on/off
   (3) Projection screen up/down
   (4) Playback source selection
   (5) Blu-ray DVD player controls
   (6) Volume and mute controls of the source equipment
   (7) Master volume and mute controls of the audio
   (8) Room lighting on/off and dimming
   (9) Window shades up/down

   b) Coordinate with the Owner Representatives regarding the University standard requirements of the control page design that are appropriate for the systems.

   c) Coordinate with other trades for connecting and configuring controls of the room lighting system and window shades.

   d) Use animation and graphics where are appropriate to create a clear and professional look and feel to the interface. Design all control pages such that the necessary signal routing to implement the various functions is transparent to the user.

   e) All control functions available on the manufacturer’s standard handheld remote control should be available in some form via the integrated touch panel control system.

   f) Use device control feedback whenever possible to give the user visual feedback that the control signal has been received and processed by the device.

   g) Provide all touch panel layouts to Consultant for review prior to installing to the system.

   h) Provide all touch panel layouts to Owner’s Representatives for review prior to the opening event.

   i) The touch panel programming will be reviewed after the Owner has used the room long enough to be more familiar with the systems and may require modification.

   j) Design the control system with opening page that requires users to enter a User ID or some form of password unless directed by the Owner’s Representatives otherwise.

   k) Provide a “Help” tab that is always available to presenters. It shall include contact information of an AV Technician or help desk and an IT Technician. Coordinate with Owner’s Representatives.

   l) Other functions as deemed appropriate through the Submittal process made part of this work.
3) Provide a PoE+ Ethernet switch for control system communication, connecting selected equipment to the campus network and to supply power for the touch panel.

d. Sub-Systems

1) Hearing Assistance System
   a) Provide wireless, radio frequency Hearing Assistance Systems for the room.
   b) Provide receivers in quantity to comply with the Americans with Disabilities Act.
   c) Configure the system to use the channel that has the clearest audio for the area served.
   d) Configure the system so that each space within the project uses different channel.
   e) Mount the antenna in the podium rack.

e. Power Sequencing System

1) Provide an AC power sequencing system, as noted on the drawings and the equipment schedule, to control the turn-on and turn-off sequence of audio and video electronics to avoid damage and disturbance due to power transients.
2) Provide remotely controllable power modules that are integrated into the connection panels for the main loudspeakers, and controlled by the AC power sequencer. Coordinate with EC for installation.
3) The system shall turn on power according to the following order:
   a) Source equipment
   b) Mixing and routing equipment
   c) DSP system
   d) Amplifiers and main loudspeakers
4) The system shall turn off power the reversed order.
5) The following equipment shall be excluded from the power sequencing system:
   a) Integrated Control System
   b) DSP’s
   c) Ethernet switches
6) Submit drawing showing power sequence design for approval by Consultant.

C. Additive Alternates

1. Video Projection System for Large IRR (130)
   a. Video Electronics
      1) Provide a desktop document camera to support lectures.
      2) Provide a signal extender to route HDMI signal from the equipment rack to the projector.
b. Video Projection and Control

1) Provide a video projector, as specified in the Equipment Schedule, mounted on the rear wall, to support rehearsals and lectures. The projector shall...

   a) ...be a lamp-free projector with laser illumination system.
   b) ...have 1-chip DLP color system.
   c) ...have native resolution of 1920x1080 or 1920x1200.
   d) ...be capable of 7,500 ANSI lumens minimum output brightness.
   e) ...have at least 10,000:1 contrast ratios with dynamic black.
   f) ...be compatible with the following video signals:

      (1) NTSC.
      (2) HDTV formats of 1080p, 1080i, 720p, 480p and 480i.
      (3) Computer video signals up to 1920x1200.

   g) ...have HDMI input that is HDCP compliant.
   h) ...have vertical lens shift and image flip functions that allow the projector to be used for ceiling mount rear projection application.
   i) ...can be remotely controlled via Ethernet and RS-232 protocol.

2) Provide projector lenses according to Equipment Schedule. Verify correct lens model for throw distance and projected image size prior to purchase of lenses.

3) Prior to Acceptance Testing, adjust the video projector settings to optimize the image quality.

4) Provide a motorized front projection screen at the location as shown on drawings. Mount the screen to the wall. Coordinate with other trades for structure support.

5) Controls of the projector and projection screen shall be via the integrated control system.

2. Loudspeaker System for Large IRR (130)

a. Audio Electronics

1) Provide a surround sound processor to support playback of audio and audio-for-video materials that are produced for 5.1 surround sound playback using the Blu-ray DVD player.

   a) The surround sound processor shall support DTS-HD Master Audio™, Dolby® TrueHD, and Dolby Digital® Plus decoding.
   b) The surround sound processor shall have a HDMI input that is HDCP compliant.
   c) The surround sound processor shall have six channels of discrete, balanced analog surround audio outputs.

2) Provide a Dante network audio enabled DSP for signal routing and processing for additional audio channels for the system.

3) Provide an Ethernet switch that is dedicated for the Dante network audio transmission.

   a) The Ethernet switch shall be a managed switch that supports 10/101/1000 Ethernet standard.
   b) The Ethernet switch shall have fiber-optic interfaces.
The Ethernet switch shall have features including VLANs (Virtual Local Area Network), QoS (Quality of Service) with DSCP, Multicast Filtering and STP (Spanning-Tree Protocol).

d) Configure the Ethernet switch according to the manufacturer’s recommendations for Dante network audio.

b. Loudspeaker

1) Provide the following loudspeakers to support 5.1 surround sound playback.

a) A single-cabinet full-range self-powered loudspeaker for center channel playback. Mount the loudspeaker to the wall with wall bracket. Coordinate with other trades for structure support.

b) Two single-cabinet full-range self-powered loudspeakers at the rear of the room for surround channels playback. Mount the loudspeakers to the side walls with wall brackets. Coordinate with other trades for structure support.

c) A self-powered subwoofer to provide low frequency extension for the loudspeaker system. Place the subwoofer on the floor near the AV rack.

3. Loudspeaker System for Traditional Performance Space (132)

a. Audio Electronics

1) Provide a surround sound processor to support playback of audio and audio-for-video materials that are produced for 5.1 surround sound playback using the Blu-ray DVD player.

a) The surround sound processor shall support DTS-HD Master Audio™, Dolby® TrueHD, and Dolby Digital® Plus decoding.

b) The surround sound processor shall have a HDMI input that is HDCP compliant.

c) The surround sound processor shall have six channels of discrete, balanced analog surround audio outputs.

2) Provide a Dante network audio enabled DSP for signal routing and processing for additional audio channels for the system.

3) Provide an Ethernet switch that is dedicated for the Dante network audio transmission.

a) The Ethernet switch shall be a managed switch that supports 10/100/1000 Ethernet standard.

b) The Ethernet switch shall have fiber-optic interfaces.

c) The Ethernet switch shall have features including VLANs (Virtual Local Area Network), QoS (Quality of Service) with DSCP, Multicast Filtering and STP (Spanning-Tree Protocol).

d) Configure the Ethernet switch according to the manufacturer’s recommendations for Dante network audio.
b. Loudspeaker

1) Provide the following loudspeakers to support 5.1 surround sound playback.

   a) A single-cabinet full-range self-powered loudspeaker for center channel playback. Rig the loudspeaker from the Unistrut at the ceiling. Provide additional Unistrut and accessories as necessary.

   b) Two single-cabinet full-range self-powered loudspeakers at the rear of the room for surround channels playback. Rig the loudspeakers from the Unistrut at the ceiling. Provide additional Unistrut and accessories as necessary.

   c) A self-powered subwoofer to provide low frequency extension for the loudspeaker system. Place the subwoofer on the floor near the AV rack.

4. Audio System for Traditional Performance Space (132)

a. Provide the following equipment to support live sound mixing and reinforcement:

   1) A four-channel wireless microphone system with ear-set microphones. Mount the receivers in a portable rack to be used at the rear of the room.

   2) A digital audio mixing system

      a) The system shall be capable of digital 24-bit processing, 48 kHz sample rates and is designed for live applications.

      b) The system shall include 16 channels of analog mic/line inputs and 16 channels of analog outputs; as well as 2 channels of AES I/O.

      c) The system shall include 16 channels of recallable microphone preamplifiers.

      d) Processors of each channel shall include compressors, gates, parametric EQ, high pass filter and delay.

      e) The system shall have expansion I/O options to allow for connecting to other digital audio systems.

      f) Include a Dante networked audio card for the mixer.

      g) The mixing system shall include MIDI interface. It shall be possible to use MIDI extender, utilizing category cables (MIDI extender N.I.C.), to send and receive MIDI messages between the mixing system and MIDI capable equipment.

   3) An Ethernet switch that is dedicated for the Dante network audio transmission.

      a) The Ethernet switch shall be a managed switch that supports 10/100/1000 Ethernet standard.

      b) The Ethernet switch shall have fiber-optic interfaces.

      c) The Ethernet switch shall have features including VLANs (Virtual Local Area Network), QoS (Quality of Service) with DSCP, Multicast Filtering and STP (Spanning-Tree Protocol).

      d) Configure the Ethernet switch according to the manufacturer’s recommendations for Dante network audio.

b. Provide a fan-less uninterruptable power supply for the digital mixing console.
5. Wireless Microphone System for Classrooms (380, 383 & 385)
   a. Provide a single channel wireless microphone system with lavaliel microphone to capture instructor’s voice for lecture capture system.
   b. Include automatic gain control (AGC) for the wireless microphone in DSP programming.
   c. Include a mixer to mix voice from the instructor and audio program played during the classes to send to the lecture capture software via USB audio interface.

6. Meeting Room (201)
   a. Provide a flat panel video display, as specified in the Equipment Schedule to support meetings.
      1) The video display shall have native resolution of 1920x1080; and have at least two HDMI inputs that are HDCP compliant.
      2) Mount the video display on the east wall. Coordinate with other trades for installation and structure support.
   b. Provide the following equipment in the credenza (by others):
      1) A Blu-ray DVD player to support playback of pre-recorded materials. Controls of the Blu-ray DVD player shall be using the front panel of the player and the IR remote included with the unit.
      2) A presentation gateway to support wired or wireless transmission of audio and video via campus network.
      3) A HDMI switcher for playback source switching.
      4) A signal extender to transmit HDMI video signal to the video display.
      5) An Ethernet switch for connecting the Blu-ray player and the presentation gateway to the campus network.
   c. Coordinate with Owner Representatives to install an O.F.E. Mac mini behind the video display.
   d. Provide a USB camera to support Skype video calls. Mount the camera at the top of the video display.
   e. Provide a computer speakerphone set to support Skype audio and video calls.
   f. Provide a USB extender in the floor box for connecting the computer speakerphone and other brought-in USB computer peripherals to the O.F.E. Mac mini. Supply power to both USB 3.0 extender transmitter and receiver using their own external power supplies.
   g. Coordinate with Owner’s Representatives and other trades to install the equipment in the owner furnished credenza, as well as power and cabling to the credenza.

PART 2 - PRODUCTS

2.1 GENERAL

A. Refer to “Equipment Schedule.” The specific products listed in the Equipment Schedule and/or shown on the drawings represent the Design Basis for the described systems. Substitutions for specific equipment will be considered only according to the conditions listed herein in the “Quality Assurance” section, and, according to any additional conditions set forth in Division 1 of the Specification.
B. Refer to "System Description", herein, and Contract Drawings and manufacturers’ manuals for certain product use, assembly and mounting information.

C. For required incidental and miscellaneous products not listed in the “Equipment Schedule”, the Audio Systems Contractor shall select products that satisfy the Contract Documents including “System Descriptions”, “Performance Requirements”, Drawings and general product descriptions that follow.

D. Incidental wording of this section shall not be construed to diminish product quantities indicated by the Equipment Schedule or other Contract Documents.

2.2 MAIN SYSTEMS AND EQUIPMENT

A. Equipment Schedule

1. See Appendix A for equipment schedule.

B. Audio Equipment

1. Microphone and Accessories
   a. Wireless Microphone Receiver (UHF):
      1) Confirm with manufacturer, frequencies appropriate for use in the project geographical area. Determine antenna splitter model per these frequency ranges.

2. Digital Signal Processing (DSP)
   a. Refer to “System Description” section herein for additional information.
   b. Design complete signal-processing system utilizing virtual audio processing objects, within the DSP platform, to implement a fully functional system according to this specification, the drawings and the equipment schedule.
   c. Submit DSP system design to Consultant for approval.
   d. Program DSP with distribution and processing objects to implement a fully functioning system. Specifically, but not exclusively:
      1) Main Loudspeakers and Surround Loudspeakers
         a) If applicable, include dedicated signal delays, gain controls, level controls and parametric equalizers, to implement manufacturer’s specifications for signal processing unique to the actual loudspeakers.
         b) Include independent high-pass filters, signal delays, gain controls, parametric equalizers (typically 10-band), et cetera, as required for system tuning.
         c) Include limiters for protection of loudspeaker components.
      2) Subwoofer
         a) If applicable, include dedicated signal delays, gain controls, level controls and parametric equalizers, to implement manufacturer’s specifications for signal processing unique to the actual loudspeakers.
         b) Include a high-pass filter.
c) Include independent signal delays, gain controls, parametric equalizers (typically 5-band), et cetera, as required for system tuning.
d) Include limiters for protection of loudspeaker components.

3) Hearing Assistance System

a) Include signal routing and gain controls.
b) Include compression, equalization and delay.

e. Configure the DSP power up mode to resume last known state.
f. Install DSP control software on an owner furnished computer dedicated to user control of the DSP system if requested to do so.
g. For Acceptance Testing, provide a portable computer and cabling to control the DSP system from the in-house mix position at each space.

3. Loudspeakers

a. Aim the loudspeakers according to the drawings. Allow for convenient minor adjustment of the angles indicated on the drawings.
b. Provide rigging/mounting suitable for hanging the loudspeakers while maintaining aim of the loudspeakers according to drawings. Provide substructure to support the rigging of the loudspeakers as needed. Design rigging to allow for convenient maintenance, repair and replacement of loudspeakers without disturbing loudspeaker aim. Submit shop and field drawings. (Refer to "Submittals" section of this document.
c. Rigging/Mounting must not touch building structure in any way that produces audible vibrations when the audio system is in use. Submit shop and field drawings according this Specification.

4. Hearing Assistance System

a. Verify with owner representatives if there are any existing RF Hearing Assistance Systems in the building.
b. Coordinate channel assignments for each space with owner representatives.
c. Inform Owner and Consultant if changing the system with different frequency band for selected spaces is required to avoid interference.

2.3 RECEPTACLES

A. General

1. Use specified brand and type or approved equal.
2. For each receptacle-type, use same make and model throughout the project.
3. Provide connector colors as listed in the schedule.
4. Use termination types listed:
   a. Single circuit audio signal cabling shall use soldered connections; crimp down, or other terminations not acceptable.
   b. On multi-channel audio cabling, using high-density connectors, crimp connections are preferred for convenience of maintenance.
   c. Single circuit video signal cabling shall typically use crimp connections terminated with appropriate, manufacturer recommended crimp equipment.
5. For soldered connections, use solder containing at least 2% silver.
6. For crimp connections, use appropriate, manufacturer recommended crimp equipment, used by trained and experienced personnel.

B. Audio Receptacles

1. Portable Cabling:

   a. All portable cabling shall be of appropriate high-quality professional heavy-duty grade.
   b. In-line connectors:

      1) XLR: use Neutrik, Switchcraft or ITT/Cannon Digital XLR series.
      2) RCA: use 75 ohm impedance connectors, for male use Neutrik Profi (soldered), Canare RCAP-C series or ADC CRCA series.
      3) BNC: use true 75 ohm impedance connectors by Canare, Neutrik, Belden, ADC or Kings.
      4) Multipin: (also see Drawings)

         a) For audio: use Whirlwind, Radial or ITT/Cannon Mass Connectors as indicated on the drawings.
         b) For audio, video and data combines: use Wireworks AV-2000 series connectors with 'Broadway' BLS latching mechanism.

2. Microphone:

   a. Use soldered connections; 3-pin or Elco/EDAC only; crimp down, direct to PCB, punchdown or other terminations not acceptable.
   b. Microphone female chassis-mount connector:

      2) Black Shell: Neutrik NC3FD-L-B-1 (gold).

   c. Microphone male chassis-mount connector:

      1) Nickel shell: NC3MD-L-1 (silver).
      2) Black shell: Neutrik NC3MD-L-B-1 (gold).

3. Tie Lines:

   a. Use soldered connections; crimp down, direct to PCB, or other terminations not acceptable.
   b. Female chassis-mount connector:

      2) Black Shell: Neutrik Combo NCJ6FI-S-B (gold).

   c. Male chassis-mount connector:

      1) Nickel Shell: Neutrik NC3MD-L-1 (silver).
      2) Black Shell: Neutrik NC3MD-L-B-1 (gold).


   a. Use soldered connections; crimp, direct to PCB, or other terminations not acceptable.
1) For stereo pairs use connector with red color ring for the right channel and white color ring for the left channel.
2) For mono connectors use connector with black color ring.

5. Unbalanced “Auxiliary In” female 3.5mm stereo mini-jack: DGS Pro-Audio (Mouser Electronics Stock #161-3502). Use soldered connections, crimp down, direct to PCB, or other terminations not acceptable.

6. Intercom male chassis-mount connector:
   a. Use soldered connections; crimp down, direct to PCB, or other terminations not acceptable.
      1) Nickel Shell: Neutrik NC3MD-L-1 (silver).
      2) Black Shell: Neutrik NC3MD-L-BAG-1 (silver).

7. Loudspeaker Receptacles: Neutrik NL4MP-UC.

8. Stage-boxes for tie lines and microphones shall be furnished with pairs of XLR-F and XLR-M, as listed above, wired in parallel.

9. Multi-pin connectors:
   a. Audio only:
      1) Use Whirlwind, Radial or ITT/Cannon Mass Connectors as indicated on the drawings.
      2) Provide hinged-mounds for connectors where shown on the panel elevations.
   b. Video-only or with audio combined:
      1) Use Wireworks AV-2000 series connectors as shown in the Drawings.
      2) Provide connectors with “Broadway Latching System” (BLS) option.

10. Panel color coordination:
    a. Use brushed ‘steel’ color connectors on white and steel color AV panels.
    b. Use black anodized connectors (if available) for black color AV panels.

C. Video and RGBx:
    1. BNC bulkhead connectors: Neutrik, Kings, Canare or Belden 75 ohm impedance, isolated-ground connectors.
    2. BNC chassis-mount connector: Neutrik, Kings or Canare 75 ohm impedance, isolated-ground connectors.
    3. Inline: Neutrik, Kings or Canare 75 ohm impedance connectors, crimped.

D. AV Data:
    1. Cat 6A RJ-45 data chassis-mount connectors: Neutrik EtherCon CAT6A chassis connectors.
    2. Cat 6 RJ-45 data chassis-mount connectors: Neutrik EtherCon CAT6 chassis connectors.
    3. Cat 5e RJ-45 data chassis-mount connectors: Neutrik EtherCon D series or Amphenol Audio D series chassis connectors.

E. Fiber Optic:
    1. Two-channel chassis-mount connectors: Neutrik opticalCON DUO chassis connectors.
    2. Four-channel chassis-mount connectors: Neutrik opticalCON QUAD chassis connectors.
CABLES

A. Use specified brand and type or approved equal. See Equipment Schedule for approved permanent installation cables.

B. Plenum rated cables shall be used per NEC Article 300.22 in any space above the ceiling tile system or other concealed if it is an environmental air space.

C. For each cable-type, use same make and model throughout the project.

D. Refer to “Cable and Conduit Anomaly Notes” at the end of this Specification, if any.

E. Audio Cables

1. Individual and multi-pair microphone and line-level shielded-pair cable in conduit and racks: #24 AWG (or larger) stranded conductors, 110 ohm, AES3-rated, low capacitance (13 pf/ft. between conductors or better).

2. Individual and multi-pair microphone and line-level shielded-pair cable for portable cable, including snakes: #24 AWG stranded conductors, 110 ohm, AES3-rated, low capacitance; Belden 1800F, Gepco DS401M, Mogami W3080 or W3135, or approved equal.
   a. Cable must be constructed for portable use and high-flexibility.
   b. Black jackets only.

3. Intercom cables in conduit:
   a. For runs under 500 ft.: #20 AWG (or larger) stranded conductors; 100% aluminum polyester foil shielding; PVC jacket.
   b. For runs greater than 500 ft.: #18 AWG (or larger) stranded conductors; 100% aluminum polyester foil shielding; PVC jacket.
   c. Verify with production intercom system manufacturer for recommended cables.

4. Individual and multi-pair intercom cable for portable cable: #24 AWG (or larger) stranded conductors, 100% aluminum polyester foil shielding; Belden 8413 or 8412, Gepco MP1022 or M1042, Sheer Wire SMR202, or approved equal.
   a. Cable must be constructed for portable use and high-flexibility.
   b. Black jackets only.

5. Loudspeaker cables in conduit:
   a. All loudspeaker cable must include twisted pair construction. Non-twisted conductors are not acceptable.
      1) Main Loudspeaker Cable: #10 AWG, twisted-pair. Use also as trunk feed to branches of low-impedance loudspeakers.
      2) Effects/Stage-monitor Loudspeakers: #12 AWG, twisted-pair.
      3) Monitor/Page Loudspeaker Cable in the public spaces and backstage areas: #14 AWG, twisted-pair wire.

6. Individual and multi-pair loudspeaker twisted-pair cable for portable use, including snakes: #12 AWG, twisted-pair wire; Belden, Gepco GSC, West Penn, or approved equal.
   a. Cable must be constructed for portable use and high-flexibility.
   b. Black jackets only.
7. Lines dropped to permanently mounted loudspeaker:
   a. Lines in conduit may be extended to loudspeakers if sheathed in black where visible to public. Absent sheathing, provide extra-flexible portable cordage and black neoprene, rubber or PVC jacket.
   b. Harness all lines for a neat installation, leaving a service loop at each termination facilitating servicing loudspeakers.

8. AVC may pursue multi-pair versions of cabling for convenience of cable-pull and termination for point-to-point connections only observing cable dressing requirements specified herein.

9. Color-Coding Required: All microphone and line-level cable should be color coded with distinct colors for each signal type based on the following list: (color coding may require that multiple cable types be used)
   a. Microphone circuits
   b. Audio Tie-lines (undedicated)
   c. Line-level feeds, system feeds and installed equipment interconnection
   d. Intercom and Monitor/Page system interconnection
   e. AES clock interconnection.

F. Video Cables

1. The permanent installed precision video cables shall be precision 75 ohm impedance, and consist of solid copper center conductor and gas-injected foam dielectric, full copper braid and foil shield with PVC jacket. The cables shall be compliant with SMPTE 292M and 424M 2.97 Gb/sec. specifications.
   a. For runs up to 230 feet: #18 AWG (or larger), RG-6/U type, low attenuation (5.0 dB/100’ or less at 750 MHz; and 7.3 dB/100’ or less at 1.5 GHz) and low return loss.
   b. For runs up to 300 feet: #16 AWG (or larger), RG-7/U type, low attenuation (4.2 dB/100’ or less at 750 MHz; and 6.1 dB/100’ or less at 1.5 GHz) and low return loss).
   c. For runs up to 370 feet: #14 AWG (or larger), RG-11/U type, low attenuation (3.7 dB/100’ or less at 750 MHz; and 5.5 dB/100’ or less at 1.5 GHz) and low return loss.

2. Color-Coding Required: All video cable should be color coded with distinct colors for each signal type based on the following list: (color coding may require that multiple cable types be used)
   a. Video/MADI Tie-lines within functional zones (undedicated)
   b. Video/MADI Tie-lines between functional zones (undedicated)
   c. Video cables between installed equipment
   d. Video Black Burst
   e. Word Clock
   f. Dedicated MADI connection.

G. Optical Fiber

1. The permanent installation optical fiber cables shall be compliant with or exceed the latest ANSI/TIA/EIA and ISO/IEC standards.
H. Antenna Cables

1. Wireless RF transmission cable in conduit: #10AWG, RG8/U type, precision 50 ohm impedance, solid copper or copper-covered aluminum center conductor, gas-injected foam dielectric, full copper braid and foil shield with PVC jacket.

I. Category Cables

1. The permanent installation Category cables shall be compliant with or exceed the latest ANSI/TIA/EIA standard.
   a. Shielded Category 6 F/UTP cables in conduit: #23 AWG, 4-pair solid bare copper conductors, overall foil shielded with PVC jacket, CMR rated cables. Comply with or exceed ANSI/TIA/EIA 568C.2 Category 6 specification. Suitable for gigabit Ethernet, digital and analog video, HDBaseT, networked audio and AES/EBU applications.
   b. Category 6 UTP cables in conduit: #23 AWG, 4-pair solid bare copper conductors, unshielded with PVC jacket, CMR rated cables. Comply with or exceed ANSI/TIA/EIA 568C.2 Category 6 specification. Suitable for gigabit Ethernet, digital and analog video, networked audio and AES/EBU applications.
   c. Category 5e UTP cables in conduit: #24 AWG, 4-pair solid bare copper conductors, unshielded with PVC jacket, CMR rated cables. Comply with or exceed ANSI/TIA/EIA 568C.2 Category 5e specification. Suitable for gigabit Ethernet, digital and analog video, networked audio and AES/EBU applications.

J. DC Control Cables

1. Provide multi-conductor, stranded cable as necessary according to good engineering practice.

K. Serial Data Cables

1. Provide stranded shield-pair cable as necessary according to good engineering practice. Verify cable type to be adequate for length of signal run.

2.5 MISCELLANEOUS EQUIPMENT

A. General

1. Install patch-cord holders near all patchbays at fixed rack locations.
2. Provide security covers over all equipment with front panel controls intended for semi-fixed settings and not capable of software security.
3. Provide foam padding for the rack drawers where microphones are stored.

B. Panels

1. Maintain a uniform appearance of panels throughout the project. Specifically, but not exclusively, use this guideline if panels are fabricated by multiple manufacturers.
2. Fabricate AV panels and other device boxes cover plates from 5052-H32 or 6061-T6 aluminum sheet no less than 0.090” thick for standard “ganged” outlet boxes of three gangs or less, and not less than 0.120” elsewhere.
3. Aluminum panels:
   a. For black aluminum panels, grain on horizontal axis and anodize.
   b. Finish in epoxy-based paint only if directed by, and to color approved by Architect.
4. Engrave all nomenclature and graphics.
   a. If mill engraved, ink-fill.
   b. If laser engraved, submit sample of text color versus background.

5. Provide panel colors (and connector colors, see elsewhere herein) according to the schedule. The color combinations are:
   a. Black panel, white lettering – generally in stage areas and in the audience chamber, and on equipment racks
   b. Brushed steel (or aluminum), clear coated, with black lettering - generally in public spaces (confirm with architect).
   c. See also panel schedule at EA drawings.
   d. Use black connectors at black panels, brushed nickel connectors at white and steel color panels (if applicable; for instance, video bulkhead only come in brushed nickel, but XLR connectors come in black and brushed nickel).

6. Contractor may submit plastic strata for approval.
   a. Gravoglass 2-plex or Gravograph Ultra panels of 1.5 mm thickness are acceptable.
   b. For these panels, use 14 Ga steel as substrate panel.
   c. Use glue recommended by the manufacturer.

7. See Submittals for submission of one panel of each color combination for approval.

C. Equipment Racks

1. Provide internal 120 V.A.C. wiring and power outlets as required for equipment and such as not to overload branch circuits.
2. Fill all unused panel spaces with blank solid or vent panels, shelves and drawers where indicated on the drawings. Observe cooling and ventilation requirements of surrounding equipment for choice of panel.
3. Use tamper-proof rack screws: Lowell SRV (or equivalent).
4. Provide adequate service loop (minimum 5'-0") and strain relief for installed cabling to equipment racks. Maintain separation of signal types when routing and bundling cable from pull boxes to the racks.
5. Use Velcro for cable dressing, Tie-wraps are specifically prohibited.
6. Fixed-in-Place Equipment Racks:
   a. Provide filtered, ventilation fan panels for each equipment rack in the Amplifier Rack Room.
   b. Locate racks so that equipment may be operated from the front and serviced from the rear without moving the racks (as conduits shall render them immovable).
      1) Wherever possible, install racks with a minimum of 36" clear in front and behind. Do not install with less than 30" in front and behind prior to seeking direction from Architect and Consultant.
   c. Carefully coordinate with Electrical Contractor to assure conduit entries into racks occur at appropriate locations on racks.
   d. Provide sides, doors and tops.
   e. Provide hinged and lockable back panels for all racks.
f. Seal, where appropriate, openings to racks to ensure that no false air is pulled or pushed by ventilation system, whether furnished as a separate item, or as part of the internal ventilation of furnished equipment.

g. Provide patch-cord and cable holders at each (bank of) equipment rack(s).

7. Mobile Equipment Racks and Podium/Lecterns:

   a. Bundle the umbilical cord cables. Wrap the umbilical cord with braided sleeving or use custom armored multi-cable.

PART 3 - EXECUTION

3.1 PERFORMANCE REQUIREMENTS

A. General

   1. Certain of the AV System's overall performance requirements may be checked readily by measurement.

   2. The systems included in this work, as designed, are expected to meet the functional requirements stated hereinafter, based upon available data and the manufacturers' published specifications.

   3. During the Bid Phase, the Contractor shall have made himself familiar with the System Description stated hereinbefore, the overall system requirements and the capabilities of specified equipment.

   4. The functional requirements stated hereinafter shall be used as a basis for evaluating requested substitutions and performing initial testing and tuning.

   5. The contractor shall report obvious errors in the Contract Documents wherein such errors would preclude the possibility of fulfilling the functional requirements.

   6. Aspects of the design which can only be verified by measurement of installed systems are not subject to reporting requirements. (However, the contractor is urged to share any concerns regarding the suitability of systems).

   7. Upon award, Contractor shall provide labor, and major and incidental equipment and materials, required to provide complete and operating systems according to the design and the intent of the stated functional requirements.

B. Frequency Response and Sound Output:

   1. Measure with “tone” controls set for flat response, using broadband calibrated pink noise applied to any microphone input for speech system or auxiliary line input for stereo system, measuring in specified bands using real-time analyzer or using specified bands of filtered pink noise centered on ANSI preferred frequencies, measuring with sound level meter.

   2. Measure system acoustical performance using a calibrated real-time analyzer or an ANSI Standard Type 1 or IEC Precision Sound Level Meter set for “slow” meter damping and flat response at normal incidence, at a height of 4 feet and pointed at the loudspeakers. All interior finishes and furnishings shall be in place, and system gain shall be adjusted to provide levels of 70 to 85 dB during normal operation at the measuring locations for these tests, unless otherwise noted herein.

   3. Unless restricted by the published specifications of a particular piece of equipment, or unless otherwise required by these Specifications, the following performance standards shall be met by each system:

      a. Set system gain to provide 75 to 85 dB SPL in measurement area during frequency response adjustments.
b. Loudspeaker Systems in theatres working in consort: with respect to a response which is flat (0 dB) from 80 to 3,150 Hz, -1 dB at 4,000 Hz, and decreases 1 dB per one-third-octave band thereafter to -6 dB at 12,500 Hz, system response in one-third-octave bands averaged over at least six locations throughout the audience shall be adjusted to be within ±3 dB. All loudspeakers work together.

c. Loudspeaker Systems in the backstage areas and public spaces: with respect to a response which is flat (0 dB) from 150 to 2,000 Hz, -4 dB at 4,000 Hz, and -8½ dB at 8,000 Hz, system response in octave bands averaged over at least three locations distributed throughout the areas served shall be adjusted to be within ±3 dB.

d. Sound Output Capability: Systems shall be capable of producing peak program levels as specified below throughout the area served without objectionable distortion, buzz, or rattle, employing as test signals several samples of recorded speech and music.

1) Performance Spaces, loudspeakers working together: 98 dB.
2) Instructional Spaces, Loudspeaker Systems: 86 dB.

4. Electrical performance for Sound Reinforcement Systems:

a. Frequency Response shall be +0 dB, -0.5 dB from 20 to 20,000 Hz for any individual electronic component.

b. Signal to Noise Ratio shall be 80 dB minimum from 20 to 20,000 Hz for any individual electronic component.

c. Crosstalk shall be better than -60 dB from 20 to 15,000 Hz, better than -55 dB at 20,000 Hz, between adjacent channels for any individual electronic component.

d. Total Harmonic Distortion shall be less than 0.30% from 20 to 20,000 Hz for any individual power amplifier operating at rated power; less than 0.10% from 20 to 20,000 Hz for any other electronic audio component driven at maximum rated input.

e. Hum and Noise:

1) With building air-handling systems operating, hum and noise shall be inaudible at normal gain settings
2) Measured at amplifier outputs: -80 dB or better relative to rated maximum amplifier output, with minimum of six inputs, master set at normal operating levels.

f. Feedback Stability Margin:

1) Adjust all systems for optimum feedback stability margin.

g. Audio-for-Video Systems:

1) Audio Frequency Response: 50 Hz-15 kHz 0, +3 dB.
2) Audio Wow and Flutter: 0.005% Wrms.

5. Electrical performance of NTSC Video Systems:

a. S/N (peak to RMS) unweighted dc to 4.2 MHz; 55 dB minimum.

b. Crosstalk, unweighted dc to 4.2 MHz; 45 dB minimum.

c. Frequency Response: within + 0.5 dB to 4.2 MHz.

d. Line and Field Tilt 2% maximum.

e. Differential Gain 3% maximum.

f. Differential Phase 2 degrees maximum.
6. Performance Test Signal Paths:
   a. Audio:
      1) Test from all source inputs (for microphones, audio tape units, et cetera) through all mixers, amplifiers, et cetera, to all signal destinations.
   b. Video:
      1) Test from all source inputs (for cameras, video tape units, et cetera) through all video distribution amplifiers, processors, switchers, et cetera.
   c. Delineation of above signal paths shall not exempt Contractor from the responsibility of checking all paths and outlets for appropriate compliance with Performance Requirements.

3.2 INSTALLATION

A. General
   1. Install equipment with all precautions necessary to prevent and guard against electromagnetic and electrostatic hum, to assure adequate ventilation, and to provide for safety of users.
   2. Employ the latest and safest techniques throughout the installation.
   3. Perform all work in strict conformance with the highest industry and craftsmanship standards. The following shall serve as guidelines:
      a. Current broadcast standards;
      b. Current recording studio practice and techniques outlined in:
         5) "AV Design Reference Manual" by Bicsi & ICIA.
         6) "Video Demystified, 4th Edition" by Keith Jack.
   4. Install all equipment neatly, plumb, square and true to line and level except as necessary for loudspeaker or microphone aiming.
   5. At Owner’s discretion, repair or reimburse Owner for damage caused by any action of Contractor’s employees or resulting from the process of installation.
   6. Provide a safety factor of at least three for all fastening and supports for fixed equipment, cabling, and components.
   7. Install all equipment, except portable equipment, such that it is held firmly in place. This shall include loudspeakers, amplifiers, cables, et cetera (an exception to this rigid mounting clause is when it is required to use resilient shock mounting to decouple a loudspeaker from the structure it is being mounted in/on).
   8. Except as may be specifically indicated herein, use no fan-cooled equipment in mobile equipment racks intended for use within a performance or presentation space.
9. Mount all permanent electronic equipment and patching facilities (if any) in electronic equipment rack cabinets (or frames, according to these documents).
10. Avoid damage to cables, equipment, and wiring.
11. Provide incidentals and accessories, compatible with other equipment, necessary to meet requirements specified herein even though not specifically called out in this specification.
12. Remove dirt and debris from audio system racks, panels and junction, pull and device boxes.
13. Seal all pre-assembled equipment racks in plastic before shipping to Project Site. Maintain plastic cover when storing racks on site prior to installation to prevent damage by materials from other trades.
14. Leave job site and all equipment and materials clean and free from marks, blemishes and Contractor's debris.

B. Audio System Isolated Technical Ground (ASITG):

1. Feeds to in-rack Power Distribution are to be provided by the EC.
2. Maintain isolation between ASITG and building electrical system ground except at the Building Ground Bus connection.
3. Provide a main isolated audio ground point (MIAGP) within each bank of audio equipment racks (i.e., one rack or multiple adjacent racks). MIAGP shall consist of a copper bus bar bonded to the rack frame and of sufficient size to accommodate all secondary ground conductors. Provide a lug on MIAGP to which Electrical Contractor shall connect an insulated copper equipment grounding conductor having a maximum of 0.1 ohm total resistance between MIAGP and ground electrode connection point. If and where aluminum lugs are used with copper wire or bus bars, anticorrosive compound must be used. The AV Contractor shall be responsible for confirming technical ground is properly electrically bonded to the building technical ground system and shall report discrepancies.
4. Secondary system grounding conductors shall be provided from all racks, audio consoles, and otherwise-ungrounded audio equipment in each area, to MIAGP. Each of these grounding conductors shall have a maximum of 0.1 ohm total resistance. Alternatively, adjacent racks may be bonded together via grounding conductors terminated at lugs attached to abutting rack sides. Each such grounding conductor shall have a maximum of 0.01 ohm total resistance. Care shall be exercised to assure grounding lugs make low-resistance contact with the rack.
5. Shield Treatments:
   a. Patchbays:
      1) All audio cable shields for balanced lines from or to installed equipment shall be grounded to ASITG by a single path. Tie shields to isolated ground at the source end (i.e., equipment outputs) only. As relates to shield terminations for lines to or from patchbays:
         a) For all output jacks (generally, top row), float (i.e. do not connect) shield drains at the jacks. Leave jack sleeves of output jacks (generally, top row) unconnected and unbussed. Bus together (within the patchbay at the jacks) the sleeves of the input jacks (generally, bottom row). Connect this bus to MIAGP in rack via secondary grounding conductor. Wires between these jacks and patchbay output terminals shall have their shield drains connected at the jacks and landed at the output sleeve terminals. For patchbays preconfigured to this method, wires to and from the patchbay may have their shields terminated on the patchbay’s sleeve terminal connectors, as requirements for floated shields are built into the.
         b) Tie the shields of balanced audio tie lines, used for temporary interconnection, to the ground pins of panel connectors and though to
jack sleeve connections at patchbays. Do not bus together the shields of these lines either to or from patchbays.

b. Other Shield Treatments:

1) The shields of portable cordage, such as, microphone cables, shall be connected at both ends to cable-connector ground terminal (or pin).
2) Insulate all cables from conduit and extraneous grounds. Do not tie the shell of cable-type microphone connectors to shield except within microphones themselves. Chassis connectors, which utilize their shells as conductors for shields (i.e. 1/4” phone jacks, 3.5mm mini-jacks, RCA jacks, et cetera), shall be insulated from their mounting plate.
3) Maintain continuity of shields at all connecting points except as required by standard practice for 'floating' shields.
4) Follow good engineering practice, as outlined above; deviate from these practices only when necessary to minimize crosstalk or to maximize signal-to-noise ratios in the audio and video systems; report deviations to the Architect and Consultant prior to implementation.

C. Wiring and Cables

1. Make wiring connections with rosin-core solder or mechanical connectors. Use mechanical connectors in strict conformance with the manufacturers' specifications with regard to wire gauge, wire type (stranding), insulation type and thickness, number of conductors at a single termination, terminal-screw diameter requirements, et cetera. Restrict use of 'wire nuts' to mains power wiring where acceptable to code and related sections. Wire nuts are not acceptable for audio connections.
2. "Punch-down"-type wire terminations are not allowed for microphone signal.
3. Clear all raceways, racks, and junction boxes of foreign matter and substances prior to installation of wire or cable.
4. Make no cable or wire splices inside of conduit or raceways.
5. Make no splices in any microphone lines. (Termination of a microphone line at an approved mechanical connector for making parallel wiring connections, or connection to pre-wired patch panels is not considered a 'splice').
6. Connections to rack-mounted equipment by means of phone plugs are not acceptable if the equipment has alternate connectors.
7. Use heat-shrinkable tubing to dress the shield and cable jacket wherever shielded cable is stripped-back for termination. The exception to this rule is when the cable terminates within the back shell of a single-circuit cable plug (accordingly, such terminations within multi-circuit plugs do require heat-shrinkable lead dress).
8. Install required microphone, line-level, loudspeaker, video and control wiring in conduits provided and installed by Electrical Contractor. Coordinate conduit-fill to minimize mixing of signal types. If cables of different signal types must be combined in conduits or raceways, the following schedule shall be used for determining acceptability of conduit fill:

a. Microphone-level circuits below -30 dBu, 20 to 20,000 Hz; non-relay DC control less than 50 volts; DC power less than 30 VA into resistive loads; CATV signal less than 1000 microvolt peak-to-peak into 50 or 75 ohms, 47 to 890 MHz.

b. Line level audio, -30 dBu to +24 dBu, 20 to 20,000 Hz; baseband and composite video, 1 volt peak-to-peak into 75 ohm, 0 to 10 MHz; color subcarrier, 0 to 4 volts peak-to-peak into 75 ohm, 3.57 to 4.43 MHz; non-relay DC control less than 50 volts; relay DC control less than 50 volts for runs less than 20 feet.

c. Loudspeaker-level circuits, greater than +24 dBu, 20 to 20,000 Hz; relay or non-relay DC control less than 50 volts; DC power less than 60 VA; synchronous control or data wiring less than 40 volts.
d. Baseband and composite video, 1 volt peak-to-peak into 75 ohm, 0 to 10 MHz; color subcarrier, 0 to 4 volts peak-to-peak into 75 ohm, 3.57 to 4.43 MHz; video synchronization and switching pulses, 4 volts peak-to-peak into 75 ohm; digital Video 0 to 3 GHz, 1Vp-p, non-relay DC control less than 50 volts; DC power less than 30 VA into resistive loads.

e. AC Power alone.

f. Additional cable combinations as approved by Consultant or specifically indicated by the Contract Documents.

9. Dress all cables within racks neatly and such that there is adequate service loop adjacent to terminations to allow at least one termination repair without unharnessing loom.

10. Install proper-fitting neoprene or nylon grommets where cables pass through holes in racks, boxes, or any other cabinetry, to prevent abrasion of the cables.

11. It is strongly recommended to test all cable lengths for serviceability before and during connection to equipment to determine if any faults have developed during the cable installation. Testing for open and short circuits shall be conducted on all cable after installation and before equipment and cable termination enclosures are closed.

D. Labels

1. General
   a. Upon request by Owner, remove visible logos from loudspeaker systems.
   b. Affix a single, small acknowledgment plate listing “Designed By:” and “Installed By:” to one AV equipment rack in the Control Room. This plate shall list the firm name, address, phone number, email address and web site of the System Consultant and AV Systems Contractor.
   c. Apply no advertising to racks, equipment, and accessories.

2. Wires and Cabling
   a. Label each and every cable in system with machine-printed wire tags protected by clear heat shrinkable tubing or with self-laminating “write-on” labels.
   b. Use a logically sequenced alphanumeric system, maintaining the same circuit designation from origin to destination.
   c. Use a color scheme that is legible and easy to understand.
   d. Attach wire tags to the cables such that they are easily read and the cable easily identified, usually about 1/2” from the cable end. Tag both ends of each cable.
   e. No two cables shall bear the same number.
   f. Multi-paired and multi-conductor cables shall bear a single number with number and conductor colors appearing on “As-Built” record documents.
   g. Ground wires need not be wire tagged.

3. Panels
   a. Clearly, logically and permanently label all custom controls, jacks and receptacles.
   b. Methods:
      1) Engrave and fill or silk screen custom rack panels.
      2) Engrave and fill receptacle box plates.
      3) Use characters at least 1/8” high on equipment mounted in rack cabinets and at least 1/4” high elsewhere, with character stroke width at least 10% of character height, wherever possible.
   c. Printed labels and embossed tape will not be accepted for labeling.
4. Racks, rack-mounted equipment and controls:
   a. Preferred method, see “Panels”.
   b. Label all rack-mounted equipment items and their controls where utilized.
   c. Engraved plastic lamicoid labels are acceptable. See “Panels” for character heights
      and spacing.
      1) Use simple and tasteful color scheme that is legible and easy to understand.
      2) Use uniform type face, font size and label size.
   d. Printed tape may be approved for labeling of racks, rack-mounted equipment and
      controls under specific circumstance(s). Submit request for approval to Consultant.
   e. Embossed tape will not be accepted for labeling.
   f. See “Panels” for character heights and spacing.

E. Polarity
   1. Install all loudspeakers to exhibit uniform polarity.
   2. Polarity of adjacent loudspeakers with respect to each other: a listener moving from in front
      of one loudspeaker to the next should sense a single apparent sound source which shifts
      smoothly and continuously as he moves. At midpoint, sound source should appear to be
      midway between loudspeakers.
   3. Polarity of lines and microphones: check for uniform polarity with respect to each other, of:
      microphone lines; lines to loudspeaker receptacles; loudspeakers; reinforcement
      microphones of the same type.
   4. Follow the “pin two is hot” standard for wiring ‘XLR’ terminations and “tip is hot” for TRS-
      terminated lines.

F. Loudspeaker Components
   1. Install loudspeaker systems so that loudspeaker devices may be removed and replaced from
      enclosures for service in the simplest possible manner.
   2. Where specifically instructed to do so, provide vibration isolation (shock mounting) of all
      loudspeakers sufficient to insure that there is no mechanical coupling from loudspeaker to
      support members or structure which might limit system acoustic gain before feedback within
      full frequency range of sound system, or which might audibly degrade sound quality. Use
      isolators such as those manufactured by Mason Industries or Peabody. Contractor shall
      insure that all safety considerations are satisfied.
   3. Provide sound insulation totaling at least one-half of the enclosure volume to inside of all
      metal back-cans. As a minimum, in cylindrical loudspeaker enclosures, line inside back and
      circumference. In rectangular loudspeaker enclosures, line inside back, top and/or bottom
      and left and/or right side. Commercially available, professional-grade, loudspeaker systems
      shall include internal sound insulation according to the manufacturer.

G. Trade Coordination
   1. Make moderate moves or changes as necessary to accommodate other equipment or
      preserve symmetry and pleasing appearance without claim for extra payments.
   2. Obtain approval from Consultant and Owner’s Representative before making changes
      necessitated by field conditions.
   3. Cooperate with other trades to achieve well-coordinated progress and satisfactory final
      results.
3.3 INITIAL TESTING AND ADJUSTMENTS

A. Equipment

1. Provide necessary calibrated test equipment.

B. Settings and Tuning

1. Adjust settings or modify components as necessary to achieve system performance conforming to Contract Documents.

C. Tests

1. Upon completion of installation, perform the following initial tests and record results:
   a. Absolute Impedance
      1) Measure impedance of each loudspeaker line at amplifier location at 250 Hz, 1 kHz, 8 kHz.
      2) With lines disconnected from their destination, measure resistance in lines to microphone, auxiliary and line inputs with receptacles open and short-circuited.

   b. Mechanical
      1) Verify integrity of support provisions.
      2) Verify absence of debris of any kind, tools, et cetera.

   c. Power and Isolated Ground
      1) Verify isolation of Audio System Isolated Technical Ground from raceway and building electrical ground.
      2) Verify integrity of signal-ground and Audio System Isolated Technical Ground connections.
      3) Verify proper provision of AC power to devices and equipment.

   d. Signal Wiring and Cables
      1) Verify absence of continuity in XLR cables between pin #1 and connector shell. Modify wiring of cables that do not conform to this standard.
      2) Verify integrity of insulation, connections and shield terminations.
      3) Verify integrity of soldered connections including absence of solder splatter, solder bridges and cold-solder joints.
      4) Verify routing and dressing of wire and cable as neat and in accordance with good engineering practice. Correct installation conditions that do not meet these requirements.
      5) Verify point-to-point continuity of all signal and control wiring and cables.
      6) Verify conformance with wire designations on “As-Built” wiring diagrams.
      7) Test microphones, loudspeakers and cables for proper polarity, correcting any discrepancies found.
e. AV Cable Infrastructure

1) Test all AV cable infrastructure including terminations within the project.
   a) In most cases, cable will be terminated to an AV panel or patchbay at one end and another patchbay or connector at the other end. Test all cables after they are terminated using the contacts of the termination as test connection points.
   b) If a cable fails an applicable test, then it must be disconnected from the termination and tested independently to determine whether the cable itself or the termination/connector is at fault. The results of this diagnostic test must be clearly stated in the Testing Report.

2) Microphone lines:
   a) All microphone cables, connectors, terminations, patchbays and patch cords must be capable of AES3-2003 signal transmission.
   b) Required tests for all microphone lines:

      (1) Length in feet.
      (2) Continuity of all conductors, including the shield/drain wire.
      (3) Freedom from short circuits.
      (4) Total capacitance between conductors: Using cap./ft. x length measured across open conductors, tolerance shall be + 15%/-25% of rated capacitance for subject length.

3) Line-level audio tie-lines, line feeds and system feeds, and intercom cabling:
   a) All line-level cables, connectors, terminations, patchbays and patch cords, except intercom cabling, must be capable of AES3-2003 signal transmission.
   b) Required tests for all line-level audio tie lines, line feeds and system feeds are as described for microphone lines.
   c) Required tests for intercom cabling:

      (1) Continuity of all conductors, including shield/drain wire.
      (2) Freedom from short circuits.

4) Loudspeaker feeds:
   a) Required tests for loudspeaker level cabling:

      (1) Length in feet.
      (2) Continuity of all conductors.
      (3) Freedom from short circuits.
      (4) Total resistance: Using Ohms/ft. x length measured through one conductor and back on the other, tolerance shall be no more than + 15% of rated DC resistance for subject length.
5) Coaxial Cables:
   a) All coaxial cable runs must be capable of MADI and HD-SDI video transmission over the distances within the venues and between the venues.
   b) All video cables, connectors, terminations, patchbays and patch cords must be compatible with the SMPTE 424M-2006 standard for 2.97Gbit/sec. transmission of uncompressed HD-SDI video.
   c) Required Tests:
      (1) Length in feet.
      (2) Continuity of all conductors.
      (3) Freedom from short circuits.
      (4) Total resistance: Using Ohms/ft. x length measured through one conductor and back on the other, tolerance shall be no more than + 10% of rated DC resistance for subject length.
      (5) Total capacitance between conductors: Using cap./ft. x length measured across open conductors, tolerance shall be no more than + 10% of rated capacitance for subject length.
      (6) Verify conformance with SMPTE 424M-2006, HD-SDI specification.

6) AV Data (F/UTP) and other Category UTP Cable Connections:
   a) All "AV Data" cables, connectors, terminations, patchbays and patch cords must be compatible with the latest ANSI/TIA/EIA-568 standard for Category 6 F/UTP standard.
   b) All F/UTP and UTP cables, connectors and terminations used for transmitting audio/video/control signals with dedicated equipment must be compatible with the latest ANSI/TIA/EIA-568 Category 5e, Category 6 UTP or Category 6 F/UTP standards based on the specification of the equipment.
   c) Required Tests:
      (1) Length in feet.
      (2) Conformance with the latest ANSI/TIA/EIA standards for Category 5e/6 UTP and F/UTP testing requirements, including but not limited to NEXT (Near End Crosstalk), Structural Return Loss, attenuation, open, shorts and characteristic impedance.

7) Fiber Optic Cables:
   a) All single-mode fiber equipment must allow the transmission of the specified signal types, such as HD-SDI video.
   b) All multi-mode fiber equipment must allow the transmission of the specified signal types, including MADI-over-fiber and DP-over-fiber.
   c) Required tests for all SMPTE fiber infrastructure:
      (1) Length in feet.
      (2) Continuity of copper conductors.
      (3) Freedom from short circuits in copper conductors.
d) Required tests for all non-SMPTE single-mode fiber infrastructure:

(1) Length in feet

e) Required tests for all multi-mode fiber infrastructure:

(1) Length in feet.
(2) Verify conformance with ANSI/TIA/EIA-526-14-B Measurement of Optical Power Loss of Installed Multi-Mode Fiber Cable Plant.

f. Hum and Noise Level

1) Adjust mixer/switcher input gain controls for 0 dB reading with pink noise at -55 dBu level at microphone input; 0 dBu at line level input.
2) Without changing gain, terminate microphone and line-level inputs with shielded resistors of 150 and 1,000 ohm, respectively.
3) Terminate power amplifier outputs with power load resistors matching nominal impedance of output terminals used in System.
4) With amplifiers at full power, measure overall hum and noise level at each power amplifier output.

a) Acceptable noise level: 80 dB below rated output of amplifier, minimum.

g. Electrical Distortion: (Only required during acceptance testing in the event of the use of non-approved equipment or evident audible electrical distortion.)

1) Adjust mixer/switcher input gain controls as described for "Hum and Noise Level" tests.
2) Terminate power amplifier outputs as described for "Hum and Noise Level" tests.
3) Apply 800 Hz sine-wave signal from oscillator having less than 0.5% total harmonic distortion to line-level input at level required to produce measured full amplifier output.
4) Measure distortion with distortion analyzer or observe waveform on oscilloscope to ascertain that distortion is less than that specified.

a) Total Harmonic Distortion: less than 0.20% max. from 20 Hz to 20 kHz.

h. Buzzes, Rattles, and Acoustic Distortion

1) Apply sine-wave sweep from 30 to 8,000 Hz at 6 dB below rated power amplifier output voltage.
2) Listen carefully for buzzes, rattles and objectionable distortion in loudspeaker systems and room furnishings, fixtures and finishes.
3) Remedy causes of objectionable electronic or loudspeaker distortion.
4) If within these systems remedy causes of buzzes or rattles.
5) If within room furnishings, fixtures or finishes, promptly notify Architect, Consultant and General Contractor indicating cause and suggesting corrective procedures.
6) Work with other trades to correct problems.

i. Provide report two weeks before site visits and check-out(s).
2. Upon completion of installation, perform the following verifications, record results, indicate date and name of verifier(s):
   a. Parasitic Oscillation and RF Pickup.
   b. Set up system for typical modes of operation (i.e., microphones connected, auxiliary audio source connected, control system connected, et cetera).
   c. Use 10 MHz bandwidth oscilloscope and loudspeaker monitoring.
   d. Check to ensure that system is free of spurious oscillation, RF pickup in absence of input signal; also with system driven momentarily to full output at 160 Hz.
   e. Remedy causes of parasitic oscillation and RF Pickup.
   f. Report results two weeks before final check-out.

3. Overall Performance
   a. Measure performance to verify conformity with respective performance specifications herein.

4. Gain Control Settings
   a. Adjust gain controls on rack-mounted equipment for optimum signal-to-noise and signal balance. Place temporary marks on settings using small pressure-sensitive arrows (preferred) or pressure-sensitive dots with indicating line. "White-Out", masking tape and other slipshod methods are not acceptable.

5. Report
   a. Upon completion of above tests and necessary adjustments, submit two copies of a written report presenting test results, including numerical values where necessary, for review by the Architect/Engineer prior to demonstration and acceptance testing.

6. Certification
   a. With the above report, submit written notice that the installation conforms to specifications, is complete, and is ready for inspection and testing by representatives of the Owner, Architect and Consultant.

D. Acceptance Testing and Demonstration of Completed Installation
   1. Upon approval of the above report, and at a time set by the Owner, demonstrate operation of each major component, using all input, control, amplification, and projection equipment. After demonstration, assist as required in the following acceptance tests by representatives of the Owner.
   2. To comply with Project Schedule and to avoid conflict with work of other sections, testing procedures may be required by Consultant to be performed at any hour of day or night. With a minimum of three-day notice of Acceptance Testing, provide specified personnel and equipment at any time during Acceptance Testing without claim for additional labor or other costs.
   3. Provide services of designated supervisor and an adequate number of technicians familiar with Work of this Section as required to comply with Project Schedule.
   4. Provide the following:
      a. Tools, as required for performance of adjustment and corrections to this Work.
      b. Spare wire and connectors and specialized connector tools if applicable.
      c. Ladders, scaffolding, lifts required to access sound system devices, connection points, junction boxes, including clusters.
d. Test equipment specified, used for Initial Testing and Adjustments.
e. A Complete set of latest stamped and actioned submittals for reference.
f. A Complete set of Shop Drawings and Initial Testing Reports.
g. Complete set of manufacturer’s original operation, instruction and service manuals for each equipment item for reference.

5. Equipment Tests

a. All aspects of the AV installation are subject to testing by the Owner or Owner's representatives to determine compliance with project specifications. Non-compliant components or systems shall, at the Owner's discretion, be corrected or replaced at the AV Contractor's expense. The AV Contractor may appeal Owner's test results by providing proof-of-compliance to be considered by Owner. Owner's testing notwithstanding, AV Contractor shall test all systems and components for compliance with project specifications and to assure that provided components meet the manufacturers' published specifications. The AV Contractor will report findings of non-compliance with manufacturer’s specifications to the manufacturer, Owner and Consultant.
b. If need for adjustment becomes evident during demonstration and testing, the Contractor’s work shall be continued until the installation operates properly in the opinion of the Consultant.
c. If final acceptance is significantly delayed because of defective new equipment or because of installation not in accordance with Contract Documents, the Contractor shall pay for all additional time and expenses of the Owner’s representatives during any resultant extensions of the acceptance-testing period.

6. Listening Tests shall consist of subjective evaluations by observers listening at various positions under various operating conditions, using speech, music and recorded program material.

3.4 CLOSE-OUT

A. Punch List

1. Perform required remedial work, without claim for additional labor or other costs. Where required, re-test and submit revised Test Report.
2. Notify Consultant and Owner's Representative of completion of Punch List.

B. Training and instruction

1. Provide on-site training sessions to Owner in operation of system with various user groups. Provide up to three, four hour sessions.
2. Provide training and instruction by personnel thoroughly familiar with systems and infrastructure provided.
3. Submit session outline and copies of “handouts” for review by Consultant 10 business days prior to scheduled sessions. Impromptu training which may occur prior to submittal and approval of training docs will not be considered as fulfilling this requirement. Instruction shall include:

   a. Demonstration of purpose for, and operation of, each component and associated infrastructure.
   c. Demonstration and explanation of operation of system controls and components including functional variations.
d. Attendance at minimally one event involving major use of each specified systems and provision of any helpful suggestions that may be appropriate.

C. Warranty

1. Submit one-year warranty dated to begin with Acceptance of the Work of this Section.
2. Submit proposal for one year and three years of additional, continued warranty and maintenance service.

3.5 OWNER’S RIGHT TO USE EQUIPMENT

A. Acceptance of the Work of this Section shall occur after completion of corrections and adjustments required by “Punch List” (as generated during Demonstration and Acceptance Testing of Completed Installation).

B. Owner reserves the right to use equipment, material and services provided as part of Work of this Section, prior to Acceptance, without incurring any obligation to Accept any equipment or completed systems until Punch List work is complete and systems comply with Contract Documents.
APPENDIX A - AUDIO-VIDEO SYSTEMS EQUIPMENT SCHEDULE

A.1 GENERAL DESCRIPTION

A. Bidders to confirm all model numbers, quantities and accessories.

B. Preserve rack space and infrastructure for add alternates.

C. Provide incidentals and accessories, compatible with other equipment, necessary to meet requirements specified herein even though not specifically called out in this specification.

A.2 EQUIPMENT SCHEDULE

A. Base Package

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LARGE INSTRUMENTAL REHEARSAL ROOM (130)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microphones and Accessories</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ceiling Microphone</td>
<td>Audix</td>
<td>M1255BO</td>
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<tr>
<td>1-channel Microphone Splitter 1x2</td>
<td>Radial</td>
<td>JS-2 w/ Jensen Transformers</td>
<td>2</td>
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<tr>
<td>2-Ch Microphone Preamp</td>
<td>Art Pro Audio</td>
<td>Pro MPA-II</td>
<td>1</td>
</tr>
<tr>
<td>Wireless Microphone System and Accessories</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>UHF Microphone Receiver w/ BodyPack Transmitter &amp; Lavalier Microphone</td>
<td>Shure</td>
<td>ULXD14/83</td>
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</tr>
<tr>
<td>Antenna Rack Mount Kit</td>
<td>Shure</td>
<td>UA440</td>
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<tr>
<td>Rechargeable Battery</td>
<td>Shure</td>
<td>SB900A</td>
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<tr>
<td>Battery Charger w/ Power Supply</td>
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<td>Audio Electronics</td>
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<td>Audio Interface</td>
<td>Focusrite</td>
<td>Scarlett 6i6</td>
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<td>Balanced/Unbalanced Line Amplifier</td>
<td>RDL</td>
<td>STA-1</td>
<td>1</td>
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<tr>
<td>DSP</td>
<td>Biamp</td>
<td>TesiraFORTE DAN CI</td>
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## Loudspeakers

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<th>Model</th>
<th>Qty.</th>
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<tbody>
<tr>
<td>Main Self-powered Loudspeakers</td>
<td>PreSonus</td>
<td>ULT 15</td>
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<tr>
<td>Rigging Hardware for Loudspeakers</td>
<td>Allen Products or Polar Focus or APE or equal</td>
<td>SAS-100-WM</td>
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## Video Electronics

<table>
<thead>
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<th>Model</th>
<th>Qty.</th>
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<tbody>
<tr>
<td>OFE Computer</td>
<td>Apple</td>
<td>Mac mini</td>
<td>OFE</td>
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<tr>
<td>OFE Wireless Keyboard &amp; Mouse</td>
<td>Apple</td>
<td>Mac mini</td>
<td>OFE</td>
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<td>HDMI Extender Transmitter for Monitor</td>
<td>Extron</td>
<td>DTP T HDMI 4K 230 Tx</td>
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</tr>
<tr>
<td>HDMI Extender Receiver for Monitor</td>
<td>Extron</td>
<td>DTP T HDMI 4K 230 Rx</td>
<td>1</td>
</tr>
<tr>
<td>Universal Blu-ray/DVD Player</td>
<td>Oppo</td>
<td>UDP-203</td>
<td>1</td>
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<tr>
<td>WebCam</td>
<td>Genius</td>
<td>WideCam F100</td>
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<tr>
<td>PTZ Camera</td>
<td>Panasonic</td>
<td>AW-HE40HW</td>
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<tr>
<td>Wall Mount Bracket for PTZ Camera</td>
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<td>by AV Contractor</td>
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<tr>
<td>HDMI Extender Transmitter for Camera</td>
<td>Extron</td>
<td>DTP T HWP 4K 331D</td>
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<td>DTP T HDMI 4K 330 Rx</td>
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<td>Blackmagic Design</td>
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<tr>
<td>HDMI Switcher at Lectern</td>
<td>AMX</td>
<td>SDX-414-DX</td>
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<td>Presentation Switcher</td>
<td>AMX</td>
<td>DVX-2255HD</td>
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## Control System

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<th>Manufacturer</th>
<th>Model</th>
<th>Qty.</th>
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<tr>
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<td>Control System Programming</td>
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<td>by AV Contractor</td>
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<td>Cisco or HP</td>
<td>by AV Contractor</td>
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<td>7-Port USB 3.0 Data Hub</td>
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<td>USB Extender Plus T (60-1471-12)</td>
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<td>USB Extender Receiver</td>
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<td>Listen Tech</td>
<td>LS-55-072 includes (1) LT-800-072-01 Transmitter (1) LA-122 Antenna Kit (1) LA-326 Rack Mount Kit (4) LR-4200-072 Receiver (4) LA-401 Ear Speaker (2) LA-430 Earphone/Neck Loop Lanyard (1) LA-381-01 12-Unit Charging Tray (1) LPT-A107-B Audio Cable (1) LA-304 Notification Signage Kit</td>
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<td>Surgex</td>
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<td>Middle Atlantic</td>
<td>MPR-SEQA</td>
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<td>CWP-120-PCON</td>
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*Continued at the next page…*
### TRADITIONAL PERFORMANCE SPACE (132)
#### Microphones and Accessories

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<tr>
<th>Description</th>
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<tr>
<td>Ceiling Microphone</td>
<td>Audix</td>
<td>M1255BO</td>
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<tr>
<td>1-channel Microphone Splitter 1x2</td>
<td>Radial</td>
<td>JS-2 w/ Jensen Transformers</td>
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<td>2-Ch Microphone Preamp</td>
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<td>Pro MPA-II</td>
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#### Wireless Microphone System and Accessories

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<td>Rechargeable Battery</td>
<td>Shure</td>
<td>SB900A</td>
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<td>Battery Charger w/ Power Supply</td>
<td>Shure</td>
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#### Audio Electronics

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<td>Balanced/Unbalanced Line Amplifier</td>
<td>RDL</td>
<td>STA-1</td>
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<tr>
<td>DSP</td>
<td>Biamp</td>
<td>TesiraFORTE DAN CI</td>
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#### Loudspeakers

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<td>PreSonus</td>
<td>ULT 15</td>
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<tr>
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#### Video Electronics

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<td>OFE Wireless Keyboard &amp; Mouse</td>
<td>Apple</td>
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<td>OFE</td>
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<td>HDMI Extender Transmitter for Monitor</td>
<td>Extron</td>
<td>DTP T HDMI 4K 230 Tx</td>
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<tr>
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<td>DTP T HDMI 4K 230 Rx</td>
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<td>Universal Blu-ray/DVD Player</td>
<td>Oppo</td>
<td>UDP-203</td>
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<tr>
<td>Document Camera</td>
<td>Elmo</td>
<td>TX-1</td>
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<td>WebCam</td>
<td>Genius</td>
<td>WideCam F100</td>
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<td>PTZ Camera</td>
<td>Panasonic</td>
<td>AW-HE40HW</td>
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<td>by AV Contractor</td>
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<tr>
<td>Description</td>
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<td>Model</td>
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<td>SDX-414-DX</td>
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<td>Presentation Switcher</td>
<td>AMX</td>
<td>DVX-2255HD</td>
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<tr>
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### Video Projection

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<tr>
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<td>Digital Projection</td>
<td>E-Vision Laser 7500</td>
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<tr>
<td>Lens for Projector</td>
<td>Digital Projection</td>
<td>2.2-3.67:1 Zoom Lens</td>
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<tr>
<td>Projector Mount, Ceiling Plate and Extension Column</td>
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<td>By AV Contractor</td>
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<tr>
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<td>Da-Lite</td>
<td>Tensioned Contour Electrol Image Size: 90&quot; x 160&quot; Top Masking: 46&quot; Surface: HD Progressive 0.9 Seamless LVC</td>
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<td>APC</td>
<td>C2</td>
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### Control System

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<thead>
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<th>Description</th>
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<tr>
<td>Touch Panel</td>
<td>AMX</td>
<td>MSD-701</td>
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<td>Control System Allocation for Mobile Devices</td>
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<td>TPC-BYOD</td>
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<td>by AV Contractor</td>
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<td>PoE+ Ethernet Switch</td>
<td>Cisco or HP</td>
<td>by AV Contractor</td>
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<td>Wireless Access Point</td>
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<td>by AV Contractor</td>
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<td>USB 3.0 Hub</td>
<td>Anker</td>
<td>7-Port USB 3.0 Data Hub</td>
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<td>USB Extender Plus R (60-1471-13)</td>
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## PROJECT MANUAL FOR:
**CP170621 - SCHOOL OF MUSIC NEW BUILDING**
**CP172801 - GENERAL SITE: SCHOOL OF MUSIC EXTENDED UTILITIES**

### Hearing Assistance System (100 seats)

<table>
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<th>Description</th>
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<th>Qty.</th>
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<td>(1) LT-800-072-01 Transmitter</td>
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<td></td>
<td>(1) LA-122 Antenna Kit</td>
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<td></td>
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<td>(1) LA-326 Rack Mount Kit</td>
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<td>(4) LR-4200-072 Receiver</td>
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<td>(2) LA-430 Earphone/Neck Loop</td>
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<td>Lanyard</td>
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### Miscellaneous

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<td>Chief/Raxxess</td>
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<td>PCR6 or MPR-x w/ RLM &amp; M Series Power Modules &amp; Additional Outlets</td>
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**AUDIO-VIDEO SYSTEMS** (For Reference Only) 274100 - A7
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<td>DSP</td>
<td>Biamp</td>
<td>TesiraFORTE CI</td>
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<td>Video Projector w/ Lens</td>
<td>Epson</td>
<td>Pro G7400U</td>
<td>1</td>
</tr>
<tr>
<td>Ceiling Mount, Ceiling Plate and Extension Column for Projector</td>
<td>Chief</td>
<td>by AV Contractor</td>
<td>1</td>
</tr>
<tr>
<td>Projection Screen</td>
<td>Da-Lite</td>
<td>Tensioned Contour Electrol Image Size: 52” x 92” Top Masking: 12” Surface: HD Progressive 0.9, Seamless LVC</td>
<td>1</td>
</tr>
<tr>
<td><strong>Control System</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Touch Panel</td>
<td>AMX</td>
<td>MSD-701</td>
<td>1</td>
</tr>
<tr>
<td>Control System Programming</td>
<td>by AV Contractor</td>
<td>by AV Contractor</td>
<td>Lot</td>
</tr>
<tr>
<td>PoE+ Ethernet Switch</td>
<td>Cisco or HP</td>
<td>by AV Contractor</td>
<td>1</td>
</tr>
<tr>
<td>Description</td>
<td>Manufacturer</td>
<td>Model</td>
<td>Qty.</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>--------------------</td>
<td>-------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>USB Extender Transmitter</td>
<td>Extron</td>
<td>USB Extender Plus T (60-1471-12)</td>
<td>1</td>
</tr>
<tr>
<td>USB Extender Receiver</td>
<td>Extron</td>
<td>USB Extender Plus R (60-1471-13)</td>
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</table>

### Hearing Assistance System (12 seats)

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing Assistance Transmitter</td>
<td>Listen Tech</td>
<td>LT-800-072-01</td>
<td>1</td>
</tr>
<tr>
<td>Rack Mount Kit for HAS Transmitter</td>
<td>Listen Tech</td>
<td>LA-326</td>
<td>1</td>
</tr>
<tr>
<td>90-Degree Helical Antenna (216 MHz)</td>
<td>Listen Tech</td>
<td>LA-124</td>
<td>1</td>
</tr>
<tr>
<td>Hearing Assistance Receivers w/ Rechargable Batteries</td>
<td>Listen Tech</td>
<td>LR-4200-072</td>
<td>2</td>
</tr>
<tr>
<td>Ear Speakers for H.A.S.</td>
<td>Listen Tech</td>
<td>LA-401</td>
<td>2</td>
</tr>
<tr>
<td>Earphone/Neck Loops Lanyard for H.A.S.</td>
<td>Listen Tech</td>
<td>LA-430</td>
<td>2</td>
</tr>
<tr>
<td>4-Port USB Charger</td>
<td>Listen Tech</td>
<td>LA-423</td>
<td>1</td>
</tr>
<tr>
<td>Notification Signage Kit</td>
<td>Listen Tech</td>
<td>LA-304</td>
<td>1</td>
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### Miscellaneous

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<tr>
<td>Equipment Rack</td>
<td>Middle Atlantic or Lowell or Chief/Raxxess or Belden or APC or equal</td>
<td>SR-40-22</td>
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<td>Rack Drawer</td>
<td>Middle Atlantic or Lowell or Chief/Raxxess</td>
<td>D3 UDE-314 ESD-3</td>
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<td>Brush Grommet Panel</td>
<td>Middle Atlantic or APC or Gator Cases or Tripp Lite</td>
<td>BR1 AR8429 GE-CBLENTBRSH1U SR1UBRUSH</td>
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<tr>
<td>Power Distribution and Sequencer</td>
<td>Middle Atlantic</td>
<td>PDS-1620R-NS</td>
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</tr>
<tr>
<td>Remotely Controllable Power Module for Self-powered Loudspeakers</td>
<td>Middle Atlantic</td>
<td>CWP-120-PCON</td>
<td>2</td>
</tr>
<tr>
<td>Rack Isolation Kit</td>
<td>Middle Atlantic or Lowell or Belden or APC or Cooper B-Line or equal</td>
<td>ISO-1</td>
<td>1</td>
</tr>
<tr>
<td>Description</td>
<td>Manufacturer</td>
<td>Model</td>
<td>Qty.</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------------------------------</td>
<td>--------</td>
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<tr>
<td>Rack Isolation Knockout</td>
<td>Middle Atlantic or Lowell or Belden or APC or Cooper B-Line or equal</td>
<td>ISO-KOP</td>
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<tr>
<td>Rack Cooper Ground Bar</td>
<td>Middle Atlantic or Lowell or Belden or APC or Cooper B-Line or equal</td>
<td>BB-12</td>
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*Continued at the next page…*
<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Microphones and Accessories</strong></td>
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<tr>
<td>Ceiling Microphone</td>
<td>Shure</td>
<td>MX202WP/C</td>
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<tr>
<td><strong>Audio Electronics</strong></td>
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<tr>
<td>Audio Interface</td>
<td>Focusrite</td>
<td>Scarlett 2i2</td>
<td>2</td>
</tr>
<tr>
<td>Balanced/Unbalanced Line Amplifier</td>
<td>RDL</td>
<td>STA-1</td>
<td>2</td>
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<tr>
<td>DSP</td>
<td>Biamp</td>
<td>TesiraFORTE CI</td>
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<tr>
<td><strong>Loudspeakers</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Self-powered Loudspeakers</td>
<td>PreSonus or QSC</td>
<td>AIR 10 K10.2</td>
<td>4</td>
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<tr>
<td>Wall-Mount for Loudspeakers</td>
<td>Adaptive Technologies Group</td>
<td>SM-075-AS</td>
<td>4</td>
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<tr>
<td><strong>Video Electronics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OFE Computer</td>
<td>Apple</td>
<td>Mac mini</td>
<td>OFE</td>
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<tr>
<td>OFE Wireless Keyboard &amp; Mouse</td>
<td>Apple</td>
<td>UDP-203</td>
<td>2</td>
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<tr>
<td>Universal Blu-ray/DVD Player</td>
<td>Oppo</td>
<td>TX-1</td>
<td>2</td>
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<tr>
<td>Document Camera</td>
<td>Elmo</td>
<td>WideCam F100</td>
<td>2</td>
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<tr>
<td>WebCam</td>
<td>Genius</td>
<td>7-Port USB 3.0 Data Hub</td>
<td>2</td>
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<tr>
<td>DXLink Receiver for Projector</td>
<td>AMX</td>
<td>DX-RX</td>
<td>2</td>
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<tr>
<td>Presentation Switcher</td>
<td>AMX</td>
<td>DVX-2250HD</td>
<td>2</td>
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<tr>
<td>USB 3.0 Hub</td>
<td>Anker</td>
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<td>2</td>
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<tr>
<td><strong>Video Projection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Video Projector w/ Lens</td>
<td>Epson</td>
<td>Pro G7400U</td>
<td>2</td>
</tr>
<tr>
<td>Ceiling Mount, Ceiling Plate and Extension Column for Projector</td>
<td>Chief</td>
<td>by AV Contractor</td>
<td>2</td>
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<tr>
<td>Projection Screen for Medium Classroom</td>
<td>Da-Lite</td>
<td>Tensioned Contour Electrol Image Size: 52&quot; x 92&quot; Top Masking: 12&quot; Surface: HD Progressive 0.9, Seamless LVC</td>
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<tr>
<td>Projection Screen for Music Education Classroom</td>
<td>Da-Lite</td>
<td>Tensioned Contour Electrol Image Size: 58&quot; x 104&quot; Top Masking: 6&quot; Surface: HD Progressive 0.9, Seamless LVC</td>
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<tr>
<td>Description</td>
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<td>Model</td>
<td>Qty.</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>--------------</td>
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<tr>
<td><strong>Control System</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Touch Panel</td>
<td>AMX</td>
<td>MSD-701</td>
<td>2</td>
</tr>
<tr>
<td>Control System Programming</td>
<td>by AV Contractor</td>
<td>by AV Contractor</td>
<td>Lot</td>
</tr>
<tr>
<td>PoE+ Ethernet Switch</td>
<td>Cisco or HP</td>
<td>by AV Contractor</td>
<td>2</td>
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<tr>
<td><strong>Hearing Assistance System (seats)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hearing Assistance Transmitter</td>
<td>Listen Tech</td>
<td>LT-800-072-01</td>
<td>2</td>
</tr>
<tr>
<td>Rack Mount Kit for HAS Transmitter</td>
<td>Listen Tech</td>
<td>LA-326</td>
<td>2</td>
</tr>
<tr>
<td>90-Degree Helical Antenna (216 MHz)</td>
<td>Listen Tech</td>
<td>LA-124</td>
<td>2</td>
</tr>
<tr>
<td>Hearing Assistance Receivers w/ Rechargeable Batteries</td>
<td>Listen Tech</td>
<td>LR-4200-072</td>
<td>4</td>
</tr>
<tr>
<td>Ear Speakers for H.A.S.</td>
<td>Listen Tech</td>
<td>LA-401</td>
<td>4</td>
</tr>
<tr>
<td>Earphone/Neck Loops Lanyard for H.A.S.</td>
<td>Listen Tech</td>
<td>LA-430</td>
<td>4</td>
</tr>
<tr>
<td>4-Port USB Charger</td>
<td>Listen Tech</td>
<td>LA-423</td>
<td>2</td>
</tr>
<tr>
<td>Notification Signage Kit</td>
<td>Listen Tech</td>
<td>LA-304</td>
<td>2</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rack Mount for Mac Mini</td>
<td>Sonnet</td>
<td>RackMac Mini</td>
<td>2</td>
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<tr>
<td>Power Distribution and Sequencer</td>
<td>Middle Atlantic</td>
<td>PDS-1620R-NS</td>
<td>2</td>
</tr>
<tr>
<td>Remotely Controllable Power Module for Self-powered Loudspeakers</td>
<td>Middle Atlantic</td>
<td>CWP-120-PCON</td>
<td>4</td>
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</table>

*Continued at the next page…*
## MISCELLANEOUS

### General

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AV Panels</td>
<td>Custom by AV Contractor or Approved Manufacturer</td>
<td>Lot</td>
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<tr>
<td>Miscellaneous Security Screws</td>
<td>Middle Atlantic or Lowell or Chief/Raxxess or Belden or APC</td>
<td>HS</td>
<td>Lot</td>
</tr>
<tr>
<td>Miscellaneous Vent and Blanks</td>
<td>Middle Atlantic or Lowell or Chief/Raxxess or Belden or APC</td>
<td>Various</td>
<td>Lot</td>
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<tr>
<td>Miscellaneous Wire and Hardware</td>
<td>Various</td>
<td>Various</td>
<td>Lot</td>
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<tr>
<td>Miscellaneous Security Covers</td>
<td>Middle Atlantic or Lowell or Chief/Raxxess or Belden or APC</td>
<td>SC-x</td>
<td>Lot</td>
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<tr>
<td>Acknowledgement Plaques for Fixed Equipment Racks</td>
<td>Custom by AV Contractor</td>
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### Cables

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Qty.</th>
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</thead>
<tbody>
<tr>
<td>Microphone &amp; Line-level Audio Cables in Conduit</td>
<td>Belden or West Penn or Gepco</td>
<td>1800B or 1696A 1800B or 1696A DA2401 DA2401 DS401 or equal</td>
<td>Lot</td>
</tr>
<tr>
<td>Loudspeaker Cables in Conduit, #12 AWG</td>
<td>Belden or West Penn or Gepco</td>
<td>5000UP or 1311A 5000UP or 1311A C207 C207 1200 or equal</td>
<td>Lot</td>
</tr>
<tr>
<td>Video Cables in Conduit for Runs Under 230 ft.</td>
<td>Belden or Extron or Gepco or Canare</td>
<td>1694A 1694A 22-098-0x 22-098-0x VSD2001 VSD2001 L-7CFB or equal</td>
<td>Lot</td>
</tr>
<tr>
<td>Video Cables in Conduit for Runs Under 300 ft.</td>
<td>Belden or Gepco or equal</td>
<td>1794A or 7855A 1794A or 7855A VHD7000 or equal</td>
<td>Lot</td>
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<tr>
<td>Video Cables in Conduit for Runs Under 370 ft.</td>
<td>Belden or Gepco or equal</td>
<td>7731A 7731A VHD1100 or equal</td>
<td>Lot</td>
</tr>
<tr>
<td>Shielded Cat 6 F/UTP (AV Data) Cables in Conduit</td>
<td>Belden or West Penn or Liberty AV Solutions or equal</td>
<td>2412F 2412F 4246F 4246F 24-4P-L6SH or equal</td>
<td>Lot</td>
</tr>
<tr>
<td>Cat 6 UTP Cables in Conduit</td>
<td>Belden or West Penn or Gepco or Liberty AV Solutions</td>
<td>2412 2412 4246 4246 CT604/500 CT604/500 24-4P-L6 or equal</td>
<td>Lot</td>
</tr>
<tr>
<td>Description</td>
<td>Manufacturer</td>
<td>Model</td>
<td>Qty.</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-----------------------------</td>
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<tr>
<td>Cat 5e UTP Cables in Conduit</td>
<td>Belden or West Penn or Gepco or Liberty AV Solutions</td>
<td>1583A 4245 CT504/350 24-4P-L5-EN</td>
<td>Lot</td>
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<tr>
<td>50-ohm Antenna Cable in Conduit</td>
<td>Belden or West Penn or Gepco</td>
<td>7810R 808F V5010</td>
<td>Lot</td>
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<tr>
<td>Control Cables in Conduit</td>
<td>Various</td>
<td>Various; by AV Contractor</td>
<td>Lot</td>
</tr>
<tr>
<td>Miscellaneous Cabling and Terminating Accessories</td>
<td>Various</td>
<td>Various; by AV Contractor</td>
<td>Lot</td>
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*Continued at the next page…*
B. Additive Alternates

<table>
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<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Qty.</th>
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<tbody>
<tr>
<td><strong>ADD ALTERNATE 1: Video Projection System for Large IRR (130)</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Video Electronics</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Document Camera</td>
<td>Elmo</td>
<td>TX-1</td>
<td>1</td>
</tr>
<tr>
<td>DXLink Receiver for Projector</td>
<td>AMX</td>
<td>DX-RX</td>
<td>1</td>
</tr>
<tr>
<td><strong>Video Projection</strong></td>
<td></td>
<td></td>
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<tr>
<td>Video Projector</td>
<td>Digital Projection</td>
<td>E-Vision Laser 7500</td>
<td>1</td>
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<tr>
<td>Lens for Projector</td>
<td>Digital Projection</td>
<td>2.2-3.67:1 Zoom Lens</td>
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<td>Projector Mount</td>
<td>Chief</td>
<td>VCMU</td>
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<td>Wall Mount Arm for Projector</td>
<td>Chief</td>
<td>WMA2S</td>
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<tr>
<td>Wall Cover for Projector Wall Mount</td>
<td>Chief</td>
<td>WMAC16</td>
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<tr>
<td>Extension Column</td>
<td>Chief</td>
<td>CMS003</td>
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</table>
| Projection Screen                               | Da-Lite        | Tensioned Contour Electrol Image Size: 90" x 160"
Top Masking: 12"
Surface: HD Progressive 0.9, Seamless
LVC | 1 |
| Wall Bracket and Mounting Hardware for Projection Screen | By AV Contractor | By AV Contractor | 1 |
| Power Filter for Projector                       | APC            | C2                  | 1    |
| **ADD ALTERNATE 2: Loudspeaker System for Large IRR (130)** |                |                     |      |
| **Audio Electronics**                            |                |                     |      |
| Surround Sound Processor                         | Crestron       | HD-XSP              | 1    |
| DSP                                              | Biamp          | TesiraFORTE DAN AI | 1    |
| 10-port L3 Gigabit PoE and PoE+ Managed Ethernet Switch for Dante Network Audio | Cisco | SG300-10MPP | 1 |
| **Loudspeaker**                                  |                |                     |      |
| Main Self-powered Loudspeakers                  | PreSonus       | ULT 15              | 3    |
| Self-powered Subwoofer                          | PreSonus       | ULT 18              | 1    |
| Rigging Hardware for Loudspeakers                | Allen Products or Polar Focus or APE or equal | SAS-100-WM | 3 |
## ADD ALTERNATE 3: Loudspeaker System for Traditional Performance Space (132)

### Audio Electronics

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Qty.</th>
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<tbody>
<tr>
<td>Surround Sound Processor</td>
<td>Crestron</td>
<td>HD-XSP</td>
<td>1</td>
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<tr>
<td>DSP</td>
<td>Biamp</td>
<td>TesiraFORTE DAN AI</td>
<td>1</td>
</tr>
<tr>
<td>10-port L3 Gigabit PoE and PoE+ Managed Ethernet Switch for Dante Network Audio</td>
<td>Cisco</td>
<td>SG300-10MPP</td>
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### Loudspeaker

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<thead>
<tr>
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<th>Qty.</th>
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<tbody>
<tr>
<td>Main Self-powered Loudspeakers</td>
<td>PreSonus ULT 15</td>
<td>3</td>
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<tr>
<td>Self-powered Subwoofer</td>
<td>PreSonus ULT 18</td>
<td>1</td>
</tr>
<tr>
<td>Rigging Hardware for Loudspeakers</td>
<td>Allen Products or Polar Focus or APE or equal</td>
<td>3</td>
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### ADD ALTERNATE 4: Audio System for Traditional Performance Space (132)

### Wireless Microphone System and Accessories

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Qty.</th>
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</thead>
<tbody>
<tr>
<td>Quad Channel UHF Microphone Receiver</td>
<td>Shure ULXD4Q</td>
<td>1</td>
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</tr>
<tr>
<td>UHF Microphone Bodpack Transmitter</td>
<td>Shure ULXD1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>EarSet Microphones</td>
<td>Countryman E6XOW6L1SL (Shure; Light Beige)</td>
<td>4</td>
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</tr>
<tr>
<td>Antenna Rack Mount Kit</td>
<td>Shure UA440</td>
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</tr>
<tr>
<td>Rechargeable Battery</td>
<td>Shure SB900A</td>
<td>8</td>
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</tr>
<tr>
<td>Battery Charger w/ Power Supply</td>
<td>Shure SBC800-US</td>
<td>1</td>
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### Main Mixing System

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Qty.</th>
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<tbody>
<tr>
<td>Main Mixing System</td>
<td>Soundcraft Si Expression 1</td>
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<tr>
<td>Main Mixing System I/O Expansion</td>
<td>Soundcraft</td>
<td>Dual Port Dante Card</td>
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<tr>
<td>Console Light</td>
<td>Littlite 18G-LED (AV Contractor to verify the compatibility with the main mixer prior to ordering)</td>
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</tr>
<tr>
<td>ATA Flight Case for Main Mixer</td>
<td>Soundcraft</td>
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<td>Wireless Microphone System and Accessories</td>
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<td>Rechargeable Battery</td>
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### Video Display

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<td>Wall Mount for Video Display</td>
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End of Appendix A

**END OF SECTION 274100**
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings 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. Noncoded addressable system, with automatic sensitivity control of certain smoke detectors and 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."

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 IV 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. Provide design calculation showing current draw on each notification circuit with allowance for minimum of 20% expansion.
3. Include voltage drop calculations for notification appliance circuits.
4. Include battery-size calculations and show that they are sized a minimum of 125% of calculated requirement.
a. Show supervisory power requirements for all equipment
b. Show alarm power requirements for all equipment
c. Show power supply rating justification showing power requirements for each of the system power supplies. Power supplies shall be sized to furnish the total connected load in a worst case condition.
5. 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.
6. 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.
7. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
8. Indicate wattage and speaker tap settings for each speaker in plan.
9. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.
10. Complete riser diagram including devices with associated tags/room no. and circuits.

D. Qualification Data: For qualified Installer.

E. Field quality-control reports.

F. 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.
G. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

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

C. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.8 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Fire Control Instruments, Inc.; a Honeywell company.
2. NOTIFIER; a Honeywell 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. Verified automatic alarm operation of smoke detectors.
5. Automatic sprinkler system water flow.
6. Heat detectors in elevator shaft and pit.
7. Fire-extinguishing system operation.
8. 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 in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
9. Recall elevators to primary or alternate recall floors.
10. Activate emergency shutoffs for gas and fuel supplies.
11. Record events in the system memory.
12. Record events by the system printer.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Low-air-pressure switch of a dry-pipe sprinkler system.
3. Fire-pump power failure, including a dead-phase or phase-reversal condition.
4. Elevator shunt-trip supervision.
5. Duct smoke detectors

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.
1. Fire alarm panel shall provide trouble and alarm outputs to building BAS system. (Energy Management Controls System)

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.
4. Control panel/unit shall have 35% spare capacity to account for future buildout.

5. Alarm initiating modules
   a. The alarm initiating zone boards in the FACP shall consist of plug-in cards.
   b. Each loop shall have a software disable "Disconnect switch mounted at the panel to disable the circuit during maintenance. This switch shall cause a "Trouble" LED to light the panel.

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, 2 line(s) of 40 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 B.
      a. Initiating Device Circuits: Style E.
      b. Notification Appliance Circuits: Style Z.
      d. Install no more than 50 addressable devices on each signaling line circuit.


D. Notification Appliance Circuit: Operation shall sound in a programmable voice evacuation message over system speakers. Minimum one loop/circuit per floor.

   1. Minimum of 1.5 amps per circuit at 24vdc.

E. Elevator Recall:

   1. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start 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.

F. 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.

G. 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.

H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
I. 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. Provide custom messages as requested by owner for "Storm" and "Lockdown" to be initiated manually at main fire alarm control panel and annunciator panel.
   e. 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.

J. 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.

K. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.


   a. Sized to 125% of the calculated requirement. Batteries must be capable of operating the panel in normal mode for 24 hours with sufficient capacity to operate the panel in alarm mode for 15 minutes at the end of that 24 hour period.

L. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.

2. Station Reset: Key- or wrench-operated switch.

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. 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.
4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
5. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
6. 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 or 20 deg 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 or 155 deg F.
   c. Provide multiple levels of detection sensitivity for each sensor.

B. Dual Smoke/Heat Detectors:
   1. Basis of Design: Gamewell FCI Velociti Series MCS-ACCLIMATE2F
   2. Detector uses a combination of photoelectronic and thermal sensing technologies.
   3. 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.
   4. 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.).
      f. Capable of heat-only alarm mode, enabled by a special command from the panel.

C. Photoelectric Smoke Detectors:
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
      d. Present sensitivity selected.
      e. Sensor range (normal, dirty, etc.).
   3. 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.

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 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
   1. Mounting: **Twist-lock base interchangeable with smoke-detector bases.**
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F.
   1. Mounting: **Twist-lock base interchangeable with smoke-detector bases.**
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.
   1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

B. 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 85 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.
   1. Horns shall be Wheelock NH or AH series or equal.
   2. Provide only where specifically shown on drawings on exterior of building.

C. 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 mounted unless otherwise indicated.
   3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
   4. Flashing shall be in a temporal pattern, synchronized with other units.
   5. Strobe Leads: Factory connected to screw terminals.
   7. Strobes shall be Wheelock RSS series with Wheelock SM, DSM synchronization control module or equal.

D. 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.
4. Mounting: **semi-recessed**.
5. Matching Transformers: Tap range matched to acoustical environment of speaker location.
6. Speakers shall be Wheelock series ET or equal.

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.

B. Material and Finish: Match door hardware.

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. Panel shall be equipped with a DACT (Digital Alarm Communicator Transmitter)

C. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically transmit through a (digital cellular communicator) data/cell phone dialer to a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on the data/cell dialer 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.

D. 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.

E. 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.

F. Secondary Power: Integral rechargeable battery and automatic charger.

G. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

H. Provide with a Digital Cellular Communicator with Two-Way Voice Transport Capability via AlarmNet. Similar to Honeywell GSMV or pre-approved equal. Digital Cellular Communicator shall be tied into the dual line Digital Dialer.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches 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. Smoke- or Heat-Detector Spacing:

3. Smooth ceiling spacing shall not exceed **30 feet**.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.
5. HVAC: Locate detectors not closer than **3 feet** from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

E. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

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 speaker 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 wiring shall be run in conduit tight to structure. No conduit runs shall run across structural pans. Mount it tight to bottom of joists/beams. Junction boxes and covers to be red.

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. Smoke dampers in air ducts of designated air-conditioning duct systems.
2. Alarm-initiating connection to elevator recall system and components.
3. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
4. Supervisory connections at valve supervisory switches.
5. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
7. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
8. Supervisory connections at fire-pump engine control panel.

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

C. 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.

D. 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.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.6 DEMONSTRATION

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

END OF SECTION 283111
SECTION 311000 – SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Protecting existing vegetation to remain.
   2. Removing existing vegetation.
   3. Clearing and grubbing.
   4. Stripping and stockpiling topsoil.
   5. Removing above- and below-grade site improvements.
   6. Disconnecting, capping or sealing site utilities.
   7. Temporary erosion- and sedimentation-control measures.

1.2 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.3 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

B. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   1. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

D. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.

F. The following practices are prohibited within protection zones:
   1. Storage of construction materials, debris, or excavated material.
   2. Parking vehicles or equipment.
   3. Foot traffic.
   4. Erection of sheds or structures.
   5. Impoundment of water.
   6. Excavation or other digging unless otherwise indicated.
   7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."
   1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.
B. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated.
C. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control drawings and requirements of authorities having jurisdiction.
B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

A. General: Protect trees and plants remaining on-site.
B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Design Professional.

3.4 EXISTING UTILITIES

A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
   1. Arrange with utility companies to shut off indicated utilities.
B. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Design Professional not less than two days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Design Professional’s written permission.
3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
   1. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
   2. Use only hand methods for grubbing within protection zones.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth of 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner’s property.

B. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermingling with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION
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SECTION 312000 – EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Excavation for paving and grading.
   2. Excavation for building foundations, slabs-on-grade, paving, and grading.
   3. Excavation for Site structures.
   4. Site filing and backfilling.
   5. Drainage course for slabs-on-grade.
   6. Consolidation and compaction.
   7. Excavation for trenches for utilities and footings.
   8. Consolidation and compaction of bedding under utilities.
   9. Rough grading.

B. Related Sections:
   1. Division 1 – Unit Prices.
   2. Section 015713 – Temporary Erosion and Sediment Control.
   3. Section 033000 – Cast-In-Place Concrete.
   4. Section 311000 – Site Clearing.
   5. Section 331100 - Water Utility Distribution Piping
   6. Section 333100 – Sanitary Utility Sewerage Piping
   7. Section 334100 – Storm Utility Drainage Piping.
   8. Section 334613 – Foundation Drainage.

1.2 DEFINITIONS

A. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials, and bottom of over excavation areas if required by the contract document.

B. Subbase Course: Aggregate layer placed between the subgrade and hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

E. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill, when sufficient approved soil material is not available from excavations.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated, regardless of the character and density of materials, including reuse or disposal of materials removed.
   1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Design Professional. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
   2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Design Professional. Unauthorized excavation, as well as remedial work directed by Design Professional, shall be without additional compensation.
G. Fill: Suitable materials used to raise existing grades.

H. Finish Grade: The top surface of sod, top surface of topsoil where sod is not indicated or exposed rock surface where indicated on the drawing.

I. Trench Backfill: Soil material or controlled low-strength material used to fill an excavation.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2. Final Backfill: Backfill placed over initial backfill to fill a trench.

J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.3 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

B. Product Data: For each type of material indicated in Part 2 of this section.

C. Contract Closeout Submittals: Submit in accordance with Division 1.
   1. Project Record Documents.
      a. Accurately record location of underground utilities remaining, rerouted utilities, and new utilities by horizontal dimensions from above grade permanent fixtures, elevations or inverts, and slope gradients.

1.4 QUALITY ASSURANCE

A. Installer’s Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

B. Testing Agency: A qualified independent geotechnical engineering testing agency shall classify proposed on-Site and borrow soils to verify that soils comply with specified requirements and to perform specified field and laboratory testing.

C. Pre-excavation Conference:
   1. Convene pre-excavation conference under provision of Division 1, one week prior to commencing Work of this Section.
   2. Contractor shall be presiding officer at conference.
   3. Conference shall be attended by Contractor, Owner’s Representative, testing agency, and earthwork subcontractor.
   4. Purpose of conference will be to review contract requirements and discuss schedules, work procedures, acceptable materials specified under this Section, locations where specified materials may be incorporated, and quality control.

1.5 PROJECT CONDITIONS

A. Existing Conditions:
   1. Locate existing underground utilities in areas of excavation Work.
      a. Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by Owner’s Representative and then only after acceptable temporary utility services have been provided.
b. Provide not less than 72 hours notice to Design Professional and Owner’s Representative and receive written authorization to proceed before interrupting any utility.

1.6 MAINTENANCE

A. Where settling is measurable or observable at excavated areas during correction period required by General Conditions, remove surface (pavement, lawn, or other finish), add backfill material, compact as specified in this Section for location of material, and replace surface treatment.

1. Restore appearance, quality, and condition of surface or finish to match adjacent materials.
2. Eliminate evidence of restoration.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
1. Provide approved borrow soil materials from off-Site when sufficient approved soil materials are not available from excavations, at no increase in Contract Sum or extension of Contract Time.
2. Dispose of any excess materials legally off site at no increase in contract sum or extension of contract time. On site disposal of suitable materials may only be permitted where shown on the drawings.
3. Fill and backfill materials shall be subject to the approval of testing agency and the Owner’s Representative.
4. For approval of fill and backfill materials, notify testing agency and Owner’s Representative at least 5 working days in advance of intention to import material.
   a. Designate proposed borrow area and excavate test pits to permit testing agency to sample as necessary from borrow area for the purpose of making acceptance tests to confirm quality of proposed material.

B. General Fill Materials
1. Definition: That material used to obtain finish subgrade levels at locations specified under this section.
2. Acceptable material: Excavated on-Site material or off-Site borrow material which is free from debris, organics, decomposable, and corrodible materials, and containing the proper moisture content, liquid limit, and plasticity index to obtain specified compaction requirements.
   a. Existing on-Site material proposed for reuse, and off-Site borrow material shall be approved by testing agency.

C. Low Volume Change Material:
1. Definition: That material used to obtain the upper 24 inches of finish subgrade beneath granular base in building areas, and material used as trench backfill material in building areas.
2. Acceptable material:
   a. On-site or Off-Site borrow material which is free from debris, organics, decomposable, and corrodible materials with a liquid limit of less than 50 percent and a plasticity index less than 30, or another material acceptable to the testing agency.
   1) Existing on-Site material proposed for reuse, and off-Site borrow material shall be approved by testing agency.
   b. A granular fill containing sufficient fines to exhibit a definite moisture/density relationship.

D. Granular Fill:
1. Definition: Free-draining granular base used beneath building slabs-on-grade and used as backfill behind foundation and retaining walls.
2. Acceptable materials: Clean crushed stone or gravel, free of Shale, clay, friable material, and debris, complying with ASTM C33 Size No. 67.

E. Pavement Subbase Course:
1. Definition: Granular base used beneath concrete pavement and other pavements indicated on Drawings.
2. Acceptable materials: Comply with APWA Street Construction and Material Specifications, Division II.

F. Crushed Limestone Fill Material:
1. Definition: That material used at trench backfill under pavements, at locations specified under this Section, and at locations indicated on Drawings.
2. Acceptable materials: Comply with APWA Street Construction and Material Specifications, Division II.

G. Bedding Materials: Type 1 aggregate per MoDOT Standard Specification for Highway Construction, Section 1007.

H. Trench Backfill Materials:
1. Slab on grades: Low volume change materials per this section.
2. Pavement areas: Low volume change material per this section.
3. Other areas: General Fill Material or other materials specified under this Section at locations specified or indicated on Drawings.

I. Backfill Material
1. Definition: Material requiring placement and compaction with manual procedures because of restricted spaces or new construction.
2. Acceptable materials: Either General Fill Material, Granular Fill Material, or other materials specified under this Section at locations specified or indicated on Drawings.

J. Suitable Soils: Suitable soils within 36 inches of finished grade in lawn and planter areas shall be cohesive soils in Soil Classification Groups ML, CL, CH or a combination thereof, free of rock or gravel greater than one (1) inch in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter.

K. Unsuitable Material
1. Definition: That excavated material which does not meet the consistency requirements of any other defined materials in this Section, including muck, frozen material, organic material, top soil, rubbish, and rock within the limits defined for General Fill Material
2. Dispose of unsuitable material off-Site, at no increase in Contract Sum or extension of Contract Time.
   a. Submit an acceptable agreement with the property owner on whose property the unsuitable material is placed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
1. Verify location and elevations of existing building foundations.
2. Verify location and elevations of existing underground utilities.
3. Verify erosion control systems are in place.
4. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protection:
1. Protect trees, shrubs, lawns, other plant growth, and other features indicated on Drawings to remain.
2. Protect bench marks, monuments, existing structures, existing fences, existing roads, existing sidewalks, existing paving, and existing curbs from damage caused by settlement, lateral movement, undermining, washout, and other hazards caused by Work of this Section.
   a. If damaged or displaced, notify Owner’s Representative and correct defects as directed by Owner’s Representative.
3. Protect above and below grade utilities which are to remain.
4. Protect adjacent and downstream properties from pollution, sedimentation, or erosion caused by the work of this Contract.

B. Precautions:
   1. Use all means necessary to control dust on and near the Work, and on and near off-Site borrow storage, and spoil areas, if such dust is caused by performance of the Work of this Section, or if resulting from the condition in which Project Site is left by Contractor.
   2. Moisten surfaces as required to prevent dust from being a nuisance to the public, neighbors, and concurrent performance of other Work on Project Site.
   3. Identify required lines, levels, contours, and datum.
   4. Identify above and below grade utilities.
   5. Provide and maintain positive surface drainage.

3.3 WATER CONTROL
A. Provide berms or channels to prevent flooding of subgrades.
B. Prevent infiltration of water into excavations from whatever sources as may exist.
C. Prevent ponding of water on finish subgrades.
D. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
E. Prevent flooding of Project Site and surrounding areas.
F. Promptly remove water collection in depressions.
   1. Provide and maintain ample means and devices with which to remove and dispose of water entering excavations.
   2. Ensure dry excavations and preservation of final lines and grades of bottoms of excavations.

3.4 EXCAVATION, GENERAL
A. Use of explosives is not permitted.
B. Excavation above subgrade as defined in paragraph 1.2 of this section is unclassified and includes excavation of any material encountered regardless of its character including rock, soil materials, debris, and other obstructions and shall be included in the base bid.
C. Perform excavation to the lines and grades indicated on Drawings within a tolerance of 0.10 foot.
   1. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction, and for inspections.
D. Perform Excavation Work in compliance with applicable requirements of authorities having jurisdiction, including United States Department of Labor, Occupational Safety and Health Administration (OSHA) “Construction Standards for Excavations, 29 CFR Part 1926”.
E. Perform Work in a manner and sequence that will provide drainage at all times and that will prevent surface water from draining into excavations.
F. Protect subgrades and foundation soils against freezing temperatures and frost.
   1. Provide protective insulation materials as necessary.
G. When excavating through roots, perform Work by hand cutting roots with sharp axe.

H. Excavation cut shall not interfere with normal 45 degree bearing splay of foundations.

I. Machine slope banks to comply with local codes, ordinances, and requirements of agencies having jurisdiction.
   1. Provide materials for shoring and bracing.
      a. Maintain shoring and bracing in excavations regardless of time period excavations will be open.
      b. Extend shoring and bracing as excavation progresses
   2. Control surface drainage down slopes.
   3. Cover slopes to prevent loss of moisture content of soil and to prevent raveling.

J. When materials encountered at subgrade are determined to be unacceptable for use by testing agency, remove such material to depths and limits determined by testing agency.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material.

K. Where depressions result from, or have resulted from the removal of surface or subsurface obstructions, open depressions to equipment working width, and remove debris and soft material as directed by testing agency, at no increase in Contract Sum or extension of Contract time.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

L. Backfill and compact over-excavations and unauthorized as specified for the area at which it occurs, at no increase in Contract Sum or extension of Contract Time.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

M. Stockpile excavation material which testing agency has approved for reuse.
   1. Stockpile soil materials without intermixing soil materials with different consistencies and gradation.
   2. Place, grade, and shape stockpiles to drain surface water.
   3. Do not stockpile within drip line of trees which are to remain.
   4. Cover stockpiles to prevent wind-blown dust.

N. Remove unacceptable excavation material from Site, at no increase in Contract Sum or extension of Contract Time.

O. Hand trim excavations.
   1. Remove loose matter.

P. Excavation for Footings and Foundations:
   1. Do not disturb bottom of excavation.
      a. Excavate by hand to final grade immediately prior to placement of concrete reinforcement.
      b. Trim bottom of excavations to required lines and grades to leave solid base to receive other work.
   2. Drill probe holes at exposed bottom of excavations as directed by testing agency.

3.5 TRENCH EXCAVATIONS

A. Use of explosives is not permitted.

B. Trench excavation is unclassified and includes excavation to required exposed subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
C. Excavate trenches to gradients, lines, depths, and elevations indicated on Drawings, within a tolerance of 0.10 foot.

D. Perform excavation Work in compliance with applicable requirements of authorities having jurisdiction, including United States Department of Labor, Occupational Safety and Health Administration (OSHA) "Construction Standards for Excavations, 29 CFR Part 1926".

E. Do not perform trench excavation in areas to receive fill until fill operations are complete to an elevation of not less than 24 inches above the top of the proposed pipe or conduit for which the trench is to receive.

F. Perform Work in a manner and sequence that will provide drainage at all times and that will prevent surface water from draining into trenches.

G. Protect subgrades against freezing temperatures and frost.

H. Provide protective insulation materials as necessary.

I. When excavating through roots, perform Work by hand cutting roots with a sharp axe.

J. Excavation cut shall not interfere with normal 45 degree bearing splay of foundations.

K. Excavate trenches to uniform width, sufficiently wide to enable installation of utilities and to allow safe inspection of installed utilities.

L. Excavate trenches 6 inches deeper than bottom of pipe elevation to allow for bedding course
   1. Hand excavate for bell of pipe.
   2. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
   3. Comply with local codes, ordinances, and requirements of agencies having jurisdiction.
   4. Provide materials for shoring and bracing.
      a. Maintain shoring and bracing in trenches regardless of time period trenches will be open.
      b. Extend shoring and bracing as excavation progresses.
   5. Control surface drainage down slopes.
   6. Cover slopes to prevent loss of moisture content of soil and to prevent raveling.
   7. Hand trim trenches.
      a. Remove loose matter.

M. When subgrade materials are encountered which testing agency determines to be unacceptable for use, remove such material to depths and limits determined by testing agency:
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material.
   2. Removal and replacement of unacceptable material will be paid on basis of Unit Prices included in the Contract Documents.

N. Where depressions result from, or have resulted from the removal of surface or subsurface obstructions, open depressions to equipment working width, and remove debris and soft material as directed by testing agency at no increase in Contract Sum or extension of Contract Time.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

O. Stockpile excavation material which testing agency has approved for reuse.
   1. Stockpile soil materials without intermixing soil materials with different consistencies and gradations.
   2. Place, grade, and shape stockpiles to drain surface water.
   3. Do not stockpile within drip line of trees which are to remain.
   4. Cover stockpiles to prevent wind-blown dust.
3.6 SUBGRADE PREPARATION FOR BUILDING SLABS-ON-GRADE

A. General:
1. Excavation for subgrade preparation is unclassified and includes excavation to required subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
2. Testing agency shall be present to observe and evaluate subgrades in building areas prior to placement of fill and/or low volume change materials and shall be present during placement and compaction of fill materials in building areas. Undercut as specified herein to develop 18 inch thick low volume change zone below building floor slabs. Subgrades in building areas shall be observed and evaluated by geotechnical engineer prior to fill and/or low volume change placement. Evaluation may include probing by geotechnical engineer and opening of test pits and/or test trenches with contractors assistance to explore areas of suspected unsuitable materials. Subgrades shall also be proof-rolled with loaded tandem axle dump truck in presence of geotechnical engineer and scarified, moisture conditioned and recompacted as specified herein prior to placement of fill and/or low volume change materials.
3. Fill material shall not be placed, spread, or rolled while the material is frozen or thawing, or during unfavorable weather conditions.
4. Moisture condition or dry fill material as required to obtain specified moisture content limits.
   a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by disking, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
9. In excavations where testing agency determines that subgrade material is unacceptable, remove unacceptable material and backfill in accordance with procedures determined by testing agency.
10. Minimize construction traffic, including foot traffic, from floor slab finished subgrades in order to prevent unnecessary disturbances of subgrade materials.
   a. If testing agency determines that finished subgrades have been disturbed, remove disturbed areas and replace and recompact to required density as directed by testing agency.
   b. If testing agency determines that rutting has occurred, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
   c. Testing agency shall be present during compaction of material.

B. In cut areas below building slabs-on-grade requiring less than 24 inches of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside building areas, excavate existing materials to a depth of not less than 24 inches below bottom of floor slab granular fill.
1. Scarify subgrade to a depth of 6 inches to result in a surface free from ruts, hummocks, and other uneven features which, in the opinion of the testing agency, would prevent uniform compaction by the equipment proposed for use.
   a. Moisture condition subgrade to achieve moisture content specified in this Section.
   b. Compact to a minimum of 95% of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
2. After scarifying, moisture conditioning, and recompacting, backfill fill areas using low volume change materials placed in loose lifts not exceeding 8 inches.
   a. Compact each lift of low volume change clay soil to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698. Compact each lift of granular low volume change material to a minimum of 95 percent of the material's maximum standard proctor dry density at a workable moisture content sufficient to obtain the required density.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

3. Fill operations shall continue in compacted layers until finish subgrade elevations have been obtained.
   a. Compact each lift of low volume change clay soil to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698. Compact each lift of granular low volume change material to a minimum of 95 percent of the material's maximum standard proctor dry density at a workable moisture content sufficient to obtain the required density.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

4. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.

5. The upper 24 inches of fill material shall be low volume change material.

6. Maintain subgrade moisture content within specified range until building slabs-on-grade are installed.
   a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
   b. Recompact and retest until required density and moisture content is obtained.

C. In areas below building slabs-on-grade requiring 24 inches or more of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside building areas, scarify subgrade to a depth of 6 inches to result in surface free from ruts, hummocks, and other uneven features which, in the opinion testing agency, would prevent uniform compaction by the equipment proposed for use.

1. Moisture condition subgrade to achieve moisture content specified in this Section.
   a. Compact to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

2. After scarifying, moisture conditioning, and recompacting, backfill areas using suitable materials as specified herein placed in loose lifts not exceeding 8 inches. Suitable on-site clay materials may be used below the 24-inch thick low volume change zone.
   a. Compact each lift of suitable clay soil or low volume change material to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698. Compact each lift of granular low volume change material to a minimum of 95 percent of the material's maximum Standard Proctor dry density at workable moisture content sufficient to obtain the required density.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

3. Fill operations shall continue in compacted layers until finish subgrade elevations have been obtained.
   a. Compact each lift of suitable clay soil or low volume change material to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

4. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.

5. The upper 18 inches of fill material shall be low volume change material.

6. Maintain subgrade moisture content within specified range until building slabs-on-grade are installed.
   a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
   b. Recompact and retest until required density and moisture content is obtained.

D. Tolerances:
   1. Top surface of finish subgrade under slabs-on-grade: Plus or minus ¼ inch from required elevations.

3.7 SUBGRADE PREPARATION FOR FOUNDATION FOOTING

A. General:
   1. Excavation for subgrade preparation for foundations is unclassified and includes excavation to required subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
   2. Testing agency shall be present during placement and compaction of fill material.
   3. Fill material shall not be placed, spread, or rolled while the material is frozen or thawing, or during unfavorable weather conditions.
   4. Moisture condition dry fill material as required to obtain specified moisture content limits.
      a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by diskng, harrowing, or pulverizing.
   5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
   6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
   7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
   8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
   9. In excavations where testing agency determines that subgrade material is unacceptable, remove unacceptable material and backfill in accordance with procedures determined by testing agency.
   10. Minimize construction traffic, including foot traffic, from floor slab finished subgrades in order to prevent unnecessary disturbances of subgrade materials.
      a. If testing agency determines that finished subgrades have been disturbed, remove disturbed areas and replace and recompact to required density as directed by testing agency.
      b. If testing agency determines that rutting has occurred, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
      c. Testing agency shall be present during compaction of material.
3.8 SUBGRADE PREPARATION AT PAVEMENTS

A. General:
1. Excavation for subgrade preparation is unclassified and includes excavation to required subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
2. Testing agency shall be present to observe proof-rolling of subgrades in pavement and sidewalk areas prior to placement of fill and shall be present during placement and compaction of fill materials in pavement and sidewalk areas. Testing agency shall also be present to observe proof-rolling of finished subgrades prior to installation of pavement and sidewalk sections.
3. Fill material shall not be placed, spread, or rolled while the material is frozen or thawing, or during unfavorable weather conditions.
4. Moisture condition or dry fill material as required to obtain specified moisture content limits.
   a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by disksing, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
9. In excavations where testing agency determines that subgrade material is unacceptable, remove unacceptable material and backfill in accordance with procedures determined by testing agency.
10. Minimize construction traffic, including foot traffic, from pavement finished subgrades in order to prevent unnecessary disturbances of subgrade materials.
   a. If testing agency determines that finished subgrades have been disturbed, remove disturbed areas and replace and recompact to required density as directed by testing agency.
   b. If testing agency determines that rutting has occurred, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
   c. Testing agency shall be present during compaction of material.

B. In cut areas below pavements requiring less than 12 inches of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside pavement areas, excavate existing material to a depth of not less than 6 inches below bottom of pavement subbase course.
1. Proof-roll subgrade and repair as required in paragraph 3.8.E below, then scarify to a depth of 6 inches to result in a surface free from ruts, hummocks, and other uneven features which, in the opinion of the testing agency, would prevent uniform compaction by the equipment proposed for use.
   a. Moisture condition subgrade to achieve moisture content specified in this Section.
   b. Compact to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
2. After scarifying, moisture conditioning, and recompacting, backfill areas using approved materials placed in loose lifts not exceeding 8 inches.
   a. Compact each lift to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
3. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.
4. Maintain subgrade moisture content within specified range until pavements are installed.
   a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
   b. Recompact and retest until required density and moisture content is obtained.

C. In areas below pavements requiring 12 inches or more of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside pavement areas, proofroll existing subgrade in presence of testing agency using a fully loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of 20 tons.
   1. Remove soft areas as directed by testing agency and recompact in loose 9 inch lifts to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
   2. After proofrolling operations are performed and observed soft areas repaired, place approved material in loose lifts not exceeding 8 inches.
      a. Compact each lift to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
         1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
         2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
   3. Fill operations shall continue in compacted layers until finish subgrade elevations have been obtained.
      a. Compact each lift to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
         1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
         2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

D. Tolerances
   1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.

E. Immediately prior to placement of pavement subbase course and pavements, proofroll subgrade in presence of testing agency using a fully loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of 20 tons.
   1. Remove soft areas as directed by testing agency and recompact in loose 9 inch lifts to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
3.9 GENERAL SITE FILL

A. General:
1. Testing agency shall be present during placement and compaction of fill material.
2. Fill material shall not be placed, spread, or rolled while the material is frozen of thawing, or during unfavorable weather conditions.
3. Moisture condition or dry fill material as required to obtain specified moisture limits.
4. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by dishing, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.

B. Perform grading to the contours and elevations indicated on Drawings:
1. Uniformly grade areas to a smooth surface, free from irregular surface changes.
2. Provide a smooth transition between existing adjacent grades and new grades.

C. Place general fill material in systematic and uniform horizontal lifts not exceeding the following loose-depth-measurements:
1. For fill material to be compacted with heavy compaction equipment: 9 inches.
2. For fill material to be compacted with hand operated tampers: 4 inches.

D. Under sidewalks and ramps compact each lift of material to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698
   1. In other areas, compact each lift of material to a minimum of 90 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698
      a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

E. Bench existing slopes horizontal sections equal in width to equipment used.

F. Where embankments, regardless of height, are placed against hillsides or existing embankments having a slope of steeper than 1 vertical to 5 horizontal, bench or step existing slope in approximately 24 inch rises:
   1. Place fill in lifts not exceeding 9 inches in loose-depth-measurement
   2. Compact material bladed out, bottom area which was cut to form benches, and fill material being placed, to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

G. Remove surplus materials from Site, at no increase in Contract Sum or extension of Contract Time.
   1. Submit an acceptable agreement with the property owner on whose property the material is placed.

H. Tolerances:
   1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.
   2. Top surface of finish subgrade under unpaved surfaces: Plus or minus ½ inch from required elevations.
3.10 INSTALLATION OF GRANULAR FILL

A. Immediately prior to placing floor slab granular base, testing agency will evaluate subgrade to determine whether moisture content is within specified range, and whether subgrade has been disturbed.
   1. In areas where testing agency determines subgrade is not within specified moisture content range, remove non-complying areas and replace and recompact to required density, within specified moisture content range, as directed by testing agency.
      a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      b. When test indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
   2. If testing agency determines that rutting has occurred or other detrimental conditions exist, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
      a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

B. Place granular fill in equal continuous layers not exceeding 6 inches.
   1. Compact granular fill using heavy vibrating equipment, in 3 passes, to achieve a total compacted thickness of 4 inches in presence of Owner’s representative or testing agency.
   2. Compact granular fill in confined areas using a combination of manually operated vibratory plates and “wacker” compaction equipment.

C. Tolerances:
   1. Top surface of finish subgrade under slabs-on-grade: Plus or minus ¼ inch from required elevations.

3.11 INSTALLATION OF PAVEMENT SUBBASE COURSE

A. Place pavement subbase course in equal continuous layers not exceeding 6 inches.
   1. Compact granular fill for pavement and sidewalk subbase course to a minimum of 95 percent of the material’s maximum standard proctor dry density in accordance with ASTM D698.
   2. Compact granular fill in confined areas using a combination of manually operated vibratory plates and “wacker” compaction equipment.
   3. Qualitative tests shall be taken after the compaction of each layer of fill by testing agency.

B. Tolerances:
   1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.

3.12 BEDDING

A. Place and compact bedding course on trench bottoms and where indicated on Drawings.
   1. Install materials in continuous layers not exceeding 6 inches compacted depth.

B. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Install bedding to a depth of 6 inches below bottom of pipe bell or conduit, to an elevation of 6 inches above pipe or conduit.

D. Compact bedding materials by slicing with a shovel and compacting with vibratory plates and “wacker” compaction equipment.

E. Support pipe and conduit during placement and compaction of bedding fill.
3.13 INSTALLATION OF BACKFILL

A. Backfill excavations promptly, but not before completion of the following:
   1. Surveying location of underground utilities for Record Documents
   2. Testing, inspecting, and approval of underground utilities
   3. Removal of concrete forms
   4. Removal of lumber, rock, paper, and other debris from areas to be backfilled
   5. Removal of temporary shoring, bracing, and sheeting

B. Backfill areas to contours and elevations indicated on Drawings, using unfrozen backfill material
   1. Do not backfill over porous, wet, frozen, thawing, or spongy surfaces
   2. Do not backfill during unfavorable weather conditions
   3. Moisture condition or dry backfill material as required to obtain specified moisture content limits
      a. Material which is too wet to allow proper compaction, as determined by testing agency
   4. Place backfill material using equipment capable of obtaining uniform loose lift thickness
   5. Compact backfill material using equipment appropriate to the material being compacted, as determined by testing agency
   6. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed backfill areas is as specified
   7. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
   8. Compaction in lawn and planter areas is 85% maximum.

C. Backfilling of curbs, slabs-on-grade, and other structures whose foundation is unprotected from water shall be accomplished as soon as forms are removed, to eliminate possibility of softening of subbase below structure

D. Backfill foundation walls with granular material, not less than 24 inches in width, to an elevation of 2 feet below finish grade.
   1. Backfill simultaneously on each side of unsupported foundation walls.
   2. Backfill upper 2 feet using General Fill Material.

E. Backfill trenches to contours and elevations indicated on Drawings, using unfrozen backfill material.
   1. Do not backfill over porous, wet, frozen, or spongy surfaces.
   2. Do not backfill during unfavorable weather conditions.
   3. Moisture condition or dry backfill material as required to obtain specified moisture content limits.
      a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by diskling, harrowing, or pulverizing.
   4. Place backfill material using equipment capable of obtaining uniform loose lift thickness.
      a. Employ a placement method of backfill operations which does not disturb or damage utilities in trenches.

F. Backfill trenches that carry below or pass under footings and that are excavated within 18 inches of footings with concrete.
   1. Place concrete to elevation equal to bottom of footings.

G. Compaction of General Backfill
   1. Maintain optimum moisture content of backfill materials to attain required compaction density.
   2. General Fill Materials used for backfill shall be placed in lifts not exceeding 9 inches in loose-depth-measure and compacted as specified for General Site Fill
   3. Granular Fill Materials used for backfill shall be placed in lifts not exceeding 6 inches in loose-depth-measure and compacted as specified for Granular Fill.
   4. Field density tests shall be taken after the compaction of each layer of backfill by testing agency.
      a. When tests indicate that any layer of backfill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

H. Compaction of Trench Backfill
   1. Compact backfill material using equipment appropriate to the material being compacted, as determined by testing agency.
2. Maintain optimum moisture content of backfill materials to attain required compaction density.
3. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed backfill area is as specified.
4. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
5. General Fill Material used for backfill shall be placed in lifts not exceeding 4 inches in loose-depth-measure with each lift compacted as specified in this section.
6. MoDOT Standard Specification for Highway Construction Type 5 aggregate used for backfill shall be placed in lifts not exceeding 6 inches in loose-depth-measure and compacted to a minimum of 97 percent of the material’s maximum Standard Proctor dry density with a moisture content near optimum in accordance with ASTM D698.
7. Field density tests shall be taken after the completion of each layer of backfill by testing agency.
   a. When tests indicate that any layer of backfill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

I. Slope grade away from building not less than 12 inches in 10 foot for a distance of not less than 6 feet outside of building lines.
   1. Make grade changes gradual.
   2. Blend slopes into level areas.
   3. Remove surplus materials from Site, at no increase in Contract Sum or extension of Contract Time.
   4. Submit an acceptable agreement with the property owner on whose property the material is placed.

J. Tolerances:
   1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.
   2. Top surface of finish subgrade under unpaved areas: Plus or minus ½ inch from required elevations.

3.14 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Geotechnical Engineer.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 6938, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
   1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft.or less of paved area or building slab, but in no case fewer than three tests.
   2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
   3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.
3.15 PROTECTION

A. Protect newly graded areas from freezing and erosion.

B. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

C. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and compact to required density prior to further construction.
   1. Testing agency shall be present during compaction of material.

END OF SECTION
SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Hot-mix asphalt paving.
   2. Asphalt traffic-calming devices.
   3. Asphalt surface treatments.

B. Related Requirements:
   1. Section 312000 "Earth Moving" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
      a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
      b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include technical data and tested physical and performance properties.
   2. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or Missouri Department of Transportation (MoDOT).

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of MoDOT for asphalt paving work.
   1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.
1.6 FIELD CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
   1. Prime Coat: Minimum surface temperature of 60 deg F.
   2. Tack Coat: Minimum surface temperature of 60 deg F.
   4. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
   5. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. Aggregate base for asphaltic pavements shall be a granular compacted crushed limestone with a gradation and quality conforming to the requirements of MoDOT Standard Specification 1007 for either Type 1 or Type 5 aggregate.

B. The maximum lift thickness for granular base shall be 4 inches.

C. Granular base thickness in excess of 4 inches shall be placed in multiple lifts with each lift being of approximate equal thickness.

D. Granular base shall be compacted to at least 100% of Standard Proctor Compaction (ASTM D-698)


G. Mineral Filler: ASTM D 242, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. Asphalt Binder: AASHTO M 320, PG 64-22.

B. Asphalt Cement: ASTM D 946/D 946M for penetration-graded material.

C. Cutback Prime Coat: ASTM D 2027, medium-curing cutback asphalt, MC-30 or MC-70.

D. Tack Coat: ASTM D 977 emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

E. Water: Potable.

F. Undersealing Asphalt: ASTM D 3141/D 3141M; pumping consistency.

2.3 MIXES

A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes approved by MoDOT; and complying with the following requirements:
   1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
a. Thickness: As shown in drawing.

   a. Thickness: As shown in drawing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
   1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
   2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
   3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Testing Agency, and replace with compacted backfill or fill as directed.

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

3.2 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Cutback Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal./sq. yd.. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.
   1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
   2. Protect primed substrate from damage until ready to receive paving.

C. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd..
   1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.3 PLACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
   1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
   2. Place hot-mix asphalt surface course in single lift.
   3. Spread mix at a minimum temperature of 250 deg F.
   4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
   5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches from strip to strip to ensure proper compaction of mix along longitudinal joints.

2. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.4 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.

2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.

3. Offset transverse joints, in successive courses, a minimum of 24 inches.

4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AIMS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.

6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.5 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 96 percent of reference laboratory density according to ASTM D 6927 or AASHTO T 245, but not less than 94 percent or greater than 100 percent.

2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent or greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.
3.6 ASPHALT TRAFFIC-CALMING DEVICES

A. Construct hot-mix asphalt speed bumps, humps, cushions, and tables over compacted pavement surfaces. Apply a tack coat unless pavement surface is still tacky and free from dust. Spread mix at a minimum temperature of 250 deg F.
   1. Tack Coat Application: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
   2. Asphalt Mix: Same as pavement surface-course mix.
   3. Before installation, mill pavement that will be in contact with bottom of traffic-calming device. Mill to a depth of 1 inch from top of pavement to a clean, rough profile.

B. Place and compact hot-mix asphalt to cross section indicated, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.7 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
   1. Base Course: Plus or minus 1/2 inch.
   2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
   1. Base Course: 1/4 inch
   2. Surface Course: 1/8 inch.
   3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

C. Asphalt Traffic-Calming Devices: Compact and form asphalt to produce the contour indicated and within a tolerance of plus or minus 1/8 inch of height indicated above pavement surface.

3.8 FIELD QUALITY CONTROL

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

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. Asphalt Traffic-Calming Devices: Finished height of traffic-calming devices above pavement will be measured for compliance with tolerances.

E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979 or AASHTO T 168.
   1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
   2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
      a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than three cores taken.
      b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
3.9 WASTE HANDLING

A. General: Handle asphalt-paving waste according to approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."

F. Replace and compact hot-mix asphalt where core tests were taken.

G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

END OF SECTION
SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Driveways.
   2. Roadways.
   3. Parking lots.
   4. Curbs and gutters.
   5. Walks.

B. Work in public right-of-way: All work in public right-of-way shall be performed per City Standards and Specifications.

1.2 ACTION SUBMITTALS

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

B. Samples: For each exposed product and for each color and texture specified.

C. Other Action Submittals:
   1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
   2. Aggregates: Aggregates must be supplied from a source previously tested and certified by MoDOT as meeting "Aggregates for Concrete" requirements in Section 1005 of MoDOT Standard Specifications. Aggregate shall be sound and durable and meet ASTM C586.

1.3 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. ACI Publications: Comply with ACI 301 unless otherwise indicated.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT


B. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 deformed bars.

C. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A; coated, deformed.

D. Epoxy-Coated, Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60 plain-steel bars.
E. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified.

2.2 CONCRETE MATERIALS AND MIXTURES

A. Portland cement concrete shall conform to MoDOT 501 and 1005 with the following modifications:
   1. All portland cement concrete shall be air entrained with 6% (± 1%) minimum air content.
   2. The use of calcium chloride is not permitted.
   3. The allowable slump shall be not more than 4 inches.
   4. The minimum 28-day compressive strength shall be 4,000-psi.
   5. Aggregate:
      a. The combined maximum weight of flint and chert shall be 1% of the weight of coarse aggregate.
      b. The maximum weight of lignite shall be 0.07% of the weight of the fine aggregate.

2.3 CURING MATERIALS

A. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

2.4 RELATED MATERIALS

A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber.

2.5 WHEEL STOPS

A. Wheel Stops: Precast, air-entrained concrete.
   1. Dowels: Galvanized steel, 3/4 inch in diameter, 10-inch minimum length.
   2. Adhesive: As recommended by wheel stop manufacturer for application to concrete pavement.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.

B. Remove loose material from compacted subbase surface immediately before placing concrete.

C. Prior to concrete paving, Contractor shall prepare mockup for concrete pavement and sidewalks. Mockup to include a minimum of 100 square feet of paving. Mockup may be installed "in-place" and must demonstrate the proposed joint types, reinforcement, sealant, and saw-cutting. Prepare mockup for Owner review and approval, prior to concrete paving.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.3 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, to match jointing of existing adjacent concrete paving.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT

A. Moisten subbase to provide a uniform dampened condition at time concrete is placed.

B. Comply with ACI 301 requirements for measuring, mixing, transporting, placing, and consolidating concrete.

C. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

D. Screed paving surface with a straightedge and strike off.

E. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.6 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.
2. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

3.7 COLD AND HOT WEATHER CONCRETE PLACEMENT

A. Cold Weather Concrete:
1. Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when the descending air temperature in the shade and away from artificial heat reaches thirty-five (35°) degrees F. Concrete operations may be resumed when the ascending air temperature in the shade and away from artificial heat reaches thirty-five (35°) degrees F.
2. When concrete work is authorized during cold weather, the concrete may be heated in accordance with ACI specifications. The temperature of the concrete shall be not less than sixty (60°) degrees F and not more than eighty (80°) degrees F at the time of placement in the forms.
3. No concrete shall be placed on frozen subgrade. Sudden cooling of concrete shall not be permitted. Concrete exposed to frost action or freezing weather shall be removed and replaced at the Contractor's expense.
4. A sufficient supply of approved blanketing material shall be provided and placed on all concrete placed between November 1 and April 1 and at other times when the ambient air temperature is expected to drop below forty (40°) degrees F. Blanketing materials shall protect the concrete and maintain a minimum temperature of forty (40°) degrees F in the concrete as measured on the surface. Concrete shall be covered for at least four days.

B. Hot Weather Concrete:
1. The provisions of this section shall apply to all concrete work, which is done when the air temperature is above eighty (80°) degrees F at the time of placement. The temperature of the concrete, when placed, shall not be high enough to cause excessive loss of slump, flash set or cold joints. Forms, reinforcing and sub-grade surfaces against which the concrete is to be placed shall be wetted down immediately before placement. In no case shall the temperature of the concrete, when placed, exceed ninety (90°) degrees F.
2. When the air temperature exceeds ninety (90°) degrees F and as soon as practicable without causing damage to the surface finish, all exposed concrete shall be kept continuously moist by means of fog sprays, wet burlap, cotton mats, or other means acceptable to the Engineer at no expense to the Owner. This cooling with water shall be in addition to the initial sealing by membrane curing compound.
3. No concrete shall be placed when the air temperature is above ninety-five (95º) degrees F.

3.8 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by curing compound.

3.9 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:
1. Elevation: 3/4 inch.
3. Surface: Gap below 10-foot-long, unleveled straightedge not to exceed 1/2 inch.
4. Joint Spacing: 3 inches.
5. Contraction Joint Depth: Plus 1/4 inch, no minus.

3.10 WHEEL STOPS
A. Install wheel stops in bed of adhesive applied as recommended by manufacturer.
B. Securely attach wheel stops to paving with not less than two [galvanized]-steel dowels located at one-quarter to one-third points. Install dowels in drilled holes in the paving and bond dowels to wheel stop. Recess head of dowel beneath top of wheel stop.

3.11 REPAIRS AND PROTECTION
A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Design Professional.
B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
C. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

3.12 FIELD QUALITY CONTROL
A. Delivery Tickets: For each load delivered, submit 3 copies indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, and design slump at time of batching.
B. Tests: Owner will retain the services of an engineering inspection and testing firm. Contractor will be responsible for coordinating and scheduling inspection. Tests will include the following: strength, air entrainment, temperature, and slump tests. Test results will be specified to be sent directly to the Contractor, Engineer and Owner’s representative.
   1. Testing agency shall perform sampling and testing of concrete specified in ACI 301 Sections 16.3, 16.4, and as follows:
      a. Test data from concrete cylinder breaks will be evaluated using procedures of the American Concrete Institute (latest edition of ACI 214) to determine if the compressive strength of the concrete tested is acceptable.
      b. Concrete will be tested at the minimum rate of one test for the first 25 cubic yards [CY] placed each day, and one test for each additional 50 CY placed. Concrete may be tested more often at the discretion of the Owner’s Representative.
      1) One additional set of test cylinders will be taken during cold weather, and as directed by Engineer, cured at Project Site under same conditions as concrete it represents.
      c. Slump, ASTM C143: 1 per each set of compressive cylinders.
      d. Air content, ASTM C173: 1 per every 50 cubic yards, or portion thereof.
      e. Unit weight, ASTM C138: 1 per every 50 cubic yards, or portion thereof.
      f. Concrete temperature, ASTM C1064: 1 measurement for every slump test.
      g. Casting of compressive cylinders, ASTM C39: 1 set of 4 cylinders for every 50 cubic yards, or portion thereof.
      h. Concrete delivery: Check batch ticket from every truck.
C. Batch plant inspection: Random basis as determined by Engineer.

END OF SECTION 321313
SECTION 321373 - CONCRETE PAVING JOINT SEALANT

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. Section Includes:
   1. Cold-applied joint sealants.

B. Related Sections:
   1. Division 32 Section "Concrete Paving" for constructing joints in concrete pavement.

1.3 ACTION SUBMITTALS

A. Product Data: For each joint-sealant product indicated.

B. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- wide joints formed between two 6-inch- long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

C. Pavement-Joint-Sealant Schedule: Include the following information:
   1. Joint-sealant application, joint location, and designation.
   2. Joint-sealant manufacturer and product name.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of joint sealant and accessory, from manufacturer.

B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for joint sealants.

C. Preconstruction Compatibility and Adhesion Test Reports: From joint-sealant manufacturer, indicating the following:
   1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility with and adhesion to joint sealants.
   2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Source Limitations: Obtain each type of joint sealant from single source from single manufacturer.
C. Product Testing: Test joint sealants using a qualified testing agency.
   1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.

D. Preinstallation Conference: Conduct conference at Project site.

1.6 PROJECT CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:
   1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (5 deg C)
   2. When joint substrates are wet.
   3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
   4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.

B. Colors of Exposed Joint Sealants: As selected by Design Professional from manufacturer's full range color.

2.2 COLD-APPLIED JOINT SEALANTS

A. Multicomponent, Pourable, Traffic-Grade, Urethane Joint Sealant for Concrete: ASTM C 920, Type M, Grade P, Class 25, for Use T.
   1. Products: Subject to compliance with requirements provide the following:
      b. Sika Corporation: Sikaflex-2C SL and Sikaflex-2C NS TG
      c. BASF: Sonolastic SL2.

2.3 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.

B. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

2.4 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

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

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install joint-sealant backings of kind indicated to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of joint-sealant backings.
   2. Do not stretch, twist, puncture, or tear joint-sealant backings.
   3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants using proven techniques that comply with the following and at the same time backings are installed:
   1. Place joint sealants so they directly contact and fully wet joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
   1. Remove excess joint sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.
3.4 CLEANING

A. Clean off excess joint sealant or sealant smears adjacent to joints as the Work progresses, by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.5 PROTECTION

A. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.
SECTION 321400 - PRESSED CONCRETE PAVERS; SAND SET INSTALLATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provision of contract, including General and Supplementary Conditions and other Division 1
      Specification Sections, apply to work of this Section.

1.2 SUMMARY
   A. Perform all work required to complete, as indicated by the Contract Documents, and furnish all supplementary items
      necessary for the proper installation of Pressed Concrete Pavers.
   B. The pressed paver installation shall be absolutely rigid, and even large slabs when subjected to vehicular traffic, shall
      not be displaced.
   C. Related Sections include the following:
      1. Section 31 22 00 Grading.
      2. Section 31 23 00 Excavation, Backfilling and Compaction.
      3. Section 32 16 00 Concrete Paving, Walks, Curbs and Gutters.
      4. Section 07 00 00 Modified Bituminous Sheet Membrane Waterproofing.
      5. Section 07 92 00 Joint Sealants.

1.3 REFERENCES
   A. Testing Standards
      2. ASTM C-127 - Test method for specific gravity and absorption of Course Aggregates.
      3. ASTM C-128 - Test method for specific gravity and absorption of Fine Aggregates.
      5. ASTM C-140 - Standard test methods for sampling and testing Concrete masonry and related units.
      6. ASTM C-293 - Flexural Strength.
      7. ASTM C-1028 - Static Coefficient of Friction.
      9. WTCL 99 - Test for Center Load Capacity.

1.4 SUBMITTALS
   A. Submit under provisions of Section 01 30 00.

   B. Product Data:
      1. Manufacturer's data sheets on each product to be used, including preparation instructions, installation methods,
         storage, handling requirements and recommendations.
      2. Submit test results for compliance with performance requirements specified herein.
      3. Submit written instructions for recommended maintenance.
C. Shop Drawings:
   1. Layout drawings of each paved area showing the pattern of pressed pavers and indicate pavers requiring cutting, drainage patterns, drains, and relationship of paving joints. Include details of setting beds, noting all materials and their thickness, show details at curbs and vertical surfaces.
   2. Details of custom (nonstandard) curbs and stair tread/risers include methods of installation.

D. Samples:
   1. Submit sample to be selected by Architect / Engineer / Landscape Architect / Owner from manufacturer’s available standard and custom colors.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: All products covered under this section shall be produced by a single manufacturer, unless otherwise specified, with a minimum of fifteen (15) years proven production of this concrete paver product.

B. Installer Qualifications: Installer shall have a minimum of five (5) years proven specialized construction experience with this product and be capable of estimating and building from blueprint plans and details, in addition to proper material handling. All work must comply with local, state/provincial licensing and bonding requirements.

1.6 MOCK-UP INSTALLATION

Prior to the start of pressed concrete paver work, construct mock-up of each type of pressed paver size and pattern area for the owner and architect to review. The mock-up will be at the project site or at a location mutually agreed to by the owner and contractor.

1. Construct the mock-up installation in a minimum 4-foot by 4-foot area of typical concrete units and slabs with all setting beds, joints, edge and curb details as shown on the drawings.

2. After review of the mock-up, it will be retained and used as a standard of quality for the pressed concrete paver work. At completion of the work, remove the mock-up installation and related materials from the project site. If the mock-up is incorporated into the actual construction, record their location and size on the actual built record drawings for the project.

1.7 DELIVERY, STORAGE AND HANDLING

A. In accordance with provisions of Section 01 60 00.

B. Pressed concrete pavers to be banded on pallets and delivered in original unopened packaging with legible manufacturer identification, manufacturing number and manufacture date.

C. Protect pressed concrete pavers during shipment, storage and construction against damage.
1.8 PROJECT CONDITIONS
A. Maintain environmental conditions (temperature, humidity and ventilation). Do not install products under adverse environmental conditions.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
A. Acceptable Manufacturer:
Tectura Designs, 800-388-8728 Phone: (715) 359-3121 Fax: (715) 359-7456
E-mail: info@tecturadesigns.com Website: www.tecturadesigns.com

B. Choose from EcoPremier, UltraFace, Textured Granite, Textured Sand, Stoney Creek, Granitex, ExpoStone, ExpoGranite, Exterior Terrazzo, SeaShell, CoolSeries, Expression, Washed Glass, Blasted Glass, ADA, Detectable Warning or Ballast pavers.

C. Substitutions: Not permitted.

D. Pressed concrete pavers equal in appearance and function that meet the requirements will be acceptable when the specified submittals from Section 00 26 00 are approved in writing by the architect prior to bid.

2.2 MATERIAL REQUIREMENTS
The pressed paver system shall include the following components:

A. Portland Cement: ASTM C-150 specification for Portland Cement,

B. Aggregates: All aggregates are tested in accordance with ASTM C127, ASTM C128, and ASTM C-136. Aggregate shall be blended to meet individual project requirements.

C. Coloring: Pigments used shall be inorganic and alkali resistant and used per manufacturer’s recommendations.

D. Factory Applied Sealer: Colorless slip and stain resistant penetrating or acrylic sealer.

2.3 PERFORMANCE REQUIREMENTS
*Performance Requirements based on 24”x24”x2” pressed paver

A. Compressive Strength: (ASTM C-140) The average compressive strength shall not be less than 8,000 psi with no individual unit less than 7,000 psi.

B. Water Absorption: (ASTM C-140) The average shall not be greater than 6 percent.

C. Flexural Strength: (ASTM C-293) Shall not be less than 800 psi.
D.  

**Center Load:** (WTCL 99) Pressed paver units shall have a tested center load capacity of 1,850 lbs.

E.  

**Freeze/Thaw:** (ASTM C-1262) Durability of the pressed paver shall meet the freeze/thaw tests per Section 8, shall have no breakage and not greater than 1 percent loss in dry weight of any individual unit when subject to 100 cycles of freeze/thaw.

F.  

**Static Coefficient of Friction:** (ASTM C-1028):  
Wet: > 0.50 and Dry: > 0.60

G.  

**Sizing Dimensions:** Shall not differ by more than 1/16 inch (1.6 mm) from width, height, length or thickness. Unit shall conform to a true plane and not differ by more than 1/16 inch (1.6 mm) in either concave and/or convex warpage.

### 2.4 INSTALLATION MATERIALS

**A. INSTALLATION OF SAND SETTING BED – PEDESTRIAN**

1. (Optional) Place a layer of the specified geotextile filter fabric uniformly on the surface of the properly prepared grade that is ready to receive the sand setting bed. Cover the designated area in its entirety.

2. Place solid steel, 3/4-inch or 1-inch thick, control bars directly on the sand or geotextile filter fabric. Install shims under bars for minor adjustment of depth and finish pressed paver elevations and slopes. Space bars approximately 7 feet apart and parallel to each other to serve as guides for strike-off boards. Spacing can vary as determined by the size of the area and layout.

3. Place sand setting bed between control bars on the sand or geotextile filter fabric to not less than thickness of the designated control bars. Spread material and strike off by pulling the material with a 8-foot long by 2-inch by 6-inch wood board several times to produce a smooth, firm and even setting bed. Add fresh material in low areas after each pass of the strike-off board. After each panel is complete, remove and advance the first control bar to the next panel position in readiness for placing and striking adjacent panels. Fill in depressions left by the control bar and any shims.

### PART 3 – EXECUTION

**3.1 INSPECTION**

A. Examine all jobsite surfaces to receive the parts of the paving materials. Notify the contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected. Installation of pressed concrete pavers and associated construction constitutes acceptance of the adjacent and underlying construction.
3.2 INSTALLATION

A. Install in accordance with contributing manufacturer's instructions. Installation requirements vary for each individual project site. Pressed pavers used, pattern, grid layout, starting point and finished elevation should be shown on plan view shop drawings which have been prepared and approved by the designer, installing contractor and/or owner.

B. 1. Install pressed concrete pavers in patterns, allowing for surface drainage as shown on the drawings. Install pressed concrete pavers in accordance with the manufacturer's installation instructions and the final reviewed shop drawings.

2. Lay out pavement in 30-foot working area modules. Set pressed concrete pavers on sand setting bed in patterns shown on the drawings with hand tight joints 1/8-inch to 3/16-inch wide joints and uniform top surfaces.

3. Field cut pressed concrete pavers in accordance with manufacturer's recommendations for methods, equipment and precautions.

4. Maintain accurate alignment and check for creep and shrinkage. Make adjustments to creep and shrinkage within the 30-foot module area.

5. Install edge restraints where required and as shown on the architectural drawings and details.

6. Sweep fine dry polymeric sand of a type and color approved by the architect over pavement surface to fill joints immediately after installing pressed pavers, slabs and curbs on setting bed. Brush in polymeric sand until joints are completely filled, remove surplus sand. Do not allow traffic on installed pressed pavers, slabs or curbing until the joints have been filled.

7. Protect newly laid pressed pavers, slabs and curbs with plywood panels on which workers stand. Advance protective panels as work progresses, but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting alignment of installed pressed pavers, slabs and curbs.
8. Install the specified joint filler where pressed concrete pavers abut curbs, vertical surfaces, and other construction.

9. Final cleaning to remove all soiling from pressed pavers for final acceptance.

Placement Tolerance:

1. Maximum of 1/16-inch (1.6 mm) height variation between adjacent pressed pavers.

2. Individual pressed pavers shall not vary more than 1/16 inch (1.6 mm) from level across width of the pressed paver.

3. Paved areas shall not vary more than 1/4 inch (6 mm) in a distance of 10 feet (3 m) measured at any location and in any direction.

4. The surface elevation of pressed pavers shall be 1/8 inch to 1/4 inch (3 mm to 6 mm) above adjacent drainage inlets, concrete collars or channels.

5. Joints between pavers to be greater than 1/16 inch (1.6 mm).

3.3 CLEANING AND PROTECTION

A. Remove and replace pressed pavers which are loose, chipped, broken, stained or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install in same manner as original units with same joint treatment to eliminate evidence of replacement.

B. Wash entire surface with phosphate free neutral cleaner, rinse with clean water and allow to dry thoroughly.

C. Apply sealer in accordance with manufacturer’s directions.

1. Penetrating or topical type sealer designed especially for pressed concrete pavers.

END OF SECTION 321400
SECTION 321723 - PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pavement markings for parking areas and roadways.
   2. Accessible parking symbols.
   3. Traffic direction arrows.

1.2 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

B. Product Data: Manufacturer's specifications and technical data including the following.
   1. Product data sheet on each product.
   2. Material safety data sheet on each product.
   3. Manufacturer's installation instructions.

C. Quality Control Submittals:
   1. Manufacturer's certificate and test reports indicating that traffic marking material complies with requirements of this Section.
   2. Manufacturer's certificate indicating that glass beads comply with requirements of this Section, including test reports indicating roundness, refractive index, flow characteristics, and gradation.

D. Color Samples: Two sets of samples of the following.
   1. 2 inch by 3 inch sample of pavement marking material illustrating manufacturers full range of standard colors.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer's Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following.
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

1.4 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer's identification.

B. Labeling: Include manufacturer's name, type of material, brand name, brand code, date of manufacturer, surface preparation, color designation, analysis of contents, instructions for application, and instructions for cleanup.

C. Storage and Protection: Comply with manufacturer's recommendations.
1.5 PROJECT CONDITIONS

A. Environmental Requirements:
   1. Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 degrees F for oil-based materials, 50 degrees F for water-based materials, and not exceeding 95 degrees F.
   2. Do not apply materials during rain or snow, or when relative humidity is above 50 percent, unless required otherwise by manufacturer's instructions.

1.6 SEQUENCING

A. Sequence Work of this Section to occur immediately prior to Substantial Completion, except as otherwise approved by Design Professional.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pavement-Marking Paint: latex, water-base emulsion; ready mixed; complying with FS TT-P-1952.
   1. Color: As determined by Owner from manufacturer’s full range.

B. Glass Beads: AASHTO M247, Type 1, including packaging and marking requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Verify surfaces to receive traffic markings is dry and pavements are free of moisture.
   2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protection: Protect surfaces not being marked and finished Work of other Sections.

B. Surface Preparation:
   1. Prepare surfaces in accordance with manufacturer's instructions.
   2. Clean surfaces to receive pavement markings free of dust, dirt, concrete curing compounds, and other surface contaminants which may adversely affect adhesion or appearance.

3.3 APPLICATION

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Design Professional.

B. Allow paving to age for 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.
D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer’s recommended rates to provide a minimum wet film thickness of 15 mils (0.4 mm).
1. Broadcast glass spheres uniformly into wet pavement markings at a rate of 6lb/gal. (0.72 kg/L).

3.4 PROTECTION
A. Protect installed markings from damage until Substantial Completion.

3.5 DEFECTIVE TRAFFIC MARKINGS
A. Traffic markings which, in the opinion of the Design Professional, do not provide initial nighttime reflectivity or do not have the specified thickness shall be repaired and replaced at no increase in Contract Sum or extension in Contract Time.

B. Traffic markings which, in the opinion of the Design Professional, do not conform to required dimensions or specified requirements shall be completely removed and replaced at no increase in Contract Sum or extension in Contract Time.

END OF SECTION 321723
SECTION 329451 – SILVA CELL 2" SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Silva Cell system for planting and paving, including Silva Cell assemblies and related accessories.
   2. Other materials including, but not limited to, geotextile, geogrid, aggregate, subbase material, backfill, root barrier, and planting soil.

B. Materials Installed But Not Furnished Under This Section:
   1. Planting soils are furnished in Section 32 94 56 - Planting Soil for Silva Cells.

C. Related Requirements:
   1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
   2. Section 01 33 00 - Submittal Procedures: For administrative and procedural requirements for processing of submittals during the construction phase.
   3. Section 01 77 00 - Closeout Procedures: For administrative and procedural requirements for completion of the Work.
   4. Section 32 12 16 - Asphalt Paving
   5. Section 32 13 13 - Concrete Paving
   6. Section 32 14 00 - Unit Paving
   7. Section 32 84 00 - Planting Irrigation
   8. Section 32 93 00 - Plants

1.02 REFERENCES

A. Definitions:
   1. AGGREGATE BASE COURSE: Aggregate material between the paving and the top of the Silva Cell deck below, designed to distribute loads across the top of the deck.
   2. AGGREGATE SUBBASE: Aggregate material between the bottom of the Silva Cell base and the compacted subgrade below, designed to distribute loads from the Silva Cell bases to the subgrade.
   3. BACKFILL: The earth used to replace or the act of replacing earth in an excavation beside the Silva Cell system to the excavation extents.
   4. FINISH GRADE: Elevation of finished surface of planting soil or paving.
   5. PLANTING SOIL: Soil as defined in Division 32, Section 32 94 56 - Planting Soil for Silva Cells, intended to fill the Silva Cell system and other planting spaces.
   6. SILVA CELL SYSTEM:
      a. Silva Cell: One assembled unit made up of 1 base, 6 post assemblies, and 1 Silva Cell deck.
      b. Silva Cell System: Two or more Silva Cells used in combination with each other and with required accessories.
   7. SUBGRADE: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill.
   8. WALK-THROUGH: A process for light compaction of soils by walking through the soil following placement.

B. Reference Standards:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. AASHTO H-20
2. ASTM International (ASTM):
   a. ASTM D448-12, Standard Classification for Sizes of Aggregate for Road and Bridge Construction
   b. ASTM D698-12a1, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ [600 kN·m/m³])
   d. ASTM D3786/D3786M-13, Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
   e. ASTM D4491-99a(2014)e1, Standard Test Methods for Water Permeability of Geotextiles by Permittivity
   g. ASTM D4632-D4632M-15, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
   h. ASTM D4751-12, Standard Test Method for Determining Apparent Opening Size of a Geotextile
   k. ASTM D6241-14, Standard Test Method for Static Puncture Strength of Geotextile and Geotextile-Related Products Using a 50mm Probe
   l. ASTM D6637-11, Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

1.03 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Conference: Prior to installation of the Silva Cell system and associated Work, meet at Project site with the Contractor, Silva Cell system installer and their field supervisor, manufacturer’s technical representative, the Landscape Architect, the Owner at the Owner’s discretion, and other entities concerned with the Silva Cell system performance.
   1. Provide at least 72 hours advance notice to participants prior to convening preinstallation conference.
   2. Introduce and provide a roster of individuals in attendance with contact information.
   3. The preinstallation conference agenda will include, but is not limited to the review of:
      a. Required submittals both completed and yet to be completed.
      b. The sequence of installation and the construction schedule.
      c. Coordination with other trades.
      d. Details, materials and methods of installation.
         1) Review requirements for substrate conditions, special details, if any, installation procedures.
         2) Installation layout, procedures, means and methods.
      e. Mock-up requirements.

B. Sequencing and Scheduling:
   1. General: Prior to beginning Work of this Section, prepare a detailed schedule of the Work involved for coordination with other trades.
   2. Schedule utility installations prior to beginning Work of this Section.
   3. Where possible, schedule the installation of the Silva Cell system after the area is no longer required for use by other trades and Work. Where necessary to prevent damage, protect installed system if Work must occur over or adjacent to the installed Silva Cell system.

1.04 SUBMITTALS

A. Action Submittals: Submit in accordance with Section 01 33 00:
A. Action Submittals: Submit these to the Landscape Architect for review and acceptance not less than 45 days prior to start of installation of materials and products specified in this Section.

1. Product Data: For each type of product, submit manufacturer's product literature with technical data sufficient to demonstrate that the product meets these specifications.

2. Test and Evaluation Reports:
   a. Submit results of compaction testing required by the Specifications for approval.
   b. Include analysis of bulk materials including soils and aggregates, by a recognized laboratory that demonstrates that the materials meet the Specification requirements.

3. Samples:
   a. One full size sample of an assembled Silva Cell.
   b. One 6-inch (150-mm) square piece of geogrid.
   c. One 6-inch (150-mm) square piece of geotextile.

4. Manufacturer's Report: Submit Silva Cell system manufacturer's letter of review and approval of the Project, including Drawings and Specifications, Addenda, Clarifications and Modifications, and for compliance with product installation requirements.

5. Qualification Statements:
   a. Manufacturer:
      1) Submit list of completed projects demonstrating durability and longevity of in-place systems.
         a) Include project name, location, and date of completion.
      2) Submit list of third party approval for stormwater management projects.
   b. Installer:
      1) Submit documentation of the qualifications of the Silva Cell system installer and their field supervisor, sufficient to demonstrate that both meet the requirements specified in Article 1.05 QUALITY ASSURANCE.
      2) Submit list of completed projects of similar scope and scale demonstrating capabilities and experience.

B. Closeout Submittals: Submit in accordance with Section 01 33 00:

B. Closeout Submittals: Submit these to the Landscape Architect at completion of installation.

1. Warranty: Submit manufacturer's warranty, fully executed.

1.05 QUALITY ASSURANCE

A. Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, State and Municipal authorities having jurisdiction. Obtain necessary permits/approvals from these authorities.

B. Manufacturer Qualifications:

1. A manufacturer whose product is manufactured in an ISO/TS 16949 compliant and ISO 9001 - 2008 registered factory.

2. A manufacturer with not less than 100 Silva Cell systems in-place, each system in use for not less than 3 years, confirming durability and longevity of the system.

3. A manufacturer with documented written approval of their product for use as a stormwater treatment device by a minimum of 3 governmental jurisdictions.

4. A manufacturer with an established and demonstrated utility service and repair process, including written procedure and photographs demonstrating work.

C. Installer Qualifications: A qualified installer with not less than 5 years of successful experience installing Silva Cell systems or related products and materials, and whose work has resulted in successful installation of underground piping, chambers and vault structures, planting soils, and planter drainage systems of a similar scope and scale in dense urban areas.

D. Installer's Field Supervisor: A full-time supervisor employed by the installer with not less than 5 years of successful experience similar to that of the installer and present at the Project site when Work is in progress.
Utilize the same field supervisor throughout the Project, unless a substitution is submitted to and approved in writing by the Landscape Architect.

E. Mock-Up: Prior to the installation of the Silva Cell system, construct a mock-up of the complete installation at the Project site in the presence of the Landscape Architect.
   1. Size and Extent: Minimum of 100 sq. ft. (9.29 sq. m.) in area and including the complete Silva Cell system installation with subbase, aggregate subbase, drainage installation, Silva Cell decks, posts, and bases, base course aggregate, geotextile, geogrid, backfill, planting soil, and necessary accessories.
   2. The mock-up area may remain as part of the installed Work at the end of the Project provided that it remains undamaged and meets the requirements of the Drawings and Specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Silva Cell System: Protect Silva Cell system components from damage during delivery, storage and handling.
   1. Store components on smooth surfaces, free from dirt, mud and debris. Store under tarp to protect from sunlight when time from delivery to installation exceeds one week.
   2. Perform handling with equipment appropriate to the size (height) of Silva Cells and site conditions; equipment may include, hand, handcart, forklifts, extension lifts, or small cranes, with care given to minimize damage to Silva Cell bases, posts, decks and adjacent assembled Silva Cells.

B. Packaged Materials: Deliver packaged materials in original, unopened containers indicating weight, certified analysis, name and address of manufacturer, and indication of conformance with State and Federal laws, if applicable. Protect materials from deterioration during delivery and while on the Project site.

C. Bulk Materials:
   1. Do not deliver or place backfill, soils, or soil amendments in frozen, wet, or muddy conditions.
   2. Provide protection including tarps, plastic and/or matting between bulk materials and finished surfaces sufficient to protect the finish material.
   3. Bring planting soil to the site using equipment and methods that do not overly mix and further damage soil peds within the soil mix.

D. Provide erosion-control measures to prevent erosion or displacement of bulk materials and discharge of soil-bearing water runoff or airborne dust to adjacent properties, water conveyance systems, and walkways. Provide additional sediment control to retain excavated material, backfill, soil amendments and planting mix within the Project limits as needed.

1.07 FIELD CONDITIONS

A. Existing Conditions: Do not proceed with Work when subgrades, soils and planting soils are in a wet, muddy or frozen condition.

1.08 WARRANTY

A. The Contractor shall warrant the Silva Cell system to be free of faults and defects in accordance with the General Conditions, except that the warranty shall be extended by manufacturer's written warranty against defects in materials and workmanship as follows:
   1. DeepRoot® warrants to the original purchaser of its Silva Cell™ product that such product will be free from defects in materials and workmanship, and perform to DeepRoot's written specifications for the warranted product, when installed and used as specifically provided in the product's installation guidelines for a period of 20 years from the date of purchase. This warranty does not cover wear from normal use, or damage caused by abuse, mishandling, alterations, improper installation and/or assembly, accident, misuse, or lack of reasonable care of the product. This warranty does not apply to events and conditions beyond DeepRoot's control, such as ground subsidence or settlement, earthquakes and other natural events, acts of third parties, and/or Acts of God. If this warranty is breached, DeepRoot® will provide a replacement product. Incurred costs, such as labor for removal of the original product, installation of replacement product, and the cost of incidental or other materials or expenses are not covered under this warranty.
   2. DeepRoot® makes no other warranties, express or implied, and specifically disclaims the warranty of merchantability or fitness for a particular purpose. DeepRoot® shall not be liable either in tort or in contract for any direct, incidental or consequential damages, lost profits, lost revenues, loss of use, or any breach of any express or implied warranty.

PART 2 - PRODUCTS
2.01 MANUFACTURER

A. Acceptable Manufacturers:

DeepRoot Green Infrastructure, LLC
101 Montgomery Street, Suite 2850
San Francisco, CA, 94104

415.781.9700
800.458.7668
Fax 415.781.0191

www.deeproot.com

B. Substitutions: Manufacturers seeking approval of their products are required to comply with the Owner's Instructions to Bidders, generally contained in the Project Manual.

C. Substitutions: Manufacturers seeking approval of their products are required to comply with the Owner's Instructions to Bidders, generally contained in the Project Manual. If such instructions are not included in Division 00 or Division 01, submit requests as specified herein.

1. Submit proposed substitutions to the Landscape Architect not less than 7 days prior to the date for receipt of Bids.

2.02 DESCRIPTION

A. The term Silva Cell shall be used to refer to a single Silva Cell or a stack of Silva Cells.

B. Silva Cells shall be designed for the purpose of growing healthy trees and providing stormwater management.

C. Silva Cells shall be modular, structural systems.

D. Each Silva Cell shall be structurally-independent from all adjacent Silva Cells for incorporating utilities and other site features as well as for future repairs.

E. Silva Cells shall be capable of supporting loads up to and including AASHTO H-20 (United States) or CSA-S6 87.5 kN (Canada) when used in conjunction with approved pavement profiles.

F. Silva Cells shall be open on all vertical faces and horizontal planes and shall have no interior walls or diaphragms.

G. Silva Cells shall be capable of providing a large, contiguous, continuous volume of planting soil that does not inhibit or prevent the following:

1. Placement of planting soil
2. Compaction testing of planting soil, once in place
3. Movement and growth of roots
4. Movement of water within the provided soil volume, including lateral capillary movement
5. Installation and maintenance of utilities placed within, adjacent to, or below the Silva Cell.

H. Silva Cells shall be able capable of being filled with a variety of soil types and soils that include peds 2 inches (50 mm) or larger in diameter as is appropriate for the application, location of the installation, and tree species.

2.03 SILVA CELL MATERIALS AND ACCESSORIES

A. Silva Cell System Components: Each "Silva Cell 2" soil cell module (hereafter Silva Cell or "cell") is composed of one base, 6 post assemblies, and one deck.

1. 1x Silva Cell 2 System:
   a. Components: One base, six 1x posts, and one deck.
   b. Assembled Dimensions (Each Cell): 47.2 inches long by 23.6 inches wide by 16.7 inches high (1200 mm long by 600 mm wide by 424 mm high).

2. 2x Silva Cell 2 System:
a. Components: One base, six 2x posts, and one deck.
b. Assembled Dimensions (Each Cell): 47.2 inches long by 23.6 inches wide by 30.9 inches high (1200 mm long by 600 mm wide by 784 mm high).]

3. 3x Silva Cell 2 System:
   a. Components: One base, six 3x posts (a combination of six 1x posts and six 2x posts), and one deck.
   b. Assembled Dimensions (Each Cell): 47.2 inches long by 23.6 inches wide by 43 inches high (1200 mm long by 600 mm wide by 1092.2 mm high).

B. Silva Cell Materials and Fabrication:

C. Manufacturer's Related Silva Cell Installation Accessories:
   1. Strongbacks: An accessory designed to stabilize the Silva Cell posts temporarily, during soil placement, and removed for reuse prior to placing decks.
   2. Anchoring Pins: Threaded pins and crossbar for securing assembled Silva Cells to subbase.

2.04 RELATED PRODUCTS

A. Root Barrier: Recyclable, black, injection molded panels manufactured with a minimum 50 percent post-consumer recycled polypropylene plastic with UV inhibitors, and integrated zipper joining system which allows instant assembly by sliding one panel into another; for redirecting tree roots down and away from hardscapes.
   1. Panel Sizes:
      a. No. UB12-2: 24 inches long by 12 inches deep by 0.080 inches thick (61 cm long by 30 cm deep by 2.03 mm thick); for use with 1x systems and for pavement profiles less than 12 inches (30 cm) deep.
      b. No. UB18-2: 24 inches long by 18 inches deep by 0.080 inches thick (61 cm long by 46 cm deep by 2.03 mm thick); for use with 2x and 3x systems, and for pavement profiles 12 inches or more in depth.
   2. Products meeting this specification:
      a. DeepRoot Tree Root Barrier (DeepRoot Green Infrastructure, LLC)

B. Geogrid: Net-shaped woven polyester fabric with PVC coating, uniaxial or biaxial geogrid, inert to biological degradation, resistant to naturally occurring chemicals, alcalis, and acids; used to provide a stabilizing force within soil structure as the fill interlocks with the grid.
   1. Tensile strength at ultimate (ASTM D6637): 1850 lbs/ft (27.0 kN/m) minimum
   2. Creep reduced strength (ASTM D5262): 1000 lbs/ft (14.6 kN/m) minimum
   3. Long term allowable design load (GRI GG-4): 950 lbs/ft (13.9 kN/m) minimum
   4. Grid aperture size (MD): 0.8 inch (20 mm) minimum
   5. Grid aperture size (CD): 1.28 inch (32 mm) maximum
   6. Roll size: 6-foot (1.8-m) width is preferred, up to 18-foot (5.4-m).
   7. Products meeting this specification:
      a. Stratagrid SG 150, (Strata Systems, Inc.); Cumming, GA; http://www.geogrid.com
      b. Miragrid 2XT (TenCate Nicolon); Norcross, GA; http://www.tencate.com
      c. Fortrac 35 Geogrid (Huesker, Inc.); Charlotte, NC; http://www.hueskerinc.com
      d. SF 20 Biaxial Geogrid (Synteen); Lancaster, SC; http://www.synteen.com

C. Geotextile: Nonwoven polypropylene fibers, inert to biological degradation and resistant of naturally occurring chemicals, alcalis and acids; applied to either the soil surface or between materials, providing filtration, separation, or stabilization properties.
   1. Grab tensile strength (ASTM D4632): 200 lbs (900 N) minimum
   2. Elongation (ASTM D4632): 50 percent minimum
   3. Trapezoid tear strength (ASTM D4533): 80 lbs (350 N) minimum
   4. Mullen burst strength (ASTM D3786): 350 psi (2400 kPa)
   5. Puncture strength (ASTM D4833): 110 lbs (490 N) minimum
   6. CBR puncture strength (ASTM D6241): 500 lbs (2225 N) minimum
   7. Apparent opening size (ASTM D4751): 80 sieve (0.18 mm) maximum
   8. Flow rate (ASTM D4491): 90 gal/min/ft² (3870 l/min/m²) minimum
   9. UV Resistance (at 500 hours): 70 percent strength retained
10. Products meeting this specification:
   a. ADS Geosynthetics 0801T (ADS Geosynthetics); http://www.ads-pipe.com
   b. Mirafi 180 N (TenCate Nicolon); Norcross, GA; http://www.tencate.com
   c. Geotex 801 (Propex Geosynthetics); Chattanooga, TN: http://www.geotextile.com

D. Plastic Cable Ties: A tensioning device or tool used to tie similar or different materials together with a specific degree of tension.

2.05 OTHER RELATED MATERIALS

A. Wood Blocking: Nominal dimensioned untreated lumber used for spacing assembled Silva Cells.

B. Drain and Distribution Pipes:

C. Aggregate Subbase (Below Silva Cell Base):
   1. Aggregate meeting one of the following specifications:
      a. Complying ASTM D1241, Type I, Gradation B; Type I mixtures shall consist of stone, gravel, or slag with natural or crushed sand and fine mineral particles passing a No. 200 sieve.

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 inches (37.5 mm)</td>
<td>100</td>
</tr>
<tr>
<td>1 inch (25 mm)</td>
<td>75 to 95</td>
</tr>
<tr>
<td>3/8 inch (9.5 mm)</td>
<td>40 to 75</td>
</tr>
<tr>
<td>No 4 (4.75 mm)</td>
<td>30 to 60</td>
</tr>
<tr>
<td>No 10 (2 mm)</td>
<td>20 to 45</td>
</tr>
<tr>
<td>No 40 (425 μm)</td>
<td>15 to 30</td>
</tr>
<tr>
<td>No 200 (75 μm)</td>
<td>5 to 15</td>
</tr>
</tbody>
</table>

   b. Local Department of Transportation (DOT) virgin aggregate that most closely meets the gradation of ASTM D1241.
   c. Ontario Provincial Standard Specification (OPSS) 1010 Granular A. Dense graded aggregates intended for use as granular base within the pavement structure, granular shouldering, and backfill.

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.5 mm</td>
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<tr>
<td>19 mm</td>
<td>85 to 100</td>
</tr>
<tr>
<td>13.2 mm</td>
<td>65 to 90</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>50 to 73</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>35 to 55</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>15 to 40</td>
</tr>
<tr>
<td>300 μm</td>
<td>5 to 22</td>
</tr>
<tr>
<td>75 μm</td>
<td>2 to 8</td>
</tr>
</tbody>
</table>

D. Aggregate Base Course (Above Silva Cell Deck):
   1. Same as aggregate subbase specified above.

E. Aggregate Base Course for Porous Pavement (Above Silva Cell Deck):
   1. Aggregate complying with ASTM D448, No. 57.

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent Passing</th>
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</thead>
<tbody>
<tr>
<td>1-1/2 inches (37.5 mm)</td>
<td>100</td>
</tr>
<tr>
<td>1 inch (25 mm)</td>
<td>95 to 100</td>
</tr>
<tr>
<td>1/2 inch (12.5 mm)</td>
<td>25 to 60</td>
</tr>
<tr>
<td>No 4 (4.75 mm)</td>
<td>0 to 10</td>
</tr>
<tr>
<td>No 8 (2.36 mm)</td>
<td>0 to 5</td>
</tr>
</tbody>
</table>
F. Setting Bed for Unit Pavers (Above Silva Cell Deck):
   1. Aggregate complying with ASTM D448, No. 8.

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 inch (12.5 mm)</td>
<td>100</td>
</tr>
<tr>
<td>3/8 inch (9.5 mm)</td>
<td>85 to 100</td>
</tr>
<tr>
<td>No 4 (4.75 mm)</td>
<td>10 to 30</td>
</tr>
<tr>
<td>No 8 (2.36 mm)</td>
<td>0 to 10</td>
</tr>
<tr>
<td>No 16 (1.18 mm)</td>
<td>0 to 5</td>
</tr>
</tbody>
</table>

G. Backfill Material (Adjacent to Silva Cells): Clean, compactable, coarse grained fill soil free of organic material, trash and other debris, and free of toxic material injurious to plant growth.

H. Planting Soil: Refer to Section 32 94 56 - Planting Soil for Silva Cells.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine the conditions under which the Silva Cells are to be installed.
   1. Carefully check and verify dimensions, quantities, and grade elevations.
   2. Carefully examine the Drawings to become familiar with the existing underground conditions before digging. Verify the location of aboveground and underground utility lines, infrastructure, other improvements, and existing trees, shrubs, and plants to remain including their root system.
   3. Notify the Contractor and the Landscape Architect in writing in the event of conflict between existing and new improvements, of discrepancies, and other conditions detrimental to proper and timely completion of the installation.
   4. Obtain written approval of changes to the Work prior to proceeding. Proceed with installation only after changes have been made and unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Take proper precautions as necessary to avoid damage to existing improvements and plantings.
   B. Prior to the start of Work, layout and stake the limits of excavation and horizontal and vertical control points sufficient to install the complete Silva Cell system.
   C. Coordinate installation with other trades that may impact the completion of the Work.

3.03 TEMPORARY PROTECTION

A. Protect open excavations and Silva Cell system from access and damage both when Work is in progress and following completion, with highly visible construction tape, fencing, or other means until related construction is complete.
   B. Do not drive vehicles or operate equipment over the Silva Cell system until the final surface material has been installed.

3.04 EXCAVATION

A. General: Excavate to the depths and shapes indicated on the Drawings. Provide smooth and level excavation base free of lumps and debris.
   B. Confirm that the depth of the excavation is accurate and includes the full section of materials required to place the subbase aggregate, Silva Cell, and pavement profile as indicated on the Drawings.
   C. Over-excavate beyond the perimeter of the Silva Cell to allow for:
      1. The extension of aggregate subbase beyond the Silva Cell layout as shown on the Drawings.
      2. Adequate space for proper compaction of backfill around the Silva Cell system.
   D. If unsuitable subgrade soils are encountered, consult the Owner's geotechnical consultants for directions on how to proceed.
   E. If conflicts arise during excavation, notify the Landscape Architect in writing and make recommendations for action. Proceed with Work only when action is approved in writing.
3.05 SUBGRADE COMPACTION

A. Compact subgrade to a minimum of 95 percent of maximum dry density at optimum moisture content in accordance with ASTM D698, Standard Proctor Method, or as approved by the Owner’s geotechnical representative.
B. Do not exceed 7 percent slope for subgrade profile in any one direction. If the 7 percent slope is exceeded, contact manufacturer's representative for directions on how to proceed.

3.06 INSTALLATION OF GEOTEXTILE OVER SUBGRADE

A. Install geotextile over compacted subgrade.
   1. Lay geotextile flat with no folds or creases.
   2. Install the geotextile with a minimum joint overlap of 18 inches (450 mm).

3.07 INSTALLATION OF AGGREGATE SUBBASE BELOW SILVA CELL BASES

A. Install aggregate subbase to the depths indicated on the Drawings.
B. Extend subbase aggregate a minimum of 6 inches (150 mm) beyond the base of the Silva Cell layout.
C. Compact aggregate subbase to a minimum of 95 percent of maximum dry density at optimum moisture content in accordance with ASTM D698, Standard Proctor Method.
D. Do not exceed 7 percent slope on the surface of the subbase. Where proposed grades are greater than 7 percent, step the Silva Cells to maintain proper relation to the finished grade.

3.08 INSTALLATION OF SILVA CELL BASE

A. Install the Silva Cell system in strict accordance with manufacturer's instructions and as specified herein; where requirements conflict or are contradictory, follow the more stringent requirements.
B. Layout and Elevation Control:
   1. Provide layout and elevation control during installation of the Silva Cell system to ensure that layout and elevations are in accordance with the Drawings.
C. Establish the location of the tree openings in accordance with the Drawings. Once the trees are located, mark the inside dimensions of the tree openings on the prepared subbase.
D. Locate and mark other Project features located within the Silva Cell layout (e.g. light pole bases, utility pipes). Apply marking to identify the extent of the Silva Cell layout around these features. Follow the layout as shown on the Drawings to ensure proper spacing of the Silva Cell bases. Refer to the Drawings for offsets between these features and the Silva Cells.
E. Check each Silva Cell component for damage prior to placement. Reject cracked or chipped units.
F. Place the Silva Cell bases on the compacted aggregate subbase. Start at the tree opening and place Silva Cell bases around the tree openings as shown on the Drawings.
G. Working from tree opening to tree opening, place Silva Cell bases to fill in the area between tree openings.
   1. Maintain spacing no less than 1 inch (25 mm) and no more than 4 inches (100 mm) apart.
H. Level each Silva Cell base as needed to provide full contact with subbase. Adjust subbase material, including larger pieces of aggregate, so each base sits solidly on the surface of the subbase. Silva Cell bases that rock or bend over any stone or other obstruction protruding above the surface of the subbase material are not allowed. Silva Cell bases which bend into dips in the subbase material are not allowed. The maximum tolerance for deviations in the plane of the subbase material under the bottom of the horizontal beams of each Silva Cell base is 1/4 inch in 4 feet (6 mm in 1200 mm).
I. Anchor Silva Cell base with 2 crossbar/pin assemblies per base.
   1. For applications where Silva Cells are installed over waterproofed structures, use wood blocking or similar spacing system consistent with requirements of the waterproofing system to maintain required spacing.

3.09 INSTALLATION OF SILVA CELL POSTS
A. [1x Silva Cell 2 System:  
1. Attach 1x posts to the installed Silva Cell base. Each base will receive six 1x posts. Place the end of the post with tabs into the base. Rotate post clockwise to snap in place.]

3.10 INSTALLATION OF STRONGBACKS, GEOGRID, BACKFILL AND PLANTING SOIL

A. For Silva Cell systems that have a perforated drain line located inside or adjacent to the system, consult Drawings for layout and details.
B. Install strongbacks on top of the Silva Cell posts by snapping into place over installed posts prior to installing planting soil and backfill.
   1. Strongbacks are required only during the placement and compaction of the planting soil and backfill.
   2. Move strongbacks as the Work progresses across the installation.
   3. Remove strongbacks prior to the installation of the Silva Cell decks.
C. Install geogrid around the perimeter of the Silva Cell system where the compacted backfill and planting soil interface.
   1. Do not place geogrid between the edge of the Silva Cells and adjacent planting areas.
   2. Cut the geogrid to allow for a 6-inch (150-mm) overlap at the Silva Cell base and a 12-inch (300-mm) overlap at the Silva Cell deck.
   3. Provide a minimum 12-inch (300-mm) overlap between adjacent sheets of geogrid.
   4. Secure geogrid with cable ties below the top of the posts, along the post ridges.
D. Place the first lift of backfill material loosely around the perimeter of the Silva Cell system, between the geogrid and the sides of the excavation. Place backfill to approximately the midpoint of the Silva Cell post. Do not compact.
E. Place the first lift of planting soil in the Silva Cell system to approximately the midpoint of the Silva Cell post.
   1. Level the planting soil throughout the system.
   2. Walk-through the placed planting soil to remove air pockets and settle the soil. Do not compact greater than 80 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method.
   3. Check placed soil for compaction with a penetrometer or densitometer or similar.
F. Compact the first lift of backfill material, previously spread, to 95 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method or in accordance with Project Specifications for hardscape areas, whichever is greater.
G. Add and compact additional backfill material so that the final finished elevation is at approximately the same level of the placed planting soil within the Silva Cells.
   1. Maintain the geogrid between the Silva Cell system and the backfill material at all times.
H. Place the second lift of backfill material loosely around the perimeter of the Silva Cell system, between the geogrid and the sides of the excavation so that the material is 2 to 3 inches below the top of the posts. Do not compact.
I. Place the second lift of planting soil inside of the Silva Cell to the bottom of the strongbacks. Walk through.

SPECIFIER: For 1x or 2x System, skip to Article 3.11 - INSTALLATION OF IRRIGATION AND WATER HARVESTING SYSTEM.

SPECIFIER: For 3x System, continue below.

J. Remove strongbacks, place one 1x posts into each of the previously-installed 2x posts. Rotate clockwise to snap in place, forming a 3x post assembly.
K. Immediately reinstall strongbacks on top of the post assembly.
L. Repeat process of alternately placing backfill and planting soil so that elevation of the compacted backfill and the walked-through planting soil are just below the level of the strongbacks.

3.11 INSTALLATION OF IRRIGATION AND WATER HARVESTING SYSTEM
A. Install irrigation and water harvesting system in accordance with the Drawings and Specifications. Remove only the minimum number of strongbacks needed to accommodate the Work and reinstall them immediately upon completion to maintain alignment of posts.

3.12 INSTALLATION OF SILVA CELL DECK

A. Obtain final approval by the Landscape Architect of planting soil installation prior to installation of the Silva Cell decks.
B. Remove strongbacks, level out the planting soil, and immediately install decks over the posts below. Place deck over the top of the posts. Push decks down until the deck clips lock into the posts, snapping the deck into place.
C. Fold the 12 inches (300 mm) of geogrid onto the top of the decks.

3.13 FINAL BACKFILL PLACEMENT AND COMPACTION

A. Place and compact final lift of backfill material to 95 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method, such that the backfill is flush with the top of the installed deck. Do not allow compacting equipment to come in contact with the decks.

3.14 INSTALLATION OF GEOTEXTILE AND AGGREGATE BASE COURSE OVER THE DECK

A. Place geotextile over the top of the deck and extend to the edge of the excavation. Overlap joints a minimum of 18 inches (450 mm). Leave enough slack in the geotextile for the aggregate base course to push the geotextile down in the gaps in between the decks.
B. Install the aggregate base course (including aggregate setting bed if installing unit pavers) over the geotextile immediately after completing the installation of the fabrics. Work the aggregate from one side of the layout to the other so that the fabric and aggregate conform to the Silva Cell deck contours.
C. Maintain equipment used to place aggregate base course completely outside the limits of the Silva Cell excavation area to prevent damage to the installed system.
D. For large or confined areas, where aggregate cannot easily be placed from the edges of the excavated area, obtain approval for the installation procedure and types of equipment to be used in the installation from the Silva Cell manufacturer.
E. Compact aggregate base course(s) to 95 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method. Utilize a vibration or plate compactor with a maximum weight of 800 lbs (362.87 kg).
F. Do not drive vehicles or operate equipment over the completed aggregate base course.

3.15 INSTALLATION OF CONCRETE CURBS AT TREE OPENINGS, AGGREGATE SUBBASE AND PAVEMENT ABOVE THE SILVA CELL SYSTEM

A. Place concrete curbs along planting areas and tree openings as shown on the Drawings to retain the aggregate base course from migrating into the planting soil.
B. When staking concrete forms (e.g. curbs around the tree openings), prevent stakes from penetrating the Silva Cell decks.
C. Turn down edge of concrete paving to the Silva Cell deck along the edges of tree openings or planting areas to retain the aggregate base course material.
D. When paving type is a unit paver or other flexible material, provide a concrete curb under the paving at the edge of the Silva Cell deck to retain the aggregate base course material at the tree opening.
E. Place paving material over Silva Cell system in accordance with the Drawings.
   1. The Silva Cell system does not fully meet loading strength until the final paving is installed. Do not operate construction equipment on top of the Silva Cell system until paving installation has been completed.
F. Use care when placing paving or other backfill on top of Silva Cell system to prevent damage to the Silva Cell system or its components.

3.16 INSTALLATION OF ROOT BARRIERS

A. Install root barrier in accordance with manufacturer's installation instructions.

3.17 INSTALLATION OF PLANTING SOIL WITHIN THE TREE PLANTING AREA
A. Remove rubble, debris, dust and silt from the top of the planting soil within the tree opening that may have accumulated after the initial installation of the planting soil within the Silva Cells.
B. Install additional planting soil within the tree openings, to the depths indicated on the Drawings.
   1. Use the same soil used within the Silva Cells for planting soil within the tree openings.
C. Compact planting soil under the tree root ball to between 85 and 90 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method, to prevent settlement of the root ball.
D. Place trees in accordance with the Drawings.

3.18 PROTECTION
A. Keep construction traffic away from the limits of the Silva Cells until the final pavement profile is in place. The Silva Cell system does not fully meet loading strength until the final paving is installed.
   1. Do not operate equipment directly on top of the Silva Cell system until paving installation has been completed.
   2. Provide fencing and other barriers to prevent vehicles from entering into the Silva Cell area.
B. When the Silva Cell installation is completed and the permanent pavement is in place, limit traffic and construction related activities to only loads less than the design loads.

3.19 CLEAN UP
A. Perform clean up during installation and upon completion of the Work. Maintain the site free of soil, sediment, trash and debris. Remove excess soil materials, debris, and equipment from the site following completion of the Work of this Section.
B. Repair damage to adjacent materials and surfaces resulting from installation of this Work using mechanics skilled in remedial work of the construction type and trades affected.

END OF SECTION
SECTION 329456 – PLANTING SOIL FOR SOIL CELLS (SILVA CELLS)

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Labor, materials, tools, supplies, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with furnishing, and delivery of planting soil and/or the modification of existing site soil for use as planting soil within the Silva Cell system.

B. The scope of Work in this Section includes, but is not limited to, the following:
   1. Locate, purchase, deliver and install imported planting soil and soil amendments.
   2. Harvest and stockpile existing site soils suitable for planting soil.
   3. Modify existing stockpiled site soil.

C. Related Requirements:
   1. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to Work of this Section.
   2. Section 01 33 00 – Submittal Procedures: For administrative and procedural requirement for processing of submittals during the construction phase.
   3. Section 01 77 00 – Closeout Procedures: For administration and procedural requirements for completion of the Work.
   4. Section 329100 Planting Soil
   5. Section 329451 Silva Cells
   6. Section 329500 LANDSCAPE ACCESORIES

1.02 REFERENCES

A. Definitions:
   1. COMPACTION: The density of soil measured as oven dry weight divided by volume.
   2. EXISTING SOIL: Mineral soil existing at the locations of proposed planting of area designated for the installation of Silva Cells after the majority of the construction within and around the planting or Silva Cell site is completed and just prior to the start of Work to excavate the soil.
   3. LANDSCAPE ARCHITECT: Landscape Architect: The person or entity, employed by the Owner to represent their interest in the review of the Work.
   4. PED: Clump or clod of soil held together by a combination of clay, organic matter, and fungal hyphae, retaining the original structure of the harvested soil.
   5. SCREENED SOIL: Soil that has been processed through a metal screen to remove or break apart soil peds (clumps /clods), roots, rocks and debris and remove larger physical items in the soil not permitted by the specification.
   6. SILVA CELLS: Structural paving support system defined in Section 329451 Silva Cells.
   7. SUBGRADE: Surface or elevation of subsoil remaining after completing excavation, or top surface of fill or backfill, before placing planting soil.

B. Reference Standards:
   1. ASTM International (ASTM)
   2. The Soil Science Society of America.
a. Methods of Soil Analysis, most current edition,


4. United States Department of Agriculture, Natural Resources Conservation Service
      http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_054242

1.03 SUBMITTALS
A. Action Submittals: Submit in accordance with Section 013300:

   A. Action Submittals: Submit these to the [Landscape Architect] [Architect] [Engineer] for review and acceptance not less than 8 weeks prior to start of installation of materials and products specified in this Section.

   1. Product Data: For each type of product, submit manufacturer's product literature with technical data sufficient to demonstrate that the product meets these specifications.
      a. For each compost product submit the manufactures certification that the compost meets the requirements for US Compost Council STA/TMECC criteria for “Compost as a Landscape Backfill Mix Component” and other requirements of the Specification.
      b. For coarse sand product submit the following analysis by a recognized laboratory:
         1) pH
         2) Manufactures Fines Modulus Index
         3) Particle size distribution (percent passing the following sieve sizes):
            3/8 inch (9.5 mm)
            No 4 (4.75 mm)
            No 8 (2.36 mm)
            No 16 (1.18 mm)
            No 30 (0.60 mm)
            No 50 (0.30 mm)
            No 100 (0.15 mm)
            No 200 (0.075 mm)

   2. Test and Evaluation Reports:
      a. Include analysis of bulk materials including soils and aggregates, by a recognized laboratory that demonstrates that the materials meet the Specification requirements.
      b. Submit required soil test analysis report for each sample of imported topsoil, existing site soil, and planting soil mixes from an approved soil-testing laboratory as follows:
         1) Do not submit planting soil mixes, for testing until all topsoil, compost, and coarse sand have been approved.
         2) If tests fail to meet the Specifications, obtain other sources of material, retest and resubmit until accepted by the Landscape Architect Landscape Architect.
         3) All testing shall be performed following the requirements of Methods of Soil Analysis, The Soil Science Society of America.
         4) Provide a particle size analysis (percent dry weight) and USDA soil texture analysis. Soil testing of planting soil mixes shall also include USDA gradation distribution of gravel, coarse sand, medium sand, and fine sand in addition to silt and clay. Reports of partical size distribution shall use USDA size nomenclature and analysis protocols.
         5) Provide the following other soil properties:
            a.) pH and buffer pH.
            b.) Percent organic content by oven dried weight.
            c.) Nutrient levels by parts per million including: phosphorus, potassium, magnesium, manganese, iron, zinc and calcium. Nutrient test shall include the testing laboratory recommendations for supplemental additions to the soil for optimum growth of the plantings specified.
d.) Soluble salt by electrical conductivity of a 1:2 soil water sample measured in Milliohm per cm.

6) All soil testing will be at the expense of the Contractor.

3. Samples:
   a. Each sample shall be double bagged packaged in two plastic zip lock style bags. Each bag shall be clearly marked with the project name, date, contractors name and telephone number, and product name.
   b. Samples of all existing site soil, topsoil, coarse sand and, compost and planting soil mixes shall be submitted at the same time as the particle size and physical analysis of that material.
   c. Samples of the existing site soil that are under existing pavement to be removed may be submitted as soon as possible after the paving is removed.
   d. Samples will be reviewed for appearance only.
   e. Provide samples for the following products.
      1) One-gallon (3.79-liter) sample of each type of existing site soil prior to adding amendments.
      2) One-gallon (3.79-liter) sample of imported topsoil.
      3) One-gallon (3.79-liter) sample of bio-retention topsoil.
      4) One-gallon (3.79-liter) sample of compost.
      5) One-gallon (3.79-liter) sample of bio-retention compost.
      6) One-gallon (3.79-liter) sample of coarse sand.
      7) One-gallon (3.79-liter) sample of unscreened planting soil mix.
      8) One-gallon (3.79-liter) sample of screened planting soil mix.
      9) One-gallon (3.79-liter) sample of bio-retention soil mix.

4. Qualification Statements:
   a. Soil supplier:
      1) Submit documentation of the qualifications of the planting soil supplier and their field supervisor, sufficient to demonstrate that both meet the requirements specified in Article 1.05 QUALITY ASSURANCE.
      2) Submit list of completed projects of similar scope and scale demonstrating capabilities and experience.

1.04 QUALITY ASSURANCE

A. Supplier: Soil mixes shall be supplied by a firm that specializes in the production of mixes of planting soils and have at least 5 years experience in providing soil mixes soils to projects of similar size and scope to this Work.

B. Soil Testing Laboratory Qualifications: The testing laboratory shall specialize in agricultural soil testing and be a member of the Soil Science Society of America’s, North American Proficiency Testing Program (NAPT). Testing results for soil particle size shall be reported using USDA sizes for sand, silt, and clay.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Weather: Do not mix or deliver soil when frozen or muddy.

B. Protect soil and soil stockpiles, from wind, rain and washing that can erode soil or separate fines and coarse material, and contamination by chemicals, dust and debris that may be detrimental to plants or soil drainage. Confine delivered materials to neat piles in areas coordinated with the site supervisor. Cover stockpiles with plastic sheeting or fabric at the end of each Workday.

C. All manufactured packaged products and material shall be delivered to the site in unopened containers and stored in a dry enclosed space suitable for the material and meeting all environmental regulations.
   1. Biological and chemical additives shall be protected from extreme humidity, cold, or heat. All products shall be freshly manufactured and dated for the year in which the products are to be used. Chemical amendments shall have original labels intact and legible, stating the guaranteed chemical analysis.

PART 2 - PRODUCTS

2.01 EXISTING SITE SOIL
A. Existing site soil: Soil at the site including the possibility of subgrade soil under existing paving that is of a texture and chemical composition that can support roots provided that compost and or fertilizer is added and the soil compaction loosened.

B. Existing site soil shall meet the following criteria:
   1. Soil objects larger than 1/4 inch (6.24 mm) in diameter. Existing site soil shall contain less than 5 percent total volume of the combination of all objects 1 to 8 inches (25 mm – 200 mm) in their largest dimension including clumps/clods of heavy clay, sandy clay or silty clay subsoil, debris, refuse, roots, stones, sticks, brush, and or litter. The soil shall contain less than 8 percent by volume total of the above objects 1/4 inch (6.24 mm) to 1 inch (25 mm) in diameter. Remove objects larger than 8 inches (200 mm) in its longest dimension.
   2. Seedlings that germinated from seeds in the soil shall be removed within one month of germination whether during the period the soil is being stored or after installation including during the plant warranty period.
   3. The Landscape Architect shall verify that the soil in the designated areas is suitable at the beginning of planting bed preparation Work. The decisions to specify the use of existing site soils is based on assumptions made during the design phase about the quality of soil which may have been covered by paving at that time or where construction activity earlier in the Project may have altered this soil. Areas and depths to which existing site soil can be harvested for use in the Silva Cells is indicated on the soil plan.
   4. Soil testing results and soil observation notes that describe the preconstruction soil conditions in the existing soil areas are included as an appendix to this Specification:

C. If the Landscape Architect determines the soil to be unacceptable or the Work of this Project has damaged areas designated for use as existing site soil to the point where the soil is no longer suitable to support the plants specified, the Landscape Architect may require modification of the damaged soil up to and including removal and replacement with soil of equal quality to the soil that existed prior to construction.
   1. Examples of damage include further compaction, contamination, grading, creation of hardpan or drainage problems, or lack of previously assumed O, A and or B-horizon soils.
   2. Do not begin Work on additional modifications or soil replacement until changes, if any, to the Contract price are approved.

D. Protect existing soil from contamination, and degradation during the construction process.
E. Excavation and storage of existing site soil:
   1. Remove existing plants, roots, stumps, paving, and non-soil debris from the surface layers of the soil.
   2. Excavate the soil over the areas and depths indicated on the plan or as directed by the Landscape Architect. Utilize techniques and equipment that retains peds (clumps/clods) of soil.
   3. During the excavation process, soils in the approved areas and depths of different color and texture should be loosely mixed to create a more uniform single soil while still retaining soil peds (clumps/clods). The Landscape Architect may request that soils encountered that are not in accordance with the soil assumptions not be included in the mixing process. Such soils should be removed from the site or may be used as fill soils if approved by the Landscape Architect.
   4. Do not screen the soil unless approved in advance by the Landscape Architect. Encountered volumes of soil that do not meet the requirement for soil objects larger than 1/4 inch (6.24 mm) in diameter should be segregated during the excavation process and removed from the site. If approved, soil may be screened through a 2-inch (50 mm) square or larger opening in order to allow the soil to meet the requirements. Isolated large objects shall be removed from the soil by
5. Stockpile the soil in locations approved in advance by the General Contractor.

   a. Store soil in bulk trash dumpsters with rear access doors if no suitable space exists at the site.

F. Amending existing site soil:
   1. Amendments for existing site soil should be calculated for a composite mix of all soils to be used.
   2. Add compost to existing site soil, up to 20 percent by moist volume to bring soil organic matter to a minimum of 3 percent by dry weight.
      a. Each 10 percent moist volume of added compost is assumed to raise the percent dry weight soil organic matter by 1.5 percent.
      b. Spread compost over the stockpile in amounts that achieve the required organic matter content. As soil is being scooped from the pile to bring to the Silva Cells, mix the compost loosely into the soil with the loader bucket. Add additional compost to the stockpile as the Work progresses to achieve even compost distribution within the mix.
      c. Do not over mix the soil. Maintain as many large soil peds (clumps/clods) as possible in the mix.

3. Add fertilizer of the types and quantity recommended by the soil test at the time of mixing.

G. Submittal Requirements: Provide a one-gallon (3.79-liter) sample of each type of existing site soil prior to adding amendments with testing data that includes recommendations for compost volumes and chemical additives for the types of plants to be grown. Samples and test samples shall represent the composite mixing of the available soils. Samples and testing data shall be submitted at the same time.

2.02 IMPORTED TOPSOIL

A. Imported topsoil: Fertile, friable soil loam topsoil suitable for the germination of seeds and the support of vegetative growth meeting the following criteria:
   1. Soil texture: USDA loam, sandy clay loam or sandy loam with clay content between 15 and 35 percent; a combined clay/silt content of no more than 60 percent; and sand between 35 and 65 percent.

2. Except where noted, imported topsoil shall NOT have been screened and shall retain soil peds (clumps/clods) larger than 2 inches (50 mm) in diameter throughout the stockpile after harvesting.
   a. Light screening through a 2-inch (50 mm) square or larger opening will be permissible in soils with clay content of 20 percent or greater if required to break up large peds (clumps/clods) or remove coarse roots and stones.
   b. Retained soil peds (clumps/clods) shall be the same color on the inside as is visible on the outside surface of the ped.

3. Soil objects larger than 1/4 inch (6.24 mm) in diameter: Imported topsoil shall contain less than 5 percent total volume of the combination of all objects 1 to 8 inch (25 mm to 200 mm) in their largest dimension including clumps/clods of heavy clay, sandy clay or silty clay subsoil, debris, refuse, roots, stones, sticks, brush, and or litter. The soil shall contain less than 8 percent by volume total of the above objects 1/4 inch to 1 inch (6.24 mm to 25 mm) in diameter. Remove all objects larger than 8 inch (200 mm) in its longest dimension.
   a. Meet the above requirement by utilizing acceptable soils sources rather than soil screening.

4. Imported topsoil may be a harvested soil from fields or development sites or purchased from suppliers who collect and process soil. The organic content and particle size distribution shall be the result of natural soil formation. Manufactured soils where sand, composted organic material or other additives have been added to the soil to meet the requirements of imported topsoil shall not be acceptable.

5. pH value shall be between 5.5 and 7.5.

7. Soluble Salt Level: Less than 2 mmho/cm.
8. Soil nutrient chemistry suitable for growing the plants specified or after modification.
9. Germinating seedlings from seeds in the soil shall be removed within one month of germination whether during the period the soil is being stored or after installation, including during the warranty period of the plants.

B. Stockpiled existing topsoil at the site meeting the above criteria may be acceptable.
C. Submittal Requirements: Provide a one-gallon (3.79-liter) sample from each imported topsoil source with required soil testing results. The sample shall be a mixture of the random samples taken around the source stockpile or field. The soil sample shall be delivered with soil peds (clumps/clods) intact that represent the size and quantity of expected peds (clumps/clods) in the final delivered soil. The sample shall represent the expected amount of objects larger than 1/4 inch (6.24 mm).

2.03 BIO-RETENTION TOPSOIL
A. Topsoil meeting the requirements of imported topsoil and with phosphorous less than 36mg/kg (ppm) per Mehlich III test.
B. Submittal Requirements: Follow the submittal requirements for imported topsoil.

2.04 COMPOST
A. Compost: Blended and ground leaf, wood and other plant based material, composted for a minimum of 9 months and at temperatures sufficient to break down woody fibers, seeds and leaf structures, free of toxic material at levels that are harmful to plants or humans. Compost feed stock shall be yard waste trimmings, blended with other plant and or manure feed stock designed to produce compost high in fungal material.
   1. Compost shall be commercially prepared compost and meet US Compost Council STA/TMECC criteria or as modified in this Section for “Compost as a Landscape Backfill Mix Component”.
   2. Submittal Requirements: Provide one-gallon (3.79-liter) sample with manufacturer’s literature and material certification that the product meets the requirements.

2.05 BIO-RETENTION COMPOST
A. Aged triple-shredded hardwood bark or aged pine fines.
   1. 1 to 3 inch (25 mm to 75 mm) typical fiber length.
B. Material shall be aged 6 months or more with dark brown color.
C. Submittal Requirements: Provide one-gallon (3.79-liter) sample with manufacturer’s literature and material certification that the product meets the requirements.

2.06 COARSE SAND
A. Clean, washed, natural sand, free of toxic materials.
   1. Coarse concrete sand, ASTM C33 Fine Aggregate, with a Fines Modulus Index of 2.8 and 3.2.
   2. Coarse sand, free of limestone, shale and slate particles. Manufactured Sand shall not be permitted.
   3. pH shall be lower than 7.4.
   4. Provide coarse sand with the following particle size distribution:

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch (9.5 mm)</td>
<td>100</td>
</tr>
<tr>
<td>No 4 (4.75 mm)</td>
<td>95 to 100</td>
</tr>
<tr>
<td>No 8 (2.36 mm)</td>
<td>80 to 100</td>
</tr>
<tr>
<td>No 16 (1.18 mm)</td>
<td>50 to 85</td>
</tr>
<tr>
<td>No 30 (0.60 mm)</td>
<td>25 to 60</td>
</tr>
<tr>
<td>No 50 (0.30 mm)</td>
<td>10 to 30</td>
</tr>
<tr>
<td>No 100 (0.15 mm)</td>
<td>2 to 10</td>
</tr>
<tr>
<td>No 200 (0.75 mm)</td>
<td>2 to 5</td>
</tr>
</tbody>
</table>
B. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with manufacturer’s literature and material certification that the product meets the requirements.

2.07 FERTILIZER

A. If noted by the soil test recommendations, add slow-release, organic fertilizer based on soil test and plant requirements.

B. Fertilizers should NOT be added to Bio-retention soils.

C. Submittal Requirements: Provide manufacturer’s literature that the product meets the requirements.

2.08 BIOLOGICAL AMENDMENTS

A. Amendments such as Mycorrhizal additives, compost tea or other products intended to change the soil biology.

2.09 UNSCREENED PLANTING SOIL MIX

A. A mixture of imported topsoil, coarse sand, and compost to make a new soil that meets the Project goals for the indicated planting area.

1. The approximate mix ratio of imported topsoil, coarse sand and compost shall be:

<table>
<thead>
<tr>
<th>Mix component</th>
<th>Percent by moist volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imported topsoil unscreened</td>
<td>50 to 60 percent</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>30 to 40 percent</td>
</tr>
<tr>
<td>Compost</td>
<td>10 percent</td>
</tr>
</tbody>
</table>

2. Final Tested Soil Organic Matter (OM): 2.75 to 4 percent (by dry weight loss ash burn).

B. Mix the coarse sand and compost together first and then add to the topsoil. Mix with a loader bucket to loosely incorporate the topsoil into the coarse sand/compost Mix. DO NOT OVER MIX. Do not mix with a soil-blending machine. Do not screen the soil. Peds (clumps/clods) of Soil, and loosely mixed Compost and coarse sand will be permitted in the overall mix.

C. At the time of soil installation, add fertilizer or biological amendments, if required, to the planting soil mix at rates recommended by the testing results for the plants to be grown.

D. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with testing data that includes recommendations for chemical additives for the types of plants to be grown. Samples and testing data shall be submitted at the same time. The sample shall be a mixture of the random samples taken around the source stockpile or field. The sample shall be delivered with soil peds (clumps/clods) intact that represent the size and quantity of expected peds (clumps/clods) in the final delivered soil mix.

2.10 SCREENED PLANTING SOIL MIX

A. A mixture of imported topsoil, coarse sand, and compost mixed off site to make a new soil that meets the Project goals for the indicated planting area.

1. A mix of imported topsoil, coarse sand and compost. The approximate Mix ratio shall be:

<table>
<thead>
<tr>
<th>Mix component</th>
<th>Percent by moist volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imported topsoil screened</td>
<td>40 to 45 percent</td>
</tr>
<tr>
<td>Coarse Sand</td>
<td>40 to 50 percent</td>
</tr>
<tr>
<td>Compost</td>
<td>10 to 15 percent</td>
</tr>
</tbody>
</table>

2. Final Tested Organic Matter: 3 to 4.5 percent (by dry weight loss ash burn).

3. Final mix shall be thoroughly screened, mixed and blended.

B. At the time of soil installation, add fertilizer or biological amendments, if required, to the planting soil mix at
rates recommended by the testing results for the plants to be grown.

C. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with testing data that includes recommendations for chemical additives for the types of plants to be grown. Samples and testing data shall be submitted at the same time. The sample shall be a mixture of the random samples taken around the source stockpile or field.

2.11 BIO-RETENTION SOIL MIX

A. A mixture of Un-screened imported Bio-retention topsoil, coarse sand, and bio-retention compost to make a new soil that meets the following Specification:

1. Mix proportions are based on actual amounts of sand, silt and clay in each of the 3 mix components. Adjust the proportion of each component so that the final mix, after blending, has the following ranges of particle sizes when tested using USDA testing protocol for soil particle size distribution.

<table>
<thead>
<tr>
<th>Particle size</th>
<th>Range percent dry weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sand 0.05 to 2.0 mm</td>
<td>60 to 75 percent</td>
</tr>
<tr>
<td>Sand fractions 0.25 to 2.0mm</td>
<td>Min 55% of the above total sand</td>
</tr>
<tr>
<td>Combined silt and clay</td>
<td>25 to 40 percent</td>
</tr>
<tr>
<td>Allowable gravel</td>
<td>up to 10%</td>
</tr>
</tbody>
</table>

2. Final Tested Soil Organic Matter: 2.0 to 4.0 percent (by dry weight loss ash burn).

3. Final pH: between 5.5 and 7.5.

4. Phosphorus in overall mix: 12 to 36 mg/kg (ppm) per Mehlich III test.

B. Mix biochar at a rate of 5% by volume into the top 6-8 inches (152mm – 203mm) of the soil profile at the time of soil installation.

C. Mix the coarse sand and compost together first and then add to the topsoil. Mix with a loader bucket to loosely incorporate the topsoil into the coarse sand/compost Mix. DO NOT OVER MIX. Do not mix with a soil-blending machine. Do not screen the soil. Peds (clumps/clods) of Soil, and loosely mixed Compost and coarse sand will be permitted in the overall mix.

D. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with testing data. Samples and testing data shall be submitted at the same time.

PART 3 - EXECUTION

3.01 INSTALLATION OF PLANTING SOIL IN SILVA CELLS

A. Refer to Section 329451 - Silva Cells.

APPENDIX TO 32 94 56 PLANTING SOIL
Existing Soil Test Data

Submittal Checklist for Reference Only

Provide submittals required to the Landscape Architect Landscape Architect for review and approval. The Submittal process may take up to 2 months prior to installation of the Silva Cell system and should be executed as soon as possible after the Contract is awarded. Testing will be at the expense of the Contractor.

SOIL COMPONENT SUBMITTALS – SUBMITTED PRIOR TO SOIL MIXING

- EXISTING SITE SOIL
  - Lab analysis for physical and chemical composition
  - One-gallon (3.79-liter) sample

PLANTING SOIL FOR SOIL CELLS
☐ IMPORTED TOPSOIL
  ☐ Lab analysis for physical and chemical composition
  ☐ One-gallon (3.79-liter) sample

☐ BIO-RETENTION TOPSOIL
  ☐ Lab analysis for physical and chemical composition
  ☐ One-gallon (3.79-liter) sample

☐ COMPOST
  ☐ Manufacturer’s literature
  ☐ Certificate of compliance with US Composting Council STA/TMECC requirements
  ☐ One-gallon (3.79-liter) sample

☐ BIO-RETENTION COMPOST
  ☐ Manufacturer’s literature
  ☐ One-gallon (3.79-liter) sample

☐ COARSE SAND
  ☐ Manufacturer’s literature
  ☐ Lab analysis for physical and chemical composition
  ☐ Manufactures Fines Modulus Index
  ☐ One-gallon (3.79-liter) sample

☐ FERTILIZER
  ☐ Manufacturer’s literature

SOIL MIX SUBMITTALS
☐ UNSCREENED PLANTING SOIL MIX
  ☐ Lab analysis for physical and chemical composition
  ☐ One-gallon (3.79-liter) sample

☐ SCREENED PLANTING SOIL MIX
  ☐ Lab analysis for physical and chemical composition
  ☐ One-gallon (3.79-liter) sample

☐ BIO-RETENTION SOIL MIX
  ☐ Lab analysis for physical and chemical composition
  ☐ One-gallon (3.79-liter) sample

END OF SECTION
SECTION 329500 – LANDSCAPE 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. Landscape Rock.
   2. Tree Grates.
   4. Weed Control Barrier.
   5. Landscape Edging.

B. Related Sections:
   1. Division 03 Section "Cast-in-Place Concrete" for installation of tree grates, bike racks, and bollard concrete footings.
   2. Division 31 Section "Site Clearing" for protection of existing trees and plantings, topsoil stripping and stockpiling, and site clearing.
   3. Division 31 Section "Earth Moving" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
   4. Division 32 Section "Concrete Paving" for subbase under pavers.
   5. Division 33 Section "Subdrainage" for below-grade drainage of landscaped area, soil trenches, and tree grates.

1.3 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Planting Soil Mix: University Provided.

D. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.

E. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
1.4 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Landscape Rock.
   2. Tree Grates.
   4. Weed Control Barrier.
   5. Landscape Edging.

B. Samples for Initial Selection:
   1. Provide color chips for Bike Racks in factory-applied color finish options.
   2. 5 lb of landscape rock for each color and texture of stone required, in labeled plastic bags.

C. Samples for Verification: For each of the following:
   1. 12-inch of landscape edging.
   2. One (1) quart of polymeric sand materials

D. Shop Drawings: For each of the following:
   1. Tree Grates.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified landscape Installer.

B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
   1. Manufacturer's certified analysis for standard products.
   2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

C. Recycled Content: Manufacturer's or fabricator's certificate indicating percentage of post-consumer recycled content by weight and pre-consumer recycled content by weight for each Product specified under this Section. Document the material cost of each Product.

D. Regional Materials: Manufacturer's certificate demonstrating that each material or product was manufactured within 500 miles of the project site. Document the material cost of each Product.
   1. Landscape Rock.

E. Minutes of Pre-Installation Meeting.

F. Closeout Submittals:
   1. Maintenance Data: For site furnishings to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Preinstallation Conference: Conduct conference at Project site.
B. Paver/Bollard Mockups: Build a mockup to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.

1. Build mockup for one (1) bollard on pavers to ADA paver zone.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

1. Cover pavers with plastic or use other materials that will prevent rust marks from steel strapping.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Store liquids in tightly closed containers protected from freezing.

PART 2 - PRODUCTS

2.1 LANDSCAPE ROCK

A. Landscape Rock: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of following type, size range, and color:

1. Missouri Rainbow Rock
2. Size Range: 3/4 to 1-1/4 inch length
3. Color: Multi-color, acceptable to Landscape Architect and owner.
4. Shape: Rounded.
5. Texture: Smooth.

2.2 ACCESSORIES

A. Polymeric Sand: A joint filler product made of approximately 80-95 percent by volume of quartz and crystalline silica, an organic or man-made chemical binder (such as portland cement) activated by water to act as a binder between the sand particles.

B. Soil Sterilizer: Total vegetation product killing all plant nutrients in the soil and preventing any vegetation from surviving.

2.3 TREE GRATES

A. Basis-of-Design Product: Subject to compliance with requirements, provide “Parkway Collection” by Neenah Foundary. 36"x72", in halves. 12-inch tree opening. Apply “Black Max” from Rhomar Industries http://www.rhomar-industries.com/products.htm to instantly turn rust into a rich dark brown.

1. For substitution requests, use the University’s substitution request form during bidding process.
2.4 BIKE RACKS
A. Product: Subject to compliance with requirements, provide the following:
      a. No substitutions will be accepted.

2.5 WEED-CONTROL BARRIER
A. Nonwoven Fabric: Polypropylene or spunbonded, 3.5 oz./sq. yd. minimum, color: black or earhtone.

2.6 LANDSCAPE EDGING
A. Aluminum Edging: Standard-profile extruded-aluminum edging, ASTM B 221, Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Permaloc Corporation.
      c. Russell, J. D. Company (The).
   2. Edging Size: 3/16 inch wide by 5-1/2 inches deep.
   3. Stakes: Aluminum, ASTM B 221, Alloy 6061-T6, approximately 1-1/2 inches wide by 12 inches long.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas to receive landscape accessories for compliance with requirements and conditions affecting installation and performance.
   B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 LANDSCAPE ROCK
A. Install weed-control barriers according to manufacturer's written instructions. Completely cover area to be rocked, overlapping edges a minimum of 6 inches.
   B. Apply landscape rock in areas indicated on plans to a depth of 6-inch average thickness, and finish level with adjacent finish grades.

3.3 TREE GRATE INSTALLATION
A. Construction concrete base with framing system according to manufacturer's written instructions.

B. Coordinate installation of tree grate with Silva Cell soil system.

C. Install tree per drawings on top on specified compacted planting soil mix.
   1. Remove burlap and metal cages per University standard.

D. Install tree grates per manufacturer's written instructions. Set grate segments flush with adjoining surfaces as shown on Drawings. Shim from supporting substrate with soil-resistant plastic.

E. Install root ball stabilization.

F. Mulch per University standard. Maintain a 3-inch minimum growth radius around base of tree.

3.4 BIKE RACK INSTALLATION

A. Install concrete thickened slab as indicated on drawings.

B. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of bike racks where required.

C. Install on sloped pavement per drawings. The top of the bike racks shall be installed flat / level.

3.5 EDGING INSTALLATION

A. Aluminum Edging: Install aluminum edging where indicated according to manufacturer's written instructions. Anchor with aluminum stakes spaced approximately 36 inches apart, driven below top elevation of edging.

3.6 CLEANUP AND PROTECTION

A. During installation, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect exterior plants from damage due to installation operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

3.7 DISPOSAL

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 329500
SECTION 331100 – WATER UTILITY DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Site potable water lines
   2. Site fire protection water lines
   3. Related accessories.

B. Related Sections:
   1. Section 312000 – Earth Moving.

1.2 SYSTEM DESCRIPTION

A. Buildings located on the MU campus will typically have potable water service from MU's distribution system. Internal fire protection will also be served by the MU distribution system. Usually one service line into a building will provide both needs. If a separate service line is required for fire protection, installation of a post indicator valve will be required.

B. Flow tests, when required, can be obtained from the system owner.

C. A permanent line shall be installed to facilitate flushing of the water service line. The line shall be a minimum of 2” diameter and shall flow the water to a location outside of the building. The line shall be connected after the 1st valve inside of the building.

D. All water connections (fire and potable) shall include the installation of testable backflow prevention assemblies as required and approved by the Missouri Department of Natural Resources and MU Construction Standards.

E. All potable water service shall have a water meter.

F. All sizing and locations for mains, services and other auxiliary equipment shall be coordinated with system owner.

G. All service line entrances to buildings shall be designed to be maintainable. If a building is being built on a slab, a pit allowing access to the water line must be installed. Water service lines under buildings are not acceptable.

H. Water service-line connections to water mains shall include a three-valve (main-tap-main) cluster which will allow for maximum valving flexibility.

I. Nutating disc meters are to be installed on applications requiring water flows equal to, or less than one-hundred (100) gallons per minute. Turbine meters are to be installed on applications requiring water flows more than one-hundred (100) gallons per minute. Compound meter are to be installed on applications that will see large peak flows over typical normal flows.

1.3 SCHEDULING

A. Site utility tie-ins shall be coordinated with the Owner's Representative. Contactor shall notify Owner’s Representative two (2) weeks in advance of desired tie-in time. Owner's Representative will give Contractor 72 hours advance notice of actual time for tie-ins.
B. Tie-ins to utility systems shall be made on weekends or nights, and work shall be done around-the-clock until the tie-in is completed. Line outages are to be kept to a minimum.

1.4 SUBMITTALS

A. Product Data: Manufacturer’s specification and technical data on the following.
   1. Piping and Restraints.
   2. Water Meters.
   3. Valves.
   4. Fire Hydrants.

B. Quality Control Submittals:
   1. Field Quality Control submittals are specified under PART 3.

C. Contract Closeout Submittals.
   1. Project Record Documents.
      a. Contractor to provide X, Y and Z as-built coordinates, prepared by Registered Land Surveyor, at 25-foot intervals of installed water line, as well as all valves, fittings, and appurtenances prior to backfill of the water line.

1.5 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer’s Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following.
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

C. Regulatory Requirements:
   1. Comply with the Missouri Department of Natural Resources requirements for fire and potable water.
   2. Comply with requirements of the University of Missouri construction standards.

1.6 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer’s identification.

B. Storage and Protection: Comply with manufacturer’s recommendations.
   1. Store valves indoors.
   2. Protect pipes from moisture and dirt.

PART 2 - PRODUCTS

2.1 MATERIALS, PIPE AND PIPE FITTINGS

A. All underground water piping shall be PVC.
   1. EXCEPTION 1: Domestic water service lines 2” or less shall be Type K copper or high density polyethylene (HDPE) piping.
   2. EXCEPTION 2: Lines passing directly over or under steam tunnels or direct buried steam/condensate lines must be ductile iron or Type K copper (2” or less) with 4” R-5 extruded polystyrene insulation board between the pipe and steam lines.
B. PVC Pipe (Open Trench Construction)
   1. 4 Inches to 12 Inches: AWWA C900; Pressure Class 235 (DR 18); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.
   2. 14 Inches to 48 Inches: AWWA C905; Pressure Rating 165 (DR 25); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.

C. Ductile-Iron Pipe
   1. 4 Inches to 12 Inches: AWWA C151; Mechanical Joint Pipe; Minimum Thickness Class 52 or Pressure Class 350; with integrally cast flanged bell, cast iron gland, and rubber gasket.
   2. Lining: Standard cement lining with asphalt coating.

D. High-Density Polyethylene (HDPE) Pipe and Fittings
   1. 2 Inches and Less: SDR9 CTS Premium Grade Pipe, AWWA C901, ASTM D3035, NSF 14 and 61, 200 psi pressure rating. Pipe to be CenCore HDPE as manufactured by Centennial Plastics or approved equal.
   2. Fittings and Joints: All molded fittings and fabricated fittings shall be fully pressure rated to match the pipe pressure rating. All fittings shall be molded or fabricated by the pipe manufacturer. Connections must be made by either the use of brass/stainless steel compression couplings with insert rings or by creating a fusion butt weld all in strict accordance with manufacturer’s recommendations. All brass fittings shall be lead free.

E. Pipe Fittings
   1. 4 Inches to 24 Inches: AWWA C153; 350 psi pressure rating.
   2. Lining: Standard cement lining with asphalt coating.
   3. All pipe fittings shall be cast-iron construction, installed wrapped with AWWA C105 polyethylene film.

F. Restraints
   1. Mechanical joint: AWWA C111. Provide retainer type packing glands with rubber gasket, for use with PVC pipe and conforming to Uni-B-13-92. Pipe sizes 4” to 12” must also be FM approved. Mechanical joint restraints shall be Megalug 2000 PV, as manufactured by EBAA Iron Inc., Eastland TX, or approved equal.
   2. Joint Retainers: Provide ductile iron split serrated ring harnesses and rod type joint retainers for PVC bell and spigot joints. Clamps shall be designed for use with PVC pipe and shall meet Uni-B-13-92 Standards and be FM approved on sizes 4” to 12”. Restraint harnesses shall be Series 1500 for pipe 4 inches to 12 inches, and Series 2800 for pipe 14 inches and larger, all as manufactured by EBAA Iron Inc., Eastland TX or approved equal.
   3. Rods, nuts and washers: ¾” SS304 all thread rods, nuts and washers.
   4. All pipe restraints and ductile iron fittings shall be installed wrapped with AWWA C105 polyethylene film.
   5. Link Assembly: Seal annular space for piping passing through walls with interlocking synthetic rubber link assembly, Link-Seal® as manufactured by PSI-Thunderline Corporation, Houston TX, or approved equal.

G. Trace Wire
   1. Tracer wire shall be #14 AWG Solid, steel core soft drawn high strength tracer wire, 250# average tensile break load, 30 mil high molecular weight-high density blue polyethylene jacket complying with ASTM-D-1248, 30 volt rating. No THHN insulated wire shall be allowed. Tracer wire shall be Copperhead Industries HS-CCS or approved equal.
   2. Tracer wire shall have moisture resistant splices for direct bury applications. Splices shall be Copperhead Industries Snakebite or 3M DBR or approved equal.
   3. Tracer wire test stations shall be designed to be easily detected by magnetic and electronic locators. A magnet shall be securely attached at the top of the upper tube of the box for locating purposes. Lid shall be blue and have a brass terminal for attaching locating equipment and a brass 5 sided nut for removing cap. Tracer wire test station shall be Copperhead Industries Snake Pit or approved equal.
2.2 WATER UTILITIES METERING

A. The University of Missouri Columbia campus has standardized on bronze disc and turbine utility meters as manufactured by BadgerMeter, Milwaukee, WI. Substitutes will not be accepted.

B. Compound Meter
   1. Construction shall comply with ANSI and AWWA C702 standards as required for domestic water compound metering applications.
   2. Meter housing shall be lead free cast bronze construction. Nose cone, straightening vanes, rotor, rotor and valve casing, measuring chamber and disc and high flow valve shall be thermoplastic construction. Register lid and shroud shall be thermoplastic and bronze and trim shall be stainless steel.
   3. Register shall be a straight-reading odometer-type totalization display (gallons), 360 degree test circle with dual center sweep hands. Register shall be installed using TORX tamper resistant seal screws. A tamper resistant calibration plug seal shall also be provided to protect from unauthorized personnel.
   4. Meters shall be Recordall Compound Series.

C. Plate Strainers
   1. Plate strainers shall exceed AWWA standards. Double-flanged housing and cover shall be constructed of cast bronze. Strainer screen and housing bolts shall be stainless steel. Housing cover seal and flange gaskets shall be neoprene rubber. Screen shall have 3/16" perforations with a minimum straining area that is double the meter inlet size. Flange connections shall be elliptical (2" meters) or round. Plate strainers shall be as manufactured by BadgerMeter or approved equal. Strainer not required for Electromagnetic meter.

2.3 VALVES AND VALVES BOXES MATERIALS

A. Non-rising Stem Gate Valves: ANSI/AWWA C509, resilient seated, bronze stem, cast-iron or ductile-iron body and bonnet, epoxy coated disc, stem nut, 250 psig working pressure, mechanical joint ends. Valves shall be Model A-2360 as manufactured by Mueller Company, Decatur IL, or approved equal. Valves shall turn clockwise to close.

B. Ball Valves: Threaded lead free bronze, 125 lb., 2-piece design, full port. Valves shall be Model T-FP-600A-LF-LL as manufactured by NIBCO, Elkhart IL, or approved equal.

C. Valve Boxes: Valve box shall be 6" PVC C900 pipe with cast iron cover No. 2195 as manufactured by Clay and Bailey Manufacturing Company, Kansas City MO, or approved equal. Lid shall be marked "WATER". Provide below grade concrete collar in planted and asphalt areas.

2.4 FIRE HYDRANT MATERIALS

A. University fire hydrants shall be Super Centurion Fire Hydrants, Model 250, Number A-423, as manufactured by Mueller Water Products, Decatur IL. No substitutions will be allowed.

B. Fire hydrants shall be painted in the following manner using Sign Painters’ 1 Shot Lettering Enamel or approved equal:

C. University water:
   1. Barrel - Metallic Gold
   2. Caps – Black

D. City water, University maintained system:
   1. Barrel - Metallic Gold
   2. Caps - Blue.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPE INSTALLATION

A. Preparation of Trench
   1. Final bury depth shall have a minimum of 42" cover to the top of the pipe.
   2. Trench bottom shall be graded to provide a smooth, firm, stable, and rock-free foundation throughout the length of the piping.
   3. All rock greater than one inch in diameter found in the trench shall be removed for a depth of six inches below the bottom of the pipe and replaced by suitable bedding material.
   4. Unstable, soft, and unsuitable materials shall be removed at the surface upon which pipes are to be laid and backfill with crushed stone as indicated on the drawings.
   5. Layers of crushed stone shall be installed in the bottom of trench as indicated on the drawings. Shape stone layer to fit bottom of piping. Dig bell holes at each pipe joint to relieve the bells of all loads and to ensure continuous bearing of the pipe barrel on the foundation.

B. Pipe Separation
   1. Finished pipe installation shall have minimum 12" separation to all other utilities.
   2. Maintain at least a ten foot (10') horizontal separation of water mains from any existing or proposed sanitary sewer. The distance must be measured edge to edge. Installation of the water main closer to a sanitary sewer is acceptable where the water main is laid in a separate trench or on an undisturbed earth shelf located on one (1) side of the sanitary sewer at an elevation so the bottom of the water main is at least eighteen inches (18") above the top of the sanitary sewer.
   3. Provide a minimum vertical distance of eighteen inches (18") between the outside of the water main and the outside of the sanitary sewer where water mains cross the sanitary sewer mains. This shall be the case where the water main is either above or below the sanitary sewer. At crossings, one (1) full length of water pipe must be located so both joints will be as far from the sanitary sewer line as possible. Special structural support for the water and sanitary sewer pipes may be required.
   4. Provide at least a ten-foot (10') horizontal separation between water mains and sanitary sewer force mains. There shall be an eighteen-inch (18") vertical separation at crossings.
   5. Locate water mains so that they do not pass through or come in contact with any sanitary sewer manhole.
   6. Consult the system owner where above conditions cannot be met.

C. Installation of Pipe and Pipe Fittings
   1. Piping 2" and less:
      a. All domestic water service piping from the water main to the building with a nominal diameter of two inches and less shall be Type K copper or HDPE piping.
      b. In all installations, Type K copper shall be used where the water line enters the building. If the water meter is located in a meter pit, the piping within the meter pit, and stubbed out on either side shall also be Type K copper.
      c. All buried copper piping shall be wrapped.
      d. For pulled pipe installations, tracer wire shall be pulled with pipe, without splices. Upon completion of installation, a continuity test on the wire shall be performed and all breaks shall be repaired.
      e. For trenched pipe installation, tracer wire shall be taped to the pipe at the three o’clock position every 5 feet. Upon completion of installation, a continuity test on the wire shall be performed and all breaks shall be repaired.
   2. PVC (Polyvinyl Chloride) Pipe: Install in accordance with AWWA C605.
3. All joints shall be restrained with joint retainers. All fittings shall be restrained with retainer type packing glands.

1. Install stainless steel rods between fittings on all offsets and between fittings, valves, and blind flanges, in addition to the Megalugs. On isolated fittings, valves, etc., attach restraint rings to PVC pipe and install stainless steel rods between fitting and restraint rings. Rods shall be positioned through the bolt holes in fitting and Megalug. Each rod will require four nuts and washers. Duct lugs are acceptable. The number of stainless steel rods required per fitting flange shall be as follows:

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>No. of Rods</th>
</tr>
</thead>
<tbody>
<tr>
<td>10” and Less</td>
<td>2</td>
</tr>
<tr>
<td>12”</td>
<td>3</td>
</tr>
<tr>
<td>14”</td>
<td>4</td>
</tr>
<tr>
<td>16”</td>
<td>5</td>
</tr>
<tr>
<td>18”</td>
<td>6</td>
</tr>
</tbody>
</table>

4. All ductile iron pipe, fittings, valves, bell end restraints, etc. shall be wrapped with a polyethylene cover conforming to AWWA C105, and installed per AWWA C600.

5. All dead end mains shall have a dry barrel fire hydrant at the end to facilitate flushing of the main.

6. Pipe shall be installed in clean condition, and shall never be laid in trenches with standing water. The trench shall be dewatered during installation of the water line. Open pipe ends shall be protected with a hard cap or inflatable plug at the end of the work day. NO PLYWOOD OR DUCTTAPE COVERINGS WILL BE ALLOWED.

D. Backfill

1. Under Pipe: All backfill under the barrel of the pipe shall be free from debris, organic matter, and stones larger than one inch, and shall be tamped into place. Sand or crushed stone aggregate (95% passing a ½” screen but not more than 10% passing a #200 sieve) are acceptable substitutes for soil.

2. Adjacent To and Top of Pipe: The first one foot of backfill over the top of pipe shall be “3/4 inch minus waste rock with fines” uncleaned crushed stone aggregate or suitable soil. Backfill shall be free of debris, brush, roots and stones or rubble more than one inch.

3. Rough final grading of subgrade and the placement of final topsoil shall be detailed on the drawings.

4. All sidewalks, paving, etc. which are removed or damaged during construction shall be replaced and shall match existing.

E. Identification

1. Install continuous plastic underground warning tape during back-filling of trench for underground water piping. Tape shall be located twenty-four (24) inches above pipe, directly over each water line.

2. Tape trace wire to the top of each water line with duct tape every five (5) feet. Wire splices shall be minimized. Terminate trace wires inside building and inside valve boxes. Drill ¼” hole in PVC valve box one inch below cast iron cover. Route wire up outside of valve box, through ¼” hole and knot. A tracer wire test station shall be installed at all fire hydrants and at all runs of piping without valves every 400 feet. Upon completion of installation and final grading, a continuity test on the wire shall be performed and all breaks shall be repaired.

3.3 WATER UTILITIES METERING INSTALLATION

A. Installation of water meter, valving, bypass loop and water sampler/test outlet shall be in strict accordance with manufacturer’s printed instructions and recommendations, applicable ANSI and AWWA requirements, and as detailed on “Bronze Disc Water Meter Installation Detail” and “Bronze Turbo Water Meter Installation Detail.”

B. The preferred location for water revenue meter installation is within a building mechanical room. In some cases, water meter may need to be installed in an exterior below-grade meter pit. These pit installations shall be installed in strict accordance with manufacturer’s printed instructions and University of Missouri-Columbia “Meter Box Pit Detail” drawing.
C. Water meters shall be installed with a three-valve bypass design using ball valves (2" or less) or OS&Y rising stem gate valves (larger than 2"). The bypass valve shall be full-flow and capable of being locked. All other valves associated with the meter installation shall be ball valves. Water meters shall be installed in a straight run with no obstructions a minimum of ten diameters upstream and five diameters downstream.

D. Water meter shall be installed after the backflow prevention device but prior to any booster pumps or pressure reducing valves.

E. Water meter shall be installed no greater than 4’ from the floor. Variations from this requirement need prior approval from system owner. If this requirement is impossible or the meter is located in an inaccessible location, the meter shall be equipped with a remote read, and the register shall be mounted no greater than 4’ from the floor.

3.4 WATER UTILITIES COMMISSIONING

A. Water service will not be turned on until the water meter is fully installed and operating satisfactorily, the downstream water piping is successfully leak tested and secure (including freeze protection), and the necessary backflow preventer device is installed and successfully tested with the delivery of the test report to Campus Facilities - Energy Management Steam and Water Distribution Engineering.

B. Only Energy Management Steam and Water Distribution personnel will be authorized to turn water service on or off.

3.5 VALVES AND VALVES BOXES INSTALLATION

A. Valve Storage: Use the following precautions for valves during storage:
   1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
   2. Protect valves from weather - valves shall be stored indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

B. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Valves shall be rigged to avoid damage to exposed valve parts. Do not use hand wheels or stems as lifting or rigging points.

C. Domestic Water Service: AWWA-Type Gate Valves: Comply with AWWA C600. Install buried valves with stem pointing up and with valve box.

D. Valve boxes shall be installed vertically with top of box even with final grade.

3.6 VALVES AND VALVES BOXES TESTING

A. All valves shall be pressure tested in accordance with standards set forth in the Water Piping Construction Standard.

B. All valves shall be disinfected in accordance with standards set forth in the Water Piping Construction Standard.

3.7 VALVES AND VALVES BOXES COMMISSIONING

A. All valves under pressure in the MU water distribution mains will be operated only by Campus Facilities - Steam & Water Distribution personnel, except in cases of extreme emergency. All valves installed as part of new construction shall remain fully closed during construction.
FIRE HYDRANT INSTALLATION

A. The location of new fire hydrants shall be determined by a collaboration of system owner, City of Columbia Fire Department and the design engineers.

B. Installation of fire hydrants maintained by the University shall be installed per “Fire Hydrant Detail” and in strict accordance with manufacturer’s written instructions.

C. Installation of fire hydrants maintained by the City of Columbia shall be in strict accordance with Columbia Water and Light Specifications as last revised.

D. The pumper nozzle shall be installed pointing to the street and/or away from the building.

FIRE HYDRANT TESTING

A. Newly installed fire hydrants shall be cleaned and pressure tested in accordance with standards set forth in this section, and will be flow tested by system owner.

FIRE HYDRANT COMMISSIONING

A. Water will be turned on to the hydrant by Campus Facilities - Energy Management Utility Distribution personnel.

B. Hydrant will be flow tested by owner.

DISINFECTION AND TESTING OF WATER UTILITY DISTRIBUTION

A. MU will perform pressure testing and disinfection of new water lines. Contractor shall prepare water line for successful pressure testing and disinfection.

B. All domestic potable water systems will be pressure tested in accordance with AWWA M23.

C. All domestic potable water systems will be disinfected and tested for bacteriological contamination before the system is put into operation, as required by the Department of Natural Resources and in accordance with AWWA C651.

D. Contractor shall ensure internal surfaces of water line shall be clean and free of foreign matter.

E. Water line shall be completely separated from MU water system for pressure tests and disinfection purposes.

B. Contractor shall install number and size of taps based off of water line size in table below:

<table>
<thead>
<tr>
<th>Pipe Diameter (in)</th>
<th>2” Taps Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>4”</td>
<td>1</td>
</tr>
<tr>
<td>6”</td>
<td>1</td>
</tr>
<tr>
<td>8”</td>
<td>1</td>
</tr>
<tr>
<td>10”</td>
<td>2</td>
</tr>
<tr>
<td>12”</td>
<td>2</td>
</tr>
</tbody>
</table>

F. Contractor shall install water line entrance and exit piping which enters and exits above ground as shown in “Taps for Flushing and Disinfection of Water Line” per University of Missouri Construction Standards. The purpose of this piping is to provide a means for flushing, pressure testing, and disinfecting the new water line.
G. Contractor shall contact Energy Management 72 hours prior to requesting flushing and disinfection of new water line.

H. Campus Facilities - Energy Management Steam and Water personnel will draw water samples for bacteriological testing and send sample off for testing.

I. Allow twenty-four (24) hours for disinfection of water line and an additional forty-eight (48) hours for return of testing before making tie-ins to existing system.

J. Commissioning
   1. System shall be placed in operation only after testing shows the absence of bacteriological contamination and approved by system owner.

K. Only Campus Facilities - Energy Management Steam and Water personnel will be allowed to operate valves on new water systems.

END OF SECTION
SECTION 333100 - SANITARY UTILITY SEWERAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Sanitary sewage piping.
   2. Manholes.
   3. Connection of building sanitary drainage system to municipal sewers.
   4. Related accessories.

B. Related Sections:
   1. Section 312000 – Earth Moving.

1.2 SUBMITTALS

A. Product Data: Manufacturer's specifications and technical data on the following:
   1. Piping.
   2. Fittings.
   3. Cleanouts.

B. Shop Drawings: Indicate dimensions, description of materials, general construction, specific modifications, component connections, anchorage methods, and installation procedures, plus the following specific requirements.
   1. Include manholes, frames, and covers.

C. Contract Closeout Submittals:
   1. Project Record Documents.
      a. Contractor to provide as-built survey, prepared by Registered Land Surveyor, that indicates the exact location, top elevations, flow lines and pipe sizes of all structures.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer’s Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

C. Regulatory Requirements:
   2. Comply with requirements of City.

D. Certificates: Certification from precast manufacturer that ConmicShield® with CONTINT was used in the fabrication of sewer manhole.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer’s identification.
B. Precast concrete sections shall not be delivered to the job until the concrete control cylinders have attained a strength of at least 80 percent of the specified minimum.

C. Precast concrete sections shall be handled carefully and shall not be bumped or dropped. Hooks shall not be permitted to come in contact with joint sections.

D. Precast concrete sections shall be inspected when delivered. All cracked or otherwise visibly defective units will be rejected. City reserves the right to inspect the production of the units at the manufacturing plant.

E. Storage and Protection: Comply with manufacturer’s recommendations.

PART 2 - PRODUCTS

2.1 MATERIALS

   1. Joints: Pipe and fittings shall have elastomeric gasket joints providing a watertight seal when tested in accordance with ASTM D3212. Gaskets shall conform to ASTM F477. Solvent welded joints shall not be permitted.

B. Concrete:
   1. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
      b. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 deformed steel.
   2. ConmicShield® with CONTINT shall be added to all precast and cast-in-place manholes in accordance with the manufacturer’s recommendations.
      a. Cast-in-place concrete invert fill and collars inside the manhole shall contain ConmicShield® with CONTINT per manufacturer’s recommendation.

2.2 COMPONENTS

   1. Base section:
      a. Floor slab: 8 inch thick, unless otherwise indicated on drawings.
      b. Walls: 6 inch thick, unless otherwise indicated on drawings.
      c. Base riser section: 6 inch thick, unless otherwise indicated on drawings.
   2. Riser section: 48 inch diameter unless otherwise indicated on Drawings, with 6 inch thick walls.
   3. Top section: Concentric cone, eccentric cone, or flat slab type, as indicated on Drawings.
      a. Top of cone to match grad rings.
   4. Grade rings: Reinforced concrete rings, 4 to 9 inches thick.
   5. Gasket: O-ring, double ring, or preformed bitumastic sealant.
   6. Steps: Steel reinforced polypropylene plastic steps per ASTM 4101, cast into base, riser and top sections at 12 inch intervals.
   7. Frame and cover: ASTM A48, Class 35B gray iron.
      a. Frame size: 24 inch inside diameter, by 9 inch riser with 4 inch width flange.
      b. Cover: 26 inch diameter, indented top design, with lettering “SANITARY SEWER” cast into cover.
   8. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
      a. Provide “boot” type nitrile rubber connections at locations indicated on Drawings.
   10. ConmicShield® with CONTINT shall be added to all precast manholes in accordance with the manufacturer’s recommendations.
       a. Cast-in-place concrete invert fill and collars inside the manhole shall contain ConmicShield® with CONTINT per manufacturer’s recommendation.
ACCESSORIES

A. Cleanouts: Cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.

B. Underground Warning Tape: Polyethylene plastic tape with magnetic detectable conductor, 6 inches wide by 4 mils thick.
   1. Imprint warning tape with “CAUTION – SEWER SERVICE LINE BURIED BELOW” in large black letters.

C. Bedding Materials: As specified under Section 312000.

D. Fill Materials: As specified under Section 312000.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Trenching: Comply with requirements of Section 312000.
   1. Grade trench bottom to provide smooth, firm, stable, and rock free foundation throughout length of pipe.
   2. Remove unstable, soft, and unsuitable materials from surface upon which pipe is to lay.
      a. Backfill with bedding materials.
   3. Shape bottom of trench to fit design of pipe.
      a. Fill unevenness with tamped bedding materials.
      b. Dig bell holes at each pipe joint to assure continuous bearing of pipe.

B. Install bedding material at trench bottom in accordance with Section 312000.
   1. Install bedding materials in continuous layers not exceeding 6 inches in compacted depth, to total depths indicated on Drawings.
   2. Compact bedding materials as specified under Section 312000.

C. Pipe Installation: Comply pipe manufacturer’s instructions.
   1. Install pipe beginning at low point of system, true to grades and alignment indicated on Drawings and unbroken continuity of invert.
   2. Install PVC pipe in accordance with ASTM D2855 and ASTM F447.
   3. Place bell ends or groove ends of piping facing upstream.
   4. Install gaskets in accordance with manufacturer’s instructions.
   5. Install bedding at sides and over top of pipe to minimum compacted thickness of 12 inches.
   6. Clean interior of piping as Work progresses.
   7. Maintain swab or drag line and pull past each joint as it is completed.
   8. Install plugs in ends of incomplete piping at end of each day and whenever Work stops.

D. Install manholes complete with accessories indicated on Drawings.
   2. Form continuous concrete channel and benches between inlets and outlets.
   3. Install top of frames and covers flush with adjacent paved surfaces.
      a. Install top of frame 3 inches above adjacent landscaped surfaces.

E. Install clean-outs and extension from sewer pipe to clean-out at grade at locations indicated on Drawings.
1. Set cleanout frame and cover in concrete pad, 18 inches by 18 inches by 12 inches deep, except at where location is in concrete paving.
2. Set top of cleanout 1 inch above surrounding grade.
3. Set top of cleanout flush with surrounding pavement.

F. Tap Connections:
1. Make connections to existing sanitary sewer and underground to comply with requirements of this Section, as indicated on Drawings.

G. Install underground warning tape continuous buried 6 inches below finish grade, above pipe line.
1. Coordinate with Section 312000.

H. Backfilling: Comply with requirements of Section 312000.

3.3 CLEANING
A. Flush piping between manholes and other structures if required by authority having jurisdiction.
1. Remove collected debris.

3.4 FIELD QUALITY CONTROL
A. Tests:
1. Perform testing of completed system in accordance with local authorities having jurisdiction.
2. Perform the following tests in accordance with APWA Street Construction and Material Specifications, Division II, Section 2509.
   a. Infiltration-exfiltration air test.
   b. Deflection test.

B. Inspections:
1. Perform inspections in accordance with APWA Street Construction and Material Specifications, Division II, Section 2509.
2. Inspect interior of piping to determine whether line displacement or other damage has occurred.
3. Make inspections after pipe between manholes and manhole locations has been installed and approximately 2 feet of backfill material in place.
   a. Reinspect at completion of Project.
4. If inspections indicate poor alignment, debris, displaced pipe, infiltration, or other defects, correct such defects and reinspect.
   a. Defects requiring correction include the following:
      1) Alignment: Less than full diameter of inside of pipe is visible between structures.
      2) Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      3) Crushed, broken, cracked, or otherwise damaged piping.
      4) Infiltration: Water leakage into piping.
      5) Exfiltration: Water leakage from or around piping.

3.5 PROTECTION
A. Protect installed sewage system from damage and/or displacement until backfilling operation is complete.

END OF SECTION
SECTION 334100 - STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Storm sewage piping.
   2. Junction boxes.
   3. Inlets.
   4. Yard drains.
   5. Related accessories.

B. Related Sections:
   1. Section 033000 – Cast-In-Place Concrete.
   2. Section 312000 – Earth Moving.
   3. Section 312316 – Excavation.
   4. Section 334613 – Foundation Drainage.

1.2 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

B. Product Data: Manufacturer’s specifications and technical data on the following:
   1. Piping.
   2. Fittings.
   3. Yard Drains.

C. Shop Drawings: Indicate dimensions, description of materials, general construction, specific modifications, component connections, and installation procedures, plus the following specific requirements:
   1. Include junction boxes, inlets, frames, covers, and grates.

D. Contract Closeout Submittals: Submit in accordance with Division 1.
   1. Project Record Documents.
      a. Accurately record location of underground utilities, by horizontal dimensions from above grade permanent fixtures, elevations or inverts, and slope gradients.

1.3 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer’s Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer’s identification.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Reinforced Concrete Pipe: ASTM C76, Class III.
   1. Fittings: Same strength of adjoining pipe.
   2. Joints:
      a. Gaskets: Contractor has option of the following:
         1) ASTM C443, flat gaskets cemented to pipe tongue or spigot.
         2) ASTM C443 O-ring gaskets.
         3) ASTM C443 roll-on gaskets.


C. High Density Polyethylene (HDPE) pipe and fittings: AASHTO M252, Type S; AASHTO M294, Type S.

D. Concrete: Comply with requirements of Section 033000.

2.2 COMPONENTS

A. Junction Boxes: ASTM C858, precast reinforced concrete.
   1. Base section:
      a. Floor slab: 8 inch thick.
      b. Walls: 6 inch thick.
      c. Base riser section: 6 inch thick.
   2. Riser section: 48 inch diameter unless otherwise indicated on Drawings, with 6 inch thick walls.
   3. Top section: Concentric cone, eccentric cone, or flat slab type, as indicated on Drawings.
      a. Top of cone to match grade rings.
   4. Grade rings: Reinforced concrete rings, 4 to 9 inches thick.
   5. Gasket: ASTM C443, rubber.
   6. Steps: Cast iron steps, case into base, riser and top sections at 16 inch intervals.
   7. Frame and cover: ASTM A48, Class 35B gray iron.
      a. Frame size: 24 inch diameter, by 9 inch riser with 4 inch width flange.
      b. Cover: 26 inch diameter, indented top design, with lettering “STORM SEWER” cast into cover.

B. Inlets: ASTM C858, precast reinforced concrete
   1. Base section:
      a. Floor slab: 8 inch thick.
      b. Walls: 6 inch thick.
      c. Base riser section: 6 inch thick.
   2. Riser section: 48 inch diameter unless otherwise indicated on Drawings, with 6 inch thick walls.
   3. Top section: Flat slab type.
      a. Opening to match grade rings.
   4. Grade rings: Reinforced concrete rings, 4 to 9 inches thick.
   5. Gasket: ASTM C443, rubber.
   6. Steps: Steel reinforced plastic steps, cast into base, riser and top sections at 16 inch intervals.

C. Yard Drains:
   1. Size: 12 inches by 12 inches unless otherwise indicated on Drawings.
4. Acceptable manufacturers and product:
   a. Nyloplast America, Inc.: Inline Drain.
   b. Comparable products of other manufacturers.

2.3 ACCESSORIES

A. Cleanouts: Cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.

B. Underground Warning Tape: Polyethylene plastic tape, 6 inches wide by 4 mils thick.
   1. Imprint warning tape with “CAUTION – SEWER SERVICE LINE BURIED BELOW” in large black letters.

C. Bedding Materials: As specified under Section 312000.

D. Backfill Materials: As specified under Section 312000.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Trenching: Comply with requirements of Section 312000.
   1. Grade trench bottom to provide smooth, firm, stable, and rock free foundation throughout length of pipe.
   2. Remove unstable, soft, and unsuitable materials from surface upon which pipe is to lay.
      a. Backfill with bedding material.
   3. Shape bottom of trench to fit design of pipe.
      a. Fill unevenness with tamped bedding material.
      b. Dig bell holes at each pipe joint to assure continuous bearing of pipe.

B. Install bedding material at trench bottom in accordance with Section 312000.
   1. Install bedding materials in continuous layers not exceeding 6 inches in compacted depth, to total depths indicated on Drawings.
   2. Compact bedding materials as specified under Section 312000.

C. Pipe Installation: Comply with pipe manufacturers instructions.
   1. Install pipe beginning at low point of system, true to grades and alignment indicated on Drawings and unbroken continuity of invert.
   2. Install concrete pipe in accordance with ACPA Concrete Piping Installation Manual.
   3. Install polyethylene corrugated pipe in accordance with ASTM D2321.
      a. Install fittings in accordance with manufacturer’s instructions.
   4. Install PVC pipe in accordance with ASTM D2835 and ASTM F402.
   5. Place bell ends or groove ends of piping facing upstream.
   6. Install gaskets in accordance with manufacturer’s instructions.
   7. Install bedding at sides and over top of pipe to minimum compacted thickness of 12 inches.
   8. Clean interior of piping as Work progresses.
   9. Maintain swab or drag line and pull past each joint as it is completed.
  10. Install plugs in ends of incomplete piping at end of each day.
D. Install junction boxes complete with accessories indicated on Drawings.
   2. Form continuous concrete channel and benches between inlets and outlets.
   3. Install top of frames and covers flush with adjacent paved surfaces.
      a. Install top of frame flush with adjacent landscaped surfaces, unless otherwise indicated on
         Drawings.

E. Install inlets complete with accessories indicated on Drawings.
   2. Form continuous concrete channel and benches between inlets and outlets.
   3. Install top of frames and covers flush with adjacent paved surfaces.
      a. Install top of frame flush with adjacent landscaped surfaces.

F. Install cleanouts and extension from storm drainage pipe to cleanout at grade at locations indicated on
   Drawings.
   1. Set cleanout frame and cover in concrete pad, 18 inches by 18 inches by 12 inches deep except at
      where location is in concrete paving.
   2. Set top of cleanout 1 inch above surrounding earth grade.
   3. Set top of cleanout flush with surrounding pavement.

G. Tap Connections:
   1. Make connections to existing storm sewer and underground structures to comply with requirements
      of this Section, as indicated on Drawings.

H. Install underground warning tape continuous buried 6 inches below finish grade, above pipe line.
   1. Coordinate with Section 312000.

I. Backfilling: Comply with requirements of Section 312000.

3.3 PROTECTION

A. Protect installed sewage system from damage of displacement until backfilling operation is complete.
SECTION 334600 - SUBDRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Sub-grade drainage system.
   2. Related accessories.

B. Related Sections:
   1. Section 312000 – Earth Moving.

1.2 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

B. Product Data: Manufacturer’s specifications and technical data including the following:
   1. Detailed specifications of construction and fabrication of the following:
      a. Pipe drainage products and accessories.
      b. Filter fabric.

C. Samples:
   1. Filter fabric.

D. Contract Closeout Submittals: Submit in accordance with Division 1.
   1. Project Record Documents.
      a. Accurately record location of underground utilities, by horizontal dimensions from above
         grade permanent fixtures, elevations or invertes, and slope gradients.

1.3 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer’s Qualifications: Firm experienced in installation of systems similar in complexity to those required
   for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

1.4 DELIVERY, STORAGE, AND HANDLING

1. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer’s
   identification.

2. Storage and Protection: Comply with manufacturer’s recommendations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Polyvinyl Chloride (PVC) Pipe and Fittings: ASTM D3034, SDR 35, with socket and spigot ends.
1. Size: 4 inch diameter.
2. Provide unperforated pipe through sleeved walls.
3. Provide unperforated pipe under paved areas.
4. Provide perforated pipe at subdrainage and underdrain systems.
5. Provide perforated pipe at subdrainage and underdrain systems.
   a. Perforations: Standard pattern per ASTM D2729:
      1) Nominal Pipe Size: 4" - 6"
      2) Hole Size: 1/2"
      3) Hole Spacing: 5" ± 1/4"
      4) Hole Rows: 2 @ 120° (±5°)

B. High Density Polyethylene (HDPE) pipe and fittings: AASHTO M252, Type S; AASHTO M294, Type S. All joints shall meet the requirements of a soiltight joint unless otherwise specified.
1. Perforation: Class II perforation per AASHTO M252 and M294.

C. Fittings: As required for installation of drainage system.

D. Filter Aggregate and Bedding Materials: Granular Fill as specified under Section 312000.

E. Debris Filter Aggregate and Bedding Materials: Clean crusted stone or gravel, free of Shale, clay, friable material, and, complying with ASTM C33 Size no. 57.

F. Geotextile Filter Fabrics
   1. Description: Fabric of polypropylene (PP) or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.

G. Structure Type: Nonwoven, needle-punched continuous filament.
1. Survivability: AASHTO M 288 Class 2
2. Styles: Flat and sock.

2.2 ACCESSORIES

A. Cleanouts: Cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, cast-iron cover.

B. Underground Warning Tape: Polyethylene plastic tape with magnetic detectable conductor, 6 inches wide by 4 mils. Thick.
1. Imprint warning tape with “CAUTION- SEWER SERVICE LINE BURIED BELOW” in large black letters.

C. Bedding Materials: As specified under Section 312000.

D. Fill Materials: As specified under Section 312000.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
1. Do not proceed until unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Preparation:
   1. Grade bottom of excavations to provide smooth, firm, stable, and rock free foundation throughout length of pipe.
   2. Remove unstable, soft, and unsuitable materials from surface upon which pipe is to lay.
      a. Backfill with clean sand or pea gravel.
   3. Shape bottom of excavation to fit design of pipe.
      a. Fill unevenness with tamped sand backfill
   4. Remove large stones or other hard matter which could damage drainage pipe or impede consistent backfilling or compaction.

3.3 INSTALLATION

A. Comply with manufacturer’s instructions.

B. Install pipe beginning at low point of system, true to grades and alignment indicated, with maximum variation from true slope of 1/8 inch in 10 feet.
   1. Install polyethylene corrugated pipe in accordance with ASTM D2321.
      a. Install fittings in accordance with manufacturer’s instructions.
   2. Cap upper ends of pipe.

C. Install filter fabric over subgrade in area to receive perforated pipe.
   1. Place 2 inch deep by not less than 12 inch wide bedding aggregate over filter fabric.

D. Install pipe over bedding aggregate with perforations facing down.
   1. Mechanically join pipe ends.

E. Install filter aggregate at sides and top of pipe in 4 inch lifts.
   1. Do not displace or damage pipe when placing filter aggregate.
   2. Provide top cover of filter aggregate of not less than 24 inches of depth, and as indicated on Drawings.
   3. Level top of aggregate cover.

F. Wrap filter fabric over aggregate cover prior to backfilling.

G. Coordinate final backfilling and compaction operations with Sections 312000.
   1. Do not allow backfilling operations to commence without observation of completed system by Engineer.
   2. Do not allow drainage pipe to be displaced during backfilling and compaction operations.

H. Connect drainage pipe to storm drainage system using unperforated pipe or through installed sleeves.

3.4 FIELD QUALITY CONTROL

A. Provide in accordance with Division 1.

B. Inspections: Allow Engineer to observe installed system prior to installation of filter aggregate cover.

END OF SECTION
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SECTION 334613 - FOUNDATION DRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Building perimeter drainage system.
   2. Retaining wall drainage system.
   3. Under slab-on-fill drainage system.
   4. Related accessories.

B. Related Sections:
   1. Section 312000 – Earth Moving.
   2. Section 334100 - Storm Utility Drainage Piping.

1.2 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

1.3 PRODUCT DATA

A. Manufacturer's specifications and technical data including the following:
   1. Pipe drainage products and accessories.

B. Samples:
   1. Submit samples of the following:

C. Contract Closeout Submittals: Submit in accordance with Division 1.

D. Project Record Documents.
   1. Accurately record location of underground utilities, by horizontal dimensions from above grade permanent fixtures, elevations or inverts, and slope gradients.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer's Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer's identification.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Polyvinyl Chloride (PVC) Pipe and Fittings: ASTM D3034, SDR 35, with socket and spigot ends.
   1. Size: 4 inch diameter.
   2. Provide unperforated pipe through sleeved walls.
   3. Provide unperforated pipe under paved areas.
   4. Provide perforated pipe at subdrainage and underdrain systems.
      a. Perforations: Standard pattern per ASTM D2729:
         1) Nominal Pipe Size: 4” - 6”
         2) Hole Size: 1/2”
         3) Hole Spacing: 5” ± 1/4”
         4) Hole Rows: 2 @ 120° (±5°)

B. High Density Polyethylene (HDPE) pipe and fittings: AASHTO M252, Type S; AASHTO M294, Type S. All joints shall meet the requirements of a soil-tight joint unless otherwise specified.
   1. Perforation: Class II perforation per AASHTO M252 and M294.

C. Fittings: As required for installation of drainage system.

D. Filter Aggregate and Bedding Materials: Granular Fill as specified under Section 312000.

E. Drainage Panels: Prefabricated geocomposite, 36 to 60 inches wide with drainage core faced with geotextile filter fabric.
   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 Wick Drain.
      b. Cosella-Dorken Products, Inc.
      c. Eljen Corporation.
      d. Greenstreak.
      e. JDR Enterprises, Inc.
      f. Midwest Diversified Technologies Incorporated.
      g. TenCate Geosynthetics.
      h. Trace-LINQ Inc.
   2. Comparable product by one of the following:
      a. American Wick Drain.
      b. Cosella-Dorken Products, Inc.
      c. Eljen Corporation.
      d. Greenstreak.
      e. JDR Enterprises, Inc.
      f. Midwest Diversified Technologies Incorporated.
      g. TenCate Geosynthetics.
      h. Trace-LINQ Inc.
   3. Drainage Core: Three-dimensional, nonbiodegradable, molded PP.
      a. Minimum Compressive Strength: 10,000 lbf/sq. ft when tested according to ASTM D 1621.
      b. Minimum In-Plane Flow Rate: 2.8 gpm/ft. of unit width at hydraulic gradient of 1.0 and compressive stress of 25 psig when tested according to ASTM D 4716.
   4. Filter Fabric: Nonwoven needle-punched geotextile, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with the following properties determined according to AASHTO M 288:
      a. Survivability: Class 1.
      b. Apparent Opening Size: No. 40 sieve, maximum.
      c. Permittivity: 0.5 per second, minimum.
   5. Film Backing: Polymeric film bonded to drainage core surface.
3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Preparation
   1. Grade bottom of excavations to provide smooth, firm, stable, and rock free foundation throughout length of pipe.
   2. Remove unstable, soft, and unsuitable materials from surface upon which pipe is to lay.
      a. Backfill with clean sand or pea gravel.
   3. Shape bottom of excavation to fit design of pipe.
      a. Fill unevenness with tamped sand backfill.
   4. Remove large stones or other hard matter which could damage drainage pipe or impede consistent backfilling or compaction.

3.3 INSTALLATION

A. Comply with manufacturer’s instructions.

B. Install pipe beginning at low point of system, true to grades and alignment indicated, with maximum variation from true slope of 1/8 inch in 10 feet.
   1. Install PVC pipe in accordance with ASTM D2855 and ASTM F402.
   2. Cap upper ends of pipe.

C. Install filter fabric over subgrade in area to receive perforated pipe.
   1. Place 2 inch deep by not less than 12 inch wide bedding aggregate over filter fabric.

D. Install pipe over bedding aggregate with perforations facing down.
   1. Mechanically join pipe ends.

E. Install drainage panel over waterproofing in accordance with manufacturer’s instructions.
   1. Overlay drainage panel filter fabric in the direction of water flow at panel joints.
   3. Coordinate installation with Division 7.

F. Install filter aggregate at sides and top of pipe in 4 inch lifts.
   1. Do not displace or damage pipe when placing filter aggregate.
   2. Provide top cover of filter aggregate of not less than 24 inches of depth, and as indicated on Drawings.
   3. Level top of aggregate cover.

G. Wrap filter fabric over aggregate cover prior to backfilling.

H. Coordinate final backfilling and compaction operations with Sections 312000.
   1. Do not allow backfilling operations to commence without observation of completed system by Engineer.
   2. Do not allow drainage pipe to be displaced during backfilling and compaction operations.

I. Connect drainage pipe to storm drainage system using unperforated pipe or through installed sleeves.
3.4 FIELD QUALITY CONTROL

A. Provide in accordance with Division 1.

B. Inspections: Allow Engineer to observe installed system prior to installation of filter aggregate cover.

C. Tests: Upon completion of installation, test drainage pipe for free flow of water.

END OF SECTION
SECTION 336113 – CHILLED WATER PIPING AND VALVES

PART 1 - GENERAL

1.1 SCOPE
A. The scope of this document is to provide instruction for the installation and testing of chilled water piping installed for the University of Missouri - Columbia.

B. The Contractor shall furnish and install all chilled water service piping as shown on the Drawings and specified herein.

1.2 RELATED DOCUMENTS
A. Drawings and general provisions of Contract, including General and Special Conditions, apply to this Section.

B. Section 312000 Earth Moving.

1.3 SUBMITTALS
A. General: Submit the following in accordance with General & Special Conditions of Contract.

B. Product data:
   1. Pipe, valves and fittings
   2. Restraining devices
   3. Valve boxes

C. Maintenance data: valves

1.4 QUALITY ASSURANCE
A. Piping, valves and their installation shall conform to the standards referenced herein.

1.5 STORAGE AND HANDLING
A. Storage: Use the following precautions for valves during storage:
   1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
   2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.
   3. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 PIPE AND PIPE FITTINGS - GENERAL
A. PVC (Polyvinyl Chloride) Pipe (for open trench construction):
1. 4 Inches to 12 Inches: AWWA C900; Pressure Class 235 (DR 18); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.
2. 14 Inches to 36 Inches: AWWA C905; Pressure Rating 165 (DR 25); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.

**B. Ductile-Iron Pipe:**
1. 4 Inches to 36 Inches: AWWA C151; Mechanical Joint Pipe; 150 psi working pressure; Minimum Thickness Class 50; with integrally cast flanged bell, cast iron gland, and rubber gasket.
2. Lining: Standard cement lining with asphalt coating.
4. Fitting Restraint: a. Mechanical joint: AWWA C111. Provide retainer type packing glands with rubber gasket, for use with PVC pipe and conforming to Uni-B-13-92. Pipe sizes 4" to 12" must also be FM approved. b. Rods, nuts and washers: ¾" SS304 all thread rods, nuts and washers. c. Joint Retainers: Provide ductile iron clamp and rod type joint retainers for PVC bell and spigot joints. Clamps shall be designed for use with PVC pipe and shall meet Uni-B-13-92 Standards and be FM approved on sizes 4" to 12".
5. EBAA Series 1600 for pipe 4 inches to 12 inches, or approved equal.
6. EBAA Series 2800 for pipe 14 inches and larger, or approved equal.
7. Link Assembly: Seal annular space for piping passing through walls with interlocking synthetic rubber link assembly, Link-Seal by Thunderline Corporation or equal.

**2.2 VALVES - GENERAL**

**A. Valves**
1. Butterfly Valves: AWWA C504, Class 150B service, with cast iron body, cast iron disc with stainless steel seating edge, BUNA-N seal, 304 stainless steel valve shaft, self-lubricating valve bearings, fully grease packed actuator with stops in the open/close position. The actuator shall have a traveling nut which shall engage alignment grooves in the housing and shall have a built-in packing leak bypass to eliminate possible packing leakage into the actuator. Valve interior and exterior surfaces except for seating shall be coated with two coats of asphalt varnish. Valves shall have mechanical joint ends. Valves shall be Pratt Groundhog or approved equal.
2. Ball Valves: Threaded bronze, 125 lb., 2-piece design, full port. Valves shall be Nibco T-580 or approved equal.
3. Valve Boxes: Valve box shall be 6" PVC pipe, ASTM D3034, SDR 35, with cast iron cover. Clay and Bailey No. 2194 or approved equal. Lid shall be marked "WATER". Provide below grade concrete collar in planted areas.

**B. Chilled Water Vent Boxes**
1. Roadway, Parking Lots and Service Drives: Heavy duty, street rated cast iron with hot-dip galvanized finish. Removable cover shall be checkered steel with stainless steel cover screws. Removable cover shall be checkered steel with stainless steel cover screws. Junction box shall have an H-20 load rating and be suitable for installation in roadway. Minimum dimensions shall be 12" x 12" x 24" (L x W x D). Junction box shall be ER Series, as manufactured by Spring City Electrical Manufacturing Co., or approved equal.
2. Grass and Sidewalks: Vent box shall be 18" PVC pipe, ASTM F679, SDR 35, with cast iron water well cover. Clay and Bailey No. 2361 or approved equal. Lid shall be marked "WATER."
2.3 TRACE WIRE

A. Tracer wire shall be #14 AWG Solid, steel core soft drawn high strength tracer wire, 250# average tensile break load, 30 mil high molecular weight-high density blue polyethylene jacket complying with ASTM-D-1248, 30 volt rating. No THHN insulated wire shall be allowed. Tracer wire shall be Copperhead Industries HS- CCS or approved equal.

B. Tracer wire shall have moisture resistant splices for direct bury applications. Splices shall be Copperhead Industries Snakebite or 3M DBR or approved equal.

C. Tracer wire test stations shall be designed to be easily detected by magnetic and electronic locators. A magnet shall be securely attached at the top of the upper tube of the box for locating purposes. Lid shall be blue and have a brass terminal for attaching locating equipment and a brass 5 sided nut for removing cap. Tracer wire test station shall be Copperhead Industries Snake Pit or approved equal.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. Preparation of Trench
   1. Grade trench bottom to provide a smooth, firm, stable, and rock-free foundation throughout the length of the piping. All rock greater than one inch in diameter found in the trench shall be removed for a depth of six inches below the bottom of the pipe and replaced by suitable bedding material.
   2. Remove unstable, soft, and unsuitable materials at the surface upon which pipes are to be laid and backfill with crushed stone as indicated on the drawings.
   3. Provide layers of crushed stone in the bottom of trench as indicated on the drawings. Shape stone layer to fit bottom of piping. Dig bell holes at each pipe joint to relieve the bells of all loads and to ensure continuous bearing of the pipe barrel on the foundation.
   4. Finished pipe installation shall have minimum 12” separation to all other utilities.

B. Installation of Pipe and Pipe Fittings
   1. PVC (Polyvinyl Chloride) Pipe: Install in accordance with AWWA C605.
   2. All underground water / chilled water piping shall be PVC.
      a. EXCEPTION: Lines passing directly over steam tunnels or direct buried steam/condensate lines must be ductile iron with 2” R-5 extruded polystyrene insulation board between the pipe and steam lines.
   3. All joints shall be restrained with joint retainers. All fittings shall be restrained with retainer type packing glands.
   4. Install stainless steel rods between fittings on all offsets and between fittings, valves, and blind flanges, in addition to the Megalugs. On isolated fittings, valves, etc., attach restraint rings to PVC pipe and install stainless steel rods between fitting and restraint rings. Position rods through the bolt holes in fitting and Megalug. Requires four nuts and washers on each rod. Duct lugs are acceptable. The number of stainless steel rods required per fitting flange are as follows:

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<tr>
<th>PIPE DIAMETER</th>
<th>NO. OF RODS</th>
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<tr>
<td>to 10”</td>
<td>2</td>
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<td>12”</td>
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<td>36”</td>
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   5. Ductile iron pipe, fittings and valves shall be wrapped with a polyethylene cover conforming to AWWA C105. Install per AWWA C600.
6. Pipe shall be installed in clean condition, and shall never be laid in trenches with standing water. Contractor shall make provisions to keep the trench dewatered during installation of the water line. Protect open pipe ends with a hard cap or inflatable plug at the end of the work day. NO PLYWOOD OR DUCTTAPE COVERINGS WILL BE ALLOWED.

7. Trace wire shall be pulled with pipe, without splices.

8. Tape trace wire to the top of each water / chilled water line with duct tape every 5 feet. Contractor shall minimize wire splices. Terminate trace wires inside building and inside valve boxes. Drill ¼" hole in PVC valve box 1" below cast iron cover. Route wire up outside of valve box, through ¼" hole and knot. Trace wire shall be tested for continuity in presence of Owner's Representative, after pulling is completed.

9. Install continuous plastic underground warning tape during back-filling of trench for underground water / chilled water and compressed air piping. Locate 24 inches above pipe, directly over each water line.

C. Trenchless Piping Installation
1. It is the desire of system owners to assure that trenchless piping installation be completed in a timely, quality and accurate manner utilizing good, well-maintained equipment and trained competent personnel. Trenchless piping must be installed on a route as close to the drawings as possible to prevent interference with buried utilities and other obstructions, and to prevent future accidental excavation damage.

2. Trenchless piping installation shall only be allowed if previously approved by system owner.

3. Directional drilling and pipe installation shall be done only by an experienced operator specializing in directional drilling and whose key personnel have at least five (5) year experience in this work.

4. Pipe installed by the directional drilled method must be located in plan as shown on the Drawings, and must be no shallower than shown on the Drawings unless otherwise approved. The actual horizontal and vertical alignment of the pilot bore shall be plotted at intervals not exceeding twenty (20) feet. This "as built" plan and profile shall be updated as the pilot bore is advanced. Instrumentation shall be utilized at all times that will accurately locate the pilot hole and measure drilling fluid flow and pressure.

5. Pilot hole shall be drilled on bore path with no deviations greater than 5 feet left/right/depth over a length of 100 feet. In the event that pilot does deviate from bore path more than this amount, the Engineer shall be notified and Engineer may require the pilot drill to be pulled back and redrilled from the location along bore path before the deviation. The final exit point of pilot hole shall be within five (5) feet of the location shown on the drawings.

6. Trenchless piping installed using directional drilling equipment shall be installed in full compliance with restrained joint piping system manufacturer's instructions.

7. Field grooving tools, pulling heads, spline insertion tools, etc. shall be piping system manufacturer's standard.

8. Comply with piping system manufacturer's requirements on maximum pulling force, minimum bend radius, maximum deflection, etc. During pull-back operations, no more than the maximum safe pipe pull pressure shall be applied at any time. Maximum allowable tensile force imposed on the pull section shall be equal to, or less than 80% of the pipe manufacturer's safe pull (tensile) strength.

9. Provide pressure relief holes at close enough intervals to prevent buckling of pavement/sidewalks. If damage does occur, the pavement shall be repaired in accordance with pavement details provided.

10. Trace wire shall be pulled with pipe, without splices. Upon completion of installation, a continuity test on the wire shall be performed and all breaks shall be repaired.

3.2 VALVE INSTALLATION

A. Valve Storage: Use the following precautions for valves during storage:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.

2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

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

B. Valve Installation

CHILLED WATER PIPING AND VALVES
1. Chilled Water Service 6" and Larger: AWWA-Type Butterfly Valves: Comply with AWWA C600. Install buried valves with stem pointing up and with valve box.
2. Chilled Water Vents: Bronze Ball Valves.
3. Valve boxes shall be installed vertically with top of box even with final grade.

3.3 PIPE TESTING

A. Field Quality Control
   1. Piping Tests: Leak and pressure tests shall follow procedures outlined in AWWA M23. Conduct piping tests before joints are covered. Use only potable water.
   2. Simultaneous Tests: Conduct leak and pressure testing at the same time. All tests shall be conducted in the presence of the Owner’s Representative — or their designee. Test at not less than 100 psig for 1 hour.
   3. Test Report: Submit Test Reports to the system owner representative.

B. Cleaning
   1. Cleaning of all piping shall be performed as detailed in section 331300 Disinfecting of Water Utility Distribution. Chilled water distribution piping does not require disinfection.

3.4 VALVE TESTING

A. All valves shall be pressure tested in accordance with standards set forth in the Chilled Water Piping.

3.5 COMMISSIONING

A. System shall be placed in operation only after piping has been leak tested, flushed clean and approved by system owner representative.

END OF SECTION
SECTION 337119 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes the following:
   A. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs.
   B. Handholes and boxes.
   C. Manholes

1.3 DEFINITION
A. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS
A. Product Data: For the following:
   A. Duct-bank materials, including separators and miscellaneous components.
   B. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
   C. Accessories for handholes, boxes.
   D. Warning tape.
B. Shop Drawings for Handholes and Boxes: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
   A. Duct entry provisions, including locations and duct sizes.
   B. Cover design.
   C. Grounding details.
   D. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
C. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.
D. Qualification Data: For professional engineer and testing agency.
E. Source quality-control test reports.
F. Field quality-control test reports.
1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Comply with ANSI C2.

C. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 PROJECT CONDITIONS

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

   A. Notify Owner per requirements in the front end documents.
   B. Do not proceed with interruption of electrical service without Owner’s written permission.

B. Existing Utilities: Information regarding underground utilities and other possible obstructions shown on documents is based on existing drawings and site investigations. Field verify exact actual conditions prior to beginning work.

1.8 COORDINATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

PART 2 - PRODUCTS

2.1 CONDUIT

A. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

   A. Comply with NEMA RN 1.
   B. Coating Thickness: 0.040 inch, minimum.
2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

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

- ALLIED Corp.
- ARNCO Corp.
- Beck Manufacturing.
- Cantex, Inc.
- CertainTeed Corp.; Pipe & Plastics Group.
- Condux International, Inc.
- ElecSys, Inc.
- Electri-Flex Company.
- IPEX Inc.
- Lamson & Sessions; Carlon Electrical Products.
- Manhattan/CDT; a division of Cable Design Technologies.
- Spiraduct/AFC Cable Systems, Inc.
- Champion Fiberglass

B. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type DB-60-PVC, ASTM F 512, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.

C. Fittings shall be suitable for watertight installations.

D. All fiberglass elbows and bends shall be long sweep.

E. Duct Accessories:
   A. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum 3” vertical and horizontal duct spacings indicated while supporting ducts during concreting or backfilling.
   B. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification for Electrical Systems."
   C. Pull String: Minimum 1/8” polypropylene or nylon monofilament utility rope.

F. Conduit
   A. Underground concrete encased electric conduit duct banks shall consist of Type DB-60 polyvinyl chloride (PVC) conduit rated for 90° C cable and meeting NEMA Standard TC-6 and ASTM F-512 for underground applications or Type EPC-40-PVC meeting NEMA Standard TC 2.
   B. The standard conduit sizes shall be 2”, 3”, 4” and 5” for all conduits.
   C. Conduits shall have long fiberglass sweep elbows.
   D. All joints shall have watertight seals.
   E. Conduit End Bells
      1. Conduit end bells for PVC conduit shall be polyvinyl chloride (PVC).
      2. Conduit end bells for rigid galvanized steel conduit shall be hot-dipped galvanized malleable iron or steel, threaded to the end of the rigid galvanized steel conduit.

2.3 CONCRETE

A. Color Additive
   1. The concrete for all 13.8kV concrete encased conduit duct banks shall have a medium red color additive. The color additive shall have a minimum concentration per manufacturer’s recommendation per yard of concrete and shall be mixed throughout the entire duct bank concrete.

B. Admixtures
   1. Air-entraining mixture shall be used for all exterior concrete and shall conform to ASTM C260. The total calculated air content by volume as determined by ASTM C231 shall be as follows:
2. Water reducing admixture shall be used to reduce the total water requirements. Water reducing admixture shall meet the requirements of ASTM C494, Type A.

3. Calcium chloride or accelerating admixtures containing calcium chloride shall not be used.

C. Proportioning
1. Concrete slump at the time of placement as determined by ASTM C13 shall be 3" to 4". Tolerance up to 1" above maximum will be allowed providing average of batches tested does not exceed maximum.

2. The minimum 28 day concrete compressive strength for concrete shall be 4,000 psi (6 sacks/cu. Yd. minimum)

D. Reinforcement
1. All concrete encased electric conduit duct banks shall contain steel reinforcing throughout the entire length as indicated on Typical Duct Bank Detail drawing. The minimum size of reinforcing steel shall be size No. 4.

E. Backfill
1. Backfill material shall be compacted clean dirt or 3/4" minus waste rock fill. No concrete or large rocks are to be used.

2.4 ACCESSORIES

A. Pull String

A. The pull string installed in spare conduits shall have a minimum of 240 lbs. tensile and shall be rot and mildew resistant. Pull string shall have permanently printed sequential measurements at one foot increments.

B. Use plastic plugs with wick for drainage to seal spare conduits in manholes.

B. Underground Warning Tape

A. Tape:
1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:
1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Warning tape shall be high visibility and imprinted at frequent intervals with black letters.
3. Inscriptions for Red-Colored Tapes: "CAUTION BURIED ELECTRICAL LINE BELOW"
4. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Warning tape shall be multi-layer laminate consisting of a high density polyethylene scrim coated with printed pigmented polyolefin film, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service. Width to be minimum of 6" and 12 mils thickness.

D. Refer to Section 260553 Identification for electrical systems.

2.5 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.
A. Color: Gray.
B. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
C. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
D. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
E. Cover Legend: Molded lettering, "ELECTRIC." "TELEPHONE." As indicated for each service.
F. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
G. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
H. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Armorcast Products Company.
   2. Carson Industries LLC.
   3. Christy Concrete Products.
   5. QUAZITE – Hubbell.

2.6
2.7 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.
B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

A. Tests of materials shall be performed by an independent testing agency.
B. Strength tests of complete boxes and covers shall be by either an independent testing agency or the manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
C. 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 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank, unless otherwise indicated.

B. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: Underground plastic utilities duct, NEMA Type DB-60-PVC or Type EPC-40-PVC installed in concrete-encased duct bank, unless otherwise indicated.

3.2 ELECTRIC UNDERGROUND DUCTS

A. Conduit and Duct Banks
   1. Conduit shall be adequately and properly supported on solid earth, or other indicated means, throughout the entire length of the run. All conduits shall be laid straight and true.
   2. Verify routing locations of conduit prior to rough-in.
3. Couplings for conduits in a group shall be staggered at least six (6) inches.
4. Underground conduit duct banks shall be installed a minimum of 36" below finished grade to the top surface of the duct bank. (unless noted otherwise on specific runs per the drawings)
5. Underground conduit duct banks shall be at least 12 inches away from all other underground utilities; gas, water, electric, telephone, communications, etc. and at least 36 inches away from steam pipe lines and steam tunnels, trenches, or manholes.
6. Conduits shall be installed with a minimum slope of ½% toward manholes or other drainage points.
7. Intermediate and base spacers shall be used to obtain uniform separation and alignment during the installation of the concrete for concrete encased duct banks. Maximum intervals between spacers shall be 8 feet.
8. Concrete encased conduit duct bank penetrations into manholes shall continue completely through the wall of the manhole and shall use one large hole rather than several smaller holes. If this method is not practical, the concrete may stop outside the manhole but must be pinned to the manhole with steel pins to prevent any differential settlement.
9. Conduit end bells shall be installed at all conduit terminations in each manhole.
   a) Conduit end bells for PVC conduit shall be cast in place in the concrete wall of the manhole and glued to each end of each Type DB PVC conduit.
   b) Conduit end bells for rigid galvanized steel conduit shall be cast in place in the concrete wall of the manhole.

B. Concrete
1. All duct banks used for 13.8 Kv system shall be encased in red concrete.
2. Placing, Curing, and Backfill
   a) Precautions shall be used to prevent ducts from floating.
   b) Concrete shall be placed with the aid of a mechanical vibrator.
   c) Curing shall be continued for at least 7 days in the case of all concrete except high-early-strength concrete for which the period shall be at least 3 days. Excavations should not be backfilled until concrete has cured.
   d) In no cases shall ductbank sidewall thickness exceed 12" from side of the duct.
3. Reinforcement
   a) The reinforcing steel shall be installed longitudinally, at each corner of the duct bank (in cross section) and along the top and bottom and sides at a maximum of 12 inches on center. All reinforcing steel (including bottom) shall have a minimum concrete cover of 1-1/2 inches. Reinforcing shall be installed latitudinal, as needed to hold the longitudinal steel in place during the placement of the concrete but no more than 48” apart. Refer to Typical Duct Bank Detail drawing.

C. Accessories
1. All empty or “spare” conduits shall have a nylon or polypropylene pull string installed for future use. Leave not less than 2 feet of slack at each end of pull string.
2. Seal the ends of all conduits at manhole penetrations. Seal water tight with plastic plugs with wick for drainage. Conduit pull string shall penetrate through seal.

D. Underground Warning Tape
1. The location of all underground conduit duct banks shall be marked by burying one or more warning tapes below grade in the backfill. The warning tape shall be placed 18 inches above the top of the conduit(s) or duct bank and shall be parallel along the full length of the run. (Refer to drawings for specific locations where warning tape distance from top of conduit is reduced due to reduced depth)
2. If the widths of the conduits or duct bank is wider than 2 feet, two or more warning tapes shall be used, all in the same plane, spacing the tapes no more than 12 inches apart horizontally across the top width of the conduits or duct bank and equally spacing the tapes in from each longitudinal outer edge of the buried conduits or duct bank.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:
   A. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, structural load rating.
3.4 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 31 Sections.

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 32 Sections.

3.5 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch(12.7-mm) sieve to No. 4(4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch(25 mm) above finished grade.

D. Install handholes and boxes with bottom below the frost line, below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for ducts and 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.

G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

A. Concrete: 3000 psi(20 kPa), 28-day strength, complying with Division 03 Section "Cast-in-Place Concrete," with a troweled finish.

B. Dimensions: 10 inches wide by 12 inches deep(250 mm wide by 300 mm deep).

3.6 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
3.7 FIELD QUALITY CONTROL

A. Electric Underground Duct
   A. All duct banks shall be inspected by system owner prior to concrete placement.
   B. Upon completion of the installation of each ductbank, demonstrate that all conduits are clear of obstructions by pulling a mandrel ½ inch smaller than the nominal size of the conduit through the entire length of each conduit.

B. Commissioning
   A. Electric Underground Duct
      1. All soil and debris shall be removed from manholes and equipment pads where ductbanks terminate.
      2. Verify all pull strings and caps are installed.

3.8 TESTING

A. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

B. All duct banks shall be inspected by system owner prior to concrete placement.

C. Upon completion of the installation of each duct bank, demonstrate that all conduits are clear of obstructions by pulling a mandrel ½" smaller than the nominal size of the conduit through the entire length of each conduit.

3.9 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 337119
SECTION 337119.13 – ELECTRICAL AND TELECOM MANHOLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings 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. Manholes.

1.3 DEFINITION
A. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS
A. Product Data: For the following:
1. Accessories for manholes, and other utility structures.
B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
1. Duct entry provisions, including locations and duct sizes.
2. Reinforcement details.
3. Frame and cover design and manhole frame support rings.
4. Ladder details.
5. Grounding details.
6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
7. Joint details.
C. Product Certificates: For concrete and steel used in precast concrete manholes, as required by ASTM C 858.
D. Source quality-control test reports.
E. Field quality-control test reports.

1.5 QUALITY ASSURANCE
A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
B. Comply with ANSI C2.
C. Comply with NFPA 70.
1.6 DELIVERY, STORAGE, AND HANDLING

A. Store **precast concrete and other factory-fabricated** underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

B. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 PROJECT CONDITIONS

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

1. Notify **Owner** no fewer than **five** days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without **Owner's** written permission.

1.8 COORDINATION

A. Coordinate layout and installation of manholes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes, as approved by Architect.

1.9 EXTRA MATERIALS

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

B. Furnish cable-support stanchions, arms, **insulators**, and associated fasteners in quantities equal to **5** percent of quantity of each item installed.

PART 2 - PRODUCTS

2.1 PRECAST MANHOLES

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

1. Carder Concrete Products.
2. Christy Concrete Products.
3. Elmhurst-Chicago Stone Co.
5. Riverton Concrete Products; a division of Cretex Companies, Inc.
6. Utility Concrete Products, LLC.
8. Wausau Tile, Inc.

B. Comply with ASTM C 858, with **structural design loading as specified in Part 3 "Underground Enclosure Application" Article** and with interlocking mating sections, complete with accessories, hardware, and features.
1. **Windows:** Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
   a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
   b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
   c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.

2. **Duct Entrances in Manhole Walls:** Cast end-bell or duct-terminating fitting in wall for each entering duct.
   a. Type and size shall match fittings to duct or conduit to be terminated.
   b. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.

C. **Concrete Knockout Panels:** 1-1/2 to 2 inches thick, for future conduit entrance and sleeve for ground rod.

D. **Joint Sealant:** Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

### 2.2 CAST-IN-PLACE MANHOLES

**A. Description:** Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

**B. Materials:** Comply with ASTM C 858 and with Division 03 Section "Cast-in-Place Concrete."

1. Minimum 28 day concrete compressive strength for concrete shall be 4,000 psi.
2. Only ready mixed concrete shall be used. Ready mixed concrete shall be mixed and transported to the job site in accordance with ASTM C94 "Specifications for Ready Mixed Concrete."
4. **Admixtures**
   a. Air-entraining mixture shall be used for all exterior concrete and shall conform to ASTM C260. The total calculated air content by volume as determined by ASTM C321 shall be as follows:

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<thead>
<tr>
<th>Maximum Aggregate Size</th>
<th>Total Air Content % Includes Trapped Air</th>
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<tbody>
<tr>
<td>¾”</td>
<td>3-8</td>
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<tr>
<td>1”</td>
<td>4-6</td>
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   b. Water reducing admixture shall be used to reduce the total water requirements. Water reducing admixture shall meet the requirements of ASTM C494, Type A.
   c. Calcium chloride or accelerating admixtures containing calcium chloride shall not be used.

C. Minimum inside dimension for a manhole is 12’x6’ and 7’ high. Refer to manhole detail on drawings for specific sizes of each manhole.


1. Shall be designed per ACI 318-02 “Building Code Requirements for Structural Concrete.”
2. Design loads shall consist of dead load, live load, impact, surcharge load, and any other loads which may be imposed upon the structure.
2.3 UTILITY STRUCTURE ACCESSORIES

A. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 36 inches.
   a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   b. Cover by NEEHAH
      1) Electric Manhole Covers to be NEEHAH R-1640-D.
      2) Telecom Manhole Covers to be NEEHAH R-1750.
   c. Located in the middle of manhole ceiling with the sump pit located directly underneath (Refer to manhole detail on drawings)
   d. Lid to have a checkered design with the LEGEND as noted below.
   e. Manhole frame shall provide a 36” diameter opening. The opening through the concrete roof of each manhole shall be 40.5” in diameter.
   f. Manhole frames and covers shall be Neenah Foundry Company Catalog No. R-1640-D, or pre-approved equal. The cover shall have two (2) pick poles 1” diameter located 180 degree apart.
   g. Vent cover and frame shall be 8-1/2” clear opening, case iron, heavy duty.

2. Cover Legend: Cast in. Selected to suit system.
   a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
   b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
   c. Legend: "SIGNAL" for communications, data, and telephone duct systems.

3. Vent Cover: Vent cover and frame shall be 8-1/2” clear opening, cast iron, heavy duty, Neenah R-5901-A with open grate lid.

B. Manhole Sump:
   1. Provide a concrete sump in the center of the floor for the collection of any water which might enter the manhole.
   2. Sump shall have concrete bottom and shall be 18 inches as shown in manhole detail drawing.
   3. The manhole floor shall slope towards the sump with a minimum slope of 1/8 inch per foot.

C. Lifting Irons in Concrete Floors: 7/8-inch- diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
   1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

D. Pulling-In Irons in walls: 7/8-inch- diameter, hot-dip galvanized, bent steel rod; stress relieved after forming, and fastened to reinforcing rod. Exposed triangular opening.
   1. Ultimate Yield Strength: 20,000-lbf Tensile Rating.
   2. 12” long by 10-7/8” Wide
   3. Cable pulling-in irons shall be: 
      a. Cooper Power Systems Catalog No. DUITI
      b. Joslyn Manufacturing and Supply Company Catalog No. J8120
      c. Hubbell/Chance Catalog No. 8120
      d. Pre-approved equal.

E. Conduit End Bells
   1. Conduit end bells for PVC conduit shall be polyvinyl chloride (PVC) type glued to the end of each PVC conduit. Conduit end bells shall be Carlon Electrical Products Catalog. No. E297_-, or approved equal by: 
      b. Certainteed Products Corp.
c. Can-Tex Industries.

2. Conduit end bells for rigid galvanized steel conduit shall be hot-dipped galvanized malleable iron or steel, threaded to the end of the rigid galvanized steel conduit and cast in place in the concrete wall of the manhole and shall be O-Z/Gedney Company Type TNS or approved equal by:
   a. Appleton Electric
   b. Crouse-Hinds.

F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

G. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

H. Cable Rack Assembly: Nonmetallic. Heavy duty type with components fabricated from nonconductive, 50% glass-reinforced nylon or fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inches high by 4 inches wide, with minimum of 9 holes for arm attachment.
   a. Stanchions shall be Model CR_-B as manufactured by Underground Devices, Inc. or approved equal.

I. Cable Support Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall heavy duty type fabricated from 50% glass-reinforced nylon or a non-metallic material having equal mechanical strength, thermal resistance, chemical resistance, dielectric strength and physical properties. Cable support arms shall be 14 inches in length, with 5 slots for cable wire ties.

1. Provide a positive locking clip for each and every cable support arm supplied to prevent disengagement of the cable support arm from the cable rack due to upward force in the support arm.
2. Cable support arms shall be Model RA14 with Model HDL lock as manufactured by Underground Devices, Inc. or approved equal.

J. Cable Support Insulators:

1. Cable support insulators shall be fabricated from high-grade electrical porcelain and shall have rounded corners and edges to prevent cable sheath damage.
2. Cable support insulators shall be Model DE11U1 as manufactured by Cooper Power Systems or approved equal.

K. Cable Ties:

1. Cable ties shall be weather resistant self-locking high strength UV-resistant black nylon, having a minimum length of 15 inches and a minimum loop tensile strength of 120lbs, meeting Military Specifications MS 3367-3-0. Cable ties shall be:
   a. Ty-Rap Catalog No. TY5275MX
   b. 3M Catalog No. 06277
   c. W.H. Brady Company Series CTUN-400HBK
   d. Or approved equal.

L. Grounding: Grounding rods shall be 3/4" diameter, 10 feet long, high strength solid steel rod with a bonded copper jacket, and UL listed. Grounding rods shall be manufactured by:

1. Copperweld Steel Company
2. ITT Weaver
3. Thomas & Betts
4. Blackburn
5. Joslyn Mfg and Supply Co
6. Or approved equal.
M. Waterproofing: All electrical manholes shall be waterproofed according to the Electric Manhole Waterproofing Spec.

N. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

O. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin.

P. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two required.

2.4 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

PART 3 - EXECUTION

3.1 UNDERGROUND ENCLOSURE APPLICATION

A. Manholes: Precast or cast-in-place concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.

2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 load rating according to AASHTO HB 17.

3.2 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Concrete work excavations shall not be backfilled until the concrete has cured, or a minimum of seven (7) days after concrete placement.

C. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Sections "Turf and Grasses" and "Plants."

E. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting and Patching."

3.3 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations, unless otherwise indicated.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Duct Entrances to Manholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.
   1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
   2. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

F. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.

3.4 INSTALLATION OF CONCRETE MANHOLES

A. Cast-in-Place Manhole Installation:
   1. All concrete work for manholes shall be formed, using proper concrete forms.
   2. Finish interior surfaces with a smooth-troweled finish.
   3. Manhole floors shall have a non-slip broom finish.
   4. Windows for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches thick, arranged as indicated.
   5. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03 Section "Cast-in-Place Concrete."

B. Precast Concrete Manhole Installation:
   1. Comply with ASTM C 891, unless otherwise indicated.
   2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
   3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:
   1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
   2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. Manhole Access: Circular opening in manhole roof; sized to match cover size.

F. Waterproofing: Apply waterproofing to all exterior surfaces of manholes after concrete has cured at least three days. Waterproofing materials and installation are specified in “Electric Manhole Waterproofing” Specification. After ducts have been connected and grouted, and before backfilling, waterproof joints and
connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

1. Follow all manufacturer’s requirements for the installation of waterproofing. Ensure that the waterproofing properly adheres to the concrete and ensure that all areas receive the required waterproofing prior to backfill.

2. Cleaning and Protection: Remove any masking materials after installation. Clean any stains on materials which would be exposed in the completed work.

G. Furnish and install all required appurtenances for each manhole, such as cast iron cable pulling-in irons, cast iron frame and cover, conduit end bells, cable racks, grounding rods, etc. Set them into position in forms before pouring concrete.

H. Cable rack stanchions shall be installed on each wall of every manhole. Maximum spacing of stanchions shall be 3'-0” on center. Stanchions shall be bolted to manhole walls using stainless steel expansion anchors in accordance with the cable rack manufacturer’s recommendations.

I. Provide a minimum of three (3) cable support arms for every stanchion supplied.

J. Cable Support Insulators: Each insulation with cables shall be tied to the cable support arm when installing the cables by wrapping two cables ties, in opposite directions, completely around the cables, the insulator, and the cable support arm. Cable ties shall be long enough to accomplish this.

K. Pulling-in Irons: Furnish and install the pulling-irons opposite each duct-bank entry.

L. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

M. Field-Installed Bolting Anchors in Manholes: Do not drill deeper than 3-7/8 inches (98 mm) for manholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

N. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

3.5 GROUNDING

A. Manholes shall have two grounding rods in each electric manhole. Ground rods shall be driven into the soil beneath the manhole and cast in place with the installation of the concrete floor of the manhole. Ground rods shall be located in diagonally opposite corners of the manhole. Located 5 inches out from each wall and projecting 6 inches above the finished floor level.

B. Manholes shall have a size 4/0 bare stranded copper conductor around the inside perimeter of each electric manhole. The conductor shall be fastened to the manhole concrete wall every 4 linear feet at a height of 6 inches above the finished floor using two-hole copper tubing straps.

C. The copper grounding conductor shall be connected to each grounding rod by means of exothermic welding.

3.6 FIELD QUALITY CONTROL

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

1. Demonstrate capability and compliance with requirements on completion of installation of utility structures.

2. Test manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.7 COMMISSIONING

A. Clean internal surfaces of manholes, including sump. Remove foreign material.

B. Verify all pull strings and caps are installed.

END OF SECTION 337119.13
SECTION 337119.15 – ELECTRICAL MANHOLE WATERPROOFING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings 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. Instruction for the installation of waterproofing of electric manholes

1.3 GENERAL

A. Outside surfaced of all subgrade floors, walls, riser, and top of new electric manholes shall be waterproofed.

1.4 SUBMITTALS

A. Product Data: For the following:
   1. Waterproofing materials

PART 2 - PRODUCTS

2.1 MATERIALS

A. Concrete Repair Materials:
   1. As recommended by waterproofing Manufacturer.

B. Water Stops
   1. Waterstops for use in manholes and at manhole penetrations shall be 6", PVC, serrated with center bulb. Waterstop to be Style 703 as manufactured by Greenstreak, St. Louis MO or approved equal.
   2. Waterstops for locations where the ductbank abuts structures shall be a Split Flange - 6", PVC serrated with center bulb for new to new installations. Waterstop to be Style 723 as manufactured by Greenstreak, St. Louis MO or approved equal. For new to existing installations waterstop shall be a Style 609 as manufactured by Greenstreak, St. Louis MO or approved equal.
   3. Waterstops for construction joints shall be 6", PVC, serrated. Waterstop to be Style 782 as manufactured by Greenstreak, St. Louis MO or approved equal.
   4. Waterstops for the precast lid to wall connection shall be Butyl-Rubber sealant. Waterstop to be Conseal CS-102 or approved equal.

C. Pre Applied sheet Waterproofing
   1. Provide Preprufe 300R membrane by Grace Construction Products or approved equal. Pre-applied integrally bonded sheet waterproofing membrane: 1.2 mm nominal thickness composite sheet membrane comprising .8 mm of high density polyethylene film, and layers of specially formulated synthetic adhesive layers. The membrane shall form an integral and permanent bond to poured concrete to prevent water migration at the interface of the membrane and structural concrete. Tape
and other accessories specified or acceptable to manufacturer of pre-applied waterproofing membrane.

D. Self-Adhesive Waterproofing Membrane
1. Self-adhesive waterproofing membrane for use to transition from pre-applied sheet waterproofing to hot applied rubberized asphalt waterproofing. Provide sheet applied, self-adhered waterproofing membrane Blueskin WP200 by Henry Company or approved equal. Self-adhesive waterproofing membrane shall have the following physical properties:
   a. Thickness: 1.5 mm (60 mils) min.
   b. Flexibility: Pass @ -40 degrees C to ASTM D1970
   c. Vapor permeance: 2.8 ng/Pa.s.m² (.05 perms) to ASTM E96,
   d. Tensile strength (membrane): 2.24 MPa to ASTM D412,
   e. Tensile strength (film): 34.5 MPa to ASTM D882,
   f. Elongation: 300% to ASTM D412,
   g. Puncture resistance: 222 N min. to ASTM E154.

E. Hot Applied Rubberized Asphalt Waterproofing
1. Components and membrane materials must be obtained as a single source from the membrane manufacturer to ensure total system compatibility and integrity. Provide Henry Company 790-11 SBS modified hot applied rubberized asphalt or approved equal. Rubberized asphalt waterproofing shall have the following qualities:
   a. Solids Content: 100%;
   b. Low Temperature Flexibility and Adhesion: No cracking, delamination or loss of adhesion @ 13 degrees F in accordance with CGSB 37-GP-50-M89;
   c. Flow (1/8 inch film on 75% angle for 5 hours @ 140 degrees F): No flow in accordance with ASTM D1191;
   d. Cone Penetration: More than 10 @ 32 degrees F, less than 110 @ 77 degrees F, less than 200 @ 122 degrees F in accordance with ASTM D1191;
   e. Water Absorption: Gain of 0.09g in accordance with CGSB 37-GP-50-M89;
   f. Flash Point (Open Cup): 545 degrees F in accordance with ASTM D92;
   g. Water Vapor Permeance (3mm Film): 0.01 perms in accordance with ASTM E96 Procedure A and 0.02 perms in accordance with ASTM E96 Procedure E.
   h. Ratio of Toughness to Peak Load: 0.04 min. in accordance with CGSB 37-GP-50-M89.
   i. Toughness: 9.2J in accordance with CGSB 37-GP-50-M89.
   j. Crack Bridging Capability: No cracking, splitting or loss of adhesion in accordance with CGSB 37-GP-50-M89.
   k. Heat Stability (5 hours @ 390 degrees F): Meets flow, penetration and low temperature flexibility in accordance with CGSB 37-GP-50-M89.

F. Hot Rubberized Asphalt Primer
1. Solvent based, synthetic rubber adhesive for hot applied rubberized asphalt membranes. Henry HE93018 polymer modified adhesive or approved equal.

G. Self adhered waterproofing primer
1. Polymer emulsion based primer for self-adhesive membranes. Henry Aquatac primer or approved equal. Self-adhesive waterproofing primer shall have the following physical properties:
   a. Color: Aqua
   b. Solids by Volume: 53%
   c. Weight: 8.3 lbs/gal
   d. Application Temperature: 25F to 104F
   e. Maximum VOC: 100 g/L
   f. Service temperature -40F to 150F

H. Neoprene Flashing
1. Neoprene flashing sheets is used with 790-11 hot rubberized asphalt membrane at expansion joints and exposed flashing details. Neoprene flashing shall be Henry HE850AA or approved equal and shall have the following physical properties:
   a. Brittleness Point: -40F
   b. Color: Black
c. Elongation (Initial) ASTM D412 – 300%
d. Tear Resistance (ASTM D624 Die C) 125 lbs/in min
e. Tensile strength, membrane: (ASTM D412 Die C) 1800 psi min
f. Thickness: 60 mils


J. Termination Sealant: Joint sealant shall be Henry HE925 BES moisture cure sealant for construction joints.

K. Termination Bars: Termination bars shall be continuous stainless steel, 1/8” x 1” in size and shall be pre-drilled for non-corrosive screw attachment on a maximum of 8” centers.

L. Drainage Pipe: 6”, schedule 80, perforated PVC piping with filter sock.

M. Protection sheet: Provide Henrgy G100S/S Protection sheet or approved equal for top of electric manholes.

N. Drainage Board: Provide Henry DB520 drainage board or approved equal. Drainage board shall have the following properties:
   1. Thickness: 7/16” thick
   2. Compressive strength: 15,000 lb/sq.ft.

O. Cold Applied Waterproofing (used with Owner permission, only in certain circumstances)
   1. Cold applied waterproofing to be used with Owner permission only in certain circumstances such as space constraints and time delays not allowing hot applied product on “green” concrete. Cold applied waterproofing shall be Henry CM100 or engineer approved equal and shall have the following physical properties:
      a. Conforms to ASTM C 836
      b. Solvent content: 0%
      c. Non Flammable, Flash point > 450 F,
      d. Elongation: >500%
      e. V.O.C. < 40 grams / Liter
      f. Can be applied to “green” concrete.

P. Flashing and Crack Treatment Membrane (for cold applied applications)
   1. Flashing and crack treatment membrane shall be 990-25 Elastomeric flashing sheet as supplied by Henry, a butyl/EPDM type, elastomeric membrane having a thickness of 47 mils.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Delivery, Storage, And Handling
   1. Deliver materials and products in labeled packages. Store and handle in strict compliance with manufacturer's instructions, recommendations and material safety data sheets. Protect from damage from sunlight, weather, excessive temperatures and construction operations. Remove damaged material from the site and dispose of in accordance with applicable regulations.
   2. Protect primer, mastic and adhesive from moisture and potential sources of ignition.
   3. Store protection board flat and off the ground. Provide cover on top and all sides.
   4. Sequence deliveries to avoid delays and minimize on-site storage.
B. Typical waterproofing installation includes concrete repairs, joint caulking, waterstops, preapplied sheet waterproofing, hot applied waterproofing and protection board. Refer to manufacturer’s literature for instructions on installation.

C. Primer - Apply primer as recommended by manufacturer and allow to dry prior to the application of the primary waterproofing membrane or membrane flashings.

D. Joint and Crack Treatment
   1. Joint sealers are required to establish and maintain airtight and waterproof continuous seals on a permanent basis, within recognized limitations of wear and aging.
   2. Joint Preparation
      a. Clean joint surfaces immediately before installation of sealants. Remove dirt, insecure coatings, moisture, oil, form release agents and other substances which could interfere with seal of sealant.
   3. Joint Size
      a. In general, depth shall not exceed one-half of the width or be less than 1/4”.
      b. For joints in concrete depth can be equal to the width in joints up to 1/2” wide. Joints 1/2” to 1” wide shall have a depth of 1/2”.
      c. When joint depth exceeds the above ratios, fill with back-up material to provide the proper depth when measured from the joint face.
   4. Application
      a. Employ only proven installation techniques, which will ensure that sealants are deposited in uniform, continuous ribbons without gaps or air pockets, with complete “wetting” of joint bond surfaces equally on opposite sides. Except as otherwise indicated, fill sealant rabbets to a slightly concave surface, slightly below adjoining surfaces. Where horizontal joints are between a horizontal surface and vertical surface, fill joint to form a slight cove, so that joint will not trap moisture and dirt.
      b. Install back-up material or joint filler to provide sealant depth required for a proper joint. Back-up material shall be of suitable size and shape so that it will fit into joint when compressed 25% to 50%. Sealants shall not be applied without back-up material and, if necessary, bond breaker strip. When installing back-up rod stock, roll the material into the joint to avoid stretching twisting or braiding.
      c. Do not seal during damp or inclement weather, or when the ambient or surface temperature is below 40°F or higher than temperatures as recommended by sealant manufacturer.
      d. Do not allow sealants to overflow from confines of joints, or to spill onto adjoining work, or to migrate into voids of exposed finishes. Clean adjoining surfaces by whatever means may be necessary to eliminate evidence of spillage.
   5. Fill cracks with joint sealant per waterproofing material construction standards.
   6. Seal cracks and joints 1/16 inch to 1/8 inch in width with a 12 inch wide, 1/8 inch thick coat of hot rubberized asphalt membrane and a 6 inch wide strip of fabric reinforcement, centered over joint.
   7. Seal cracks and joints 1/8 inch to ½ inch in width with a 12 inch wide, 1/8 inch thick coat of hot rubberized asphalt membrane and a 6 inch wide strip of neoprene flashing centered over joint.

E. Application of Hot Rubberized Asphalt Membrane
   1. Ensure concrete is ready to receive hot applied rubberized asphalt membrane.
   2. Apply membrane smooth, free from air pockets, wrinkles or tears and to manufacturer’s instructions. Ensure full bond of membrane to substrate.
   3. Apply first layer of hot rubberized asphalt membrane evenly to a minimum thickness of 90 mils to form a continuous monolithic coating over horizontal and vertical surfaces including previously reinforced areas.
   4. Apply fabric reinforcing sheet and firmly press into first layer of hot membrane. Overlap fabric approximately ¼ inch ensuring that a layer of membrane is present between overlaps. Apply second layer of membrane over the fabric to a minimum thickness of 1/8 inches providing a total thickness of 215 mils.

F. Installation of Protection Course/Separation Sheet
   1. Protection shall be rolled onto hot applied rubberized asphalt membrane while still warm and tacky.
   2. Lap protection course 2 inches on side laps and 6 inches on end laps.
   3. Starting at the low points or drains lay the protection course membrane in full continuous sheets in a shingle pattern. Stager all end laps.
G. Cast-in-place Concrete Substrates
1. Do not proceed with installation until concrete has properly cured and dried. If recommended by the manufacturer, special primers may be used to allow priming and installation of hot applied waterproofing sooner than 7 days. Priming may begin as soon as the concrete will maintain structural integrity.
2. Fill form tie rod holes with concrete and finish flush with surrounding surface.
3. Repair bigholes over 13 mm (0.5 in.) in length and 6 mm (0.25 in.) deep and finish flush with surrounding surface.
4. Remove scaling to sound, unaffected concrete and repair exposed area.
5. Grind irregular construction joint to suitable flush surface.
6. Treat joints and install flashing as recommended by waterproofing manufacturer.

H. Waterstops for manhole penetrations
1. Waterstops shall be installed in strict accordance with manufacturer's recommendations with particular care being given to properly setting in adhesive and maintaining the required 2" minimum concrete coverage.

3.2 CLEANING AND PROTECTION
A. Remove any masking materials after installation. Clean any stains on materials which would be exposed in the completed work.
B. Protect completed membrane waterproofing from subsequent construction activities as recommended by manufacturer.
C. Butt joint between precast lids shall be sealed immediately after placing lids in order to minimize water infiltration prior to applying waterproofing. Seal with horizontal joint sealant as specified.

3.3 QUALITY ASSURANCE
A. Installer shall be firm which has at least 3 years of experience in work of the type required by these Construction Standards.
B. For each type of material required for the work of this section, provide primary materials which are the products of one manufacturer to the extent possible.
C. Constructor shall show notify owner when waterproofing has been installed and is ready for inspection prior to covering up. Obtain approval from owner prior to covering.

3.4 PROJECT CONDITIONS
A. Perform work only when existing and forecasted weather conditions are within the limits established by the manufacturer of the materials and products used.
B. Proceed with installation only when substrate construction and preparation work is complete and in condition to receive sheet membrane waterproofing.

3.5 EXECUTION
A. Refer to manufacturer's literature for requirements for preparation of substrates. Surfaces shall be structurally sound and free of voids, spalled area, loose aggregate and sharp protrusions. Remove contaminates such as grease, oil and wax from exposed surfaces. Remove dust, dirt, loose stone and debris. Use repair materials and methods which are acceptable to membrane manufacturer.
3.6 WARRANTY

A. Provide written five (5) year material warranty for sheet membrane waterproofing issued by the membrane manufacturer upon completion of the work.

END OF SECTION 337119.15
SECTION 337149 - MEDIUM-VOLTAGE 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 cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

1.3 DEFINITIONS


1.4 SUBMITTALS

A. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.

B. Qualification Data: For Installer.

C. Material Certificates: For each cable and accessory type, signed by manufacturers.

D. Source quality-control test reports.

E. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.
   1. Installer shall have a minimum 3 years experience splicing MV cable. Provide documentation demonstrating experience with shop drawing submittal.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency’s Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.
D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with IEEE C2 and NFPA 70.

1.6 PROJECT CONDITIONS

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

1. Notify Owner per requirements in the front end documents.
2. Do not proceed with interruption of electric service without Owner’s written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following: (No substitutions are allowed)

1. Cables:
   a. Kerite Co. (The); Hubbell Incorporated.
   b. Okonite Company (The).

2. Cable Splicing and Terminating Products and Accessories:
   a. 3M; Electrical Products Division.

2.2 CABLES

A. Cable Type: 15kV Cable

B. Strand Screen: Extruded semiconducting EPR. Must meet or exceed electrical and physical requirements of ICEA S-93-639, NEMA WC74 S-97-682, AIEC CS8 and UL 1072.

C. Conductor: Annealed, uncoated copper compact stranded ASTM B-496.

D. Insulation: 15kV insulated with 100% Ethylene Propylene Rubber (EPR) for 133 percent insulation level, 220 mils average thickness (198 mils minimum). The insulation shall not contain any polyethylene.

E. Insulation Screen: Extruded semiconducting EPR. Must meet or exceed electrical and physical requirements of ICEA S-93-639/NEMA WC74 & S-97-682, AIEC CS8 and UL 1072. The screen shall not contain any polyethylene.

F. Shield: Shield shall be overlapped 5 mil bare copper tape, helically applied.

G. Jacket: Jacket thickness shall not be less than 80 mils of black polyvinyl chloride.

H. Temperature Ratings
1. Wet or dry normal rating – 105 deg C
2. Emergency rating – 140 deg C
3. Short circuit rating – 250 deg C
1. Standard sizes used on University of Missouri campus; System owner must approve the conductor sizes prior to installation.
   1. #2
   2. #4/0
   3. 350kcmil
   4. 500kcmil

J. The cable must be flat line corona tested with less than 5 picocoulombs by manufacturer. Cable shall meet the requirements of AEIC CS6, ICEA S 68-516 and UL 1072.

2.3 SPLICE KITS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
   1. Premolded, cold-shrink-rubber, in-line splicing kit type QS-III as manufactured by 3M.

2.4 TERMINATIONS

A. Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.

B. Terminations shall be outdoor type cold shrink silicone rubber skirted termination kit as manufactured by 3M.

2.5 FIRE TAPE

A. Fire Tape shall be 3” wide Scotch 77 Fire-Retardant Electric Arc Proofing Tape manufactured by 3M.

2.6 ARC-PROOFING MATERIALS

A. Arc-Proofing Tape: Fireproof tape, shall be 3” wide Scotch® 77 Fire-Retardant Electric Arc Proofing Tape manufactured by 3M.

2.7 FAULT INDICATORS (FOR REFERENCE ONLY)

A. Indicators will be provided and installed by owner.

B. Indicators: Automatically reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

C. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.8 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.
3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Pull Conductors: Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values.
   1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
   2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

D. Support cables according to Division 26 Section "Common Work Results for Electrical."

E. All cables shall be installed in concrete encased duct banks, manholes or cable trays.

F. Install "buried-cable" warning tape 18 inches above duct bank.

G. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.

H. Install cable splices at pull points and elsewhere as indicated; use specified kits.

I. Install terminations at ends of conductors and seal with standard kits.
   1. Care shall be taken not to damage the cable during installation. The cable ends shall be kept sealed when not being worked on to prevent water entry. System Owner shall be notified of any damage to evaluate repair or replacement requirements.
   2. Terminations and splices shall only be performed by personnel trained and experienced in the installation of this type of material. Each termination or splice shall be inspected by System Owner personnel prior to the installation of the outer covering.

J. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
   1. Fire tape all exposed cable in manholes using a minimum overlap of 50%. Fire tape into duct where practical.
   2. Clean cable sheath.
   3. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
   4. Smooth surface contours with electrical insulation putty.
   5. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
   6. Band arc-proofing tape with 1-inch- (25-mm-) wide bands of half-lapped, adhesive, glass-cloth tape 2 inches (50 mm) o.c.

K. Seal around cables passing through fire-rated elements according to Division 07 Section "Penetration Firestopping."

L. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
   1. Ground cables shall installed in each section.
      a. A #2 stranded, 600V cable shall be used when a #2 or #4/0 primary cable is being installed.
      b. A #4/0 stranded, 600V cable shall be used when a 350 kcmil primary cable is being installed.
2. Ground all terminations and splices in manholes or at equipment.

M. Identify cables according to Division 26 Section "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

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

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
3. Cable testing:
   a. The cable shall have DC High Potential Test after it has been pulled into the duct and the splice or termination has been prepared but before the shrink tubing has been installed.
   b. Cable shall have 60kV DC applied for 15 minutes with data taken at 1 minute intervals.
   c. Written report shall be delivered to system owner including all data and results or conclusions.
   d. Cable is to be grounded for 30 minutes after test.
4. Insulation ground testing:
   a. Insulation ground wall test (Meggar) at 5kV DC is to be performed after all splices and terminations have been completed.
   b. Written report of test results with resistance values shall be delivered to System Owner.

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

3.3 COMMISSIONING

A. All in service switchgear shall be operated by System Owner personnel only.

B. All splices, terminations, testing, grounding, and fire taping shall be completed prior to System Owner personnel energizing cable.

END OF SECTION 260513
SECTION 337173 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes instruction for the installation and testing of revenue class electric energy meters installed on the University of Missouri-Columbia Campus.

1.3 SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Describe electrical characteristics, features, and operating sequences, both automatic and manual. Include the following:
   1. Electricity-metering equipment.

B. Shop Drawings: For electricity-metering equipment.
   1. Dimensioned plans and sections or elevation layouts.
   2. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.
   3. Mounting and anchoring devices recommended by manufacturer to resist seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Manufacturer Seismic Qualification Certification for Electricity-Metering Equipment: Submit certification that equipment components and their mounting and anchorage provisions have been designed to remain in place without separation of any parts or loosening of factory-made connections when subjected to the seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

   Include the following:
   1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculations.
   2. Detailed description of equipment mounting and anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control reports.

E. Operation and Maintenance Data: For electricity-metering equipment to include in emergency, operation, and maintenance manuals.

F. Owner (Energy Management Department) shall review shop drawing submittals and provide final approval.

1.4 QUALITY ASSURANCE

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

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to other facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Owner per requirements in the front end documents.
   2. Do not proceed with interruption of electrical service without Owner's written permission.

PART 2 - PRODUCTS

2.1 EQUIPMENT FOR ELECTRICITY METERING FURNISHED BY OWNER

A. Manufacturers:
   1. Landis & Gyr AXS4e Solid-State Meter
      a. 4-Wire Wye Application.
         1) Form 9S.

2.2 EQUIPMENT FOR ELECTRICITY METERING PROVIDED BY CONTRACTOR

A. Current Transformers
   2. Current transformers (CT’S) shall be of a design for indoor use suitable for electricity metering grade. The current transformer body construction shall be of molded insulation. The preferred outside body shape or configuration shall be Grecian Urn style. The CT’s shall be window-type with voltage application range of 1.2 to 15kV.
   3. The combination of ratio and rating factor (RF) of selected CT's shall be chosen to pick up a small load. At service full load, meter current must not exceed 20 amperes or the CT's maximum rating whichever is smaller. Service full load shall be determined from the smaller of either the transformer secondary full load amps or the main service protective device. CT ratio and RF rating shall be coordinated with the Energy Management Electric Distribution.

<table>
<thead>
<tr>
<th>Service Full Load(s)</th>
<th>CT Ratio (CTR)</th>
<th>Minimum Rating Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200A≤S≤1600A</td>
<td>800:5</td>
<td>2 @ 55° C Ambient</td>
</tr>
<tr>
<td>1600A≤S≤1800A</td>
<td>1200:5</td>
<td>1.5 @ 55° C Ambient</td>
</tr>
<tr>
<td>1800A≤S≤2250A</td>
<td>1500:5</td>
<td>1.5 @ 55° C Ambient</td>
</tr>
<tr>
<td>2250A≤S≤3000A</td>
<td>3000:5</td>
<td>1 @ 55° C Ambient</td>
</tr>
</tbody>
</table>

4. Other CT specifications shall be as follows:
   a. ANSI Accuracy Class, 60 Hz
   b. B0.2 Burdens per ANSI
   c. Polarity permanently molded primary H1/H2 and secondary X1/X2
   d. Stainless steel Name Plate shall carry all information prescribed by the ANSI standard and installed at easy to read location.

B. Wiring
   1. All secondary current circuit wiring shall be of pvc insulated, flexible, multi-stranded and colored (red, yellow, blue, white) wire with appropriate gauge as shown in the table, in section 3.1 below.
   2. All potential wiring shall be #12 AWG pvc insulation, solid and colored (red, yellow, blue, white) wires.

C. Meter Base (Socket)
   1. The Meter Sockets shall conform to ANSI Standard C12.7-1993. The meter base shall have CT’s short-circuiting arrangement and disconnect switches for potential circuits.
      a. Meter socket to be Milbank #UC7237-XL or equal.

D. Fuse Blocks
   1. Cooper Industries, Bussman Fuse Block #BM6033B, 30A, 600V
E. Fuse
1. Cooper/Bussmann KTK-2, 15A.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. The installation of energy meter shall be according to NEC, ANSI, and IEEE C12 Electricity Metering standards, where applicable.

C. The Contractor shall supply and install current transformers, fuse block and fuses, meter socket, meter, conduits, prescribed wires and other material and gadgets required to complete the job.

D. Meter Wiring
   1. The maximum distance in feet between CT and meter shall meet ANSI accuracy classification at B0.2 accuracy class.
   
<table>
<thead>
<tr>
<th>AWG Copper Wire Size</th>
<th>No. 12 Multi-stranded</th>
<th>No. 10 Multi-stranded</th>
<th>No. 8 Multi-stranded</th>
<th>No. 6 Multi-stranded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Distance (in feet)</td>
<td>31</td>
<td>49</td>
<td>79</td>
<td>126</td>
</tr>
</tbody>
</table>

   2. Energy Management Electric Distribution Crew shall terminate all wires at the current transformers, fuse block, and the meter.

E. Meter Location
   1. The location of the meter shall be coordinated with the system owner. Consideration shall be given to the monthly meter read in determining the accessibility of the location.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

   1. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.

3.3 FIELD QUALITY CONTROL

A. Warranty and Other Requirements
   1. After the new installation is energized for the first time, the system owner shall perform an "in service" test in the presence of the contractor or his representative. All deficiencies other than the meter shall be corrected by the contractor.

B. Commissioning
   1. The meter shall be programmed and inserted into socket by system owner personnel.

END OF SECTION 337173
SECTION 337313 – MEDIUM-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 transformers with medium-voltage primaries:

1. Pad-mounted, less-flammable liquid-filled, dead front, outdoor rated, radial feed transformer. (School of Music Building Transformer TO BE SUPPLIED BY CONTRACTOR)

1.3 DEFINITIONS


1.4 SUBMITTALS

A. MU Campus Facilities – Energy Management Electric Distribution must approve submittals prior to construction of each type of transformer supplied.

B. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.

C. Shop Drawings: Diagram power and control wiring.

D. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

   1. Underground primary and secondary conduit stub-up location.
   2. Dimensioned concrete base, outline of transformer, and required clearances.
   3. Ground rod and grounding cable locations.

E. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly 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. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Source quality-control test reports.
G. Field quality-control test reports.

H. Follow-up service reports.

I. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers 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. Comply with latest versions of all applicable standards including, but not limited to:
   1. IEEE
   2. ANSI
   3. IEEE
   4. NESC
   5. NEMA
   6. Federal Occupational Safety and Health Standards

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

1.7 PROJECT CONDITIONS

A. Service Conditions: IEEE C57.12.0, usual service conditions except for the following:
   1. Exposure to seismic shock or to abnormal vibration, shock, or tilting.

1.8 COORDINATION

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

B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Acme Electric Corporation; Power Distribution Products Division.
   2. Cooper Industries; Cooper Power Systems Division.
   4. GE Electrical Distribution & Control.
   5. Square D; Schneider Electric.
   6. ABB
2.2 LIQUID-FILLED PAD MOUNT TRANSFORMERS

A. Description: IEEE C57.12, latest revision and UL 1062, liquid-filled, 2-winding pad mounted transformers. Transformer to be new, liquid immersed, self cooled type with bolt-on covers. Re-manufactured equipment will not be acceptable.

B. Efficiency, Impedance and Losses: Transformer efficiency shall meet all DOE and 10 CFR Part 431 requirements. Percent impedance shall meet all applicable standards.

C. Compartment Type:
1. High and low voltage compartments assemble side by side as an integral unit with no live parts accessible without opening the compartment doors.
2. Compartment depth shall be minimum 24 inches.
3. High voltage compartment to be located on the left with separation from low voltage compartment by a metal barrier.
4. No bolts, screws, or other fastening devices shall be externally removable.
5. No openings where sticks, rods, or other devices could be inserted and contact live parts.
6. Compartments and exterior surfaces shall limit water entry by preventing holding or pooling of water or liquids.
7. A clear, non-conductive, hinged barrier with latching mechanism shall be installed in the low voltage compartment in a manner which will completely restrict access to the low voltage compartment with barrier in closed position. Barrier shall be clearly marked “Danger Arc Flash Hazard”.
8. Low voltage bushings shall be supported to the top of transformer to prevent oil leaking form the bushing due to the weight of the cables attached to them.

D. Enclosure:
1. Supply with jacking provisions and lugs for lifting.
2. Enclosure and base constructed for sliding and rolling.
3. Enclosure shall be tamper proof.
4. Have self-starting penta-head bolts.
5. Shall prevent accumulation and pooling of water.

E. Doors:
1. Secondary compartment door shall include provisions for a lock, which must be removed to remove the penta-head bolt.
2. Primary compartment door shall be separate and interlocked with the secondary door such that the secondary door must be opened before primary door can be opened.
3. Primary door shall also be secured by penta-head bolts other than the bolts securing the secondary door.

F. Paint: Munsell Green #7.0GY3.29/1.5, minimum thickness of 2.5 MIL. Touch up paint to be supplied with transformer and given to Owner.


H. Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic. Liquid shall be biodegradable and nontoxic zero mortality trout fry testing. The fluid shall be certified to comply with US EPA Environmental Technology Verification (ETV) requirements and tested for compatibility with transformer components. Fluid shall be Factory Mutual (FM) approved, UL classified transformer fluid (UL-EOVK) and UL Classified Dielectric Medium (UL-EOUV).

I. Insulation Temperature Rise: 65 deg C when operated at rated KVA output. Winding insulation shall be 120 deg C. Transformer shall be rated to operate at rated KVA in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. without loss of service life expectancy.

J. Basic Impulse Level: Primary - 95 kV; Secondary – 30 kV.
K. Primary Voltage: **13,800V**.

L. Secondary Voltage: **480Y/277 V**.

M. Size: **1000kVA**

N. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

O. Primary Windings: Copper; designed to withstand high 3rd, 9th and 15th harmonic circulating currents, and transposed for reduced losses if recommended by manufacturer.

P. Secondary Windings: Copper; transposed for reduced losses if recommended by manufacturer, individual conductors to be insulated, and parallel conductors to be used instead of one larger single conductor or single thin tape type conductor.

Q. Transformer Core: Steel core stock designed and constructed to reduce eddy current losses at fundamental and harmonic frequencies.

R. Neutral Conductor: Sized to handle two (2) times the rate phase current continuously.

S. High-Voltage Switch: **300 A**, make-and-latch rating of minimum 10-kA RMS, symmetrical, arranged for radial feed with 3-phase, 2-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment. Switch to be rated to interrupt transformer current.

T. Primary Fuses: 150-kV fuse assembly with fuses complying with IEEE C37.47. Rating of current-limiting fuses shall be 50-kA RMS minimum at specified system voltage.
2. Current limiting fuses shall have an interrupting capacity greater than 40,000A
3. Fusing combination shall provide full range protection for low and high current faults.
4. Three spare bayonet fuses shall be supplied with the transformer. (This totals six bayonet fuses)
5. Let through current of the in-tank current limiting fuse cannot exceed the interrupting rating of the high voltage switch specified.

U. Surge Arresters: Three (3), 10 kV rated, 8.4 kV MCOV, elbow type. Transformers must have mountings provided for lightning arrestors.

V. High-Voltage Terminations and Equipment: Dead front, 95kV BIL rating, with universal-type 15 kV, 600A bushing wells for dead-front bushing-well inserts and no-load break, bolted elbow connection., complying with ANSI/IEEE 386 (ANSI Standard C119.2) and including the following:
1. Bushing-Well Inserts: One for each high-voltage bushing well.
2. Parking Stands: One for each high-voltage bushing well.
3. Bushings to include a semi-conductive coating and shall be mounted such that coating is solidly grounded to tank.
4. Shall have covers in place for shipping and storage.
5. Dead Front
   a. Radial Feed
      1) Three (3) – 600A primary bushing, suitable for delta connection of 13,800V deadbreak elbow connectors
   b. Loop Fee
      1) Six (6) – 600A primary bushing, suitable for delta connection of 13,800V dead break elbow connectors

W. Low-Voltage Terminations and Equipment: Four (4) secondary bushings shall be supplied for wye connection including the following:
1. 30 kV BIL rating with tinned spade-type bushings having minimum eight (8) -9/16” connection holes on 1 ¾” centers.
2. Bushings to be supported to top of transformer to prevent oil leaking from the bushing due to the weight of the cables attached to them.

X. Grounding: Provide three (3) grounding connections, each with two (2) \( \frac{1}{2} \)-13 UNC tapped holes. One (1) each in primary and secondary compartments and outside of tank. Copper connection strap from the neutral to ground shall be provided. Provide one ground rod in opening.

Y. Provide engraved nameplate with manufacturer standard information plus the following: (DUPLICATE Nameplate shall be affixed to the interior of the secondary compartment door)
1. KVA rating
2. Primary voltage
3. Secondary voltage
4. BIL ratings
5. Temperature rating
6. Voltages for each tap setting
7. Date of manufacture
8. Winding conductor type
9. Impedance (%)
10. Circuit diagrams of switch configuration and rating.
11. Delta-wye diagram
12. Statement: “Transformer filled with less-flammable fluid containing no detectable PCB's at time of manufacture.”
13. Total weight of unit (lbs)
14. Unit weight without oil.

Z. Labelling as follows:
1. Standard manufacturer labels for pad mount equipment.
2. Blue ‘Contains No PCB's” label placed inside secondary compartment door and outside of tank.
3. A “Danger – High Voltage” label on outside of primary compartment door meeting all applicable standards.
4. A “Secondary Barrier Installed” label installed on the outside of the secondary compartment door.

AA. Accessories:
1. Drain Valve: 1 inch (25 mm), with sampling device in primary compartment.
2. Dial-type thermometer.
3. Liquid-level gage inside low voltage compartment.
4. Pressure-vacuum gage.
5. Pressure Relief Valve: Qualitrol Series 201 or approved equal for NEC Code 450-23 application. Volume of valve must meet all applicable codes.

2.3 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.”

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.00.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for medium-voltage transformers.

B. Examine roughing-in of conduits and grounding systems to verify the following:
   1. Wiring entries comply with layout requirements.
   2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

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

3.2 INSTALLATION

A. Install transformers on concrete bases.
   1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Section "Hangers and Supports for Electrical Systems."
   2. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit and 4 inches (100 mm) high.
   3. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."
   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. Tack-weld or bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70. A minimum of 8' clear area in front of compartment doors and 3' clear area on the other sides of the transformer. Locate unit in accessible location for maintenance, operation and placement. Exact location of transformer to coordinated with Owner's Representative.

C. Care shall be taken during lifting/moving not to damage or bump the transformer.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
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. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. After installing transformers but before primary is energized, verify that grounding system is tested at specified value or less.
   2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
   3. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   5. Test impedance of supplied transformer to verify in range specified

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

D. Test Reports: Prepare written reports to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

E. System owner to perform TTR, Megger and Ground testing prior to transformer energization.

F. System owner to set proper tap on transformer, energize and check for proper voltage.

END OF SECTION 337313
<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDMI Extender Receiver for Monitor</td>
<td>Extron</td>
<td>DTP T HDMI 4K 230 Rx</td>
<td>1</td>
</tr>
<tr>
<td>HDMI Switcher</td>
<td>Extron</td>
<td>SW2 HD 4K</td>
<td>1</td>
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<tr>
<td>Ethernet Switch</td>
<td>Cisco or HP</td>
<td>by AV Contractor</td>
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**Video Display**

<table>
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<td>UN55J6201AFXZA</td>
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<td>Wall Mount for Video Display</td>
<td>Chief</td>
<td>LTM1U</td>
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End of Appendix A

**END OF SECTION 274100**