

WET-PIPE SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes wet-pipe sprinkler system guidelines for system design, installation, and certification.
- B. Related Sections:
 - 1. Section 26 05 03 - Equipment Wiring Connections: Execution requirements for electric connections to equipment specified by this section.

1.2 REFERENCES

- A. National Fire Protection Association:
 - 1. NFPA 13 - Installation of Sprinkler Systems.

1.3 SYSTEM DESCRIPTION

- A. System to provide coverage for entire building.
- B. Provide a hydraulically designed system to NFPA 13 occupancy requirements.
- C. Obtain up-to-date flow test data. Determine volume and pressure of incoming water supply from water flow test data. Provide flow test data on the Shop Drawings.
- D. Interface sprinkler system with building fire and smoke alarm system.
- E. For new systems, provide fire department connections as indicated on Drawings.

1.4 PERFORMANCE REQUIREMENTS

- A. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
- B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated
 - 1. Provide fire-hydrant flow test records to indicate the following conditions:
 - a. Time of test
 - b. Name and Company of person performing the test
 - c. Location of Residual Fire Hydrant
 - d. Location of Flow Fire Hydrant
 - e. Static Pressure at Residual Fire Hydrant
 - f. Measured Flow at Flow Fire Hydrant

g. Residual Pressure at Residual Fire Hydrant

- C. Sprinkler system design shall be approved by authorities having jurisdiction.
1. Margin of Safety for Available Water Flow and Pressure: 10 psi less static pressure, 10 psi less residual pressure and 10% less flow.
 2. Recommended Sprinkler Occupancy Hazard Classifications:
 - a. As noted on Contract Documents.
 3. Recommended Minimum Density for Automatic-Sprinkler Piping Design:
 - 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.
 4. Maximum Protection Area per Sprinkler: Per UL listing.
 5. Total Combined Hose-Stream Demand Requirement: Per 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.

1.12 SUBMITTALS

- A. Division 01 - Submittal Procedures: Submittal procedures.
- B. Shop Drawings: Provide layout of finished ceiling areas indicating sprinkler locations coordinated with ceiling installation and the work of other trades (ductwork, lights and any other ceiling mounted devices). Show detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
- C. Product Data: Submit data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- D. Design Data: Submit design calculations signed and sealed by a professional engineer.
- E. Sprinklers shall be referred to on drawings, submittals, and other documentation, by the sprinkler identification or model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.

1.13 CLOSEOUT SUBMITTALS

- A. Division 01 - Execution and Closeout Requirements: Closeout procedures.
- B. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and inspector's test locations.
- C. Operation and Maintenance Data: Submit components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.

1.14 QUALITY ASSURANCE

- A. Perform Work in accordance with NFPA 13.

1.15 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum three years documented experience.
- C. Design system under direct supervision of Professional Engineer experienced in design of this Work and licensed at Project location (state).

1.16 DELIVERY, STORAGE, AND HANDLING

- A. Division 01 - Product Requirements: Product storage and handling requirements.
- B. Store products in shipping containers until installation.
- C. Furnish piping with temporary inlet and outlet caps until installation.

1.17 WARRANTY

- A. Division 01 - Execution and Closeout Requirements: Product warranties and product bonds.
- B. Furnish five (5) year manufacturer warranty for system components.

1.18 EXTRA MATERIALS

- A. Division 01 - Execution and Closeout Requirements: Spare parts and maintenance products.
- B. Furnish extra sprinklers under provisions of NFPA 13.
- C. Furnish suitable wrenches for each sprinkler type.
- D. Furnish metal storage cabinet in location designated by Architect, adjacent to system riser.

PART 2 PRODUCTS

2.1 SPRINKLERS

- A. Suspended Ceiling Type:
 - 1. Type: Concealed pendant type with coverplate.
 - 2. Color of coverplate: Coordinate color with architect.
 - 3. Fusible Link: temperature rated for specific area hazard.

- B. Exposed Area Type:
 - 1. Type: Standard upright type.
 - 2. Finish: Brass.
 - 3. Fusible Link: temperature rated for specific area hazard.
- C. Side wall Type:
 - 1. Type: Recessed horizontal side wall type with matching escutcheon plate.
 - 2. Finish: Chrome plated.
 - 3. Escutcheon Plate Finish: Chrome plated.
 - 4. Fusible Link: temperature rated for specific area hazard.
- D. Guards: Finish to match sprinkler finish.

2.2 PIPING SPECIALTIES

- A. Wet Pipe Sprinkler Riser Check Valve: Ductile iron body, swing check type valve with brass seat and rubber-faced or aluminum-bronze clapper with elastomer seal. Provide complete with main drain valve and pressure gauges. Rated for 250 psi working pressure. Valve internal components shall be replaceable without removing from the installed position.
- B. Electric Alarm: Electrically operated gong with pressure alarm switch.
- C. Water Flow Switch: Vane type switch for mounting horizontal or vertical, with two contacts; rated 10 amp at 125 volt AC and 2.0 amp at 24 volt DC.
- D. Fire Department Connections:
 - 1. Free-standing type provided by Site Utility Contractor.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with NFPA 13.
- B. Install approved reduced-pressure back-flow preventer assembly at sprinkler system water source connection.
- C. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent fire department connectors to allow full swing of fire department wrench handle.
- D. Locate outside alarm-gong on building wall as indicated on Drawings.
- E. Place pipe runs to minimize obstruction to other work.
- F. Install piping in concealed spaces above finished ceilings.
- G. Center sprinklers in two directions in ceiling tile and install piping offsets.

1. A stainless steel flexible drop system may be used to properly locate sprinkler heads. The drop system shall be supplied with required supporting members and bracing. Drop system shall be provided with braided jacket, un-braided systems will not be accepted.
 - H. Do not install sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install sprinklers with cracked bulbs.
 - I. Sprinkler bulb protector shall be removed by hand after installation. Do not use tools or any other device(s) to remove the protector that could damage the bulb in any way.
 - J. Install guards on sprinklers where required to protect sprinklers from physical damage.
 - K. Hydrostatically test entire system.
 - L. Require test be witnessed by authority having jurisdiction.
- 3.2 INTERFACE WITH OTHER PRODUCTS
- A. Verify signal devices are installed and connected to fire alarm system.
- 3.3 CLEANING
- A. Section 01 70 00 - Execution and Closeout Requirements: Final cleaning.
 - B. Flush entire piping system of foreign matter.
- 3.4 PROTECTION OF INSTALLED CONSTRUCTION
- A. Section 01 70 00 - Execution and Closeout Requirements: Protecting installed construction.
 - B. Apply masking tape or paper cover to protect concealed sprinklers, cover plates, and sprinkler escutcheons not receiving field paint finish. Remove after painting. Replace painted sprinklers with new.

END OF SECTION 21 13 13

SECTION 21 13 16 DRY-PIPE SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes dry-pipe sprinkler system guidelines for system design, installation, and certification.
- B. Related Sections:
 - 1. Section 21 05 13 - Common Motor Requirements for Fire-Suppression Equipment: Product requirements for motors for placement by this section.
 - 2. Section 21 05 48 - Vibration and Seismic Controls for Fire-Suppression Piping and Equipment: Product requirements for vibration isolators for placement by this section.
 - 3. Section 26 05 03 - Equipment Wiring Connections: Execution requirements for electric connections to equipment specified by this section.

1.2 REFERENCES

- A. National Fire Protection Association:
 - 1. NFPA 13 - Installation of Sprinkler Systems.

1.3 SYSTEM DESCRIPTION

- A. System to provide coverage for building areas noted.
- B. Provide a hydraulically designed system to NFPA 13 occupancy requirements.
- C. Obtain up-to-date flow test data. Determine volume and pressure of incoming water supply from water flow test data. Provide flow test data on the Shop Drawings.
- D. Interface system with building fire and smoke alarm system.
- E. For new systems, provide fire department connections as indicated on Drawings.

1.4 SUBMITTALS

- A. Section 01 33 00 - Submittal Procedures: Submittal procedures.
- B. Shop Drawings: Provide layout of finished ceiling areas indicating sprinkler locations coordinated with ceiling installation and the work of other trades (ductwork, lights and any other ceiling mounted devices). Show detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.

- C. Product Data: Submit data on sprinklers, valves, pumps, compressors and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- D. Design Data: Submit design calculations signed and sealed by a professional engineer.
- E. Sprinklers shall be referred to on drawings, submittals, and other documentation, by the sprinkler identification or model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.

1.5 CLOSEOUT SUBMITTALS

- A. Section 01 70 00 - Execution and Closeout Requirements: Closeout procedures.
- B. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.
- C. Operation and Maintenance Data: Submit components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.

1.6 QUALITY ASSURANCE

- A. Perform Work in accordance with NFPA 13.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum three years documented experience.
- C. Design system under direct supervision of Professional Engineer experienced in design of this Work and licensed at Project location (state).

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.
- B. Store products in shipping containers until installation.
- C. Furnish temporary end caps and closures on piping and fittings. Maintain in place until installation.

1.9 WARRANTY

- A. Section 01 70 00 - Execution and Closeout Requirements: Product warranties and product bonds.

- B. Furnish five (5) year manufacturer warranty for air compressor and pump.

1.10 EXTRA MATERIALS

- A. Section 01 70 00 - Execution and Closeout Requirements: Spare parts and maintenance products.
- B. Furnish extra sprinklers under provisions of NFPA 13.
- C. Furnish suitable wrenches for each sprinkler type.
- D. Furnish metal storage cabinet in location designated by Architect, adjacent to system riser.

PART 2 PRODUCTS

2.1 SPRINKLERS

- A. Suspended Ceiling Type:
 - 1. Type: Semi-recessed dry-pendant type with matching escutcheon plate.
 - 2. Finish: Chrome plated.
 - 3. Escutcheon Plate Finish: Chrome plated.
 - 4. Fusible Link: temperature rated for specific area hazard.
- B. Exposed Area Type:
 - 1. Type: Standard upright type.
 - 2. Finish: Brass.
 - 3. Fusible Link: temperature rated for specific area hazard.
- C. Side wall Type:
 - 1. Type: Recessed horizontal side wall dry type with matching escutcheon plate.
 - 2. Finish: Chrome plated.
 - 3. Escutcheon Plate Finish: Chrome plated.
 - 4. Fusible Link: temperature rated for specific area hazard.
- D. Guards: Finish to match sprinkler finish.
- E. Escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.

2.2 PIPING SPECIALTIES

- A. Dry Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber faced or aluminum-bronze clapper with elastomer seal to automatically actuate electric alarm, with accelerator. Valve internal components shall be replaceable without removing the valve from the installed position. Valve shall be externally resettable. Required air pressure shall be 13 psi / 90 kPa.
- B. Electric Alarm: Electrically operated gong with pressure alarm switch.

- C. Water Flow Switch: Vane type switch for mounting horizontal or vertical, with two contacts; rated 10 amp at 125-volt AC and 2.0 amp at 24 volt DC.

2.3 AIR COMPRESSOR

- A. Compressor: Single unit, electric motor driven, motor, motor starter, safety valves, check valves, air maintenance device incorporating electric pressure switch and unloading valve.

2.4 ELECTRICAL CHARACTERISTICS AND COMPONENTS

- A. Motors: In accordance with Section 21 05 13.
- B. Controls: Supervisory switches, Water Level Supervisory Switches, Tank Temperature Supervisory Switches, Room Temperature Supervisory Switches.
- C. Disconnect Switch: Factory mount in control panel or on equipment.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with NFPA 13.
- B. Install approved back-flow preventer assembly at sprinkler system water source connection.
- C. Install outside alarm-gong on building wall as indicated on Drawings
- D. Install piping to minimize obstruction with other work.
- E. Install piping in concealed spaces above finished ceilings.
- F. Center sprinklers in two directions in ceiling tile and install piping offsets.
- G. Do not install sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install sprinklers with cracked bulbs.
- H. Sprinkler bulb protector shall be removed by hand after installation. Do not use tools or any other device(s) to remove the protector that could damage the bulb in any way.
- I. Install guards on sprinklers where required to protect sprinklers from physical damage.
- J. Install air compressor on vibration isolators. Refer to Section 21 05 48.
- K. Hydrostatically test entire system.
- L. Require test be witnessed by authority having jurisdiction.

3.2 INTERFACE WITH OTHER PRODUCTS

- A. Verify devices are installed and connected to fire alarm system.

3.3 CLEANING

- A. Section 01 70 00 - Execution and Closeout Requirements: Final cleaning.
- B. Flush entire piping system of foreign matter.

3.4 PROTECTION OF INSTALLED CONSTRUCTION

- A. Section 01 70 00 - Execution and Closeout Requirements: Protecting installed construction.
- B. Apply masking tape or paper cover to sprinklers, cover plates, and sprinkler escutcheons not receiving field painted finish. Remove after painting. Replace painted sprinklers with new.

END OF SECTION 21 13 16

GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ball valves.
2. Plug valves.
3. Check valves.

B. Related Sections:

1. Section 22 05 03 – Plumbing Pipe, Tube and Fittings
2. Section 22 05 29 - Hangers and Supports for Plumbing Piping and Equipment.
3. Section 22 07 00 - Plumbing Insulation

1.2 REFERENCES

A. ASTM International:

1. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
2. ASTM D4101 - Standard Specification for Propylene Injection and Extrusion Materials.

B. Manufacturers Standardization Society of the Valve and Fittings Industry:

1. MSS SP 80 - Bronze Gate, Globe, Angle and Check Valves.
2. MSS SP 110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

1.3 SUBMITTALS

A. Division 01 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit manufacturers catalog information with valve data and ratings for each service.

C. Manufacturer's Installation Instructions: Submit hanging and support methods, joining procedures.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Division 01 - Execution and Closeout Requirements: Requirements for submittals.
- B. Project Record Documents: Record actual locations of valves.
- C. Operation and Maintenance Data: Submit installation instructions, spare parts lists, exploded assembly views.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum years documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Division 01 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 - Product Requirements: Environmental conditions affecting products on site.
- B. Do not install valves underground when bedding is wet or frozen.

1.8 WARRANTY

- A. Division 01 - Execution and Closeout Requirements: Requirements for warranties.
- B. Furnish five-year manufacturer warranty for valves excluding packing.

1.9 EXTRA MATERIALS

- A. Division 01 - Execution and Closeout Requirements: Requirements for extra materials.
- B. Furnish two packing kits for each size valve.

PART 2 PRODUCTS

2.1 BALL VALVES

- A. Manufacturers:
 - 1. Apollo Valves, Conbraco Company.
 - 2. Crane Valve, North America.
 - 3. Hammond Valve Model.

4. Jomar Valve
 5. Milwaukee Valve Company.
 6. NIBCO, Inc. Model.
 7. Stockham Valves & Fittings Model.
 8. Victaulic
- B. 4 inch and Smaller: MSS SP 110, 600 psi WOG, two-piece brass or bronze body, chrome plated brass ball and stem, full port, PTFE seats, blow-out proof stem, solder or threaded ends, lever handle.

2.2 PLUG VALVES

- A. Manufacturers:
1. DeZURIK, Unit of SPX Corp.
 2. Flow Control Equipment, Inc.
 3. Homestead Valve.
- B. 2 inches and Smaller: MSS SP 78, Class 150, semi-steel construction, round port, full pipe area, pressure lubricated, Teflon packing, threaded ends. Furnish one plug valve wrench for every ten plug-valves with minimum of one wrench.
- C. 2-1/2 inches and Larger: MSS SP 78, Class 150, semi-steel construction, round port, full pipe area, pressure lubricated, Teflon packing, flanged ends. Furnish wrench-operated.

2.3 CHECK VALVES

- A. Spring Loaded Check Valves:
1. Manufacturers:
 - a. Apollo Valve, Conbraco Company
 - b. Crane Valve, North America.
 - c. Hammond Valve.
 - d. Milwaukee Valve Company.
 - e. NIBCO, Inc.
 - f. Stockham Valves & Fittings.
 - g. Victaulic Company.
 2. 2 inches and Smaller: MSS SP 139, Class 250 bronze body, in-line spring lift check, silent closing, Buna-N disc, integral seat, solder or threaded ends.

3. 2-1/2 inches and Larger: MSS SP 71, Class 125, wafer or globe style, cast iron body, bronze seat, center guided bronze disc, stainless steel spring and screws, flanged ends.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Division 01 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify piping system is ready for valve installation.

3.2 INSTALLATION

- A. Install valves with stems upright or horizontal, not inverted.
- B. Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
- C. Install 3/4-inch ball valves with cap for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment.
- D. Install valves with clearance for installation of insulation and allowing access.
- E. Provide access where valves and fittings are not accessible. Coordinate size and location of access doors with Division 08.
- F. Refer to Section 22 05 29 for pipe hangers.
- G. Refer to Section 22 07 00 for insulation requirements for valves.
- H. Refer to Section 22 05 03 for piping materials applying to various system types.

3.3 VALVE APPLICATIONS

- A. Valves installed in the domestic water piping system shall be Lead-Free per NSF 61, Annex G or NSF 372 requirements.
- B. Install shutoff and drain valves at locations indicated on Drawings in accordance with this Section.
- C. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- D. Install globe valves for throttling, bypass, or manual flow control services.
- E. Install spring loaded check valves on discharge of water pumps.
- F. Install ball valves in domestic water systems for shut-off service.
- G. Install globe valves in domestic water systems for throttling service.

END OF SECTION 22 05 23

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe hangers and supports.
2. Hanger rods.
3. Inserts.
4. Flashing.
5. Sleeves.
6. Mechanical sleeve seals.
7. Formed steel channel.
8. Firestopping relating to plumbing work.
9. Firestopping accessories.
10. Equipment bases and supports.

B. Related Sections:

1. Section 22 05 03 – Plumbing Pipe, Tube and Fittings.
2. Division 03 - Concrete Forming and Accessories.
3. Division 03 - Cast-In-Place Concrete.
4. Division 07 - Joint Protection.
5. Division 09 - Painting and Coating.
6. Division 07 - Requirements for roof flashing installation.

1.2 REFERENCES

A. American Society of Mechanical Engineers:

1. ASME B31.9 - Building Services Piping.

B. ASTM International:

1. ASTM E84 - Test Method for Surface Burning Characteristics of Building Materials.
 2. ASTM E119 - Method for Fire Tests of Building Construction and Materials.
 3. ASTM E814 - Test Method of Fire Tests of Through Penetration Firestops.
 4. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.
 5. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.
- C. American Welding Society:
1. AWS D1.1 - Structural Welding Code - Steel.
- D. FM Global:
1. FM - Approval Guide, A Guide to Equipment, Materials & Services Approved by Factory Mutual Research for Property Conservation.
- E. Manufacturers Standardization Society of the Valve and Fittings Industry:
1. MSS SP 58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
 2. MSS SP 69 - Pipe Hangers and Supports - Selection and Application.
 3. MSS SP 89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- F. Underwriters Laboratories Inc.:
1. UL 263 - Fire Tests of Building Construction and Materials.
 2. UL 723 - Tests for Surface Burning Characteristics of Building Materials.
 3. UL 1479 - Fire Tests of Through-Penetration Firestops.
 4. UL 2079 - Tests for Fire Resistance of Building Joint Systems.
 5. UL - Fire Resistance Directory.

1.3 DEFINITIONS

- A. Firestopping (Through-Penetration Protection System): Sealing or stuffing material or assembly placed in spaces between and penetrations through building materials to arrest movement of fire, smoke, heat, and hot gases through fire rated construction.

1.4 SYSTEM DESCRIPTION

- A. Firestopping Materials: shall comply with ASTM E119, ASTM E814, and/or UL 263, UL 1479 to achieve fire ratings as noted on Drawings for adjacent construction, but not less than 1-hour fire rating.

1. Ratings may be 3-hours for firestopping in through-penetrations of 4-hour fire rated assemblies unless otherwise required by applicable codes.

1.5 PERFORMANCE REQUIREMENTS

- A. Firestopping: Conform to UL for fire resistance ratings and surface burning characteristics.
- B. Firestopping: Provide certificate of compliance from authority having jurisdiction indicating approval of materials used.

1.6 SUBMITTALS

- A. Division 01 - Submittal Procedures.
- B. Product Data:
 1. Hangers and Supports: Submit manufacturers catalog data including load capacity.
 2. Firestopping: Submit data on product characteristics, performance and limitation criteria.
- C. Firestopping Schedule: Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance rating of adjacent assembly.
- D. Manufacturer's Installation Instructions:
 1. Hangers and Supports: Submit special procedures and assembly of components.
 2. Firestopping: Submit preparation and installation instructions.
- E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.7 QUALITY ASSURANCE

- A. Through Penetration Firestopping of Fire Rated Assemblies: UL 1479 or ASTM E814 with 0.10-inch water gage minimum positive pressure differential to achieve fire F-Ratings and temperature T-Ratings as indicated on Drawings, but not less than 1-hour.
 1. Wall Penetrations: Fire F-Ratings as indicated on Drawings, but not less than 1-hour.
 2. Floor and Roof Penetrations: Fire F-Ratings and temperature T-Ratings as indicated on Drawings, but not less than 1-hour.
 - a. Floor Penetrations within Wall Cavities: T-Rating is not required.
- B. Through Penetration Firestopping of Non-Fire Rated Floor and Roof Assemblies: Materials to resist free passage of flame and products of combustion.

1. Noncombustible Penetrating Items: Noncombustible materials for penetrating items connecting maximum of three stories.
 2. Penetrating Items: Materials approved by authorities having jurisdiction for penetrating items connecting maximum of two stories.
- C. Fire Resistant Joints in Fire Rated Floor, Roof, and Wall Assemblies: ASTM E1966 or UL 2079 to achieve fire resistant rating as indicated on Drawings for assembly in which joint is installed.
 - D. Fire Resistant Joints Between Floor Slabs and Exterior Walls: ASTM E119 with 0.10-inch water gage minimum positive pressure differential to achieve fire resistant rating as indicated on Drawings for floor assembly.
 - E. Surface Burning Characteristics: 25/450 flame spread/smoke developed index when tested in accordance with ASTM E84.
 - F. Perform Work in accordance AWS D1.1 for welding hanger and support attachments to building structure.

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with 5 years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum 5 years documented experience.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Division 01 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Accept materials on site in original factory packaging, labeled with manufacturer's identification.
- C. Protect from weather and construction traffic, dirt, water, chemical, and damage, by storing in original packaging.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 - Product Requirements: Environmental conditions affecting products on site.
- B. Do not apply firestopping materials when temperature of substrate material and ambient air is below 60 degrees F.
- C. Maintain this minimum temperature before, during, and for minimum 3 days after installation of firestopping materials.
- D. Provide ventilation in areas to receive solvent cured materials.

1.11 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.12 WARRANTY

- A. Division 01 - Execution and Closeout Requirements: Product warranties and product bonds.
- B. Furnish five-year manufacturer warranty for pipe hangers and supports.

PART 2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Manufacturers:

1. Carpenter & Paterson Inc.
2. Creative Systems Inc.
3. Flex-Weld, Inc.
4. Glope Pipe Hanger Products Inc.
5. Michigan Hanger Co.
6. Superior Valve Co.

B. Plumbing Piping - DWV:

1. Conform to ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89.
2. Hangers for Pipe Sizes 1-1/2 inches and Larger: Carbon steel, adjustable, clevis.
3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
4. Vertical Support: Steel riser clamp.
5. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
6. Copper Pipe Support: Copper-plated, carbon-steel adjustable, ring.

C. Plumbing Piping - Water:

1. Conform to ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89.
2. Hangers for Pipe Sizes 1/2 to 4 inches: Carbon steel, adjustable, clevis.
3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.

4. Vertical Support: Copper-plated, Steel riser clamp.
5. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
6. Floor Support for Hot Pipe Sizes 4 inches and Smaller: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
7. Copper Pipe Support: Copper-plated, Carbon-steel ring.

2.2 ACCESSORIES

- A. Hanger Rods: Mild steel threaded both ends, threaded on one end, or continuous threaded.

2.3 INSERTS

- A. Inserts: Malleable iron case or galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.4 FLASHING

- A. Metal Flashing: 26 gage thick galvanized steel.
- B. Metal Counterflashing: 22 gage thick galvanized steel.
- C. Lead Flashing:
 1. Waterproofing: 5 lb./sq. ft sheet lead.
 2. Soundproofing: 1 lb./sq. ft sheet lead.
- D. Flexible Flashing: 47 mils thick sheet butyl; compatible with roofing.
- E. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.5 SLEEVES

- A. Sleeves for Pipes Through Non-fire Rated Floors: 18 gage thick galvanized steel.
- B. Sleeves for Pipes Through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gage thick galvanized steel.
- C. Sealant: Acrylic; refer to Section 07 90 00.

2.6 MECHANICAL SLEEVE SEALS

- A. Manufacturers:
 1. Thunderline Link-Seal, Inc.
 2. NMP Corporation.

- B. Product Description: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between object and sleeve, connected with bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.7 FORMED STEEL CHANNEL

- A. Manufacturers:

1. B-Line Systems.
2. Unistrut Corp.

- B. Product Description: Galvanized 12 gage thick steel. With holes 1-1/2 inches on center.

2.8 FIRESTOPPING

- A. Manufacturers:

1. Dow Corning Corp.
2. Fire Trak Corp.
3. Hilti Corp.
4. International Protective Coating Corp.
5. 3M fire Protection Products.
6. Specified Technology, Inc.

- B. Product Description: Different types of products by multiple manufacturers are acceptable as required to meet specified system description and performance requirements; provide only one type for each similar application.

1. Silicone Firestopping Elastomeric Firestopping: [Single] [Multiple] component silicone elastomeric compound and compatible silicone sealant.
2. Foam Firestopping Compounds: [Single] [Multiple] component foam compound.
3. Formulated Firestopping Compound of Incombustible Fibers: Formulated compound mixed with incombustible non-asbestos fibers.
4. Fiber Stuffing and Sealant Firestopping: Composite of [mineral] [ceramic] fiber stuffing insulation with silicone elastomer for smoke stopping.
5. Mechanical Firestopping Device with Fillers: Mechanical device with incombustible fillers and silicone elastomer, covered with sheet stainless steel jacket, joined with collars, penetration sealed with flanged stops.
6. Intumescent Firestopping: Intumescent putty compound which expands on exposure to surface heat gain.

- 7. Firestop Pillows: Formed mineral fiber pillows.
- C. Color: As selected from manufacturer's full range of colors.

2.9 FIRESTOPPING ACCESSORIES

- A. Primer: Type recommended by firestopping manufacturer for specific substrate surfaces and suitable for required fire ratings.
- B. Installation Accessories: Provide clips, collars, fasteners, temporary stops or dams, and other devices required to position and retain materials in place.
- C. General:
 - 1. Furnish UL listed products or products tested by other approved independent testing laboratory.
 - 2. Select products with rating not less than rating of wall or floor being penetrated.
- D. Non-Rated Surfaces:
 - 1. Stamped steel, chrome plated, hinged, split ring escutcheons or floor plates or ceiling plates for covering openings in occupied areas where piping is exposed.
 - 2. For exterior wall openings below grade, furnish mechanical sealing device to continuously fill annular space between piping and cored opening or water-stop type wall sleeve.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Division 01 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify openings are ready to receive sleeves.
- C. Verify openings are ready to receive firestopping.

3.2 PREPARATION

- A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of firestopping material.
- B. Remove incompatible materials affecting bond.
- C. Install backing or damming materials to arrest liquid material leakage.
- D. Obtain permission from Architect/Engineer before using powder-actuated anchors.
- E. Obtain permission from Architect/Engineer before drilling or cutting structural members.

3.3 INSTALLATION - INSERTS

- A. Install inserts for placement in concrete forms.
- B. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe 4 inches and larger.
- D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

3.4 INSTALLATION - PIPE HANGERS AND SUPPORTS

- A. Install in accordance with ASME B31.1, ASME B31.5, ASME 31.9, ASTM F708, MSS SP 58, MSS SP 69, MSS SP 89.
- B. Where insulated horizontal piping occurs, provide hanger of adequate size to allow for pipe insulation to be run continuously through the hanger assembly.
- C. Support vertical piping and tubing at base and at each floor.
- D. Support horizontal piping as scheduled.
- E. Install hangers with minimum 1/2-inch space between finished covering and adjacent work.
- F. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- G. Maximum spans below were taken from MSS SP-69 for water service and from model plumbing codes. Most restrictive piping and spacing dimensions are shown.
- H. Install hangers for CAST-IRON SOIL piping with the following maximum horizontal spacing and minimum rod diameters:

PIPE SIZE (IN.)	HORIZONTAL HANGER SPACING (FT)	ROD DIAMETER (IN.)
1½, 2	5	3/8
3	5	1/2
4, 5	5	5/8
6	5	3/4
8 - 12	5	7/8

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

- I. Install hangers for STEEL piping with the following maximum horizontal spacing and minimum rod diameters:

PIPE SIZE (IN.)	HORIZONTAL HANGER SPACING (FT)	ROD DIAMETER (IN.)
½ - 1¼	7	3/8
1½	9	3/8
2	10	3/8
3	11	1/2
4	12	5/8
6	12	3/4
8 - 12	12	7/8

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

- J. Install hangers for COPPER tubing with the following maximum horizontal spacing and minimum rod diameters:

PIPE SIZE (IN.)	HORIZONTAL HANGER SPACING (FT)	ROD DIAMETER (IN.)
½ - 1¼	5	3/8
1½, 2	6	3/8
2½	8	1/2
3, 4, 5	10	1/2
6	10	5/8
8	10	3/4

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

K. Support horizontal CPVC piping as scheduled below:

PIPE SIZE (IN.)	HORIZONTAL HANGER SPACING (FT)	ROD DIAMETER (IN.)
½ - 1	3	3/8
1¼, 2	4	3/8
2½, 3	4	1/2
4, 5	4	5/8
6	4	3/4
8	4	3/4

1. Install vertical supports for CPVC piping every 5 ft for piping 1" and smaller and every 6 ft for 1¼" and larger

L. Install hangers for DWV PVC piping with the following maximum horizontal spacing and minimum rod diameters:

PIPE SIZE (IN.)	HORIZONTAL HANGER SPACING (FT)	ROD DIAMETER (IN.)
½ - 1	3	3/8
1¼, 2	4	3/8
2½, 3	4	1/2
4, 5	4	5/8
6	4	3/4
8	4	3/4

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

M. Place hangers within 12 inches of each horizontal elbow.

N. Use hangers with 1-1/2-inch minimum vertical adjustment.

O. Support horizontal cast iron pipe adjacent to each hub.

P. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.

- Q. Support piping and tubing not listed above per MSS SP-69 and manufacturer's written instructions.
- R. Prime coat exposed steel hangers and supports. Refer to Division 09. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- S. Provide clearance in hangers and from structure and other equipment for installation of insulation. Refer to Section 22 07 00.

3.5 INSTALLATION - EQUIPMENT BASES AND SUPPORTS

- A. Provide housekeeping pads of concrete, minimum 3-1/2 inches thick and extending 6 inches beyond supported equipment. Refer to Section 03 30 00.
- B. Using templates furnished with equipment, install anchor bolts, and accessories for mounting and anchoring equipment.
- C. Construct supports of steel members. Brace and fasten with flanges bolted to structure.

3.6 INSTALLATION - FLASHING

- A. Provide flexible flashing and metal counterflashing where piping penetrates weather or waterproofed walls and floors.
- B. Flashing for roof penetrations shall be provided by the roofing contractor.
- C. Flash floor drains in floors with topping over finished areas with lead, 10 inches clear on sides with minimum 36 x 36-inch sheet size. Fasten flashing to drain clamp device.
- D. Seal floor, shower and/or mop sink drains watertight to adjacent materials.
- E. Adjust storm collars tight to pipe with bolts, caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.7 INSTALLATION - SLEEVES

- A. Exterior watertight entries: Seal with mechanical sleeve seals.
- B. Set sleeves in position in forms. Provide reinforcing around sleeves.
- C. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- D. Extend sleeves through floors 1 inch above finished floor level. Caulk sleeves.
- E. Where piping penetrates floor, ceiling, or wall, close off space between pipe and adjacent work with firestopping insulation and caulk [airtight]. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
- F. Install chrome plated steel or stainless-steel escutcheons at finished surfaces.

3.8 INSTALLATION - FIRESTOPPING

- A. Install material at fire rated construction perimeters and openings containing penetrating sleeves, piping and other items, requiring firestopping.
- B. Fire Rated Surface:
 - 1. Seal opening at rated floor, wall, partition, ceiling, and/or roof as follows:
 - a. Install sleeve through opening and extending beyond minimum of 1 inch on both sides of building element.
 - b. Size sleeve allowing minimum of 1-inch void between sleeve and building element.
 - c. Pack void with backing material.
 - d. Seal ends of sleeve with UL listed fire resistive silicone compound to meet fire rating of structure penetrated.
- C. Non-Rated Surfaces:
 - 1. Seal opening through non-fire rated wall, partition, floor, ceiling, and/or roof opening as follows:
 - a. Install sleeve through opening and extending beyond minimum of 1 inch on both sides of building element.
 - b. Size sleeve allowing minimum of 1-inch void between sleeve and building element.
 - c. Install type of firestopping material recommended by manufacturer.
 - 2. Install wall escutcheons, floor plates or ceiling plates where conduit, penetrates non-fire rated surfaces in occupied spaces. Occupied spaces include rooms with finished ceilings and where penetration occurs below finished ceiling.
 - 3. Exterior wall openings below grade: Assemble rubber links of mechanical sealing device to size of piping and tighten in place, in accordance with manufacturer's instructions.
 - 4. Interior partitions: Seal pipe penetrations at clean rooms, laboratories, hospital spaces, computer rooms, telecommunication rooms, data rooms and. Apply sealant to both sides of penetration to completely fill annular space between sleeve and conduit.

3.9 FIELD QUALITY CONTROL

- A. Division 01 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.
- B. Inspect installed firestopping for compliance with specifications and submitted schedule.

3.10 CLEANING

- A. Division 01 - Execution and Closeout Requirements: Requirements for cleaning.
- B. Clean adjacent surfaces of firestopping materials.

3.11 PROTECTION OF FINISHED WORK

- A. Division 01 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Protect adjacent surfaces from damage by material installation.

END OF SECTION 22 05 29

SECTION 22 07 00
PLUMBING INSULATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plumbing piping insulation, jackets and accessories.

B. Related Sections:

1. Section 22 05 29 – Hangers and Supports for Plumbing Piping and Equipment.
2. Division 09 - Painting and Coating: Execution requirements for painting insulation jackets and covering specified by this section.

1.2 REFERENCES

A. ASTM International:

1. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
3. ASTM C450 - Standard Practice for Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.
4. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
5. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
6. ASTM C585 - Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
7. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
8. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
9. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
10. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

11. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
 - B. National Fire Protection Association:
 1. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
 - C. Underwriters Laboratories Inc.:
 1. UL 723 - Tests for Surface Burning Characteristics of Building Materials.
- 1.3 SUBMITTALS
- A. Division: Submittal procedures.
 - B. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.
 - C. Manufacturer's Installation Instructions: Submit manufacturers published literature indicating proper installation procedures.
 - D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- 1.4 QUALITY ASSURANCE
- A. Test pipe insulation for maximum flame spread index of 25 and maximum smoke developed index of not exceeding 50 in accordance with ASTM E84, UL 723, and NFPA 255.
 - B. Pipe insulation manufactured in accordance with ASTM C585 for inner and outer diameters.
 - C. Factory fabricated fitting covers manufactured in accordance with ASTM C450.
- 1.5 QUALIFICATIONS
- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
 - B. Applicator: Company specializing in performing Work of this section with minimum three years documented experience.
- 1.6 DELIVERY, STORAGE, AND HANDLING
- A. Division 01: Requirements for transporting, handling, storing, and protecting products.
 - B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
 - C. Protect insulation from weather and construction traffic, dirt, water, chemical, and damage, by storing in original wrapping.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 - Product Requirements: Environmental conditions affecting products on site.
- B. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.
- C. Maintain temperature before, during, and after installation for minimum period of 24 hours.

1.8 FIELD MEASUREMENTS

- A. Verify all field measurements prior to fabrication.

1.9 WARRANTY

- A. Division 01: Product warranties and product bonds.
- B. Furnish one year minimum.
- C. Furnish five-year manufacturer warranty for manmade fiber.

PART 2 PRODUCTS

2.1 MANUFACTURER

- A. Manufacturers for Glass Fiber and Mineral Fiber Insulation Products:
 - 1. CertainTeed.
 - 2. Knauf.
 - 3. Johns Manville.
 - 4. Owens-Corning.
- B. Manufacturers for Closed Cell Elastomeric Insulation Products:
 - 1. Aeroflex. Aerocell.
 - 2. Armacell, LLC. Armaflex.
 - 3. Nomaco. K-flex.

2.2 PIPE INSULATION

- A. TYPE P-1: ASTM C547, molded glass fiber pipe insulation.
 - 1. Thermal Conductivity: 0.27 at 75 degrees F.
 - 2. Operating Temperature Range: 0 to 850 degrees F.
 - 3. Vapor Barrier Jacket: ASTM C1136, Type I, factory applied reinforced foil kraft with self-sealing adhesive joints.

4. Jacket Temperature Limit: minus 20 to 150 degrees F.
- B. TYPE P-5: ASTM C534, Type I, flexible, closed cell elastomeric insulation, tubular.
1. Thermal Conductivity: 0.27 at 75 degrees F.
 2. Operating Temperature Range: Range: Minus 70 to 180 degrees F.

2.3 PIPE INSULATION JACKETS

- A. Vapor Retarder Jacket:
1. ASTM C921, white Kraft paper with glass fiber yarn, bonded to aluminized film.
 2. Moisture vapor transmission: ASTM E96; 0.02 perm-inches.
- B. PVC Plastic Pipe Jacket:
1. Product Description: ASTM D1784, one-piece molded type fitting covers and sheet material, off-white color.
 2. Thickness: 15 mils.
 3. Connections: Pressure sensitive color matching vinyl tape.

2.4 PIPE INSULATION ACCESSORIES

- A. Vapor Retarder Lap Adhesive: Compatible with insulation.
- B. Covering Adhesive Mastic: Compatible with insulation.
- C. Galvanized steel insulation protection shield. MSS SP-69, Type 40. Length: Based on pipe size and insulation thickness.
- D. Closed Cell Elastomeric Insulation Pipe Hanger: Polyurethane insert with aluminum or stainless-steel jacket single piece construction with self-adhesive closure. Thickness to match pipe insulation.
- E. Insulating Cement: ASTM C195; hydraulic setting on mineral wool.
- F. Adhesives: Compatible with insulation.
1. Indoor Vapor Retarder Finish:
 - a. Cloth: Untreated; 9 oz/sq yd weight.
 - b. Vinyl emulsion type acrylic, compatible with insulation, white color.

2.5 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-97.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
 - c. Marathon Industries, Inc.; 290.
 2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- C. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; CP-96.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-33.
 2. calculated per 40 CFR 59, Subpart D (EPA Method 24).
- D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
1. Manufacturers:
 - a. Aeroflex USA Inc.; Aeroseal.
 - b. Armacell LCC; 520 Adhesive.
 - c. Foster Products Corporation, H. B. Fuller Company; 85-75.
 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. Marathon Industries, Inc.; 225.
 2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.

- c. Marathon Industries, Inc.; 225.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- G. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Manufacturers:
 - a. Dow Chemical Company (The); 739, Dow Silicone.
 - b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. Speedline Corporation; Speedline Vinyl Adhesive.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).

2.6 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 that meets the requirement of the South Coast Air Quality Management District Rule #1168. VOC limits to be per amendment date 1/7/05.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-35.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
 - c. Marathon Industries, Inc.; 590.
 - 2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 5. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
 - 1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-30.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-35.

- c. Marathon Industries, Inc.; 501.
 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
 3. Service Temperature Range: 0 to 180 deg F.
 4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 5. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
1. Manufacturers:
 - a. Childers Products, Division of ITW; Encacel.
 - b. Foster Products Corporation, H. B. Fuller Company; 60-95/60-96.
 - c. Marathon Industries, Inc.; 570.
 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
 3. Service Temperature Range: Minus 50 to plus 220 deg F.
 4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 5. Color: White.
 6. For outdoor aluminum finish, use 60-39 mastic.

2.7 SEALANTS

- A. Joint Sealants:
1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products - Manufacturers:
 - a. Childers Products, Division of ITW; CP-76.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-45.
 - c. Marathon Industries, Inc.; 405.
 2. Joint Sealant for Polystyrene Products - Manufacturers:
 - a. Childers Products, Division of ITW; CP-70.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-45/30-46.
 - c. Marathon Industries, Inc.; 405.
 3. Materials shall be compatible with insulation materials, jackets, and substrates.
 4. Permanently flexible, elastomeric sealant.
 5. Service Temperature Range: Minus 100 to plus 300 deg F.

6. Color: White or gray.
 7. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- B. FSK and Metal Jacket Flashing Sealants:
1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-76-8.
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
 - c. Marathon Industries, Inc.; 405.
 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Fire- and water-resistant, flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 40 to plus 250 deg F.
 5. Color: Aluminum.
 6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
- C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Manufacturers:
 - a. Childers Products, Division of ITW; CP-76.
 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Fire- and water-resistant, flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 40 to plus 250 deg F.
 5. Color: White.
 6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).

2.8 FIELD APPLIED FABRIC – REINFORCING MASH

- A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.
1. Manufacturers:
 - a. Vimasco Corporation; Elastafab 894.

B. Woven Glass-Fiber Fabric for Equipment Insulation: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.

1. Manufacturers:

a. Childers Products, Division of ITW; Chil-Glas No. 5.

C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for equipment and pipe.

1. Manufacturers:

a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.

b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

1. Manufacturers:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.10 SECUREMENTS

A. Bands:

1. Manufacturers:

a. Childers Products; Bands.

b. PABCO Metals Corporation; Bands.

c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015-inch-thick, 3/4-inch-wide with closed seal.

3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, 3/4-inch-wide with closed seal.

4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

5. Copper clad annealed steel wire having a minimum 16-gauge thickness.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.
 - a. Manufacturers:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; CD.
 - 3) Midwest Fasteners, Inc.; CD.
 2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - a. Manufacturers:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; Cupped Head Weld Pin.
 - 3) Midwest Fasteners, Inc.; Cupped Head.
 3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Manufacturers:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 4. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Manufacturers:
 - 1) GEMCO.
 - 2) Midwest Fasteners, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.080-inch nickel-copper alloy.
1. Manufacturers:
 - a. C & F Wire.

- b. Childers Products.
- c. PABCO Metals Corporation.

2.11 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC per ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040-inch-thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.
- C. Stainless-Steel Corner Angles: 0.024-inch-thick, minimum 1 by 1-inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Division 01: Coordination and project conditions.
- B. Verify piping and or equipment has been tested before applying insulation materials.
- C. Verify surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION - PIPING SYSTEMS

- A. Piping Exposed to View in Finished Spaces: Locate insulation and cover seams in least visible locations.
- B. Install insulation continuously through all hanger assemblies.
- C. Continue insulation through penetrations of building assemblies or portions of assemblies having fire resistance rating of one hour or less. Provide intumescent firestopping when continuing insulation through assembly. Finish at supports, protrusions, and interruptions. Refer to Division 07 for penetrations of assemblies with fire resistance rating greater than one hour.
- D. Piping Systems Conveying Fluids Below Ambient Temperature:
 - 1. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.
 - 2. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
 - 3. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor retarder adhesive or PVC fitting covers.
- E. Glass Fiber Board Insulation

1. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
 2. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.
 3. Cover wire mesh or bands with cement to a thickness to remove surface irregularities.
- F. Hot Piping Systems less than 140 degrees F:
1. Furnish factory-applied or field-applied standard jackets. Secure with outward clinch expanding staples or pressure sensitive adhesive system on standard factory-applied jacket and butt strips or both.
 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
 3. Do not insulate unions and flanges at equipment, but bevel and seal ends of insulation at such locations.
- G. Inserts and Shields:
1. Piping 1-1/2 inches Diameter and Smaller: Install galvanized steel shield between pipe hanger and insulation.
 2. Piping 2 inches Diameter and Larger: Install insert between support shield and piping and under finish jacket.
 - a. Insert Configuration: Minimum 6 inches long, of thickness and contour matching adjoining insulation; may be factory fabricated.
 - b. Insert Material: Compression resistant insulating material suitable for planned temperature range and service.
 3. Piping Supported by Roller Type Pipe Hangers: Install galvanized steel shield between roller and inserts.
- H. Insulation Terminating Points:
1. Branch Piping 1 inch and Smaller: Terminate hot water piping at union upstream of the control valve.
 2. Condensate Piping: Insulate entire piping system and components to prevent condensation.
- I. Closed Cell Elastomeric Insulation:
1. Push insulation on to piping.
 2. Miter joints at elbows.
 3. Seal seams and butt joints with manufacturer's recommended adhesive.
 4. When application requires multiple layers, apply with joints staggered.
 5. Insulate fittings and valves with insulation of like material and thickness as adjacent pipe.
- J. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces: Finish with PVC jacket and fitting covers.

- K. Prepare pipe insulation for finish painting. Refer to Division 09.

3.3 INSTALLATION - EQUIPMENT

- A. Factory Insulated Equipment: Do not insulate.
- B. Exposed Equipment: Locate insulation and cover seams in least visible locations.
- C. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.
- D. Equipment Containing Fluids Below Ambient Temperature:
 - 1. Insulate entire equipment surfaces.
 - 2. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
 - 3. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
 - 4. Finish insulation at supports, protrusions, and interruptions.
- E. Equipment Containing Fluids 140 degrees F or Less:
 - 1. Do not insulate flanges and unions, but bevel and seal ends of insulation.
 - 2. Install insulation with factory-applied or field applied jackets, with or without vapor barrier. Finish with glass cloth and adhesive.
 - 3. Finish insulation at supports, protrusions, and interruptions.
- F. Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting.
- G. Nameplates and ASME Stamps: Bevel and seal insulation around; do not cover with insulation.
- H. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation for easy removal and replacement without damage.
- I. Prepare equipment insulation for finish painting. Refer to Division 09.

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 for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies.

3.5 SCHEDULES

A. Water Supply Services Piping Insulation Schedule:

PIPING SYSTEM	INSULATION TYPE	PIPE SIZE	INSULATION THICKNESS (inches)
Domestic Hot Water Supply and Recirculation	P-1	1-1/4 inches and smaller	1.0
		1-1/2 inches and larger	1.5
Domestic Cold Water	P-1 or P-5	1-1/4 inches and smaller	0.5
		1-1/2 inches and larger	1.0

END OF SECTION 22 07 00

SECTION 22 30 10
PLUMBING EQUIPMENT

PART 1-GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 (General Requirements) sections of the Project Manual apply to this Section.
- B. The General Conditions shall be carefully examined before proposals for any work are submitted. Division 22 shall not be interpreted as waiving or overruling any requirements expressed in the General Conditions unless Division 22 sections contain statements more definitive or more restrictive.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Water Heaters
 - 2. Pumps
 - 3. Expansion Tanks
- B. Related Sections include the following:
 - 1. Section 22 05 03 – Plumbing Pipe, Tube and Fittings
 - 2. Section 22 05 23 – General-Duty Valves for Plumbing Piping
 - 3. Section 22 05 29 – Hangers and Supports for Plumbing Piping and Equipment
 - 4. Section 22 07 00 – Plumbing Insulation
 - 5. Section 22 42 00 – Plumbing Fixtures

1.3 SUBMITTALS

- A. Submittals shall be in accordance with Section 220500 – Plumbing General.
- B. The Contractor shall submit manufacturer’s catalog data for the following:
 - 1. Water Heaters
 - 2. Pumps
 - 3. Expansion Tanks
- C. The Contractor shall submit Operation and Maintenance Data in accordance with Section 220500 for the following:
 - 1. Water Heaters
 - 2. Pumps

PART 2 - PRODUCTS

2.1 WATER HEATERS

- A. General

1. Packaged water heater systems shall be furnished factory wired and UL listed. Final electrical connections shall be provided as indicated in Division 26.
2. Storage tanks shall be insulated so that the maximum heat loss of the tank does not exceed 14 BTUH per square foot of tank surface area or the current ASHRAE 90 standards, whichever is more stringent.
3. Water heater systems shall meet current ASHRAE 90A efficiency requirements.
4. Packaged water heater located in food preparation or food storage areas shall be National Sanitation Foundation certified and bear the NSF label.
5. Provide the services of a manufacturer's representative experienced in the installation and operation of this equipment for not less than one workday on-site for installation inspection, startup, and instruction of owner's personnel.

B. Gas Fired Instantaneous Water Heater

1. Gas fired, tankless, condensing, wall-mounted water heater(s) shall be direct vent and certified by CSA Group to the latest edition of ANSI standard Z21.10.3/CSA 4.3.
2. Water heater(s) shall have a 8-year limited Heat Exchanger warranty and 5-year limited Parts warranty.
3. Unit(s) shall be designed to burn natural gas.
4. Water heater(s) shall be vented with 3" Stainless Steel, CPVC, or Polypropylene vent pipe at a distance of 150 feet (or equivalent) with each elbow equal to 5' feet of pipe length.
5. Water heater(s) shall be rated for 150 psi working water pressure and 300 psi test pressure.
6. Gas supply pressure shall be 3.5" to 10.5" WC for natural gas.
7. Unit(s) shall have a steel case, dual stainless steel heat exchangers, eco premixed burner, negative pressure gas valve, dual venturi, 3/4" inlet gas connection, 3/4" brass inlet/outlet water connections, water holding capacity of 1.2 gallons, and a condensate collector.
8. Unit(s) shall include features such as an adjustment for installations at high elevation, temperature lockout, and temperature options from 98-120°F in 1°F intervals and 125-140°F in 5°F intervals.
9. Unit(s) shall include an internal circulation pump and 0.5 gallon buffer tank.
10. The water heater(s) shall be controlled by an internal circuit board that monitors the inlet and outlet temperatures with installed thermistors, sensing and controlling flow rate to set point temperature with air-fuel ratio controls in order to maintain thermal combustion efficiency.
11. Unit(s) shall include safety features such as flame sensor system, high limit sensors, overheat prevention device, freeze protection mode, and fan motor rotation detector.

12. Multi-system (cascade) applications that require 2 to 16 units shall be installed by connecting the units using cable-only connections (Ready-Link). Cascade systems can be common vented with up to 8 units when a Common Vent Backflow Damper Collar Kit is installed.
13. The water heater(s) shall exceed the energy efficiency requirements of ASHRAE 90.1-2013 and be listed by SCAQMD rule 1146.2 (Type 1) for Low NOx that complies with 14 ng/J or 20 ppm NOx requirements @ 3% O2.
14. Approved manufacturers: Navien, Rinnai, Norritz

2.2 PUMPS

- A. Hot Water Recirculation Pumps shall have capacities and motor HP as noted on the drawings. Pump shall be of all bronze construction and shall be furnished with companion flanges. Pump assembly shall be provided with isolation valves, check valve, two test plugs for insertion of pressure gauges and temperature sensor. Temperature sensor shall be connected to Building Automation System (BAS). BAS system shall cycle pump on and off as indicated on the mechanical drawings.
 1. Approved Manufacturers: Bell & Gossett, Taco, Grundfos

2.3 EXPANSION TANK

- A. Pre-pressurized diaphragm type steel expansion tank. Tank shall conform to ASME Section VIII construction for 125 psig, (200 psig WOG), tank shall have rigid polypropylene lining for corrosion control, butyl rubber diaphragm. Provide pressure gauge on system connection piping.
- B. Thermal expansion tank shall be installed to absorb expansion from hot water generator and storage tanks under no-flow or low-flow conditions. System connection shall not be located upstream of check valves or regulating valves or downstream of mixing valves or in a manner that shall negate this purpose.
- C. Thermal expansion tank pressurization shall be field charged to match the domestic water system pressure when pumps are energized and when water temperature in storage tank is at 40 to 80°F temperature. Acceptance volume shall be based upon the difference between system pressure and temperature relief valve pressure.
- D. Approved Manufacturers: Amtrol, Bell & Gossett, Wessels

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All equipment, piping and accessories shall be installed in strict accordance with manufacturer's requirements.
- B. Water heaters exceeding heat input capacity of 200,000 BTUH (58.6 KW) or nominal water capacity of 120 gallons fall are under the jurisdiction of the North Carolina Department of Labor in accordance with General Statute Chapter 95, Article 7A, Section

95-69 10. The Contractor shall obtain NC DOL inspection and approval for water heaters meeting one of the criteria listed above.

- C. Water heaters which are not provided with recirculating piping system shall be provided with heat trap type of piping arrangement on the hot water outlet of the water heater.
- D. Drain and thermal purge from all pumps shall be extended to within 4 inches of floor drain.
- E. Water heater relief valves shall be piped as indicated or to a point which will not cause personal injury or property damage and shall be readily observable by the building occupants.
- F. Provide isolation valves for all equipment and accessories.
- G. Unions shall be provided adjacent to all equipment or wherever necessary to facilitate the removal of equipment for repair or replacement. Unions for copper tubing up to and including 2-inch diameter shall be brass ground joint with socket ends for solder. Unions for copper tubing 2-1/2 inches in diameter and over shall be standard brass flanges and so stamped. No lip type unions or long screws will be permitted. The contractor shall furnish and install all structural steel angles, channels, etc. necessary to properly support all fixtures and equipment to the satisfaction of the Professional.
- H. Furnish and install isolation valves at the cold water and hot water supply tapings and an AGA/ASME pressure and temperature relief valve for each water heater.
- I. The drawings are diagrammatic in showing plumbing equipment layout. Variations in differing manufacturer's piping arrangements and physical equipment size require careful layout by the Contractor. The Contractor shall coordinate his layout so as to provide adequate clearances to allow for maintenance and inspection. In particular, equipment supports shall not obstruct floor drains or utility trench access and piping shall be installed to allow sufficient vertical clearance above treatment tanks.

END OF SECTION 22 30 10

SECTION 22 42 00
PLUMBING FIXTURES

PART 1-GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 (General Requirements) sections of the Project Manual apply to this Section.
- B. The General Conditions shall be carefully examined before proposals for any work are submitted. Division 22 shall not be interpreted as waiving or overruling any requirements expressed in the General Conditions unless Division 22 sections contain statements more definitive or more restrictive.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Water Closets
 - 2. Urinals
 - 3. Lavatories
 - 4. Sinks
 - 5. Electric Water Coolers
- B. Related Sections include the following:
 - 1. Section 22 05 03 – Plumbing Pipe, Tube and Fittings
 - 2. Section 22 05 23 – General-Duty Valves for Plumbing Piping
 - 3. Section 22 05 29 – Hangers and Supports for Plumbing Piping and Equipment
 - 4. Section 22 07 00 – Plumbing Insulation

1.3 SUBMITTALS

- A. Submittals shall be in accordance with Section 220500 – Plumbing General.
- B. The Contractor shall submit manufacturer’s catalog data for the following:
 - 1. Water Closets
 - 2. Urinals
 - 3. Lavatories
 - 4. Sinks
 - 5. Electric Water Coolers
 - 6. Flush Valves
 - 7. Toilet Seats
 - 8. Fixture Carriers
 - 9. Faucets and Mixing Valves
- C. The Contractor shall submit Operation and Maintenance Data in accordance with Section 220500 for the following:

1. Electric Water Coolers
2. Flush Valves
3. Faucets and Mixing Valves

PART 2 - PRODUCTS

2.1 GENERAL

- A. All fixtures shall be furnished complete with traps, faucets, wastes, supplies with stops, etc., as required. All exposed metal parts shall be chromium plated.
- B. Fixtures and equipment shall be those of reputable manufacturers and shall be new and the best of their respective kinds.
- C. All fixtures and equipment of similar types shall be of the same manufacturer unless indicated otherwise on the drawings or specified herein.
- D. Fixtures shall be mounted at mounting heights as indicated.
- E. If fixtures and equipment indicated in the Contract Documents are not currently manufactured, the manufacturer's current equivalent to the indicated fixtures and equipment shall be provided at no additional cost, subject to review and acceptance by the Professional.

2.2 PLUMBING FIXTURES

- A. See Plumbing Fixture Schedule on Drawings for Fixture Specification. Manufacturers shall be equal to those listed on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fixtures and equipment shall be installed in a neat and workmanlike manner and in accordance with the manufacturer's recommendations. The quality of installation shall be subject to the approval of the Professional.
- B. All wall mounted lavatories, chair carriers and supports shall be suitable to the type of construction wherein they are located. Urinals and water closets shall be supported by chair carriers.
- C. All fixtures and equipment must be protected against damage during the progress of construction. Upon completion of construction, all fixtures and equipment must be thoroughly cleaned and left in perfect working order. All piping and accessories having polished, plated or finished surfaces shall be protected to prevent scarring or other damage and protect the finish against damage.
- D. Provide isolation valves for all fixtures, equipment, and accessories.
- E. All fixture supplies and waste lines shall be run to wall unless construction requires, they be run to floor. All supplies through walls shall be provided with angle stops. All

supplies through floors shall be provided with straight stops. Unions shall be provided adjacent to all equipment or wherever necessary to facilitate the removal of equipment for repair or replacement. Unions for copper tubing up to and including 2-inch diameter shall be brass ground joint with socket ends for solder. Unions for copper tubing 2-1/2 inches in diameter and over shall be standard brass flanges and so stamped. No lip type unions or long screws will be permitted. The contractor shall furnish and install all structural steel angles, channels, etc. necessary to properly support all fixtures and equipment to the satisfaction of the Professional.

- F. Drain piping from all backflow preventers, relief valves and vents, drain down connections, kitchen equipment, etc. shall be extended to within 4 inches of a floor sink or floor drain unless otherwise directed.
- G. Mop receptor drains shall be sized for the outlet pipe size shown on the drawings and shall be equipped with a deep seal P-trap. The contractor shall be responsible for proper height setting and leveling of drains.
- H. Water closet floor flanges shall be cast iron, screwed or caulked, not less than ¼ inch thick; not less than 2 inches caulking depth. Bolted with approved gasket between closet bowl and flange. Closet screws shall be of brass. The use of commercial putty or plaster for setting closet bowls is prohibited.
- I. Apply a bead of waterproof caulking around the edge of surface mounted plumbing fixture to mask any irregularities between the fixture and wall finish. Color of caulk shall match the fixture color.

3.2 MOUNTING HEIGHTS

- A. Plumbing fixture mounting heights shall be as indicated on the drawings. Mounting heights for barrier free fixtures shall meet the requirements of the ADA Accessibility guidelines. These guidelines shall apply unless superseded by more stringent State or Local requirements.

END OF SECTION 22 42 00

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 COORDINATION

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.
- C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined *10 CFR Part 431* published by the US Department of Energy
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T 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.

2.6 VARIABLE FREQUENCY DRIVES

A. Scope

- a. This section provides requirements for AC inverter type adjustable frequency, variable speed drives or herein identified as AC drives for use with (NEMA B, NEMA A, NEMA C, NEMA E, synchronous) design AC motors.
- b. All cabling from VFDs feeding associated equipment shall consist of 3-phase, 3 ground, copper tape spiral shield, galvanized steel interlocked armor cable.

B. Manufacturers

- a. The manufacturer of the AC drive shall be a certified ISO 9001 quality facility. ABB, Danfoss (Graham), Eaton, Emerson, Johnson Controls or prior approved equal meeting the requirements of this section.
- b. All VFD's in project shall be by the same manufacturer. This shall include all pumps and air handler fans, where indicated on the plans.

C. Regulatory Requirements

- a. UL listed.
- b. EN Standard CE marked for the following:
 - Low Voltage Directive (73/23/EEC)
 - EN50178
 - EMC Directive (89/336/EEC)
 - EN61800-3 Adjustable Speed electrical power drive systems Part 3
- c. Designed, constructed and tested in accordance with NEMA, ICS, NFPA and IEC standards.

D. Environmental Requirements

- a. The AC drive construction ½ hp to 5 hp 230V and 1 hp to 7.5 hp 480V shall be IP20/open according to Standard EN50178. 7.5 hp to 10 hp 230V and 10 hp to 20 hp 480V shall be Type 1. Both are designed to operate as Pollution degree 2 conforming to IEC 664-1, EN50718 and NEMA ICS-1. Drives above 20 hp 480V and 15 hp 230V shall meet Type 1 Pollution degree 3 according to IEC 664-1, EN50718 and NEMA ICS-1.
- b. The AC drive will be designed to operate in an ambient temperature from 0 to 40 degrees C (32 to 104 degrees F).
- c. The storage temperature range shall be -25 to 70 degrees C.
- d. The maximum relative humidity shall be 95% at 40 degrees C, non-condensing.
- e. The AC drive will be rated to operate at altitudes less than or equal to 1000m (3300 ft).
- f. The AC drive will meet the IEC 68-2-6-vibration specification.
- g. The AC drive shall be designed and constructed to be of finger safe construction with enclosure open to operator access according to IP20 standards.

E. Related Document

- a. Division 26 – Electrical

F. Equipment

- a. General Description
 - i. The AC drive shall utilize soft switching technology and voltage vector control.
 - ii. The AC drive shall have the Hand/Off/Auto function.
 - iii. The AC drive shall have a VFD/bypass system design that is serviceable while operating in bypass mode. This includes a drive disconnect to ensure service personnel safety, a 2-contactor bypass for full speed operation, and an isolation barrier to ensure service personnel safety and repair of the drive while operating in full speed bypass mode. Bypass shall have a separate integral disconnect.
 - iv. Each AC drive shall have voltage/single phase protection of the drive and bypass system to ensure continued operation after utility power failures. Drive protection modules shall be ATC Diversified Electronics SLU-100-ASA 0315PB or equivalent. Protection modules shall monitor incoming 480V 3-phase power and shall interrupt 120V control circuit. Install modules in drive cabinet.
 - v. The AC drive shall have common control in both drive and bypass modes.
 - vi. Each AC drive shall have M.O.V. lightning protection.
 - vii. The AC drive shall have safety interlocks for all modes of operation.
 - viii. A manufacturer's warranty shall be provided on all materials and workmanship of no less than 1 year from the date of start-up or 18 months from date of shipment.
- b. Ratings

- i. The AC drive shall be designed to operate from an input voltage of 208/230 +/- 15% VAC or 400/460 +/-15% VAC.
- ii. The AC drive shall operate from an input voltage frequency range from 47.5 to 63 Hz.
- iii. The displacement power factor shall not be less than 0.95 lagging under any speed or load condition.
- iv. The efficiency of the AC drive at 100% speed and load shall not be less than 96%.
- v. The constant torque overtorque capacity will be 150% for 1 minute (The variable torque overtorque capacity will be 110% for 1 minute).
- vi. The output switching frequency of the drive will be randomly modulated and selectable at 2 kHz, 4 kHz, 12 kHz or 16 kHz depending on drive rating for low noise operation.
- vii. The output frequency shall be from 0.1 to 500 Hz (selectable at 50 Hz, 60 Hz, 200 Hz, 500 Hz).
- viii. The AC drive will be able to provide rated motor torque at 0.5 Hz in a Sensorless Flux Vector mode using a standard motor and no tachometer feedback.

c. Protection

- i. Upon power-up, the AC drive shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, (dynamic brake failure), DC to DC power supply, control power, and the pre-charge circuit.
- ii. The AC drive shall be protected against short circuits between output phases; between output phases and ground; on the control terminal outputs; and the internal supplies. The logic and analog outputs shall also be optically isolated.
- iii. The AC drive shall have a minimum of power loss ride-through of 200 msec. The AC drive shall have the user-defined option of frequency fold-back to increase the duration of the power loss ride-through.
- iv. The AC drive shall have a selectable ride through function which will allow the logic to maintain control for a minimum of one second without faulting.
- v. For a fault condition other than ground fault, short circuit or internal fault, an auto restart function will provide restart.
- vi. The deceleration mode of the AC drive shall be programmable for normal and fault conditions. The stop modes shall include free-wheel stop, fast stop and DC injection braking.

- vii. A synchronized restart shall be provided that will catch a spinning motor by sensing the motor frequency and rotational direction and synchronize the AC drive's output prior to restarting.
- viii. Upon loss of the analog process follower reference signal, the AC drive shall fault ad/or operate at a user defined speed set between software programmed low speed and high-speed settings.
- ix. The AC drive shall have solid state protection that is UL listed and meets UL 508C as a Class 20 overload protection and meets IEC 947. The adjustment shall be from 0.45 to 1.05 percent of the current output of the AC drive.
- x. The AC drive shall have a thermal switch with a user selectable pre-alarm that will provide a minimum of 60 seconds delay before over temperature fault.

d. Operator Interface

- i. The full English operator interface terminal will offer the modification of AC drive adjustments via a touch keypad. All electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics will be shown.
- ii. The AC drive keyboard will announce horsepower and voltage.
- iii. The display shall be capable to be configured to display multiple parameters with numeric data that is selectable and scalable by the operator. A user defined display value proportional to output frequency shall be available. As a minimum the display values shall consist of speed reference, output frequency, output current, motor torque, output voltage, line voltage, DC voltage, motor thermal state, drive thermal state, motor speed and output power.

G. Execution

a. Installation

- i. The installation shall be in compliance with the manufacturer's instructions, drawings and recommendations. The AC drive manufacturer shall provide a factory certified technical representative to supervise the contractor's installation, testing and start-up of the AC drive(s).
- ii. The contractor shall assume the responsibility for coordinating the purchased equipment with the motor served and with the automatic temperature control system, paying specific attention to the signal sent and received, the ground source and the required speed range.
- iii. The manufacturer shall provide start-up of the variable frequency drive and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. The commissioning personnel shall be the same personnel that will provide the factory service and warranty repairs at the customer's site. Sales personnel and other agents who are not factory certified technicians for VFD field repair are not acceptable as commissioning agents.

Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system. Start-up shall include customer operator training at the time of the equipment commissioning.

- iv. The VFD shall be mounted with operator interface between 4'-6" and 5'-6" above finished floor for visibility and accessibility.

H. Training

- a. An on-site training session of (4) hours duration shall be provided by a representative of the AC drive manufacturer and shall included in the base bid for the project.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 05 13

EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Expansion compensators.
 - 2. Rubber expansion joints.
 - 3. Flexible-hose expansion joints.
 - 4. Pipe bends and loops.

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. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.
 - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
- C. Welding certificates.
- D. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.
- E. 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:
 - 1. Steel Shapes and Plates: AWS D1.1, "Structural Welding Code - Steel."
 - 2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

- A. Expansion Compensators: Double-ply corrugated steel, stainless-steel, or copper-alloy bellows in a housing with internal guides, antitorque device, and removable end clip for positioning.
 - 1. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
 - 2. Configuration for Copper Piping: Two-ply phosphor-bronze or stainless-steel bellows and bronze or stainless-steel shroud.
 - 3. Configuration for Steel Piping: Two-ply stainless-steel bellows and carbon-steel shroud.
 - 4. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
 - 5. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Solder joint or threaded.
 - 6. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
 - 7. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Flanged or threaded.

- B. Rubber Expansion Joints: ASTM F 1123, fabric-reinforced rubber with external control rods and complying with FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
1. Arch Type: Single arches.
 2. Spherical Type: Single spheres.
 - a. Minimum Pressure and Temperature Ratings for NPS 1-1/2 to NPS 4: 150 psig at 220 deg F.
 - b. Minimum Pressure and Temperature Ratings for NPS 5 and NPS 6: 150 psig at 220 deg F.
 - c. Minimum Pressure and Temperature Ratings for NPS 8 to NPS 12: 150 psig at 220 deg F.
 3. Material: BR.
 4. End Connections: Full-faced, integral, steel flanges with steel retaining rings.
- C. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.
1. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder-joint end connections.
 - a. NPS 2 and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
 - b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
 2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder-joint end connections.
 - a. NPS 2 and Smaller: Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.
 - b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.
 3. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and flanged end connections for NPS 2-1/2 and larger.
 - a. NPS 2 and Smaller: Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
 - b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
 - c. NPS 8 to NPS 12: Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.
 4. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and flanged end connections for NPS 2-1/2 and larger.

- a. NPS 2 and Smaller: Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.
- b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.
- c. NPS 8 and Larger: Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

2.2 MATERIALS FOR ANCHORS

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

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

- A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

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

3.2 PIPE BEND AND LOOP INSTALLATION

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

3.3 SWING CONNECTIONS

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

3.4 ALIGNMENT-GUIDE INSTALLATION

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

3.5 ANCHOR INSTALLATION

- A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.
- C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.
- D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints or compensators are indicated.

- E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION 23 05 16

METERS AND GAGES 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:
 - 1. Thermometers.
 - 2. Gages.
 - 3. Test plugs.
 - 4. Flowmeters.
 - 5. Thermal-energy meters.

1.3 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated; include performance curves.
- B. Shop Drawings: Schedule for thermometers, gages, flowmeters and thermal-energy meters indicating manufacturer's number, scale range, and location for each.
- C. Product Certificates: For each type of thermometer, gage, flowmeter and thermal-energy meter, signed by product manufacturer.
- D. Operation and Maintenance Data: For flowmeters and thermal-energy meters to include operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

- A. Case: Die-cast aluminum or brass, 7 inches long.
- B. Tube: Red or blue reading, mercury or organic liquid filled, with magnifying lens.
- C. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- D. Window: Glass or plastic.
- E. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- F. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- G. 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 DUCT-TYPE, LIQUID-IN-GLASS THERMOMETERS

- A. Case: Die-cast aluminum, 7 inches long.
- B. Tube: Red or blue reading, mercury or organic filled, with magnifying lens.
- C. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- D. Window: Glass or plastic.
- E. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- F. Stem: Metal, for installation in mounting bracket and of length to suit installation.
- G. Mounting Bracket: Flanged fitting for attachment to duct and made to hold thermometer stem.
- H. Accuracy: Plus, or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.3 THERMOWELLS

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

- B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.4 PRESSURE GAGES

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

1. Case: Liquid-filled type, drawn steel or cast aluminum, 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass or plastic.
8. Ring: Brass.
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.

- B. Remote-Mounting, Dial-Type Pressure Gages: ASME B40.100, indicating-dial type.

1. Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter for panel mounting.
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.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass or plastic.
8. Ring: Brass.
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. Syphons: NPS 1/4 coil of brass tubing with threaded ends.
3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.5 TEST PLUGS

- A. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

- B. Minimum Pressure and Temperature Rating: 300 psig at 250 deg F.
- C. Core Inserts: One or two self-sealing rubber valves.
 - 1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
 - 2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.
- D. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, two thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
 - 1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be 0 to 200 psig.
 - 2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F.
 - 3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
 - 4. Carrying case shall have formed instrument padding.

2.6 WAFER-ORIFICE FLOWMETERS

- A. Description: Differential-pressure-design orifice insert for installation between pipe flanges; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.
- B. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
- C. Pressure Rating: 300 psig.
- D. Temperature Rating: 250 deg F.
- E. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.
- F. Permanent Indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
 - 1. Scale: Gallons per minute.
 - 2. Accuracy: Plus, or minus 1 percent between 20 and 80 percent of range.
- G. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot hoses in carrying case.
 - 1. Scale: Gallons per minute.
 - 2. Accuracy: Plus, or minus 2 percent between 20 and 80 percent of range.
- H. Operating Instructions: Include complete instructions with each flowmeter.

2.7 VENTURI FLOWMETERS

- A. Description: Differential-pressure design for installation in piping; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.
- B. Construction: Bronze, brass, or factory-primed steel; with brass fittings and attached tag with flow conversion data.
- C. Pressure Rating: 300 psig.
- D. Temperature Rating: 250 deg F.
- E. End Connections for NPS 2 and Smaller: Threaded.
- F. End Connections for NPS 2-1/2 and Larger: Flanged or welded.
- G. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.
- H. Permanent Indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
 - 1. Scale: Gallons per minute.
 - 2. Accuracy: Plus, or minus 1 percent between 20 and 80 percent of range.
- I. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot hoses in carrying case.
 - 1. Scale: Gallons per minute.
 - 2. Accuracy: Plus, or minus 2 percent between 20 and 80 percent of range.
- J. Operating Instructions: Include complete instructions with each flowmeter.

2.8 TURBINE FLOWMETERS

- A. Description: Insertion type for inserting turbine into piping and measuring flow directly in gallons per minute.
- B. Construction: Bronze or stainless-steel body; with plastic turbine or impeller and integral direct-reading scale.
- C. Pressure Rating: 150 psig minimum.
- D. Temperature Rating: 220 deg F. minimum.
- E. Display: Visual instantaneous rate of flow.

- F. Accuracy: Plus, or minus 2-1/2 percent.

2.9 PITOT-TUBE FLOWMETERS

- A. Description: Insertion-type, differential-pressure design for inserting probe into piping and measuring flow directly in gallons per minute.
- B. Construction: Stainless-steel probe of length to span inside of pipe; with integral transmitter and direct-reading scale.
- C. Pressure Rating: 150 psig minimum.
- D. Temperature Rating: 220 deg F. minimum.
- E. Display: Visual instantaneous rate of flow.
- F. Integral Transformer: For low-voltage power connection.
- G. Accuracy: Plus, or minus 1 percent for liquids and gases.

2.10 FLOW INDICATORS

- A. Description: Instrument for installation in piping systems for visual verification of flow.
- B. Construction: Bronze or stainless-steel body; with sight glass and plastic pelton-wheel indicator and threaded or flanged ends.
- C. Pressure Rating: 150 psig.
- D. Temperature Rating: 220 deg F.
- E. End Connections for NPS 2 and Smaller: Threaded.
- F. End Connections for NPS 2-1/2 and Larger: Flanged.

2.11 INSERTION-TURBINE, THERMAL-ENERGY METER SYSTEMS

- A. Description: Flow sensor, strainer, two temperature sensors, transmitter, meter, and connecting wiring.
- B. Flow Sensor: Insertion-type turbine or paddle-wheel element with corrosion-resistant-metal body and transmitter.
 - 1. Pressure Rating: 150 psig.
 - 2. Temperature Range: 40 to 250 deg F.
- C. Meter: Solid-state integrating type.

1. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
2. Accuracy: Plus, or minus 1 percent.
3. Battery Pack: Five-year lithium battery.

D. Strainer: Full size of main line piping.

2.12 INLINE-TURBINE, THERMAL-ENERGY METER SYSTEMS

A. Description: Flow sensor, two temperature sensors, transmitter, meter, and connecting wiring.

B. Flow Sensor: Turbine-type water meter with corrosion-resistant-metal body and transmitter.

1. Pressure Rating: 150-psig minimum working-pressure rating.
2. Temperature Range: 40 to 250 deg F.

C. Meter: Solid-state integrating type.

1. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
2. Accuracy: Plus, or minus 1 percent.
3. Battery Pack: Five-year lithium battery.

D. Strainer: Full size of main line piping.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install liquid-in-glass thermometers as indicated on the drawings and in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler and chiller.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Outside-air, return-air, and mixed-air ducts.

B. Provide the following temperature ranges for thermometers:

1. Heating Hot Water: 30 to 240 deg F, with 2-degree scale divisions.
2. Chilled Water: 30 to 120 deg F, with 2-degree scale divisions.
3. Air Ducts: Minus 40 to plus 110 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 liquid-filled-case-type pressure gages at chilled water inlets and outlets of chillers.

- C. Install liquid-filled-case-type pressure gages at suction and discharge of each pump.

3.3 INSTALLATIONS

- A. Install direct-mounting thermometers and adjust vertical and tilted positions.
- B. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.
- C. Install thermowells with socket extending one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated.
- D. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.
- E. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
- F. Install remote-mounting pressure gages on panel.
- G. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).
- H. Install needle-valve and syphon fitting in piping for each pressure gage for steam.
- I. Install test plugs in tees in piping.
- J. Install flow indicators, in accessible positions for easy viewing, in piping systems.
- K. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.
- L. Install flowmeter elements in accessible positions in piping systems.
- M. Install differential-pressure-type flowmeter elements with at least minimum straight lengths of pipe upstream and downstream from element as prescribed by manufacturer's written instructions.
- N. Install wafer-orifice flowmeter elements between pipe flanges.
- O. Install permanent indicators on walls or brackets in accessible and readable positions.
- P. Install connection fittings for attachment to portable indicators in accessible locations.
- Q. Install flowmeters at discharge of hydronic system pumps and at inlet of hydronic air coils.
- R. Assemble components and install thermal-energy meters.
- S. Mount meters on wall if accessible; if not, provide brackets to support meters.

3.4 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy-meter transmitters to meters.

3.5 ADJUSTING

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

END OF SECTION 23 05 19

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 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
 - 3. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
 - 4. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
 - 5. Division 23 Section(s) "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel pipe hangers and supports.
 - 2. Fiberglass pipe hangers.
 - 3. Thermal-hanger shield inserts.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze pipe hangers. Include Product Data for components.
 - 2. Metal framing systems. Include Product Data for components.
 - 3. Pipe stands. Include Product Data for components.
 - 4. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel.", AWS D1.3, "Structural Welding Code--Sheet Steel.", AWS D1.4, "Structural Welding Code--Reinforcing Steel." and ASME Boiler and Pressure Vessel Code: Section IX.
- B. Welding: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1, "Structural Welding Code--Steel."
 - 2. AWS D1.2, "Structural Welding Code--Aluminum."
 - 3. AWS D1.3, "Structural Welding Code--Sheet 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. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 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. Material: Carbon Steel
- C. Coating: Galvanized, Hot dipped galvanized
- 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. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
- C. 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. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

- A. Mechanical-Expansion Anchors: Insert-wedge-type 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.

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 base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 1. Base: Plastic.
 - 2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 3. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Bases: One or more plastic.
 2. Vertical Members: Two or more protective-coated-steel channels.
 3. Horizontal Member: Protective-coated-steel channel.
 4. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.8 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.
1. Properties: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use 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.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated 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-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.
 - 2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.
- G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- I. Install hangers and supports to allow controlled thermal 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 procedure 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 2”.

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 23 05 29

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 SUBMITTAL

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment (Note: Plastic Labels utilized in a return air plenum shall be listed and approved for use in a return air plenum):
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch-thick, and having predrilled holes for attachment hardware.
 2. Letter Color: White.
 3. Background Color: Red.
 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

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.
- B. Letter Color: Red.
- C. Background Color: White.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. (Note: Plastic Labels utilized in a return air plenum shall be listed and approved for use in a return air plenum):
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, and as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

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

2.5 CEILING DOT

- A. Provide color coded ceiling dot where HVAC isolation valves & equipment are located above. Conform to owner color standard.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surface 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.
- B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above, removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Chilled-Water Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.
2. Heating Water Piping:
 - a. Background Color: Yellow.
 - b. Letter Color: Black.
3. Refrigerant Piping:
 - a. Background Color: Yellow.
 - b. Letter Color: Black.
4. Drain Piping:
 - a. Background Color: Yellow.
 - b. Letter 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; and shutoff valves. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 1. Valve-Tag Size and Shape:
 - a. Chilled Water: 2 inches, round.
 - b. Refrigerant: 2 inches, round.
 - c. Hot Water: 2 inches, round.
 - d. Gas: 2 inches, round.
 2. Valve-Tag Color:
 - a. Chilled Water: Natural.
 - b. Refrigerant: Natural.
 - c. Hot Water: Natural.

d. Gas: Natural.

3. Letter Color:

a. Chilled Water: Black.

b. Refrigerant: Black.

c. Hot Water: Black.

d. Gas: Black.

3.5 WARNING-TAG INSTALLATION

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

3.6 CEILING DOT INSTALLATION

- A. Locate on ceiling grid below associated valve

END OF SECTION 23 05 23

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes TAB to produce design objectives for the following:

- 1. Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
- 2. Hydronic Piping Systems:
 - a. Constant-flow systems.
 - b. Variable-flow systems.
 - c. Primary-secondary systems.
- 3. HVAC equipment quantitative-performance settings.
- 4. Kitchen hood airflow balancing.
- 5. Space pressurization testing and adjusting.
- 6. Vibration measuring.
- 7. Sound level measuring.
- 8. Indoor-air quality measuring.
- 9. Existing systems TAB.
- 10. Verifying that automatic control devices are functioning properly.
- 11. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

- C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
- D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- E. NC: Noise criteria.
- F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- G. RC: Room criteria.
- H. Report Forms: Test data sheets for recording test data in logical order.
- I. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.
- J. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.
- K. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.
- L. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- M. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- N. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- O. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- P. TAB: Testing, adjusting, and balancing.
- Q. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- R. Test: A procedure to determine quantitative performance of systems or equipment.
- S. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

- A. Qualification Data: Within 15 days from Contractor's Notice to Proceed, submit 4 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 45 days from Contractor's Notice to Proceed, submit 4 copies of the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit 4 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
- D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- E. Sample Report Forms: Submit two sets of sample TAB report forms.
- F. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by AABC or NEBB.
- B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.
 - 1. Agenda Items: Include at least the following:
 - a. Submittal distribution requirements.
 - b. The Contract Documents examination report.
 - c. TAB plan.
 - d. Work schedule and Project-site access requirements.
 - e. Coordination and cooperation of trades and subcontractors.
 - f. Coordination of documentation and communication flow.
- C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

- D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
- E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."
- F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
 - 1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.
- G. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2007, Section 7.2.2 - "Air Balancing."
- H. ASHRAE/IESNA 90.1-2007 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2007, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

- A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.8 WARRANTY

- A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 2. Systems are balanced to optimum performance capabilities within design and installation limits.
- B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
 2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201,

"Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible, and their controls are connected and functioning.
- L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.
- M. Examine strainers for clean screens and proper perforations.
- N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- P. Examine system pumps to ensure absence of entrained air in the suction piping.
- Q. Examine equipment for installation and for properly operating safety interlocks and controls.
- R. Examine automatic temperature system components to verify the following:
 - 1. Dampers, valves, and other controlled devices are operated by the intended controller.
 - 2. Dampers and valves are in the position indicated by the controller.
 - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
 - 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
 - 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 - 6. Sensors are located to sense only the intended conditions.

7. Sequence of operation for control modes is according to the Contract Documents.
 8. Controller set points are set at indicated values.
 9. Interlocked systems are operating.
 10. Changeover from heating to cooling mode occurs according to indicated values.
- S. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
1. Permanent electrical power wiring is complete.
 2. Hydronic systems are filled, clean, and free of air.
 3. Automatic temperature-control systems are operational.
 4. Equipment and duct access doors are securely closed.
 5. Balance, smoke, and fire dampers are open.
 6. Isolating and balancing valves are open and control valves are operational.
 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
1. Comply with requirements in ASHRAE 62.1-2007, Section 7.2.2 - "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling unit components.
- L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 - 2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

- a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
 3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
 4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
 5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
 6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
 - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure terminal outlets and inlets without making adjustments.
1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.
1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
- B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 3. Measure total system airflow. Adjust to within indicated airflow.
 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
 7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 8. Record the final fan performance data.
- C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance systems similar to constant-volume air systems.
 2. Set terminal units and supply fan at full-airflow condition.
 3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 4. Readjust fan airflow for final maximum readings.
 5. Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.

6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
 7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
 8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
- D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
 3. Set terminal units at full-airflow condition.
 4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 5. Adjust terminal units for minimum airflow.
 6. Measure static pressure at the sensor.
 7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 1. Open all manual valves for maximum flow.
 2. Check expansion tank liquid level.
 3. Check makeup-water-station pressure gage for adequate pressure for highest vent.

4. Check flow-control valves for specified sequence of operation and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
 1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 4. Report flow rates that are not within plus or minus 5 percent of design.
- B. Set calibrated balancing valves, if installed, at calculated presettings.
- C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
 1. Determine the balancing station with the highest percentage over indicated flow.
 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 3. Record settings and mark balancing devices.
- F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

- G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS

- A. Balance the primary system crossover flow first, then balance the secondary system.

3.11 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.12 PROCEDURES FOR CHILLERS

- A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. If water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatt.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatt.
6. Capacity: Calculate in tons of cooling.

7. If air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.13 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

3.14 PROCEDURES FOR BOILERS

- A. If hydronic, measure entering- and leaving-water temperatures and water flow.
- B. If steam, measure entering-water temperature and flow and leaving steam pressure, temperature, and flow.

3.15 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Water Coils: Measure the following data for each coil:
 1. Entering- and leaving-water temperature.
 2. Water flow rate.
 3. Water pressure drop.
 4. Dry-bulb temperature of entering and leaving air.
 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 6. Airflow.
 7. Air pressure drop.
- B. Refrigerant Coils: Measure the following data for each coil:
 1. Dry-bulb temperature of entering and leaving air.
 2. Wet-bulb temperature of entering and leaving air.
 3. Airflow.
 4. Air pressure drop.
 5. Refrigerant suction pressure and temperature.

3.16 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

- C. Measure outside-air, wet- and dry-bulb temperatures.

3.17 PROCEDURES FOR COMMERCIAL KITCHEN HOODS

- A. Measure, adjust, and record the airflow of each kitchen hood. For kitchen hoods designed with integral makeup air, measure and adjust the exhaust and makeup airflow. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.
 - 1. Install welded test ports in the sides of the exhaust duct for the duct Pitot-tube traverse. Install each test port with a threaded cap that is liquid tight.
- B. After balancing is complete, do the following:
 - 1. Measure and record the static pressure at the hood exhaust-duct connection.
 - 2. Measure and record the hood face velocity. Make measurements at multiple points across the face of the hood. Perform measurements at a maximum of 12 inches (300 mm) between points and between any point and the perimeter. Calculate the average of the measurements recorded. Verify that the hood average face velocity complies with the Contract Documents and governing codes.
 - 3. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to room airflow patterns to achieve optimum results.
- C. Visually inspect the hood exhaust duct throughout its entire length in compliance with authorities having jurisdiction. Begin at the hood connection and end at the point it discharges outdoors. Report findings.
 - 1. Check duct slopes as required.
 - 2. Verify that duct access is installed as required.
 - 3. Verify that point of termination is as required.
 - 4. Verify that duct air velocity is within the range required.
 - 5. Verify that duct is within a fire-rated enclosure.
- D. Report deficiencies.

3.18 PROCEDURES FOR VIBRATION MEASUREMENTS

- A. Use a vibration meter meeting the following criteria:
 - 1. Solid-state circuitry with a piezoelectric accelerometer.
 - 2. Velocity range of 0.1 to 10 inches per second.
 - 3. Displacement range of 1 to 100 mils.
 - 4. Frequency range of at least 0 to 1000 Hz.
 - 5. Capable of filtering unwanted frequencies.
- B. Calibrate the vibration meter before each day of testing.
 - 1. Use a calibrator provided with the vibration meter.
 - 2. Follow vibration meter and calibrator manufacturer's calibration procedures.

- C. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.
 - 1. Turn off equipment in the building that might interfere with testing.
 - 2. Clear the space of people.
- D. Perform vibration measurements after air and water balancing and equipment testing is complete.
- E. Clean equipment surfaces in contact with the vibration transducer.
- F. Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.
- G. Measure and record vibration on rotating equipment over 3 hp.
- H. Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.
 - 1. Pumps:
 - a. Pump Bearing: Drive end and opposite end.
 - b. Motor Bearing: Drive end and opposite end.
 - c. Pump Base: Top and side.
 - d. Building: Floor.
 - e. Piping: To and from the pump after flexible connections.
 - 2. Fans and HVAC Equipment with Fans:
 - a. Fan Bearing: Drive end and opposite end.
 - b. Motor Bearing: Drive end and opposite end.
 - c. Equipment Casing: Top and side.
 - d. Equipment Base: Top and side.
 - e. Building: Floor.
 - f. Ductwork: To and from equipment after flexible connections.
 - g. Piping: To and from equipment after flexible connections.
 - 3. Chillers and HVAC Equipment with Compressors:
 - a. Compressor Bearing: Drive end and opposite end.
 - b. Motor Bearing: Drive end and opposite end.
 - c. Equipment Casing: Top and side.
 - d. Equipment Base: Top and side.
 - e. Building: Floor.
 - f. Piping: To and from equipment after flexible connections.

- I. For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.
- J. Inspect, measure, and record vibration isolation.
 - 1. Verify that vibration isolation is installed in the required locations.
 - 2. Verify that installation is level and plumb.
 - 3. Verify that isolators are properly anchored.
 - 4. For spring isolators, measure the compressed spring height, the spring OD, and the travel-to-solid distance.
 - 5. Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

3.19 PROCEDURES FOR SOUND-LEVEL MEASUREMENTS

- A. Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.
- B. Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and that has NIST certification.
- C. Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm, use a windscreen on the microphone.
- D. Perform sound-level testing after air and water balancing and equipment testing are complete.
- E. Close windows and doors to the space.
- F. Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.
- G. Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.
- H. Take sound measurements at a height approximately 48 inches above the floor and at least 36 inches from a wall, column, and other large surface capable of altering the measurements.
- I. Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.
- J. Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.

1. Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.
- K. Perform sound testing at <Insert number> locations on Project for each of the following space types. For each space type tested, select a measurement location that has the greatest sound level. If testing multiple locations for each space type, select at least one location that is near and at least one location that is remote from the predominant sound source.
1. Private office.
 2. Open office area.
 3. Conference room.
 4. Auditorium/large meeting room/lecture hall.
 5. Classroom/training room.
 6. Patient room/exam room.
 7. Sound or vibration sensitive laboratory.
 8. Hotel room/apartment.
 9. Each space with a noise criterion of RC or NC 25 or lower.
 10. Each space with an indicated noise criterion of RC or NC 35 and lower that is adjacent to a mechanical equipment room or roof mounted equipment.
 11. Inside each mechanical equipment room.

3.20 PROCEDURES FOR INDOOR-AIR QUALITY MEASUREMENTS

- A. After air balancing is complete and with HVAC systems operating at indicated conditions, perform indoor-air quality testing.
- B. Observe and record the following conditions for each HVAC system:
1. The distance between the outside-air intake and the closest exhaust fan discharge, cooling tower, flue termination, or vent termination.
 2. Specified filters are installed. Check for leakage around filters.
 3. Cooling coil drain pans have a positive slope to drain.
 4. Cooling coil condensate drain trap maintains an air seal.
 5. Evidence of water damage.
 6. Insulation in contact with the supply, return, and outside air is dry and clean.
- C. Measure and record indoor conditions served by each HVAC system. Make measurements at multiple locations served by the system if required to satisfy the following:
1. Most remote area.
 2. One location per floor.
 3. One location for every 5000 sq. ft..
- D. Measure and record the following indoor conditions for each location two times at two-hour intervals, and in accordance with ASHRAE 113:
1. Temperature.
 2. Relative humidity.

3. Air velocity.
4. Concentration of carbon dioxide (ppm).
5. Concentration of carbon monoxide (ppm).
6. Nitrogen oxides (ppm).
7. Formaldehyde (ppm).

3.21 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.
- D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.
- F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
- G. Check the interaction of electrically operated switch transducers.
- H. Check the interaction of interlock and lockout systems.
- I. Check main control supply-air pressure and observe compressor and dryer operations.
- J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
- K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.22 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances (code required minimums must meet or exceed rates indicated on plans):
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Minus 5 to plus 10 percent.
 2. Air Outlets and Inlets: minus 10 to plus 10 percent.
 3. Heating-Water Flow Rate: minus 10 to plus 10 percent.
 4. Cooling-Water Flow Rate: minus 10 to plus 10 percent.

3.23 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.24 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
 - 1. Title page.
 - 2. Name and address of TAB firm.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB firm who certifies the report.
 - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 - 11. Summary of contents including the following:

- a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer, type size, and fittings.
 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outside, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data: Include the following:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 - j. Number of belts, make, and size.
 - k. Number of filters, type, and size.
 2. Motor Data:

- a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
- a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Filter static-pressure differential in inches wg.
 - f. Preheat coil static-pressure differential in inches wg.
 - g. Cooling coil static-pressure differential in inches wg.
 - h. Heating coil static-pressure differential in inches wg.
 - i. Outside airflow in cfm.
 - j. Return airflow in cfm.
 - k. Outside-air damper position.
 - l. Return-air damper position.
 - m. Vortex damper position.

G. Apparatus-Coil Test Reports:

1. Coil Data:
- a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch o.c.
 - f. Make and model number.
 - g. Face area in sq. ft.
 - h. Tube size in NPS.
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
- a. Airflow rate in cfm.
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outside-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.
 - f. Entering-air, wet- and dry-bulb temperatures in deg F.
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - h. Water flow rate in gpm.
 - i. Water pressure differential in feet of head or psig.

- j. Entering-water temperature in deg F.
- k. Leaving-water temperature in deg F.
- l. Refrigerant expansion valve and refrigerant types.
- m. Refrigerant suction pressure in psig.
- n. Refrigerant suction temperature in deg F.
- o. Inlet steam pressure in psig.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

- 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Sheave dimensions, center-to-center, and amount of adjustments in inches.
- 2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 - g. Number of belts, make, and size.
- 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

- 1. Report Data:
 - a. System and air-handling unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft.

- g. Indicated airflow rate in cfm.
- h. Indicated velocity in fpm.
- i. Actual airflow rate in cfm.
- j. Actual average velocity in fpm.
- k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:

- 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Test apparatus used.
 - d. Area served.
 - e. Air-terminal-device make.
 - f. Air-terminal-device number from system diagram.
 - g. Air-terminal-device type and model number.
 - h. Air-terminal-device size.
 - i. Air-terminal-device effective area in sq. ft.
- 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

- 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
- 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.

L. Packaged Chiller Reports:

1. Unit Data:
 - a. Unit identification.
 - b. Make and model number.
 - c. Manufacturer's serial number.
 - d. Refrigerant type and capacity in gal.
 - e. Starter type and size.
 - f. Starter thermal protection size.
 - g. Compressor make and model number.
 - h. Compressor manufacturer's serial number.
2. Water-Cooled Condenser Test Data (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering-water temperature in deg F.
 - d. Leaving-water temperature in deg F.
 - e. Entering-water pressure in feet of head or psig.
 - f. Water pressure differential in feet of head or psig.
3. Air-Cooled Condenser Test Data (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering- and leaving-air temperature in deg F.
4. Evaporator Test Reports (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering-water temperature in deg F.
 - d. Leaving-water temperature in deg F.
 - e. Entering-water pressure in feet of head or psig.
 - f. Water pressure differential in feet of head or psig.
5. Compressor Test Data (Indicated and Actual Values):
 - a. Suction pressure in psig.
 - b. Suction temperature in deg F.
 - c. Discharge pressure in psig.
 - d. Discharge temperature in deg F.
 - e. Oil pressure in psig.
 - f. Oil temperature in deg F.
 - g. Voltage at each connection.
 - h. Amperage for each phase.
 - i. Kilowatt input.
 - j. Crankcase heater kilowatt.

- k. Chilled-water control set point in deg F.
 - l. Condenser-water control set point in deg F.
 - m. Refrigerant low-pressure-cutoff set point in psig.
 - n. Refrigerant high-pressure-cutoff set point in psig.
6. Refrigerant Test Data (Indicated and Actual Values):
- a. Oil level.
 - b. Refrigerant level.
 - c. Relief valve setting in psig.
 - d. Unloader set points in psig.
 - e. Percentage of cylinders unloaded.
 - f. Bearing temperatures in deg F.
 - g. Vane position.
 - h. Low-temperature-cutoff set point in deg F.
- M. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:
- 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Unit make and model number.
 - d. Compressor make.
 - e. Compressor model and serial numbers.
 - f. Refrigerant weight in lb.
 - g. Low ambient temperature cutoff in deg F.
 - 2. Test Data (Indicated and Actual Values):
 - a. Inlet-duct static pressure in inches wg.
 - b. Outlet-duct static pressure in inches wg.
 - c. Entering-air, dry-bulb temperature in deg F.
 - d. Leaving-air, dry-bulb temperature in deg F.
 - e. Condenser entering-water temperature in deg F.
 - f. Condenser leaving-water temperature in deg F.
 - g. Condenser-water temperature differential in deg F.
 - h. Condenser entering-water pressure in feet of head or psig.
 - i. Condenser leaving-water pressure in feet of head or psig.
 - j. Condenser-water pressure differential in feet of head or psig.
 - k. Control settings.
 - l. Unloader set points.
 - m. Low-pressure-cutout set point in psig.
 - n. High-pressure-cutout set point in psig.
 - o. Suction pressure in psig.
 - p. Suction temperature in deg F.
 - q. Condenser refrigerant pressure in psig.

- r. Condenser refrigerant temperature in deg F.
- s. Oil pressure in psig.
- t. Oil temperature in deg F.
- u. Voltage at each connection.
- v. Amperage for each phase.
- w. Kilowatt input.
- x. Crankcase heater kilowatt.
- y. Number of fans.
- z. Condenser fan rpm.
- aa. Condenser fan airflow rate in cfm.
- bb. Condenser fan motor make, frame size, rpm, and horsepower.
- cc. Condenser fan motor voltage at each connection.
- dd. Condenser fan motor amperage for each phase.

N. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

- a. Unit identification.
- b. Location.
- c. Service.
- d. Make and size.
- e. Model and serial numbers.
- f. Water flow rate in gpm.
- g. Water pressure differential in feet of head or psig.
- h. Required net positive suction head in feet of head or psig.
- i. Pump rpm.
- j. Impeller diameter in inches.
- k. Motor make and frame size.
- l. Motor horsepower and rpm.
- m. Voltage at each connection.
- n. Amperage for each phase.
- o. Full-load amperage and service factor.
- p. Seal type.

2. Test Data (Indicated and Actual Values):

- a. Static head in feet of head or psig.
- b. Pump shutoff pressure in feet of head or psig.
- c. Actual impeller size in inches.
- d. Full-open flow rate in gpm.
- e. Full-open pressure in feet of head or psig.
- f. Final discharge pressure in feet of head or psig.
- g. Final suction pressure in feet of head or psig.
- h. Final total pressure in feet of head or psig.
- i. Final water flow rate in gpm.
- j. Voltage at each connection.
- k. Amperage for each phase.

O. Boiler Test Reports:

1. Unit Data:

- a. Unit identification.
- b. Location.
- c. Service.
- d. Make and type.
- e. Model and serial numbers.
- f. Fuel type and input in Btuh.
- g. Number of passes.
- h. Ignition type.
- i. Burner-control types.
- j. Voltage at each connection.
- k. Amperage for each phase.

2. Test Data (Indicated and Actual Values):

- a. Operating pressure in psig.
- b. Operating temperature in deg F.
- c. Entering-water temperature in deg F.
- d. Leaving-water temperature in deg F.
- e. Number of safety valves and sizes in NPS.
- f. Safety valve settings in psig.
- g. High limit setting in psig.
- h. Operating-control setting.
- i. High-fire set point.
- j. Low-fire set point.
- k. Voltage at each connection.
- l. Amperage for each phase.
- m. Draft fan voltage at each connection.
- n. Draft fan amperage for each phase.
- o. Manifold pressure in psig.

P. Vibration Measurement Reports:

1. Date and time of test.
2. Vibration meter manufacturer, model number, and serial number.
3. Equipment designation, location, equipment, speed, motor speed, and motor horsepower.
4. Diagram of equipment showing the vibration measurement locations.
5. Measurement readings for each measurement location.
6. Calculate isolator efficiency using measurements taken.
7. Description of predominant vibration source.

Q. Sound Measurement Reports: Record sound measurements on octave band and dBA test forms and on an NC or RC chart indicating the decibel level measured in each frequency band for both "background" and "HVAC system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms:

1. Date and time of test. Record each tested location on its own NC curve.
2. Sound meter manufacturer, model number, and serial number.
3. Space location within the building including floor level and room number.
4. Diagram or color photograph of the space showing the measurement location.
5. Time weighting of measurements, either fast or slow.
6. Description of the measured sound: steady, transient, or tonal.
7. Description of predominant sound source.

R. Indoor-Air Quality Measurement Reports for Each HVAC System:

1. HVAC system designation.
2. Date and time of test.
3. Outdoor temperature, relative humidity, wind speed, and wind direction at start of test.
4. Room number or similar description for each location.
5. Measurements at each location.
6. Observed deficiencies.

S. Instrument Calibration Reports:

1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.25 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:
 - a. Measure airflow of at least 10 percent of air outlets.
 - b. Measure water flow of at least 5 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Measure sound levels at two locations.
 - e. Measure space pressure of at least 10 percent of locations.
 - f. Verify that balancing devices are marked with final balance position.
 - g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect.
3. Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.26 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 23 05 93

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings 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. Calcium silicate.
- b. Cellular glass.
- c. Flexible elastomeric.
- d. Mineral fiber.
- e. Phenolic.
- f. Polyisocyanurate.
- g. Polyolefin.
- h. Polystyrene.
- i. Mass loaded vinyl

2. Adhesives.
3. Mastics.
4. Lagging adhesives.
5. Sealants.
6. Factory-applied jackets.
7. Field-applied fabric-reinforcing mesh.
8. Field-applied cloths.
9. Field-applied jackets.
10. Tapes.
11. Securements.
12. Corner angles.

B. Related Sections:

1. Division 21 Section "Fire-Suppression Systems Insulation."
2. Division 22 Section "Plumbing Insulation."
3. Division 23 Section "Metal Ducts" for duct liners.

4. Division 33 Section "Underground Hydronic Energy Distribution" for loose-fill pipe insulation in underground piping outside the building.

1.3 ACCEPTABLE MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Aeroflex
 2. Armacell
 3. Certain Teed Corp.
 4. Johns Manville
 5. Knauf Insulation
 6. Owens Corning
 7. Pittsburg Corning Corp.

- B. Listing of manufacturers name does not guarantee approval. All equipment must meet or exceed quality and capacities of specified equipment. Final approval will be based on equipment submittals. Any manufacturer not listed but wishing to bid this project shall submit a written request 14 days prior to bid date, prior approval is required for all manufacturers not listed.

1.4 SUBMITTALS

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

- B. Shop Drawings:
 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 2. Detail attachment and covering of heat tracing inside insulation.
 3. Detail insulation application at pipe expansion joints for each type of insulation.
 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 6. Detail application of field-applied jackets.
 7. Detail application at linkages of control devices.
 8. Detail field application for each equipment type.

- C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.
 1. Sample Sizes:
 - a. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
 - b. Sheet Form Insulation Materials: 12 inches square.

- c. Jacket Materials for Pipe: 12 inches long by NPS 2.
 - d. Sheet Jacket Materials: 12 inches square.
 - e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.
- D. Qualification Data: For qualified Installer.
- E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- F. Field quality-control reports.
- G. Chilled water pump insulation installation instructions.

1.5 QUALITY ASSURANCE

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

- A. Coordinate 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.

- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. 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. Calcium Silicate:
 - 1. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 - 2. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
 - 3. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
- G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Block Insulation: ASTM C 552, Type I.
 2. Special-Shaped Insulation: ASTM C 552, Type III.
 3. Board Insulation: ASTM C 552, Type IV.
 4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 5. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
 6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- H. 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.
- I. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- J. 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 FSK jacket. For equipment applications, provide insulation with factory applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- K. 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.
- L. Mineral-Fiber, Preformed Pipe Insulation:
1. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 2. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- M. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.
- N. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- O. Phenolic:

1. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
 2. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
 3. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
 4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - a. Preformed Pipe Insulation: ASJ.
 - b. Board for Duct and Plenum Applications: ASJ.
 - c. Board for Equipment Applications: ASJ.
- P. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
1. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
 2. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches as tested by ASTM E 84.
 3. Fabricate shapes according to ASTM C 450 and ASTM C 585.
 4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - a. Pipe Applications: ASJ-SSL.
 - b. Equipment Applications: ASJ-SSL.
- Q. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
- R. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.
- S. Mass Loaded Vinyl: Flexible, non-reinforced mass loaded vinyl that resists the passage of sound waves and reduced the transmission of airborne noise. Weight of 1 lb/sq ft; 0.100" thickness, -40 deg F to 180 deg F temperature range. Noise transmission loss (db) shall be included in the submittal per ASTM E-90-97 E413-87.

2.2 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. CertainTeed Corp.; FlameChek.
 - b. Johns Manville; Firetemp Wrap.

- c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
- d. Thermal Ceramics; FireMaster Duct Wrap.
- e. 3M; Fire Barrier Wrap Products.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
 - 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).
- C. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
 - 1. 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).
- D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. 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. 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).
- F. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F.
- G. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. 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).
- H. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. 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 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. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 4. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
 - 2. Service Temperature Range: 0 to 180 deg F.
 - 3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 - 4. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
 - 2. Service Temperature Range: Minus 50 to plus 220 deg F.
 - 3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - 4. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 200 deg F.
 - 3. Solids Content: 63 percent by volume and 73 percent by weight.
 - 4. Color: White.

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

4. Color: White.

2.6 SEALANTS

A. Joint Sealants: Cellular-Glass, Phenolic, Polyisocyanurate and Polystyrene Products.

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

B. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.
5. 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 Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.
5. For indoor applications, 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).

2.7 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

6. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.
- B. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.
- C. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for duct, equipment, and pipe.

2.9 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

2.10 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. Adhesive: As recommended by jacket material manufacturer.
 2. Color: Color-code jackets based on system.
 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 4. Factory-fabricated tank heads and tank side panels.
- D. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - a. Finish and thickness are indicated in field-applied jacket schedules.
 - b. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union cover.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
 - a. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - b. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union cover.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

- E. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.

- F. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

- G. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
- H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.11 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 11.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 6.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 - 1. Width: 2 inches.
 - 2. Thickness: 6 mils.
 - 3. Adhesion: 64 ounces force/inch in width.
 - 4. Elongation: 500 percent.
 - 5. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Width: 2 inches.
 - 2. Thickness: 3.7 mils.
 - 3. Adhesion: 100 ounces force/inch in width.
 - 4. Elongation: 5 percent.
 - 5. Tensile Strength: 34 lbf/inch in width.
- E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
 - 1. Width: 3 inches.

2. Film Thickness: 4 mils.
3. Adhesive Thickness: 1.5 mils.
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Width: 3 inches.
2. Film Thickness: 6 mils.
3. Adhesive Thickness: 1.5 mils.
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:

1. 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.
2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

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. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030-inch-thick by 2 inches square.
 - b. Spindle: Aluminum, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

- a. Baseplate: Perforated, nylon sheet, 0.030-inch-thick by 1-1/2 inches in diameter.
 - b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
- a. Baseplate: Galvanized carbon-steel sheet, 0.030-inch-thick by 2 inches square.
 - b. Spindle: Aluminum, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, 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.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.

2.13 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040-inch-thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation 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 prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of 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. 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 duct and 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.

4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at 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. 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" firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves

- and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Pipe: Install insulation continuously through floor penetrations.
 3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

- A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 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 end 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. Provide 1" foam-core insulation on all chilled water pumps. Install pump insulation per foam-core insulation manufacturer's pump insulation installation instructions. Include pump insulation installation instructions with insulation submittals.
 2. 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:
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.

3.7 CALCIUM SILICATE INSULATION INSTALLATION

- A. Insulation Installation on Boiler Breechings and Ducts:
1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.

2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.8 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs 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 cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.9 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.

3.10 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 75 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 75 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, space 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. 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. 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.

3.11 PHENOLIC INSULATION INSTALLATION

A. General Installation Requirements:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders on below ambient services, 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.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.12 POLYISOCYANURATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

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, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.13 POLYOLEFIN INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube 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 polyolefin 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 polyolefin 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 cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
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.

3.14 POLYSTYRENE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

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, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed section of polystyrene insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.15 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.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive

or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.

3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch- circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.16 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

3.17 FINISHES

- A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: Coat exposed outdoor flexible elastomeric insulation with two coats of manufacturer's recommended protective white coating; or cover with aluminum jacketing all exposed outdoor flexible elastomeric insulation, in lieu of paint.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.18 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, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

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

3.19 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply return, and outdoor air.
2. Indoor, exposed outdoor air.
3. Outdoor, concealed supply and return.
4. Outdoor, exposed supply and return.
5. Indoor, concealed and exposed, Type I, commercial, kitchen hood exhaust.
6. Indoor, concealed and exposed kitchen hood make-up air.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Indoor, exposed supply and return air in air conditioned, occupied spaces
4. Exhaust ductwork, including Type II Kitchen Exhaust and Dishwasher Exhaust
5. Factory-insulated flexible ducts.
6. Factory-insulated plenums and casings.
7. Flexible connectors.
8. Vibration-control devices.
9. Factory-insulated access panels and doors.

3.20 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Supply-air Ducts, concealed (installed above ceilings):
 - 1. Mineral-Fiber Blanket: 2 inches thick and installed R-5.0.
- B. Return Air Ducts, Transfer Ducts; Concealed (installed above ceilings):
 - 1. 1" thick flexible elastomeric duct liner (provided with anti-microbial growth coating).
- C. Exposed Supply Ductwork in Air Conditioned, Occupied Spaces:
 - 1. Wrap the first 10'-0" of exposed supply, return or exhaust ductwork in occupied areas with a mass loaded vinyl noise barrier or as noted on plans.
 - 2. Mineral-Fiber Blanket: 1 inch thick and installed R-3.
 - a. Jacket shall be paintable in the field
- D. Exposed Supply and Return Ductwork exposed in Air-Conditioned Utility Spaces (Conditioned Mechanical Rooms or Mechanical Rooms used as Return Air Plenums) and Exposed in Non-Air-Conditioned Spaces (Boiler Rooms, et. Al):
 - 1. Mineral-Fiber Board Insulation: 2 inches thick and installed R-5.0.
- E. Outside-Air Ducts:
 - 1. Mineral-Fiber Blanket: 2 inches thick and installed R-5.0.
- F. Type-I Commercial Kitchen Hood Exhaust Ducts:
 - 1. Fire Rated Insulation System as identified in this specification section.
- G. Type-II Commercial Kitchen Hood and Dishwasher Exhaust Ducts:
 - 1. None.
- H. Kitchen Hood Make-Up Air Ducts:
 - 1. Mineral-Fiber Blanket: 2 inches thick and installed R-6.0.

3.21 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- B. Supply-air, return-air and outside-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 3 inches and 3-lb/cu. ft. nominal density.
 - 2. Mineral-Fiber Board: 3 inches thick and 3-lb/cu. ft. nominal density.

3.22 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
- C. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, condenser bundles, heat-recovery bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles as recommended by the manufacturer.
- D. Chilled-water pump insulation shall be one of the following:
 - 1. Cellular Glass: 2 inches thick.
 - 2. Flexible Elastomeric: 1 inch thick
 - 3. Polyisocyanurate: 1-1/2 inches thick.
- E. Heat-exchanger (water-to-water for cooling service) insulation shall be one of the following:
 - 1. Cellular Glass: 2 inches thick.
 - 2. Flexible Elastomeric: 1 inch thick.
 - 3. Mineral-Fiber Board: 1 inch thick and 2-lb/cu. ft. nominal density.
 - 4. Polyisocyanurate: 1-1/2 inch thick.
- F. Chilled-water expansion/compression tank insulation shall be one of the following:
 - 1. Cellular Glass: 1-1/2 inches thick.
 - 2. Flexible Elastomeric: 1 inch thick.
 - 3. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.
 - 4. Polyisocyanurate: 1 inch thick.
- G. Heating-hot-water expansion/compression tank insulation shall be one of the following:
 - 1. Cellular Glass: 1-1/2 inches thick.
 - 2. Flexible Elastomeric: 1 inch thick.
 - 3. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.
 - 4. Polyisocyanurate: 1 inch thick.
- H. Chilled-water air-separator insulation shall be one of the following:
 - 1. Cellular Glass: 1-1/2 inches thick.
 - 2. Flexible Elastomeric: 1 inch thick.
 - 3. Polyisocyanurate: 1 inch thick.
- I. Heating-hot-water air-separator insulation shall be one of the following:
 - 1. Cellular Glass: 1-1/2 inches thick.
 - 2. Flexible Elastomeric: 1 inch thick.
 - 3. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.
 - 4. Polyisocyanurate: 1 inch thick.

3.23 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.

3.24 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate, Cold Water Make-up and Equipment Drain Water:
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 3/4 inch thick.
 - c. Polyisocyanurate: 1 inch thick.
- B. Chilled Water Supply and Return:
 - 1. Insulation shall be one of the following:
 - a. Cellular Glass: 2 inches thick.
 - b. Phenolic: 1-1/2 inch thick.
 - c. Polyisocyanurate: 1-1/2 inches thick.
- C. Heating-Hot-Water Supply and Return:
 - 1. NPS 1-1/2" and Smaller: Insulation shall be one of the following:
 - a. Cellular Glass: 2 inches thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.
 - c. Phenolic: 1-1/2 inch thick.
 - d. Polyisocyanurate: 1-1/2 inches thick.
 - 2. NPS 2" and Larger: Insulation shall be the following:
 - a. Cellular Glass: 2 inches thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.
 - c. Phenolic: 2 inches thick.
 - d. Polyisocyanurate: 2 inches thick.
- D. Refrigerant Suction and Hot-Gas Piping:
 - 1. Insulation shall be installed per the manufacturer's recommendations.

E. Hot Service Drains:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Calcium Silicate: 1-1/2 inches thick.
 - b. Cellular Glass: 1-1/2 inches thick.
 - c. Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch thick.

F. Hot Service Vents:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Calcium Silicate: 1-1/2 inches thick.
 - b. Cellular Glass: 1-1/2 inches thick.
 - c. Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch thick.

3.25 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 3 inches thick.
 - b. Flexible Elastomeric: 2 inches thick.
 - c. Phenolic: 1-1/2 inch thick.
 - d. Polyisocyanurate: 2 inches thick.

B. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be as recommended by the manufacturer.

3.26 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. Ducts, Plenums, and Piping, concealed (installed above ceilings) and Exposed in Air-Conditioned Occupied Spaces:

1. None.

D. Ducts, Plenums, and Piping, Exposed in Air-Conditioned Utility Spaces (Conditioned Mechanical Rooms and Mechanical Rooms used as Return Air Plenums):

1. 8-ounce canvas with lagging adhesive.

E. Ducts, Plenums, and Piping, Exposed in Non-Air-Conditioned Spaces (Boiler Rooms, et. al.):

1. PVC: 20 mils thick (N/A if installed in a return air plenum).
2. Aluminum, Smooth: 0.016 inch thick.

F. Equipment, concealed (installed above ceilings):

1. None.

G. Equipment, Exposed (all applications):

1. PVC: 20 mils thick (N/A if installed in a return air plenum)
2. Aluminum, Smooth: 0.016 inch thick.

3.27 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Ducts and Plenums, Concealed:

1. PVC: 20 mils thick.
2. Aluminum, Smooth: 0.016 inch thick.

D. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Aluminum, Smooth: 0.016 inch thick.

E. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Aluminum, Smooth with 0.032 inch thick.

F. Equipment, Concealed:

1. None.

G. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Painted Aluminum, Smooth: 0.016 inch thick.

H. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Aluminum, Smooth with 0.032 inch thick.

I. Piping, Concealed:

1. None.

J. Piping, Exposed:

1. PVC, Color-Coded by System: 20 mils thick.
2. Aluminum, Smooth: 0.016 inch thick.

3.28 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 23 07 00

BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Direct Digital Controls (DDC) – BACnet compliant
- B. Programming and Graphics
- C. Controllers (Global, Standalone, Application Specific)
- D. Communications
- E. Sensors
- F. Valves, Dampers and actuators
- G. Electrical appurtenances and wiring systems
- H. Sequence of Operation

1.02 RELATED WORK

- A. Section 23 - Mechanical General Requirements
- B. Division 26 - Electrical

1.03 SHOP DRAWINGS

- A. System Architecture (BACnet LAN scheme)
- B. Wiring diagrams
- C. Valves and actuators
- D. Dampers and actuators
- E. System schematics for all mechanical systems
- F. Material lists with part numbers and quantities, as appropriate
- G. Technical/Product data sheets for each piece of equipment
- H. Sequence of Operation for each system
- I. As-built drawings of installed system

1.04 SUBMITTALS

- A. Submit Shop Drawings of the complete Building Automation System (DDC System) for review and approval.
- B. Drawings shall be submitted on standard sheet size format (8-1/2" x 11", 11" x 17", or 24" x 36").
- C. Drawings shall be bound within a standard 3-ring binder, cover, or other suitable permanent binder. For projects in which the controls submittals will be less than one-half inch thick, the submittal documents may be securely stapled in the upper left-hand corner provided the cover sheet and back sheet are printed on card stock (heavy bond paper).
- D. Submit *five* (5) copies of submittal drawings for review by the Owner.
- E. At completion, furnish as-built drawings in bound form and on CD.

- F. Submit documentation for all DDC programming in graphical form (AutoCAD or Visio format, or equal) as a part of the as-built documentation.
- G. Submit manufacturer's operating instruction manual for the DDC control system for use in owner training.
- H. Submit Certificate of Training upon completion of all scheduled training of the owner's operating personnel.

1.05 CODES AND REFERENCE STANDARDS

The latest edition of the following standards and codes in effect and amended as of the date of the supplier's proposal, and any subsections thereof as applicable, shall govern the design and selection of equipment and material supplied.

- A. NFPA 70 - National Electrical Code (NEC)
- B. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers (Handbooks)
- C. ANSI/ASHRAE Standard 135 (1995) – BACnet: A Data Communication Protocol for Building Automation and Control Networks
- D. UL 916 - Standard for Energy Management Equipment
- E. FCC – Part 15, Subpart J
- F. City, County, State and Federal regulations and codes in effect as of the date of the Contract

- 1.06 PERMITS Except as otherwise indicated, the system supplier shall secure and pay for all permits, inspections, and certifications required for his work and arrange for all necessary approvals by the governing authorities.

1.07 QUALITY ASSURANCE

- A. Responsibility: The supplier of the HVAC digital logic control system shall be responsible for inspection and Quality Assurance (QA) for all materials and workmanship furnished by him.
- B. Component Testing: Maximum reliability shall be achieved through extensive use of high quality, pre-tested components. The manufacturer prior to shipment shall individually test each and every controller, sensor, and all other DDC components.
- C. Tools, Testing and Calibration Equipment: The control system supplier shall provide all tools, testing, and calibration equipment necessary to ensure reliability and accuracy of the control system.
- D. Authorized Representative: The systems control contractor shall have been in business a minimum of three years and be the authorized representative for the manufacturer of the BACnet components.

1.08 WARRANTY

The DDC control system installed under this Specification shall be free from defects in material and workmanship under normal use and service for a period of twelve (12) months after final acceptance by the Owner. If within the twelve (12) month warranty period, any equipment, software, or labor is found to be defective in workmanship or materials, it shall be replaced free of charge by the Controls system installer. Warranty service shall be available to the job site during normal working hours.

1.09 PREVENTATIVE MAINTENANCE

The DDC control system installed as part of this project shall include a preventative maintenance schedule including two four-hour inspections per building twice within the first year of operation. The college desires one service company to have responsibility for maintaining the entire campus-wide automation system. Therefore, the successful bidder shall be responsible for conducting similar inspections at all campus buildings with DDC controls.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Installation of the system shall be by qualified employees of the temperature control system manufacturer or its exclusive authorized representative and qualified subcontractor. Indirect temperature control work by non-qualified installing contractors performing work without direct supervision from the authorized representative will not be accepted.
- B. The installing contractor shall provide all tools, testing and calibration equipment necessary to ensure reliability and accuracy of the control system.

2.02 SYSTEM REQUIREMENTS

- A. Requirement:
ALL POINTS SHALL HAVE FULL RANGE MANUAL OVERRIDES, SYSTEM SAFETIES
Owner SHALL HAVE PRIORITY OVER MANUAL OVERRIDE.
- B. Furnish a totally native BACnet-based system for distributed logic control in accordance with this specification. The system operator's terminal, all global controllers, and all input/output devices shall communicate using the protocols and local area network (LAN) standards as defined by ANSI/ASHRAE Standard 135 – 1995 (BACnet). No gateways shall be used.
- C. The proposed system must be completely compatible with the owner's existing web based Tridium DDC control system. The controls contractor shall include in his proposal any and all hardware, software, engineering or graphics development required to integrate the new control system into the existing graphical user interface. If a separate front-end computer is required then the contractor is also required to provide the necessary hardware, programming, and software to communicate to all the owner's existing buildings and provide graphic displays for the new building and all equipment currently controlled by the Tridium system.
- D. The system shall be a complete system of automatic temperature controls of the Direct Digital Control (DDC) type with electric and electronic accessories and components as indicated and as required.
- E. All control items, except thermostats, sensors and transmitters located in rooms shall be properly identified with engraved plastic nameplates permanently attached. Nameplates shall have white letters on a black background.
- F. Room thermostat, sensor and transmitter locations shall be coordinated to align vertically or horizontally with adjacent light switches or other control devices. Room thermostats and sensors shall be mounted with the bottom 5'-0" above the floor.
- G. Owner's Representative shall furnish disk file copies of the building floor plan(s) in AutoCAD (or other compatible drafting package format) for use by the DDC system Contractor in creating custom system graphics for displays.

2.03 SENSORS, TRANSMITTERS AND THERMOSTATS

- A. Temperature Sensors: Thermistor type with an accuracy of plus or minus 0.40-degree F over the entire control range. Sensors for pipe installations shall be immersion type, brass well, and thermistor with integral lead wire. Sensors for duct application shall be insertion probe type, stainless steel probe, integral handibox, and thermistor with integral lead wire. Space temperature sensors shall be compatible with the unit controller and shall be provided in a decorative metal or plastic enclosure. Space temperature sensors shall be provided with setpoint adjustment (lever or slide type), and override pushbutton, and connection port for field service tool. Outdoor temperature sensors shall be mounted inside a protective weather and sun shield.
- B. Space Temperature Sensor: Wall mounted room sensor, no occupant controls. The controller shall also be capable of functioning as a field service tool to allow maintenance personnel to observe and adjust all control parameters resident in the terminal unit controller. These control parameters shall also be adjustable from the global controller. Sensor shall be standard two-wire connection and have a thermistor, housed in a decorative plastic enclosure.
- C. Humidity Sensors: Thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH and 32 to 140-degree F. Duct mounted type sensors shall have a stainless-steel insertion element, sealed to prohibit corrosion. Sensors shall be selected for wall, duct or outdoor type installation as appropriate.
- D. Current Switches (Type 1): For proving fan or pump operational status, provide split-core type current status switches with adjustable setpoint and solid-state internal circuitry. Current switch shall have induced power, trip point set adjustment to plus or minus 1% over a range of 1 to 135 amps, trip and power LED, and field adjustable to indicate both On-Off conditions and loss of load (broken belt, etc.). Units shall have a five-year manufacturer's warranty. Current switches shall be Hawkeye Series H-908 by Veris Industries or approved equal.
- E. Low Temperature Sensors: For sensing low temperatures in air handling units, provide SPST type switch, 35 to 45-degree F range, manual reset, vapor charged twenty-foot-long sensing element, and 120-volt electrical power connection.

2.04 MISCELLANEOUS MATERIALS

- A. Panels: All enclosures for DDC controllers and devices shall be fabricated in accordance with UL Standards from code gauge steel. Enclosures shall be provided with a continuous hinge on the door and a flush latching mechanism. Enclosures shall be shop painted with standard grade enamel coating. Back panels shall be furnished when required to facilitate installation of boards or accessories. All enclosures installed outdoors shall be constructed to NEMA 3R standards. All controllers shall be installed within an approved enclosure unless the controller will be installed within the control cabinet section of the equipment that it is intended to control. Enclosures shall facilitate the mounting of gauges, switches, pilot lights, and the like, on the face panel when required. Control devices that are mounted on the face of the panel shall be identified with engraved nameplates.
- B. Power Transformers: Step-down power transformers shall be provided for all DDC controllers and associated accessory devices as required. Transformers shall be sized and selected to accommodate all connected accessory items. Transformers shall be UL Listed Class 2 type with 120 VAC primary, 24 VAC secondary.

- C. Relays: Miscellaneous control relays shall be provided as required to energize or control equipment and devices within the control system. Relays shall be located as close as practical to the controlled device (motor, motor starter, etc.). Where approved by NEC, relays may be installed within starters and equipment control panels where space is available. Relays installed outside of the controlled device shall be provided with a NEMA enclosure suitable for the location where installed.
- D. Wiring: All wiring shall be installed in a neat and professional manner. Control wiring shall not be installed in power circuit conduits or raceways unless specifically approved for that purpose. All wiring shall be plenum rated cable where concealed and in EMT conduits when exposed.
 - 1. Provide all interlock and control wiring. Provide wiring as required by functions as specified and as recommended by equipment and device manufacturers to achieve the specified control functions.
 - 2. Low voltage conductors shall be stranded bare or tinned copper with premium grade polymer alloy insulation. For shielded cable, furnish multi-conductor of overall polyester supported aluminum foil with stranded tinned copper drain wire to facilitate grounding. Coaxial shield shall be copper braided type. Provide shielded cable where recommended by the equipment or device manufacturer, grounded in strict accordance with the manufacturer's recommendations.
 - 3. Low voltage wiring shall be UL Listed type for the intended application. Non-plenum type cable shall be UL Type CM and /or CMR. Plenum type cable shall be UL type CMP and /or CL3P for approved plenum installations.

DIRECT DIGITAL CONTROL SYSTEM

2.05 GENERAL: The Direct Digital Control (DDC) System shall consist of native BACnet type global controller(s) and standalone or application specific unitary controller(s) configured as a distributed communications network composed of one or more levels of BACnet compliant local area networks (LAN). No gateways shall be used except when required to interface with specific equipment furnished by another manufacturer (e.g.: chiller controllers, packaged equipment controllers, etc.). The intent of the distributed control strategy is to install the controllers in close proximity to the equipment being controlled, and to distribute the processing to each standalone DDC panel. In the event of a communications failure of the BACnet LAN, the controllers shall be capable of operating in standalone mode. All devices (global controllers, standalone controllers, programmable controllers, etc.) shall be UL Listed, FCC approved, and BACnet compliant.

2.08 WORK INCLUDED

- A. Furnish a totally native BACnet-based system based on distributed logic control in accordance with this specification section. The existing operator's terminal, all global controllers, logic controllers, and all input/output devices shall communicate using the protocols and local area network (LAN) standards as defined by ANSI/ASHRAE Standard 135-1995, BACnet. All DDC controllers, including unitary controllers, shall be native BACnet devices. In general, no gateways shall be used except when required to interface with specific equipment furnished by another manufacturer. Scope of work will include, but not be limited to, the following:
 - 1. Provide all necessary BACnet compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS)

- for every controller in the system, including unitary controllers. All direct digital logic hardware is to comply with BACnet.
2. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.
 3. Implement the detailed design for all system-standard analog and binary objects, distributed control and system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.
 4. Design, provide, and install all equipment enclosures, panels, data communication network cables needed, and all associated hardware.
 5. Provide and install all interconnecting cables between supplied enclosures, logic controllers, and input/output devices.
 6. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this contract.
 7. Provide complete manufacturer's product data for all items that are supplied. Include vendor name of every item supplied.
 8. Provide qualified supervisory personnel and technicians at the job site to assist in all phases of system installation, startup, and commissioning.
 9. Provide for operator training as described in this Section.
 10. Provide "as-built" documentation, operator's terminal software, diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.
 11. Provide new dampers, valves, actuators, sensors, controllers, and the like. No used components shall be provided as any part or piece of the installed system.

2.09 SYSTEM DESCRIPTION

A. General Requirements

1. The existing graphical user interface provides web access for monitoring, controlling, scheduling, and alarm notification for all buildings connected to the system. The CAS utilizes the campus WAN to interconnect all of the buildings to the network server. At the conclusion of this project, the new building system will be added to the existing server software and will provide the same functionality and look as the existing system.
2. A distributed logic control system completes with Direct Digital Control (DDC) and Direct Analog Control (DAC) software shall be provided. System shall be totally based on ANSI/ASHRAE Standard 135 – 1995, BACnet. This system is to control all mechanical equipment, including all unitary equipment such as packaged air conditioning units, and all air handling units, boilers, chillers, and any other listed equipment on this project using native BACnet-compliant components.
3. The entire processing system shall be in complete compliance with the BACnet standard. The system shall use BACnet protocols and LAN types throughout and exclusively. Non-BACnet compliant or proprietary equipment or systems (including gateways, except as specified previously) shall *not* be acceptable and are specifically prohibited.
4. All logic controllers for terminal units, air handlers, central mechanical equipment, and Microsoft Windows-based operator's terminal(s) shall communicate and share data, utilizing only BACnet communication protocols.

5. All logic controllers shall be fully programmable. Programmable controllers for every terminal unit, air handler, all central plant equipment, and any other piece of controlled equipment shall be provided. Programming tools shall be provided as part of the operator workstation for every controller supplied for the project.
6. The Controls Contractor shall assume complete responsibility for the entire controls system as a single source. He shall certify that he has factory-trained personnel on staff under his direct employ on a daily basis. These employees shall be qualified to engineer, program, debug, and service all portions of the BACnet based logic control system. This shall include operator's terminal, global controllers, routers, programmable controllers, terminal unit controllers, sensors and all other components of the system.

B. Basic System Features

1. Zone-by-zone direct digital logic control of space temperature, scheduling, optimum start, equipment alarm reporting, and override timers for after-hours usage. A zone is the area served by one HVAC logic controller unit, VAV box, or multi-zone unit.
2. Operator's terminal software shall be Microsoft Windows 7 based. The Building Automation System application program shall be written to communicate specifically utilizing BACnet protocols. Software shall be multi-tasking, capable of executing and displaying multiple instances in individual windows while running concurrently with other Windows programs such as word processors or database programs. Software shall support Windows Dynamic Data Exchange (DDE) interfaces. Software shall strictly follow Microsoft Windows API guidelines. Systems using proprietary software or operating systems other than that described above are strictly prohibited. Operation of the terminal software shall be simple and intuitive.
3. Operator's terminal software shall contain an easy-to-operate system allowing configuration of system-wide BACnet controllers, including management and display of the controller programming. This system shall provide the capability to configure controller binary and analog inputs and outputs.
4. Operator's terminal operating system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages. Graphics generation shall be done using standard Windows packages. No proprietary graphics generation software shall be required.
5. When specified, at least one operator's terminal shall be equipped to act as a system server. This system server shall store custom copies of loadable software for all field components and shall be capable of automatic or manual reloading of such software into the field components as required. The system server shall also gather and archive system operating data, such as trendlogs, energy logs, and other historical operating data.
6. Complete energy management firmware, including self-adjusting optimum start, demand limiting, global control strategies and logging routines for use with total control systems shall be supplied. All energy management firmware shall be resident in field hardware and shall not be dependent on the operator's terminal for operation. Operator's terminal software is to be used for access to field-based energy management control firmware only.
7. Priority password security systems shall prevent unauthorized use. Each user shall have an individual password. The user shall only be given access to the system functions required for individual job performance.

8. Equipment monitoring and alarm functions, including information for diagnosing equipment problems shall be included with the system.
9. The complete system, including, but not limited to terminal unit controllers, global controllers and operator's terminals shall auto-restart, without operator intervention, on resumption of power after a power failure. Database stored in global controller memory shall be battery-backed up for a minimum of one (1) year. Logic controllers for all air handlers and all unitary equipment shall utilize EEPROM for all variable data storage. Batteries on unitary controllers shall not be allowed.
10. System design shall be modular and have proven reliability.
11. All software and /or firmware interface equipment for connection to remote monitoring station from field hardware or the operator's terminal shall be provided.
12. System shall be capable of equipment runtime totalization of fans, heaters, boilers, pumps and the like and capable of alarm generation and alarm dial-out to remote sites.
13. Communication wiring from field controllers shall NOT be run in star patterns.
14. All controllers shall communicate using protocols and LAN types contained in the ANSI/ASHRAE Standard 135 – 1995, BACnet.
15. All DDC hardware and software shall be designed and manufactured by U.S. corporations. All hardware shall be Listed Underwriters Laboratories (UL) for Open Energy management Equipment (PAZX) under the UL Standard for Safety (UL 916) in both the U.S. and Canada, with integral labels showing the rating.
16. All hardware shall be in compliance with FCC Part 15, Subpart J, Class A.

2.10 OPERATOR'S TERMINAL

A. Operating System

1. The GUI shall run on latest Microsoft Software.
 - a. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.
 - b. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:
 - i. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
 - ii. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.

- iii. Graphics shall support layering and each graphic object shall be configurable for assignment to one a layer. A minimum of six layers shall be supported.
 - iv. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
 - v. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
 - vi. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
 - vii. Commands to start and stop binary objects shall be done by right clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
 - viii. Adjustments to analog objects, such as set points, shall be done by right clicking the selected object and using a graphical slider to adjust the value. No entry of text shall be required.
- c. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:
- i. Create, delete or modify control strategies.
 - ii. Add/delete objects to the system.
 - iii. Tune control loops through the adjustment of control loop parameters.
 - iv. Enable or disable control strategies.
 - v. Generate hard copy records or control strategies on a printer.
 - vi. Select points to be alarmable and define the alarm state.
 - vii. Select points to be trended over a period of time and initiate the recording of values automatically.
- d. On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.
- e. Security. Each operator shall be required to log on to that system with a username and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.
- f. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

- g. Alarm Console
 - i. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.
 - ii. When the Alarm Console is enabled, a separate alarm notification window will supercede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

2. WEB BROWSER CLIENTS

- a. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ . Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.
- b. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the DDC system, shall not be acceptable.
- c. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
- d. The Web browser client shall support at a minimum, the following functions:
 - i. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
 - ii. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
 - iii. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
 - iv. Storage of the graphical screens shall be in the Network Area Controller (NAC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
 - v. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.

- vi. User's shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
- vii. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
 - 1. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
 - 2. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
- viii. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
- ix. View logs and charts
- x. View and acknowledge alarms
- xi. Setup and execute SQL queries on log and archive information
- xii. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
- xiii. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

C. Display of Scheduling Object Information

- 1. Operator's terminal display of weekly schedules shall show all information in convenient 7-day (weekly) format for each schedule. This includes all On/Off times (accurate to the minute) for each day's events.
- 2. BACnet exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the normal weekly schedules. These specialty schedules shall be displayed at the operator's terminal in a format similar to the weekly schedules, with input requirements similar to weekly schedules. Holiday and event schedules shall be entered as either single day entries, date-to-date entries (covering a range of days), or by weekday (for example, a specific day of a given week each month). The operator shall be able to scroll through the months for each year as a minimum.
- 3. At the Operator's Terminal, the system user shall be capable of changing all information for a given weekly or specialty schedule if logged on with the appropriate security access.

D. Alarm Indication

- 1. Operator's Terminal shall provide audible, visual and printed means of alarm indication. The alarm dialog box shall always become the top dialog box regardless of the application(s) being run at the time (such as a word processor). Printout of alarms shall be sent to the assigned terminal and port.

2. Alarm messages shall be logged. Alarm log shall be archived to the hard disk of the system terminal. Each entry shall include a description of the event which generated the alarm, time and date of alarm occurrence, time and date of status return to normal, and time and date of alarm acknowledgment.
3. Alarm messages shall be provided in user definable text (English or other user defined language) and shall be accessible either at the Operator's Terminal or via remote (modem) communication. When specified, designated alarms shall be available for dial out to pager alarms for 'on call' personnel.

E. Trendlog Information

1. DDC system shall be capable of periodically monitoring the values or status of selected feedback or control data from the system global controller(s) or field controllers and archiving this information on the operator's terminal. Archived files shall be appended with new sample data, allowing samples to be accumulated over a user defined period. Systems that overwrite previously archived data samples shall not be allowed, unless limited file size is specified. Samples in a trendlog shall be available for viewing at the operator's terminal. Displays of trendlog data shall be in spreadsheet format. Operator shall be capable of scrolling through all trendlog data. System shall automatically open archive files as needed to display archived data when the operator scrolls through the data vertically. All trendlog information displays shall be shown in standard engineering units.
2. Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x, y) graphs that display up to six object types at the same time in different colors. Graphs shall show object type values relative to time.
3. Operator shall be able to change trendlog setup information. This shall include the data points and status information being trendlogged as well as the interval at which the information is to be logged. All trendlog functions shall be password protected. The operator shall be capable of viewing or setting up a trendlog for any prompted or read-only item.
4. The system shall provide a means for the operator to directly export data to a comma-delimited file format for use in third-party software spreadsheets or other database programs. The system operation shall not be affected in any way by this data exchange.

F. Energy Log Information

1. DDC system shall periodically gather energy log data stored in field terminal controllers and archive this information on the operator terminal's hard disk. Archive data shall be appended with the new data and allow data to be accumulated over several years. Systems that overwrite archived data shall not be allowed unless limited file size is specified. System shall automatically open archive files as needed to display archived data when the operator scrolls through the data. All energy log information shall be displayed in standard engineering units.
2. System software shall be capable of graphing the Energy Log data. Software shall be capable of creating graphs in two-axis (x, y) format that shows recorded data relative to time. All data shall be stored in comma-delimited file format for direct use by third party software spreadsheets or other database programs. System operation shall not be affected by on-line access to the energy information.

3. Operator shall be able to modify the energy log setup information. This shall include which meters are to be logged, meter pulse value, and what types of energy units are being logged. All energy meters monitored by the system shall be capable of being logged. All energy logging operations shall be password protected.
4. Provide capability for the operator to export to a comma-delimited file format all energy-logged data for use by third party software spreadsheets or other database programs. System operation shall not be affected by on-line access to the energy information.

G. Configuration/Setup

1. Provide means for the operator to display and change the system configuration. This shall include, but not be limited to: system time, day of the week, date of daylight savings time set forward/back, printer termination, port addresses, modem port and speed, and the like. Items shall be modified utilizing easily understood terminology by means of simple mouse/cursor key movements.

H. Programming Tools

1. Operator's Terminal shall include programming tools for all controllers supplied. If a new software package is proposed it is the contractor's responsibility to load all programming tools/ engineering software on all of the owner's existing operator terminals and laptops, as well as provide all connectors for connection to field devices with portable terminals. All controllers shall be programmed using graphical tools that allow the user to connect function blocks on screen that provide sequencing of all control logic. Function blocks shall be represented by graphical displays that are easily identified and distinct from different types of blocks. Graphical programming that uses simple rectangles and squares is not acceptable.
2. User shall be able to pick graphical function block from the menu and place on screen. Programming tools shall place lines connecting appropriate function blocks together automatically. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.
3. Programming tools shall include a test mode. Test mode shall show user the real-time data on top of graphical display of selected function blocks. Data shall be updated real-time with no interaction by the user. Function blocks shall be animated to show status of data inputs and outputs. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.

2.11 GLOBAL BUILDING CONTROLLERS (GBCs)

- A. The controls contractor shall supply one or more global controller as part of this contract. Number of global controllers required is dependent on the type and quantity of DDC devices.
- B. The Global Building Controller shall provide the interface between the LAN and the field control devices and provide global supervisory control functions over the control devices connected to the GBC. It shall be capable of executing application control programs to provide:
 - a. Calendar functions
 - b. Scheduling

- c. Trending
- d. Alarm monitoring and routing
- e. Time synchronization
- f. Integration of LonWorks controller data and BACnet controller data
- g. The GBC must provide the following hardware features as a minimum:
 - 1. Ethernet Port - 10 Mbps
 - 2. One One RS-232 port
 - 3. One BACnet MS/TP Port
 - 4. Battery Backup
 - 5. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
 - 6. The GBC must be capable of operation over a temperature range of 0 to 55°C
 - 7. The GBC must be capable of withstanding storage temperatures of between 0 and 70°C.
 - 8. The GBC must be capable of operation over a humidity range of 5 to 95% RH, non-condensing.
 - 9. The GBC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the GBC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
 - 10. Event Alarm Notification and actions
 - 11. The GBC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
 - 12. The GBC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
 - 13. Alarm generation shall be selectable for annunciation type and acknowledgement requirements.
- h. Provide for the creation of a minimum of eight alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
- i. Provide timed (schedule) routing of alarms by class, object, group, or node.
- j. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
- k. Control equipment and network failures shall be treated as alarms and annunciated.

- l. Alarms shall be annunciated in any of the following manners as defined by the user:
 - m. Screen message text
 - n. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
 - i. Day of week
 - ii. Time of day
 - iii. Recipient
 - o. Pagers via paging services that initiate a page on receipt of email message
 - p. Graphic with flashing alarm object(s)
 - q. Printed message, routed directly to a dedicated alarm printer
 - r. Audio messages
 - s. The following shall be recorded by the NAC for each alarm (at a minimum):
 - i. Time and date
 - ii. Location (building, floor, zone, office number, etc.)
 - iii. Equipment (air handler #, accessway, etc.)
 - iv. Acknowledge time, date, and user who issued acknowledgement.
 - v. Number of occurrences since last acknowledgement.
 - t. Alarm actions may be initiated by user defined programmable objects created for that purpose.
 - u. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
 - v. A log of all alarms shall be maintained by the GBC and/or a server (if configured in the system) and shall be available for review by the user.
 - w. Provide a “query” feature to allow review of specific alarms by user defined parameters.
 - x. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
 - y. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.
- C. Data Collection and Storage
- a. The GBC shall have the ability to collect data for any property of any object and store this data for future use.
 - b. The data collection shall be performed by log objects, resident in the GBC that shall have, at a minimum, the following configurable properties:
 - c. Designating the log as interval or deviation.

- d. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
 - e. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
 - f. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
 - g. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
 - h. All log data shall be stored in a relational database in the NAC and the data shall be accessed from a server (if the system is so configured) or a standard Web Browser.
 - i. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.
 - j. All log data shall be available to the user in the following data formats:
 - k. HTML
 - l. XML
 - m. Plain Text
 - n. Comma or tab separated values
 - o. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.
 - p. The GBC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other GBC on the network. Provide the ability to configure the following archiving properties, at a minimum:
 - q. Archive on time of day
 - r. Archive on user-defined number of data stores in the log (buffer size)
 - s. Archive when log has reached its user-defined capacity of data stores
 - t. Provide ability to clear logs once archived
- D. AUDIT LOG
- a. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:
 - b. Time and date
 - c. User ID
 - d. Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

E. DATABASE BACKUP AND STORAGE

- a. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
- b. Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.
- c. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

2.12 ROUTER, CONVERTER, OR REPEATER

Routing functions shall be performed using only BACnet standard protocols as defined by ASHRAE Standard 135-1995. The converter interconnects a standard computer serial port with an MS/TP LAN. Repeater functions shall be handled by a device to selectively interconnect four (4) portions of MS/TP LAN as a minimum.

1. **ROUTERS:** The router function shall perform the BACnet definition functions of interconnecting two or more BACnet LANs together, forming a BACnet internetwork. The router shall have optional plug-in boards permitting the following BACnet communication methods:
 - a. The router shall have the routing functionality of interconnecting BACnet Ethernet and/or ARCNET high-speed LAN to BACnet MS/TP LAN and/or more PTP LAN.
 - b. The router shall have capability of interconnecting BACnet Ethernet high-speed LAN to BACnet ARCNET high-speed LAN.
 - c. BACnet PTP (RS-232 point-to-point) communication shall be available on the global controller by including an (optional) modem. The PTP modem option shall operate under the BACnet half-router communication protocol.
 - d. BACnet messages may be routed to all LANs installed on the router at the same time with no operator intervention.
2. **CONVERTER:** A converter shall (optionally) be provided to interface an (optional) portable field service computer from its serial port (RS-232) to the BACnet MS/TP LAN (RS-485).
3. **REPEATERS:** BACnet repeaters shall provide selective interconnection to 4-segments of MS/TP LAN as a minimum. The repeater shall be an active device, containing logic capable of detecting and repeating signals from one MS/TP LAN segment to all other segments. Repeaters shall permit additional nodes to be added to the MS/TP LAN, up to a maximum of 128 nodes.

3.1 GENERAL CONTROLS INSTRUMENTATION

A. Control Panels:

UNCW Southeast Dining Facility
Price Drive, Wilmington NC 28403
PE Project No. 71193.00
SCO # 19-21358-01B

BUILDING AUTOMATION SYSTEM
23 09 00 - 17
Construction Documents Package 2 - Building
August 5, 2020

1. Panels shall have hinged doors and be marked with engraved labels. Panels used as a location for mounting control devices shall have a document holder located on the inside of the door.
2. Provide common keying for all panels.
3. Entrance and exit wiring should be on the panel sides.
4. All heat generating devices shall be located at the top of the panel.
5. Combined Temperature and Carbon Dioxide Sensors:
 - a. Where indicated on plans, a combined temperature and carbon dioxide sensor shall be provided in a single package. Combined sensor shall be Telaire Airestat Model 5010 or as manufactured by Veris CDW/E series. Housing shall be blank with a momentary pushbutton for override of unoccupied operation. The carbon dioxide sensor shall be non-dispersive infrared type with an accuracy of ± 100 ppm or 7% of the reading (whichever is greater). Elevation correction adjustment and software for self-correction of drift to better than ± 10 ppm per year shall be incorporated.
 - b. Temperature sensors shall be capable of being replaced without the need for controller re-calibration. Temperature sensors shall accordingly have manufactured space temperature and setpoint signal precision tolerances of no greater than 1°F.
6. Temperature Sensors:
 - a. All internal temperature sensors for air handler and unit temperature readings shall be temperature averaging cable that spans across the full face of the associated coil. Install per manufacturer requirements.

B. Labels and Tags:

1. Provide labels for all field devices including sensors, meters, transmitters and relays. Labels shall be plastic laminate and located adjacent to the device.
2. Labels of field devices (both locally and software ID's) shall be associated with their respective air handler, boiler, chiller, etc.

3.2 ELECTRONIC SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required. Thermistor sensing, RTD and transmitter sensing is acceptable for any application.
- B. Fan Coil Unit Thermostats and other Thermistor Temperature Sensors (type II) and Transmitters:
 1. Accuracy: Plus, or minus 1 deg F at calibration point.
 2. Wire: as recommended by building automation system provider.
 3. Insertion Elements in Ducts: Single point, length as required by application.
 4. Averaging Elements in Ducts: 12 inches.

5. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
6. Room Sensor: Sensor with lever setpoint adjust, on/override to.
7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. RTDs and Transmitters:

1. Accuracy: Plus, or minus 1 deg F at calibration point.
2. Wire: as recommended by building automation system provider.
3. Insertion Elements in Ducts: Single point, length as required by application.
4. Averaging Elements in Ducts: 12 inches.
5. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
6. Room Sensor: Space sensor located in public area (corridors, lobby, etc) shall be metallic wall plate type 2 thermistor with no logo or adjustment dial. Or sensor with setpoint adjust, on/override to match existing.
7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

D. Humidity Sensors: Bulk polymer sensor element.

1. Accuracy: 3 percent full range with linear output.
2. Room Sensor Range: 20 to 80 percent relative humidity.
3. Room Sensor Cover Construction: Manufacturer's standard locking covers.
4. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
5. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of 0 to 120 degrees.
6. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

E. Pressure Transmitters/Transducers:

1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA.
 - c. Building Static-Pressure Range: 0- to 1-inch wg .
 - d. Duct Static-Pressure Range: 0- to 5-inch wg.
2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.

4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

3.3 STATUS SENSORS

- A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa). Or current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 120 percent of rated motor current.
- B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.
- C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 120 percent of rated motor current.
- D. Status of fans, pumps, or motor using current switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
- E. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

3.4 CO₂ and CO sensors

- A. Carbon Dioxide and Carbon Monoxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C) and factory calibrated, with continuous or averaged reading, 4- to 20-mA output; for wall mounting or duct mounting as required by application.

3.5 AIR/WATER FLOW MEASURING STATIONS

- A. Duct Airflow Station: Air flow station to be provided by controls contractor.
 1. Casing: Galvanized-steel frame.
 2. Ebtron thermal dispersment technology type is acceptable.
 3. For water flow Onicon flow meter (OR AS NOTED ON PLANS)

3.6 THERMOSTATS

- A. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.

1. Label switches ["FAN ON-OFF"].
 2. Mount on single electric switch box.
- B. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
- C. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
 2. Selector Switch: Integral, manual on-off-auto.
- D. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
1. Bulbs in water lines with separate wells of same material as bulb.
 2. Bulbs in air ducts with flanges and shields.
 3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
 4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
 5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
 6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.
- E. Fire-Protection Thermostats where shown on plans or points list: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature, and the following:
1. Reset: Manual.
 2. Reset: Automatic, with control circuit arranged to require manual reset at central control panel; with pilot light and reset switch on panel labeled to indicate operation.
- F. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.
- G. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-]reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below set point.
1. Bulb Length: Minimum 10 feet.
 2. Quantity: As required by application.

H. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or above set point.

1. Bulb Length: Minimum 10 feet.
2. Quantity: As required by application.

3.7 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
2. Actuator on VAV, FCU, UV, Blower coil terminal unit valves are failed in place floating signal type.
3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
4. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Valves: Size for torque required for valve close off at maximum pump differential pressure.
2. Dampers: Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
 - e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
3. Coupling: V-bolt and V-shaped, toothed cradle.

4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
6. Power Requirements (Two-Position Spring Return): 24 V ac.
7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
8. Proportional Signal: 2- to 10-V dc or 4 to 20 mA.
9. Tri-state: Floating signal.
10. Temperature Rating: 40 to 104 deg F (5 to 40 deg C).
11. Run Time: Sized as required for application.

3.8 CONTROL VALVES

- A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- B. The manufacturer shall warrant all components a period of 5 years from the date of production, with the first two years unconditional.
- C. Manufacturers:
 1. Danfoss Inc.; Air Conditioning & Refrigeration Div.
 2. Erie Controls.
 3. Hayward Industrial Products, Inc.
 4. Belimo
- D. Pressure Independent Control Valves
 1. Dynamic control valve shall accurately control flow, independent of system pressure fluctuation. Pressure independent control valves shall be provided on all hot water and chilled water coils for all new and existing air handling units.
 2. Housing shall be constructed of Ductile Iron ASTM A536-65T, Class 60-45-18 rated at no less than 580 psi static pressure.
 3. Valve shall be electronic, dynamic, modulating 2-way control.
 4. Dual pressure/temperature test valves for verifying accuracy of flow performance shall be available for all valve sizes.
 5. Actuator shall be driven by a 24Vdc motor, and shall accept 2-10 Vdc, 4-20mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals.
 6. Actuator shall be capable of providing 4-20mA or 2-10 Vdc feedback signal to the control system.
 7. External LED readout of current valve position and maximum valve position setting shall be standard.
 8. Optional fail-safe system to power valve to either open or closed position from any position in case of power failure shall be available.
 9. Flow regulation unit shall consist of 304 Stainless Steel and hydrogenated acrylonitrile butadiene rubber (1/2"-1-1/2") or 316 Stainless Steel and EPDM (2"-6").
 10. Flow regulation unit shall be accessible for maintenance.

11. Accuracy: The control valves shall accurately control the flow from 0 to 100% full rated flow with an operating pressure differential range of 5 to 50 PSID across the valve.
12. Close-Off Pressure Rating: 200 PSI.
13. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
14. The use of pressure independent valves piped in parallel to achieve the rated coil flow shall be permitted. Actuators shall be electronically programmed to permit sequencing the flow with a single control output point. The use of external devices to permit sequencing is not acceptable.
15. NPS 2" and smaller pressure independent control valves for individual coil control shall be provided as part of a pipe package supplied by the valve manufacturer. The supply side of the coil shall contain an integrated isolation ball valve/manual air vent with a P/T port. The return side shall contain a union fitting with a P/T port, pressure independent control valve, an integrated isolation ball valve/manual air vent with a P/T port. Shut-off valves as an integrated part of the pressure independent control valve are prohibited.

E. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 (DN 50) and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
 - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
4. Sizing: 3 to 5 psi maximum pressure drop at design flow rate or the following:
 - a. Two Position: Line size.
 - b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
 - c. Three-Way Modulating: Twice the load pressure drops, but not more than value specified above.
5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

F. Butterfly Valves: 200-psig (1380-kPa), maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: Wafer.

2. Disc Type: Nickel-plated ductile iron.
 3. Sizing: 1-psig (7-kPa) maximum pressure drop at design flow rate.
- G. Terminal Unit Control Valves (VAV, FCU, UV): Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
1. Rating: Class 125 for service at 125 psig (860 kPa) and 250 deg F (121 deg C) operating conditions.
 2. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.
 3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Actuator is floating signal fail in place type.

3.9 DAMPERS

- A. Dampers: AMCA-rated, parallel or opposed-blade design; 0.108-inch- (2.8-mm-) minimum thick, galvanized-steel or 0.125-inch- (3.2-mm-) minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- (1.6-mm-) thick galvanized steel with maximum blade width of 8 inches (200 mm) and length of 48 inches (1220 mm).
1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
 3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
 4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. (50 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (1000 Pa) when damper is held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

3.10 CONTROL CABLE

- A. HVAC control systems shall be full DDC. All control wiring in the cable tray shall use purple and yellow colored plenum rated cable. Each color shall be consistent for the entire project and noted on the plans. Blue should be used for the primary network cable and yellow for the secondary network connections.

3.11 CENTRAL PLANT AND AIR HANDLER LOGIC CONTROLLERS

- A. Provide one or more native BACnet logic controllers for each air handler and provide native BACnet logic controllers as needed for central plant control that adequately cover all objects listed in the object list (“points list”). Provide for spare inputs and outputs on controllers. All

controllers shall interface to global controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable. No auxiliary or non-BACnet controllers shall be used.

B. BACnet Conformance:

1. Logic controllers shall as a minimum support MS/TP BACnet LAN type. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as native BACnet devices. Logic controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:
 - a. Files Functional Group
 - b. Reinitialize Functional Group
 - c. Device Communications Functional Group
 2. Refer to Section 22.2, BACnet Functional Groups, in the BACnet Standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
 3. Standard BACnet object types supported shall include as a minimum – Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
- C. Logic controllers shall include universal inputs with 10-bit resolution that accept 3K and 10K thermistors, 0-10 VDC, 0-5 VDC, 4-20 mA and dry contact signals. Any input on the controller may be either analog or binary. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display (Alerton Microset). Controller shall include binary and analog outputs on board. Analog outputs shall be switch selectable as either 0-10 VDC or 4-20 mA. Software shall include scaling features for analog outputs. Logic controller shall include 24 VDC voltage supplies for use as power supply to external sensors.
- D. All program sequences shall be stored on board the logic controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by the controller a minimum of ten times per second and be capable of multiple PID loops for control of multiple devices. All calculations shall be complete using floating-point math and system shall support display of all information in floating-point nomenclature at the operator's terminal.
- E. Programming of logic controllers shall be completely modifiable in the field over the installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Logic controller shall be programmed using programming tools as described in the Operator's Terminal section of this specification.
- F. All programming tools shall be provided as part of the system. Provide documentation in flowchart form of all programming as part of the final system as-built documentation.
- G. Logic controller shall include software-scheduling functions on board without depending on any external device. Scheduling shall be via a BACnet schedule object for seven-day-of-the-week scheduling. Controller shall include interface capability for optional plug-in hardware clock

with battery back-up. Provide optional hardware clock as shown on object drawing list included in the Contract Documents (plans or specifications).

- H. Logic controller shall include support for intelligent field sensor (Alerton Microset). Display on field sensor shall be programmable at logic controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See Sequences of Operation for specific display requirements at intelligent field sensor.

3.12 TERMINAL UNIT CONTROLLERS

- A. Provide one native BACnet programmable logic controller for each piece of unitary mechanical equipment that adequately covers all objects listed in the object list for the unit. All controllers shall interface to the global controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic programs as needed for complete control of the unit.
- B. BACnet Conformance
 - 1. Logic controllers shall as a minimum support MS/TP BACnet LAN type. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps as a native BACnet device. Logic controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:
 - a. Files Functional Group
 - b. Reinitialize Functional Group
 - c. Device Communications Functional Group
 - 2. Refer to Section 22.2, BACnet Functional Groups, in the BACnet Standard for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
 - 3. Standard BACnet object types supported shall include as a minimum – Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
- C. Logic controllers shall include universal inputs with 10-bit resolution and that can accept 3K and 10K thermistors, 0-5 VDC, 4-20 mA and dry contact signals. Any input controller may be either analog or binary. Controller shall also include support and modifiable programming for interface to intelligent room sensor (Alerton Microset). Controllers shall include binary outputs on board.
- D. All program sequences shall be stored on board logic controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by the controller ten (10) times per second and shall be capable of multiple PID loops for control of multiple devices.
- E. Programming of logic controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Logic controller shall be programmed using programming tools as described in Operator Terminal section of this specification.

- F. All programming tools shall be provided as a part of the system. Provide documentation in flowchart form of all programming as part of the final system as-built documentation.
- G. Logic controller shall include software-scheduling functions on board without depending on any external device. Scheduling shall be via BACnet schedule object for seven-day-of-the-week scheduling. Controller shall include interface capability for optional plug-in hardware clock with battery back up. Provide optional hardware clock as shown on the object list included with the Contract Documents (plans and specifications).
- H. Logic controller shall include support for intelligent field sensor (Alerton Microset). Display on field sensor shall be programmable at logic controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See Sequence of Operation for specific display requirements at intelligent field sensor.

3.13 UTILITY MONITORING SOFTWARE INTEGRATION

- A. The Systems Integrator is responsible for providing trends for integration into the BAS.
- B. All points from all noted utilities to be monitored shall be compiled, and actively displayed with the new building BAS System.
- C. System shall provide browser access to unit controllers and associated setpoints and tuning parameters. The Building Automation System shall be comprised of BACnet or LonMark/LonTalk controllers. Should the NAC network connection be interrupted, the DDC components shall continue to provide local control using the last known state of any global variables (OA temperature, Demand Value, Price of Energy, etc.) It shall be the DDC contractor's responsibility to effectively design and program standalone control while coordinating the required DDC integration and communication to the NAC.

PART 3 - EXECUTION

3.01 TRAINING

- A. The Controls Contractor shall provide complete on-site training for the Owner's designated operating personnel. Training shall include all functional aspects of the control system and all modes of system operation. System modes include occupied/unoccupied, heating/cooling, economizer, startup/shutdown, energy management, and alarm event operations. Training of Owner's operating personnel shall include a minimum of eight (8) hours of system instruction, conducted during one or two site visits for a combined total of eight hours of instruction. Additional instruction time may be requested by the Owner for an additional fee if needed for training additional personnel or if more instruction is requested. Training is not intended to include in-depth instruction in system programming.
- B. Training shall be conducted during normal working hours, Monday through Friday, at the project site. When applicable, the training may be conducted at the Owner's central energy management office in addition to training on site.
- C. Contractor shall furnish one (1) copy of the system Operator's Manual to the Owner. This manual should be delivered to the Owner at the time of training. This manual is in addition to the system As-built documents which are intended to show wiring configurations and sensor locations.

END OF SECTION 23 09 00

UNCW Southeast Dining Facility
Price Drive, Wilmington NC 28403
PE Project No. 71193.00
SCO # 19-21358-01B

BUILDING AUTOMATION SYSTEM
23 09 00 - 29
Construction Documents Package 2 - Building
August 5, 2020

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Pipes, tubes, and fittings.
 2. Piping specialties.
 3. Piping and tubing joining materials.
 4. Valves.
 5. Pressure regulators.

1.2 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 2. Service Regulators: 65 psig minimum unless otherwise indicated.
- B. Natural-Gas System Pressure within Buildings: More than 0.5 psig but not more than 2 psig.
- C. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 2 psig , and is reduced to secondary pressure of 0.5 psig or less.
- D. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.3 QUALITY ASSURANCE

- A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - 4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.2 PIPING SPECIALTIES

- A. Appliance Flexible Connectors:
 - 1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
 - 2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
 - 3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
 - 4. Corrugated stainless-steel tubing with polymer coating.
 - 5. Operating-Pressure Rating: 0.5 psig.
 - 6. End Fittings: Zinc-coated steel.
 - 7. Threaded Ends: Comply with ASME B1.20.1.
 - 8. Maximum Length: 72 inches.
- B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
 - 1. Copper-alloy convenience outlet and matching plug connector.
 - 2. Nitrile seals.
 - 3. Hand operated with automatic shutoff when disconnected.
 - 4. For indoor or outdoor applications.
 - 5. Adjustable, retractable restraining cable.
- C. Y-Pattern Strainers:
 - 1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
 - 2. End Connections: Threaded ends for NPS 2 and smaller.
 - 3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
 - 4. CWP Rating: 125 psig
- D. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

- A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
 - 1. CWP Rating: 125 psig.
 - 2. Threaded Ends: Comply with ASME B1.20.1.
 - 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 - 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 - 6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

2.5 PRESSURE REGULATORS

- A. General Requirements:
 - 1. Single stage and suitable for natural gas.
 - 2. Steel jacket and corrosion-resistant components.
 - 3. Elevation compensator.
 - 4. End Connections: Threaded for regulators NPS 2 and smaller.
- B. Appliance Pressure Regulators: Comply with ANSI Z21.18.
 - 1. Body and Diaphragm Case: Die-cast aluminum.
 - 2. Springs: Zinc-plated steel; interchangeable.
 - 3. Diaphragm Plate: Zinc-plated steel.
 - 4. Seat Disc: Nitrile rubber.
 - 5. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 - 6. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
 - 7. Regulator vent limiting device.
 - 8. Maximum Inlet Pressure: 2 psig.

2.6 DIELECTRIC UNIONS

- A. Minimum Operating-Pressure Rating: 150 psig.
- B. Combination fitting of copper alloy and ferrous materials.
- C. Insulating materials suitable for natural gas.
- D. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.7 SLEEVES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.8 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
 - 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. Include one nut and bolt for each sealing element.

2.9 LABELING AND IDENTIFYING

- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 OUTDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.

- B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
 - 1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.
- C. Install underground, PE, natural-gas piping according to ASTM D 2774.
- D. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 3. Replace pipe having damaged PE coating with new pipe.
- E. Install fittings for changes in direction and branch connections.
- F. Exterior-Wall Pipe Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. 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.

3.2 INDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

- G. Locate valves for easy access.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- L. Verify final equipment locations for roughing-in.
- M. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- N. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- O. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- P. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- R. Connect branch piping from top or side of horizontal piping.
- S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment.
- T. Do not use natural-gas piping as grounding electrode.

3.3 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing or copper connector.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

- C. Install earthquake valves aboveground outside buildings according to listing.

3.4 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints:
 - 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
- G. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1 and Smaller: Maximum span, 96 inches minimum; rod size, 3/8 inch
 - 2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
 - 3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.

3.6 CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within view of each gas-fired appliance and equipment (72" max). Install union between valve and appliances or equipment.
- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.7 FIELD QUALITY CONTROL

- A. Test, inspect, and purge natural gas according to NFPA 54 and the International Fuel Gas Code and authorities having jurisdiction.
- B. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 23 11 23

SECTION 23 21 23
HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Close-coupled, in-line centrifugal pumps.

1.3 DEFINITIONS

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

1.4 SUBMITTALS

- A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
- B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 ACCEPTABLE MANUFACTURERS

- A. Listing of manufacturers name does not guarantee approval. All equipment must meet or exceed quality and capacities of specified equipment. Final approval will be based on equipment submittals. Any manufacturer not listed but wishing to bid this project shall submit a

written request 14 days prior to bid date, prior approval is required for all manufacturers not listed.

1.6 QUALITY ASSURANCE

- A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
- B. Store pumps in dry location.
- C. Retain protective covers for flanges and protective coatings during storage.
- D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
- E. Comply with pump manufacturer's written rigging instructions.

1.8 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.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.
- B. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tapings at inlet and outlet, and threaded flanged connections. Casing shall include vent and drain ports.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
 3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
 5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
- C. Premium efficiency motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
- D. Capacities and Characteristics: As indicated on the drawings.

2.2 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser: Angle pattern, 175-psig pressure rating, cast -iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.
- B. Triple-Duty Valve: Angle or straight pattern, 175-psig pressure rating, cast-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

- A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 23 Section "Common Work Results for HVAC."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For supported equipment, 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.

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

3.3 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Install continuous-thread hanger rods and spring hangers with vertical-limit stop of sufficient size to support pump weight. Vibration isolation devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

E. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and spring hangers with vertical-limit stop of sufficient size to support pump weight. Vibration isolation devices are specified in Division 21 Section "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment." Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment/Hangers and Supports for HVAC Piping and Equipment."

F. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.

1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

- C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation, HI 2.1-2.5, " Vertical Pumps for Nomenclature, Definitions, Application and Operation."
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.5 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install check valve and throttling or triple-duty valve on discharge side of pumps as indicated on the drawings.
- F. Install Y-type strainer or suction diffuser and shutoff valve on suction side of pumps as indicated on the drawings.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.
- I. Install check valve and gate or ball valve on each condensate pump unit discharge.
- J. Install electrical connections for power, controls, and devices.
- K. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup check according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Perform the following startup checks for each pump before starting:

- a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
5. Prime pump by opening suction valves and closing drains and prepare pump for operation.
 6. Start motor.
 7. Open discharge valve slowly.

3.7 DEMONSTRATION

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

3.8 INSULATION

- A. Following start-up, inspection and approval by the engineer of all pump, pump accessory, installation and operation, provide pump insulation (as dictated by pump service), according to 230700.

END OF SECTION 23 21 23

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-407C:
 - 1. Suction Lines for Air-Conditioning Applications: 230 psig.
 - 2. Suction Lines for Heat-Pump Applications: 380 psig.
 - 3. Hot-Gas and Liquid Lines: 380 psig.
- B. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

1.3 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.4 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type K or L
- B. Wrought-Copper Fittings: ASME B16.22.

- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 - 3. Operator: Rising stem and hand wheel.
 - 4. Seat: Nylon.
 - 5. End Connections: Socket, union, or flanged.
 - 6. Working Pressure Rating: 500 psig.
 - 7. Maximum Operating Temperature: 275 deg F.
- B. Packed-Angle Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze.
 - 2. Packing: Molded stem, back seating, and replaceable under pressure.
 - 3. Operator: Rising stem.
 - 4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
 - 5. Seal Cap: Forged-brass or valox hex cap.
 - 6. End Connections: Socket, union, threaded, or flanged.
 - 7. Working Pressure Rating: 500 psig.
 - 8. Maximum Operating Temperature: 275 deg F.
- C. Check Valves:
 - 1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
 - 2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
 - 3. Piston: Removable polytetrafluoroethylene seat.
 - 4. Closing Spring: Stainless steel.
 - 5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
 - 6. End Connections: Socket, union, threaded, or flanged.

7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24 V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 450 psig

H. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.

3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

I. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

K. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 microns, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: as indicated on the drawings.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

L. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 microns, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: tons as indicated on the drawings

9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

M. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
- B. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
- C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- D. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.
- E. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
 1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
 2. NPS 1-1/2 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
 3. NPS 2 to NPS 3: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
 4. NPS 4: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.
- F. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.
- G. Safety-Relief-Valve Discharge Piping:
 1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
 2. NPS 1-1/2 and Smaller: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.
 3. NPS 2 to NPS 3: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

4. NPS 4: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install diaphragm packless valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at strainers if they are not an integral part of strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.
- E. Install a full-sized, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 1. Install valve so diaphragm case is warmer than bulb.
 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
 1. Solenoid valves.
 2. Thermostatic expansion valves.
 3. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.
- L. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping in accordance with the equipment manufacturer's recommendations.
- C. Install refrigerant piping according to ASHRAE 15.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Install piping adjacent to machines to allow service and maintenance.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.

- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- S. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

3.4 PIPE JOINT CONSTRUCTION

- A. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- B. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BA_g, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

- A. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- B. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1/2: Maximum span, 60 inches minimum rod size, 1/4 inch
 - 2. NPS 5/8 Maximum span, 60 inches minimum rod size, 1/4 inch
 - 3. NPS 1 Maximum span, 72 inches minimum rod size, 1/4 inch
 - 4. NPS 1-1/4 Maximum span, 96 inches minimum rod size, 3/8 inch
 - 5. NPS 1-1/2 Maximum span, 96 inches minimum rod size, 3/8 inch
 - 6. NPS 2 Maximum span, 96 inches minimum rod size, 3/8 inch
 - 7. NPS 2-1/2 Maximum span, 108 inches minimum rod size, 3/8 inch
 - 8. NPS 3 Maximum span, 10 feet minimum rod size, 3/8 inch
 - 9. NPS 4 Maximum span, 12 feet minimum rod size, 1/2 inch

- C. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. Comply with ASME B31.5, Chapter VI.
 - 2. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Install core in filter dryers after leak test but before evacuation.
 - 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 - 4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Verify that compressor oil level is correct.
 - 2. Open compressor suction and discharge valves.

3. Open refrigerant valves except bypass valves that are used for other purposes.
 4. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 23 00

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single wall round ducts and fittings.
3. Double wall round ducts and fittings.
4. Sheet metal materials.
5. Duct liner.
6. Sealants and gaskets.
7. Hangers and supports.

B. Related Sections:

1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

- B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

1.4 SUBMITTALS

- A. Product Data: For each type of the following products:

- 1. Liners and adhesives.
- 2. Sealants and gaskets.

- B. Shop Drawings:

- 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
- 2. Factory- and shop-fabricated ducts and fittings.
- 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
- 4. Elevation of top of ducts.
- 5. Dimensions of main duct runs from building grid lines.
- 6. Fittings.
- 7. Reinforcement and spacing.
- 8. Seam and joint construction.
- 9. Penetrations through fire-rated and other partitions.
- 10. Equipment installation based on equipment being used on Project.
- 11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
- 12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

- C. Delegated-Design Submittal:

- 1. Sheet metal thicknesses.
- 2. Joint and seam construction and sealing.
- 3. Reinforcement details and spacing.
- 4. Materials, fabrication, assembly, and spacing of hangers and supports.
- 5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

- D. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

- 1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
- 2. Suspended ceiling components.
- 3. Structural members to which duct will be attached.
- 4. Size and location of initial access modules for acoustical tile.
- 5. Penetrations of smoke barriers and fire-rated construction.
- 6. Items penetrating finished ceiling including the following:

- a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.
- E. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 - 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
 - 3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2007, 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."

Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Lindab Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO Incorporated.
 - d. Sheet Metal Connectors, Inc.
 - e. Spiral Manufacturing Co., Inc.
 - f. Hamlin
- 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."

2.3 DOUBLE-WALL ROUND DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Lindab Inc.
 2. McGill AirFlow LLC.
 3. SEMCO Incorporated.
 4. Sheet Metal Connectors, Inc.
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "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."
 - a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
 2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "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."
 - a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
 3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "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."
- D. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch- diameter perforations, with overall open area of 23 percent.
- E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
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. 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.

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/A 653M.
1. Galvanized Coating Designation: G60.
 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- D. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

- A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

- a. Aeroflex USA Inc.
 - b. Armacell LLC.
 - c. K-Flex USA.
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 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 3. Butt transverse joints without gaps, and coat joint with adhesive.
 4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted edge overlapping.
 5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
 6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
 7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
 8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.
 - c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
 9. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other

buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 2. Tape Width: 4 inches.
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
 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.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Solvent-Based Joint and Seam Sealant:
1. Application Method: Brush on.
 2. Base: Synthetic rubber resin.
 3. Solvent: Toluene and heptane.
 4. Solids Content: Minimum 60 percent.
 5. Shore A Hardness: Minimum 60.
 6. Water resistant.
 7. Mold and mildew resistant.

8. 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.
1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
 6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- G. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 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:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, 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 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
- B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.
- C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class C.

5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 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.

3.6 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.

3.7 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. All medium pressure supply mains from built-up Air Handling Units to the terminal box connections.
 - b. Low pressure supply ducts (single zone units and supply ductwork downstream of terminal boxes): Test representative duct sections, totaling no less than 10 percent of total installed duct area for each designated pressure class.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Test for leaks before applying external insulation.
 - 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - 6. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
 - 1. Visually inspect duct system to ensure that no visible contaminants are present.
 - 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.9 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.

- B. Use service openings for entry and inspection.
1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with 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.
 4. Coils and related components.
 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 6. Supply-air ducts, dampers, actuators, and turning vanes.
 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 START UP

- A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel unless noted otherwise.
- B. Supply Ducts:

1. Ducts Connected to Indoor Units and Packaged Heat Pumps:
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 4.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.

2. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive 3-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 4.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.

- C. Return Ducts:

1. Ducts Connected to Indoor Units and Packaged Heat Pumps:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 4.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.

2. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 4.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.

- D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

- a. Pressure Class: Negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 4.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
2. Ducts Connected to Equipment Not Listed Above:
- a. Pressure Class: Positive or negative 3-inch wg, or as applicable for fan static pressure listed in schedules.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 4
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
1. Ducts Connected to Indoor Units or Packaged Heat Pumps:
- a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 4.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
2. Ducts Connected to Equipment Not Listed Above:
- a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 4.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
- F. Kitchen Ductwork:
1. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
- 2.
- a. Concealed: Carbon-steel sheet
 - b. Welded seams and joints.
 - c. Pressure Class: Positive or negative 2-inch wg
 - d. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
 - e. SMACNA Leakage Class: 3.
- G. Intermediate Reinforcement:
1. Galvanized-Steel Ducts: Galvanized steel.
2. Stainless-Steel Ducts:
- a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
3. Aluminum Ducts: Aluminum.

H. Double-Wall Duct Interstitial Insulation:

1. Supply Air Ducts: 1 inch thick.
2. Return Air Ducts: 1 inch thick.

I. 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.

J. 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 23 31 13

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Smoke dampers.
7. Combination fire and smoke dampers.
8. Flange connectors.
9. Duct silencers.
10. Turning vanes.
11. Remote damper operators.
12. Duct-mounted access doors.
13. Flexible connectors.
14. Flexible ducts.
15. Duct accessory hardware.
16. Airflow Monitoring Stations

B. Related Sections:

1. Division 23 Section "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. 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. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
 - 1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control damper installations.
 - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
 - e. Duct security bars.
 - f. Wiring Diagrams: For power, signal, and control wiring.
- C. Source quality-control reports.
- D. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- 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.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
 2. Exposed-Surface Finish: Mill phosphatized.
- C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304.
- 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. 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. Greenheck Fan Corporation.
 4. Nailor Industries Inc.
 5. Pottorff; a division of PCI Industries, Inc.
 6. Ruskin Company.
 7. SEMCO Incorporated.
- B. Description: Gravity balanced.
- C. Maximum Air Velocity: 1500 fpm.
- D. Maximum System Pressure: 2-inch wg.
- E. Maximum Leakage: 40" wide, 1% of max. flow.
- F. Frame: 0.09-inch- thick extruded aluminum, with welded corners.
- G. Blades: Multiple single-piece blades, maximum 6-inch width, 0.050-inch- thick aluminum sheet with sealed edges.
- H. Blade Action: Parallel.
- I. Blade Seals: Extruded vinyl, mechanically locked.
- J. Blade Axles:
1. Material: Aluminum.

- 2. Diameter: 0.20 inch.
- K. Tie Bars and Brackets: Aluminum.
- L. Return Spring: Adjustable tension.
- M. Bearings: Steel ball or synthetic pivot bushings.
- N. Accessories: (as noted on plans or required by installation)
 - 1. Electric actuators.
 - 2. Chain pulls.
 - 3. Screen Mounting: Front mounted in sleeve.
 - a. Sleeve Thickness: 20-gage minimum.
 - b. Sleeve Length: 6 inches minimum.
 - 4. Screen Mounting: Rear mounted.
 - 5. Screen Material: Aluminum.
 - 6. Screen Type: Bird or Insect (as noted on drawings)
 - 7. 90-degree stops.

2.3 BAROMETRIC RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Air Balance Inc.; a division of Mestek, Inc.
 - 2. American Warming and Ventilating; a division of Mestek, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. Nailor Industries Inc.
 - 5. Pottorff; a division of PCI Industries, Inc.
 - 6. Ruskin Company.
 - 7. SEMCO Incorporated.
- B. Suitable for horizontal or vertical mounting.
- C. Maximum Air Velocity: 1000 fpm.
- D. Maximum System Pressure: 2-inch wg.
- E. Maximum Leakage: 40" wide, 1% of max. flow.
- F. Frame: 0.09-inch- thick extruded aluminum, with welded corners.
- G. Blades:
 - 1. Multiple, 0.025-inch- thick, roll-formed aluminum.
 - 2. Maximum Width: 2 inches.

3. Action: Parallel.
4. Balance: Gravity.
5. Eccentrically pivoted.

H. Blade Seals: Vinyl.

I. Blade Axles: ½" diameter synthetic

J. Tie Bars and Brackets:

1. Material: Aluminum.
2. Rattle free with 90-degree stop.

K. Return Spring: Adjustable tension.

L. Bearings: Synthetic.

M. Accessories: (as noted on plans or required by installation)

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Flange on intake.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. American Warming and Ventilating; a division of Mestek, Inc.
 - c. METALAIRE, Inc.
 - d. Nailor Industries Inc.
 - e. Ruskin Company.
2. Suitable for horizontal or vertical applications.
3. Frames:
 - a. Hat-shaped, galvanized-steel channels, 16-gauge minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.

- d. Galvanized-steel, 16-gauge thick.
- 5. Blade Axles: Galvanized steel.
- 6. Bearings:
 - a. Molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 7. Tie Bars and Brackets: Galvanized steel.

2.5 CONTROL DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating; a division of Mestek, Inc.
 - 2. Greenheck Fan Corporation.
 - 3. METALAIRE, Inc.
 - 4. Metal Form Manufacturing, Inc.
 - 5. Nailor Industries Inc.
 - 6. Ruskin Company.
- B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- C. Frames:
 - 1. Hat shaped.
 - 2. Galvanized-steel channels, 0.064 inch thick.
 - 3. Mitered and welded corners.
- D. Blades:
 - 1. Multiple blade with maximum blade width of 8 inches, airfoil design.
 - 2. Opposed-blade design.
 - 3. Galvanized steel.
 - 4. 14-gauge thickness.
 - 5. Blade Edging: Closed-cell neoprene edging.
 - 6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- E. Blade Axles: 1/2-inch- diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
 - 1. Operating Temperature Range: From minus 40 to plus 200 deg F.
- F. Bearings:
 - 1. Stainless-steel sleeve.

2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.6 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Per plans
- 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 2000-fpm velocity.
- D. Fire Rating: 1-1/2 and 3 hours.
- E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 20-gauge galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 1. Minimum Thickness: 0.052 or 0.138-inch-thick, as indicated, and of length to suit application.
 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links (unless noted otherwise).

2.7 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Per plans
- B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 and 3 hours.

- E. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- F. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links (unless noted otherwise).
- G. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.
- 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, 20-gauge thickness, galvanized sheet steel; length to suit wall or floor application.
- L. Master control panel for use in dynamic smoke-management systems.
- M. Damper Motors: Modulating or two-position action.
- N. 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." and Division 26 Sections.
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 - 7. Electrical Connection: 120V or 24V as noted on the drawings.
- O. Accessories: (as indicated on the drawings)
 - 1. Auxiliary switches for position indication.
 - 2. Momentary test switch, damper mounted.

2.8 DUCT SILENCERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Industrial Noise Control, Inc.
 2. Price
 3. Ruskin Company.
 4. Vibro-Acoustics.
- B. General Requirements:
1. Factory fabricated.
 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.
- C. Shape:
1. Rectangular straight with splitters or baffles.
 2. Round straight with center bodies or pods.
 3. Rectangular elbow with splitters or baffles.
 4. Round elbow with center bodies or pods.
 5. Rectangular transitional with splitters or baffles.
- D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G60, galvanized sheet steel, 0.034 inch thick.
- E. Inner Casing and Baffles: ASTM A 653/A 653M, G60 galvanized sheet metal, 0.034-inch-thick, and with 1/8-inch- diameter perforations.
- F. Special Construction:
1. Suitable for outdoor use.
 2. High transmission loss to achieve STC 45.
- G. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- H. Principal Sound-Absorbing Mechanism:
1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
 2. Dissipative type with fill material.
 - a. Fill Material: Moisture-proof nonfibrous material.
 - b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.
 3. Lining: Mylar bag.

- I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
 - 1. Lock form and seal or continuously weld joints.
 - 2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 - 3. Reinforcement: Cross or trapeze angles for rigid suspension.
- J. Source Quality Control: Test according to ASTM E 477.
 - 1. Testing in accordance with ASTM E-477.
 - 2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
 - 3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.
- K. Capacities and Characteristics: As indicated on the drawings.

2.9 TURNING VANES

- A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- 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 30 inches wide and double wall for larger dimensions.

2.10 REMOTE DAMPER OPERATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pottorff; a division of PCI Industries, Inc.
 - 2. Ventfabrics, Inc.
 - 3. Young Regulator Company.
 - 4. Metropolitan.
- B. Description: Cable system designed for remote manual damper adjustment.

- C. Tubing: Brass.
- D. Cable: Stainless steel.
- E. Wall-Box Mounting: Recessed, 3/4 inches deep.
- F. Wall-Box Cover-Plate Material: Stainless steel.

2.11 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating; a division of Mestek, Inc.
 - 2. Ductmate Industries, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. McGill AirFlow LLC.
 - 5. Nailor Industries Inc.
 - 6. Pottorff; a division of PCI Industries, Inc.
 - 7. Ruskin
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
 - 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - d. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
 - 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: Single wall, 12-gauge.
 - 3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
 - 4. Factory set at 2" to 10" for positive pressure and -4" to -10" for negative pressure.

5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.12 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Ductmate Industries, Inc.
 2. Duro Dyne Inc.
 3. Ventfabrics, Inc.
 4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 1. Minimum Weight: 26 oz./sq. yd.
 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 3. Service Temperature: Minus 40 to plus 200 deg F.
- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 1. Minimum Weight: 24 oz./sq. yd.
 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 3. Service Temperature: Minus 50 to plus 250 deg F.
- G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 1. Minimum Weight: 16 oz./sq. yd.
 2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
 3. Service Temperature: Minus 67 to plus 500 deg F.
- H. 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.

2.13 FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Flexmaster U.S.A., Inc.
 2. McGill AirFlow LLC.
 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
 1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 2. Maximum Air Velocity: 4000 fpm.
 3. Temperature Range: Minus 10 to plus 160 deg F.
- C. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.
 1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 2. Maximum Air Velocity: 4000 fpm.
 3. Temperature Range: Minus 20 to plus 250 deg F.
 4. Insulation R-value: Comply with ASHRAE/IESNA 90.1-2007.
- D. 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.

2.14 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.15 AIRFLOW MONITORING STATIONS

- A. Air Measuring Stations to be furnished under this section of specification and installed under Division 23 Section. Provide where indicated and scheduled, an airflow measuring element assembly capable of continuously monitoring the airflow capacity in the duct.
1. The airflow sensing elements shall be constructed of 6000 Series extruded aluminum, forming two (2) integral chambers for Total and Static pressure averaging, without the physical presence of forward projecting sensors. Individual Total and Static pressure sensing elements are not acceptable.
 2. The number of sensing ports on each element, and the quantity of elements utilized at each installation, shall comply with the ASHRAE Standard #111 for duct traversing. The airflow traverse elements shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without amplification nor flow correction (K factors), or field calibration, with an accuracy of 2% of actual flow for operating velocities as low as 100 feet per minute.
 3. The airflow elements shall not induce a pressure drop greater than .03" Water Column at 2000 FPM, nor shall the sound level within the duct be amplified by its presence in the air stream. Each airflow measuring element shall contain multiple Total and Static pressure sensors.
 4. Where primary flow elements are located outside of the manufacturers published installation guidelines the manufacturer shall be consulted, and approve of any special configurations, such as air equalizers and/or additional and strategically placed measuring points as may be required.
 5. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be two inches to three inch to facilitate matching connecting ductwork.
 6. The main take-off point from both the total pressure and the static pressure elements MUST be symmetrical. The probes shall be mounted in an eight-inch-deep, 16-gauge galvanized steel casing with 90-degree undrilled flanges, fabricated to the duct size, and shall contain multiple airflow traverse elements interconnected as herein before described.
 7. An identification label shall be placed on each element listing the Model No., System Served, Size and Identifying Tag Number.
 8. The airflow measuring element shall be by Ebtron (or approval equal).
- B. Airflow Indicating Transducers to be furnished and installed under this section of the specification.
1. Provide individual airflow transducers, especially selected for the required design operating spans of each of the above primary elements.

2. The electronic flow transducer(s) shall be solid-state analog type, with infinite resolution to facilitate volume tracking control functions. Microprocessor based transducers with time-sharing of multiple square root extractors and/or controllers are not acceptable.
3. The transducer(s) shall be housed in a NEMA 1 enclosure with integral terminal strip for field wiring, and power and output signal conduit connection port.
4. Each transducer's output shall not be affected by direction of mounting (attitude) or external vibrations and shall be furnished with a factory calibrated span. The analog output signal shall be linear to air volume, which is factory set for a full-scale value equal to 110% of the maximum design capacity of the flow measuring element served for variable air volume applications, or 200% of the design operating value for constant volume applications.
5. Electronic transducers shall operate on 16 to 36 VDC: Transducer(s) shall have outputs of 4 to 20 mA/2-wire or 0-10VDC/3-wire.
6. Each transducer shall be provided with a local indicating meter. The local digital indicating meter shall be one half-inch high, three- and one-half digit liquid crystal display (LCD) type. The LCD shall indicate the measured air volume in engineering units of cubic feet per minute (CFM). The meter shall be calibrated to an accuracy of + 1 count.
7. Transducer performance shall be equal or better than the following:
 - Hysteresis: +0.05%
 - Linearity: +0.4%
 - Repeatability: +0.1%
 - Temperature Effects: <+0.03% F.S./°F
 - Over-pressure: 5 PSIG Proof
 - Response: <0.25 seconds for full span input
 - Noise Filtration: Low Pass Filter, factory set @ 3.2Hz
 - Transducer Span: < 2 times the design velocity pressure @ maximum flow
 - Accuracy: +0.5% F.S. (Terminal Point) / +0.35% F.S. (BFSL)
8. The airflow indicating transducers shall be the FIT-1001D as manufactured by Ebtron (or approval equal).

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 and manufacturer's instructions.
- H. Connect ducts to duct silencers with flexible duct connectors.
- I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream from duct filters.
 - 3. At drain pans and seals.
 - 4. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 5. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 6. Control devices requiring inspection.
 - 7. Elsewhere as indicated.
- J. Install access doors with swing against duct static pressure.
- K. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body plus Ladder Access: 25 by 17 inches.
- L. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

- M. Install flexible connectors to connect ducts to equipment.
- N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- O. Connect terminal units to supply ducts directly or with maximum 6-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- P. Connect diffusers or light troffer boots to ducts with maximum 48-inch lengths of flexible duct clamped or strapped in place.
- Q. Connect flexible ducts to metal ducts with approved strap and sealant.
- R. Install duct test holes where required for testing and balancing purposes.
- S. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00

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.
- B. See fan schedule on drawings for additional requirements and specific options required for each fan.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. In-line centrifugal fans.
 - 2. Centrifugal roof ventilators
 - 3. Makeup air units

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on sea level.
- B. Operating Limits: Classify according to AMCA 99.

1.4 ACCEPTABLE MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. refer to plans
- B. Listing of manufacturers name does not guarantee approval. All equipment must meet or exceed quality and capacities of specified equipment. Final approval will be based on equipment submittals. Any manufacturer not listed but wishing to bid this project shall submit a written request 14 days prior to bid date, prior approval is required for all manufacturers not listed.

1.5 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.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, wiring diagrams, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- C. Operation and Maintenance Data: For power ventilators to include operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.8 COORDINATION

- A. Coordinate size and location of structural-steel support members.

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

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL FANS

- A. Description: In-line, direct- or 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. Companion Flanges: For inlet and outlet duct connections.
 - 2. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 - 3. Motor and Drive Cover (Belt Guard): Galvanized steel.
- F. Capacities and Characteristics: As indicated on the drawings.

2.2 CENTRIFUGAL ROOF VENTILATORS

- A. Description: Direct- or 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 for UL 762 kitchen hood exhaust fans.
 - 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.
 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 4. Fan and motor isolated from exhaust airstream.
- E. Accessories: (See drawings for required accessories).
1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
 2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
 3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
 4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops. Backdraft dampers on all roof mounted supply fans shall be motorized.
- F. Roof Curbs: Galvanized steel; 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: 8 inches (unless noted otherwise).
 3. Pitch Mounting: Manufacture curb for roof slope.
 4. Metal Liner: Galvanized steel.
 5. Burglar Bars: 1/2-inch- thick steel bars welded in place to form 6-inch squares (where indicated on the drawings).
 6. Vented Curb: Unlined with louvered vents in vertical sides (where indicated on the drawings).
- G. Capacities and Characteristics: As indicated on the drawings.

2.3 KITCHEN MAKEUP AIR UNITS WITH PACKAGED HEATING AND DX COOLING

- A. Unit with Integral Indirect gas-fired Heating and Packaged DX Cooling shall be fully assembled at the factory and consist of an insulated metal cabinet, outdoor air intake with aluminum bird screen, motorized intake damper, filter assembly for intake air, packaged DX cooling system, condensate drain pan, P trap, sensors, supply air blower assembly, and electrical control unit with all specified components and internal accessories factory installed and tested and prepared for single-point high voltage connection.

CABINET

- A. Materials: Formed, single wall metal cabinet with fiberglass duct liner insulation, fabricated to permit access to internal components for maintenance.
 - 1. Outside casing: 18 gauge, galvanized (G90) steel meeting ASTM A653 for components that do not receive a painted finish. Pre-painted components as supplied by the factory shall have polyester urethane paint on 18-gauge G60 galvanized steel. Base rail is 12 gauge, galvanized (G90) steel.
 - 2. Internal Assemblies: 24 gauge galvanized (G90) steel except for motor supports which shall be minimum 14 gauge galvanized (G90) steel.
- B. Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.
 - 1. Materials: Fiberglass insulation. If insulation other than fiberglass is used, it must also meet the Fire Hazard Classification shown below.
 - a. Thickness: 1 inch (25 mm)
 - b. Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.
 - c. Location and application: Floor of each unit shall be insulated with either one half inch thick or 1 inch thick rigid fiberglass insulation, covered on one surface with integral aluminum foil.
- C. Access panels: Unit shall be equipped with removable access panels to provide easy access to all major components. Access panels shall be fabricated of 18-gauge steel. Removable access panels shall incorporate a formed drip edge.
- D. Supply Air blower assembly: Blower assembly consists of an electric motor and a belt driven, double width, double inlet forward curve blower. Assembly shall be mounted on heavy gauge galvanized rails and further mounted on minimum 1.125-inch-thick neoprene vibration isolators.
- E. Control panel / connections: Unit shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections.
- F. Indirect Gas-Fired Furnace:
 - 1. Shall be ETL Certified as a component of the unit.
 - 2. Shall have an integral combustion gas blower.
 - 3. Shall be ETL Certified for installation downstream of a cooling coil.
 - 4. Shall have fault sensors to provide fault conditions to optional digital controller or building controls.
 - 5. Shall have 4-pass tubular heat exchangers, constructed of type 409 stainless steel. Heat exchanger tubes shall be installed on the vest plate by means of swaged assembly, welded connections are not acceptable. Heat exchanger tubes shall be supported by a minimum of two fabricated assemblies that support the tubes and also permit expansion and contraction of the tubes.

6. Heat exchanger shall have a one-year warranty.
7. Shall be encased in a weather-tight metal housing with intake air vents. Large, metal lift-off or hinged door shall provide easy access to the enclosed vest plate, control circuitry, gas train, burner assembly and exhaust blower.
8. Shall include a kit for Outdoor mounting with Standard venting.
- G. Condensate drain pan: Drain Pan shall be an integral part of the MAU whenever a cooling option is included. Pan shall be formed of welded austenitic stainless steel sheet material and provided with a welded stainless steel drain connection at the front for connection to a P trap. Drain pan shall be sloped in two directions to provide positive draining and drain connector shall be sealed at penetration through cabinet wall.
- H. P trap: If the unit is equipped with a condensate drain pan, contractor shall provide, or fabricate, and install an appropriate P trap, in accordance with all local and area codes and Best Practices.
- I. Cooling Coil; shall be rated for noted glycol fill %, per plans. Coil shall be equipped with all appurtenant controls as specified elsewhere in this section. The coil shall be provided with applicable coil coating rated for exposure to salt air coastal applications to extend the life. All supporting structure and drain pans shall be stainless steel. The cooling coil is to be an integral module, incorporated into the unit with local control based on external setpoint.
- J. Dampers: Motorized Intake Air dampers of low leakage type shall be factory installed.
- K. Sensors are considered to be part of various optional operational modes or device controllers and are to be factory supplied and installed as specified by the A/E.

BLOWER

- A. Blower section construction, Supply Air: Belt drive motor and blower shall be assembled onto a minimum 14-gauge galvanized steel platform and must have neoprene vibration isolation devices, minimum of 1 - 1/8 inches thick.
- B. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.
- C. Centrifugal blower housing: Formed and reinforced steel panels to make curved scroll housing with shaped cutoff.
- D. Forward curved blower (fan) wheels: Galvanized or aluminum construction with inlet flange and shallow blades curved forward in direction of airflow. Mechanically attached to shaft with set screws.
- E. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating".

MOTORS

- A. General: Blower motors greater than .75 horsepower shall be "NEMA Premium" unless otherwise indicated. Compliance with EPart minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently

lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure. Drives shall be sized for a minimum of 150% of driven horsepower and pulleys shall be fully machined cast-type, keyed and fully secured to the fan wheel and motor shafts. Electric motors of ten horsepower or less shall be supplied with an adjustable drive pulley. Comply with requirements in Division 23 05 13, matched with fan load.

- B. Motors shall be 60 cycle, 3 phase, 460 volt.

UNIT CONTROLS

- A. The unit shall be constructed so that it can function as a stand-alone heating and cooling system controlled by factory-supplied controllers, thermostats and sensors or it can be operated as a heating and cooling system controlled by a Building Management System (BMS).
- B. Sensors to be provided with the unit include:
 - 1. Cooling Inlet Air Sensor

FILTERS

- A. Unit shall have 2" thick permanent metal filters located in the outdoor air intake and shall be accessible from the exterior of the unit.

2.4 MOTORS

- A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
- B. Enclosure Type: Totally enclosed, fan cooled.

2.5 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 spring isolators having a static deflection of 1 inch. Vibration control devices are specified in Division 23 Section "Vibration Control for HVAC Piping and

Equipment."

1. Secure vibration controls to concrete bases using anchor bolts cast in concrete base.
- C. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.
- D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- E. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch. 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 23 34 23

SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
1. Shutoff single-duct air terminal units.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Ceiling 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.
- D. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Instructions for resetting minimum and maximum air volumes.
 2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Compliance: Applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- E. Listing of manufacturers name does not guarantee approval. All equipment must meet or exceed quality and capacities of specified equipment. Final approval will be based on equipment submittals. Any manufacturer not listed but wishing to bid this project shall submit a written request 14 days prior to bid date, prior approval is required for all manufacturers not listed.

1.5 COORDINATION

- A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

- A. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.
- B. Casing: 22-gauge steel.
 - 1. Casing Lining: 1/2-inch- thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. Cover liner with nonporous foil.
 - 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - 3. Air Outlet: S-slip and drive connections.
 - 4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.
 - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

- C. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
 2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.
- E. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.
1. Primary and secondary overtemperature protection.
 2. Nickel chrome 80/20 heating elements.
 3. Airflow switch.
 4. Noninterlocking disconnect switch.
 5. Fuses (for coils more than 48 A).
 6. Magnetic contactor for each step of control (for three-phase coils).
- F. DDC Controls: Bidirectional damper operators and microprocessor-based controller and room sensor shall be compatible with temperature controls specified in Division 23 Section "Instrumentation and Control for HVAC" and shall have the following features:
1. Damper Actuator: 24 V, powered closed, spring return open.
 2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
 - a. Proportional, plus integral control of room temperature.
 - b. Time-proportional reheat-coil control.
 - c. Occupied and unoccupied operating mode.
 - d. Remote reset of airflow or temperature set points.
 - e. Adjusting and monitoring with portable terminal.
 - f. Communication with temperature-control system specified in Division 23 Section "Instrumentation and Control for HVAC."
 3. Room Sensor: Wall mounted temperature sensor
 4. DDC controller shall be supplied by the BAS contractor to be factory mounted by the terminal box manufacturer.
- G. Control Sequence: See Sequence of Operation.

2.2 SOURCE QUALITY CONTROL

- A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.
- B. Verification of Performance: Rate air terminal units according to ARI 880.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air terminal units' level and plumb. Maintain sufficient clearance for normal service and maintenance per NEC and SCO requirements.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to air terminal units to allow service and maintenance.
- C. 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.
- D. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts."
- E. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

3.4 STARTUP SERVICE

- A. Complete installation and startup check according to manufacturer's written instructions and do the following:
 - a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - b. Verify that controls and control enclosure are accessible.
 - c. Verify that control connections are complete.
 - d. Verify that nameplate and identification tag are visible.
 - e. Verify that controls respond to inputs as specified.

3.5 DEMONSTRATION

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

END OF SECTION 23 36 00

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Rectangular and square ceiling diffusers.
2. Perforated diffusers.
3. Louver face diffusers.
4. Linear bar diffusers.
5. Linear slot diffusers.
6. Linear bar 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 ACCEPTABLE MANUFACTURERS

- A. Listing of manufacturers name does not guarantee approval. All equipment must meet or exceed quality and capacities of specified equipment. Final approval will be based on equipment submittals. Any manufacturer not listed but wishing to bid this project shall submit a written request 14 days prior to bid date, prior approval is required for all manufacturers not listed.

1.4 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. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.
- C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.
- 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. 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.
- E. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

- A. Rectangular and Square Ceiling Diffusers:
 - 1. Devices shall be specifically designed for variable-air-volume flows.
 - 2. Material: Steel or Aluminum as indicated on the drawings.
 - 3. Finish: Baked enamel, white unless noted otherwise.
 - 4. Face Size: 24 by 24 inches or as indicated on the drawings.
 - 5. Face Style: Four cone.
 - 6. Mounting: As required.
 - 7. Pattern: Fixed.
 - 8. Dampers: Radial opposed blade.
- B. Perforated Diffuser:
 - 1. Devices shall be specifically designed for variable-air-volume flows.
 - 2. Material: Steel backpan and pattern controllers, with steel or aluminum face as indicated on the drawings.
 - 3. Finish: Baked enamel, white unless noted otherwise.
 - 4. Face Size: 24 by 24 inches or as indicated on the drawings.
 - 5. Duct Inlet: Round or Square as indicated on the drawings.
 - 6. Face Style: Flush.
 - 7. Mounting: T-bar.
 - 8. Pattern Controller: Adjustable with louvered pattern modules at inlet.
 - 9. Dampers: Radial opposed blade.
- C. Louver Face Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material: Steel or Aluminum as indicated on the drawings.
3. Finish: Baked enamel, white unless noted otherwise.
4. Face Size: As indicated on the drawings.
5. Mounting: As required.
6. Pattern: Four-way core style, unless noted otherwise.
7. Dampers: Radial opposed blade.

2.2 REGISTERS AND GRILLES

A. Linear Bar Grille:

1. Material: Aluminum.
2. Finish: Baked enamel, white unless noted otherwise. Coordinate with arch plans
3. Face Arrangement: 1/2-by-1/2-by-1/2-inch grid core.
4. Distribution plenum.
 - a. Internal insulation.
 - b. Inlet damper.
5. Frame: 1-1/4 inches wide.
6. Mounting: Concealed.
7. Damper Type: Adjustable opposed blade.

2.3 CEILING LINEAR SLOT OUTLETS

A. Linear Slot Diffuser:

1. Devices shall be specifically designed for variable-air-volume flows.
2. Material - Shell: Steel or Aluminum as indicated on the drawings.
3. Material - Pattern Controller and Tees: Aluminum.
4. Finish - Face and Shell: Baked enamel, white exterior with black interior, unless noted otherwise.
5. Finish - Pattern Controller: Baked enamel, black.
6. Finish - Tees: Baked enamel, white.
7. Slot Width: As indicated on the drawings.
8. Number of Slots: as indicated on the drawings.
9. Length: as indicated on the drawings.
10. Accessories:
 - a. End caps in lay-in ceilings.
 - b. End Borders where not installed in lay-in ceilings.
 - c. Insulated plenum: By manufacturer black finish unless otherwise noted.

2.4 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13

SECTION 23 52 16
CONDENSING BOILERS

PART 1. GENERAL

1.1 SCOPE

- A. The work to be performed includes all new equipment, labor and materials required to furnish and install high-efficiency Pulse hydronic boilers as described in this specification.

1.2 REFERENCES

- A. ASME Section IV.
- B. ASME CSD1 - Controls and Safety Devices.
- C. ANSI Z21.13.
- D. CSA - CGA/AGA
- E. GE GAP
- F. NEC - National Electrical Code

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model, weights (shipping, installed, and operating), installation and start-up instructions, along with furnished accessory information.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for boilers including ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in the manufacturing of pulse combustion, high efficiency, condensing boilers, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. The hot water boiler maximum working pressure will be 160 psig.
- C. Pulse Boiler Flame Safeguard Control will be of an accepted quality manufacturer bearing UL Certification.

- D. The entire boiler system and its installation shall conform to the manufacturer's instructions, applicable codes and associated National Board requirements.
- E. The equipment shall, as a minimum, be in strict compliance with the requirements of this specification and shall be the manufacturer's standard commercial product unless specified otherwise. Additional equipment features, details, accessories, etc. which are not specifically identified but which are a part of the manufacturer's standard commercial product, shall be included in the equipment being furnished.
- F. The equipment shall be of the type, design, and size that the manufacturer currently offers for sale and appears in the manufacturer's current catalog.
- G. The equipment shall fit within the allocated space, leaving ample allowance for maintenance and inspection.
- H. The equipment shall be new and fabricated from new materials. The equipment shall be free from defects in materials and workmanship.
- I. All units of the same classification shall be identical to the extent necessary to ensure interchangeability of parts, assemblies, accessories, and space parts wherever possible.
- J. In order to provide unit responsibility for the specified capacities, efficiencies, and performance, the boiler manufacturer shall certify in writing that the equipment being submitted shall perform as specified.

1.5 WARRANTY

- A. Boiler manufacturer shall guarantee in writing equipment to be free of defects for one year after start-up date or 18 months from factory shipment, and to repair or replace at manufacturer's expense any defective parts. Unit shall receive such factory tests as are deemed advisable by the manufacturer to check construction and operation.
- B. The pressure vessel shall be guaranteed against thermal shock for 10 years when utilized in a closed loop hydronic heating system with a maximum temperature differential rating of up to 170 °F. The boiler pressure vessel shall be guaranteed accordingly without a minimum flow rate or return water temperature requirement. The boiler shall not require the use of flow switches or other devices to ensure minimum flow.
- C. The pressure vessel shall carry a 10-year warranty against material and workmanship defects.
- D. The combustor and exhaust pipes (heat exchanger) shall be guaranteed against flue gas corrosion for a period of 10 years for carbon steel boilers and a period of 5 years for stainless steel boilers.

- E. All parts not covered by the above warranties shall carry a one-year warranty. This shall include all electrical and burner components.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

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

2.2 BOILER CONSTRUCTION

- A. The exhaust decoupler shall be constructed of ¼” corrosion resistant Corten and include a flue gas condensate drain.
- B. The combustor shall be constructed of SA-53B ERW pipe.
- C. The pressure vessel shell shall be SA-53B ERW pipe or SA-285 Grade C plate. The heads shall be SA-516 Grade 70 plate. The pressure vessel shall be fully insulated with 2” of high temperature insulation.
- D. The pulse combustor location shall be such that all combustor assembly components are located within water-backed areas.
- E. The boiler’s pressure vessel, combustor, and exhaust decoupler shall be encased in an 18 gauge metal cabinet with primer and finish coat of paint.
- F. Boilers utilizing copper heat exchanger construction are not acceptable.

2.3 BOILER DESIGN

- A. Boiler shall be fire-tube design, utilizing the principles of pulse combustion. The boiler shall be self-aspirating and require no forced or induced draft fan to supply air for combustion after ignition.
- B. External convection and radiation heat losses to the boiler room from the boiler shall be less than 0.5% of the rated boiler input. The boiler shall not contain any refractory, refractory lining or ceramic in the furnace or firebox.
- C. The boiler shall be designed for operation in a condensing mode, in order to extract the latent heat from the combustion products. The boiler shall have a minimum acceptable fuel-to-water efficiency of 91% at a return water temperature of 80 °F and at the full rated input capacity of the boiler. Overall efficiency at the low fire rated input capacity will be 98%.
- D. The boiler shall be able to operate without the use of a 3-way valves or primary/secondary piping loops.
- E. The boiler shall have no minimum return water temperature requirements.
- F. The boiler shall have no minimum flow rate requirements.

2.4 CONTROLS

- A. The flame safeguard system shall be Fulton Model RM7865 with LED display module. The control shall provide a 35-second pre-purge and post-purge. The control shall maintain a

running history of operating hours, number of cycles, and the most recent six faults. The control shall have the capability to be connected to a keyboard display module that will retrieve this information.

- B. Pulse Combustion controls shall include the following:
1. Operating Temperature Controller for automatic start/stop of the pulse combustion process. Controller will have auto-tune PID capabilities for simplified loop configuration and fast response to water temperature fluctuations. A Type J temperature sensor shall be located in the boiler pressure vessel.
 2. High limit temperature aquastat with manual reset.
 3. One low water cutoff probe in the boiler shell with manual reset and push-to-test capability.
 4. Air safety switch to prevent operation unless sufficient pre-purge air is assured.
 5. High condensate cut-off probe located in the exhaust decoupler.
 6. A Proof of Flame switch and Flame Rod operating in parallel, to prove combustion.
- C. A combustion control system shall be furnished which provides a turndown ratio of 5:1 per ANSI Z21.13 (3:1 for LPG Fired Boilers) over the input range from high to low fire. The supply temperature and setpoint temperature shall be displayed at all times by the operating temperature control. Firing rate shall be controlled by a continuous 4-20mA analog signal to a modulation motor.
- D. All controls to be panel mounted and so located on the boiler as to provide ease of servicing the boiler without disturbing the controls and also located to prevent possible damage by water according to CSA requirements. Electrical power supply shall be 120 volts, 60 cycle, single phase, 10 Amps maximum. Boiler shall draw less than 1 Amp while in run mode. No additional electric power shall be required for devices such as forced draft fans.
- E. When multiple boilers are to be installed in a common hydronic loop, an MCS sequencing control shall be provided to stage the boilers. The control shall include automatic rotation of the lead boiler, an adjustable outdoor reset schedule, multiple setback schedules, domestic hot water priority, and a digital display. The MCS control shall stage each boiler on at low fire. After all boilers are running, the MCS control will then modulate the boilers as a group. To ensure proper integration with the boiler controls, the boiler manufacturer shall supply the MCS control.

2.4 MAIN GAS TRAIN COMPONENTS

- A. The boiler shall have an integral gas train, factory assembled and installed. The main gas train will include:
1. One manual shut-off valve at gas inlet.
 2. Gas inlet trap.
 3. Gas regulator rated for a maximum 14" wc supply pressure.
 4. Two safety shut-off valves. One to be solenoid and one motorized valve.
 5. Independent low and high gas pressure switches shall be supplied.

2.5 BOILER FITTINGS

- A. Boiler shall be supplied with a ASME Section IV approved, side outlet type safety valve. The safety relief valve size shall be in accordance with ASME code requirements.
- B. Temperature and pressure gauges shall be mounted on top of the boiler.
- C. A condensate drain connection shall be provided in the exhaust decoupler. A Fulton condensate drain kit will be provided to collect and drain the flue gas condensate.

2.4 INSTALLATION

- A. The boiler shall be CSA approved as a direct vent boiler. A conventional chimney or stack shall not be required. Direct venting shall be accomplished with AL-29-4C stainless steel, single (or double) wall. Vent piping shall be installed in accordance with applicable national and local codes and per the boiler manufacturers' recommendations.
- B. The boiler shall have the outside combustion air intake supply ducted with PVC pipe. An air intake muffler shall be provided by the boiler manufacturer and mounted within 10 feet of the boiler intake connection.
- C. An external muffler to be provided by the boiler manufacturer and mounted within 10 feet of the boiler exhaust connection.

2.6 EMISSIONS

- A. The boiler shall operate with CO emissions less than 100 PPM corrected to 3% O₂ and shall with NO_x emissions less than 50 PPM corrected to 3% O₂ over the entire turndown range.

2.7 OPERATING MANUAL

- A. Instructions for installation, operation and maintenance of the boiler shall be contained in a manual provided with each boiler unit.
- B. A wiring diagram corresponding to the boiler configuration shall be permanently affixed to the boiler near the electrical panel.

PART 3 EXECUTION

3.0 INSTALLATION

- A. Equipment and materials shall be installed in an approved manner and in accordance with the boiler manufacturers' installation requirements.
- B. The installer shall construct a level continuous concrete pad (min. 3-1/2 inches high) for the entire boiler system according to the boiler manufacturer's erecting instructions.

- C. Assemble unit sections and parts shipped loose or unassembled for shipment purposes. Follow manufacturer's installation recommendations and instructions.
- D. Install electrical control items furnished by manufacturer per wiring diagram provided by manufacturer.
- E. Complete water piping installation as required by manufacturer for operation of system.
- F. Provide air intake and exhaust piping, size and type as recommended by the manufacturer.
- G. Provide boiler manufacturer recommended manifold pipe and fittings from each boiler to nearest floor drain or as indicated.

3.1 FIELD QUALITY CONTROL

- A. After boiler installation is completed, the manufacturer shall provide the services of a field representative for starting the unit and training the operator.
- B. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boilers and piping. Obtain certification for completed boiler units, deliver to Owner, and obtain receipt.

END OF SECTION 23 52 16

ROOFTOP AIR HANDLING UNITS

PART 1: GENERAL

1.01 SECTION INCLUDES

- A. Outdoor (Rooftop) Air Handling & DOAS Units.

1.02 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- B. AMCA 99 - Standards Handbook.
- C. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
- D. AMCA 300 - Test Code for Sound Rating Air Moving Devices.
- E. AMCA 500 - Test Methods for Louver, Dampers, and Shutters.
- F. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
- G. AHRI 430 - Central-Station Air-Handling Units.
- H. AHRI 435 - Application of Central-Station Air-Handling Units.
- I. ASTM B117 - Standard Practice for Operating Salt Spray Apparatus.
- J. NEMA MG1 - Motors and Generators.
- K. NFPA 70 - National Electrical Code.
- L. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- M. UL 723 - Test for Surface Burning Characteristics of Building Materials.
- N. UL 900 - Test Performance of Air Filter Units.
- O. UL 1995 - Standard for Heating and Cooling Equipment.
- P. UL 94 - Test for Flammability of Plastic Materials for Parts in Devices and Appliances.
- Q. IBC 2000, 2003 - International Building Code.
- R. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
- S. NFPA 5000 - Building Construction and Safety Code.
- T. ASHRAE 90.1 Energy Code.
- U. AHRI Standard 1060 - Rating Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment.
- V. GSA 2003 Facilities Standard - 5.9 HVAC Systems and Components.

1.03 SUBMITTALS

- A. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements. Computer generated fan curves for each air handling unit shall be submitted with specific design operating point noted. A computer-generated psychometric chart shall be submitted for each cooling coil with design points and final operating point clearly noted. Sound data for discharge, radiated and return positions shall be submitted by octave band for

each unit. Calculations for required baserail heights to satisfy condensate trapping requirements of cooling coil shall be included.

B. Product Data:

1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, finishes of materials, electrical characteristics, and connection requirements.
2. Provide data of filter media, filter performance data, filter assembly, and filter frames.
3. Provide manufacturer's installation instructions.

1.04 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Air Handler products specified in this section must show a minimum five years documented experience and complete catalog data on total product.

1.05 SAFETY AGENCY LISTED & CERTIFICATION

- A. Air Handling units shall be cETLus safety listed to conform with UL Standard 1995 and CAN/CSA Standard C22.2 No. 236. Units shall be accepted for use in New York City by the Department of Building, MEA 342-99-E.
- B. Air handler furnished with double width, double inlet (DWDI) fans and/or plenum fans where applicable, shall be certified in accordance with the central station air handling units certification program, which is based on AHRI Standard 430.
- C. Air handling unit water heating & cooling coils shall be certified in accordance with the forced circulation air cooling and air heating coils certification program, which is based on AHRI Standard 410.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site.
- B. Accept products on site on factory-furnished shipping skids. Inspect for damage.
- C. Store in clean dry place and protect from construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

PART 2: PRODUCTS

2.01 GENERAL DESCRIPTION

- A. Configuration: Fabricate as detailed on prints.
- B. Performance: Conform to AHRI 410 and 430 Standards. See schedules on prints.
- C. Acoustics: Sound power levels (dB) for the unit shall not exceed the specified levels shown on the unit schedule. The manufacturer shall provide the necessary sound treatment to meet these levels if required.

2.02 UNIT CONSTRUCTION

- A. Fabricate unit with heavy gauge channel posts and panels secured with mechanical fasteners. All panels, access doors, and ship sections shall be sealed with permanently applied bulb-type gasket. Shipped loose gasketing is not allowed.
- B. Panels and access doors shall be constructed as a 2-inch nominal thick; thermal broke double wall assembly, injected with foam insulation with an R-value of not less than R-13.
 - 1. The outer panel shall be constructed of G60 painted galvanized steel.
 - 2. The inner liner shall be constructed of G90 galvanized steel.
 - 3. The floor plate shall be constructed as specified for the inner liner.
 - 4. Unit will be furnished with solid inner liners.
- C. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, maximum 5 inches of positive or 6 inches of negative static pressure. Deflection shall be measured at the panel midpoint.
- D. The casing leakage rate shall not exceed .5 cfm per square foot of cabinet area at 5 inches of positive static pressure or 6 inches of negative static pressure (.0025 m3/s per square meter of cabinet area at 1.24 kPa static pressure).
- E. Module to module field assembly shall be accomplished with an overlapping, full perimeter internal splice joint that is sealed with bulb type gasketing on both mating modules to minimize on-site labor and meet indoor air quality standards.
- F. Access doors shall be flush mounted to cabinetry, with minimum of two six-inch-long stainless-steel piano-type hinges, latch and full size handle assembly. Access doors shall swing outward for unit sections under negative pressure. Access doors on positive pressure sections, shall have a secondary latch to relieve pressure and prevent injury upon access.
- G. Provide cross broke roofcap system to divert water from the top surface of the air handler. The rain shed roofcap shall have 2" standing seams covered with splice cap channels to seal top seam. Splice cap shall break down over sides of standing seam to protect the ends of the seam.
 - 1. Cooling coil piping vestibule 18" deep shall be factory installed of standard cabinet construction on the coil connection side of the unit. Roofcap over vestibule shall be a continuous single piece covering both the coil section and the vestibule. Roofcap seams between coil section and vestibule are not allowed.
 - 2. Heating coil piping vestibule 18" deep shall be factory installed of standard cabinet construction on the coil connection side of the unit. Roofcap over vestibule shall be a continuous single piece covering both the coil section and the vestibule. Roofcap seams between coil section and vestibule are not allowed.
- H. The unit shall have a 6-inch curb ready base for structural rigidity and condensate trapping. The curb-ready base shall be designed with sloped drip pans located under all unit sections except duct openings and shall be supported by frame member.
- I. Roof curb kit of 16-inch height shall provide support for the air handler on the building roof and provide a weather protected area for terminating and securing the roof membrane. The roof curb kit shall be manufactured by the air handler unit manufacturer.
- J. Construct drain pans from stainless steel with cross break and double sloping pitch to drain connection. Provide drain pans under cooling coil section. Drain connection centerline shall

be a minimum of 3'' above the base rail to aid in proper condensate trapping. Drain connections that protrude from the base rail are not acceptable. There must be a full 2'' thickness of insulation under drain pan.

2.03 FAN ASSEMBLIES

- A. Acceptable fan assembly shall be a double width, double inlet, class II, belt-drive type housed forward curved fan dynamically balanced as an assembly, as shown in schedule. Maximum fan RPM shall be below first critical fan speed. Fan assemblies shall be dynamically balanced by the manufacturer on all three planes and at all bearing supports. Copper lubrication lines shall be provided and extend from the bearings and attached with grease fittings to the fan base assembly near access door. If not supplied at the factory, contractor shall mount copper lube lines in the field. Fan and motor shall be mounted internally on a steel base. Factory mount motor on slide base that can be slid out the side of unit if removal is required. Provide access to motor, drive, and bearings through hinged access door.
- B. Fan and motor shall be mounted internally on a steel base. Factory mount motor on slide base that can be slid out the side of the unit if removal is required. Provide access to motor, drive, and bearings through hinged access door. Fan and motor assembly shall be mounted on 2" deflection spring vibration type isolators inside cabinetry.

2.04 BEARINGS, SHAFTS, AND DRIVES

- A. Bearings: Basic load rating computed in accordance with AFBMA - ANSI Standards. The bearings shall be designed for service with an L-50 life of 200,000 hours and shall be a heavy-duty pillow block, self-aligning, grease-lubricated ball or spherical roller bearing type.
- B. Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.
- C. V-Belt drives shall be cast iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed. Fixed sheaves, matched belts, and drive rated based on motor horsepower. Minimum of 2 belts shall be provided on all fans with 10 HP motors and above. Standard drive service factor minimum shall be 1.1 S.F. for 1/4 HP – 7.5 HP, 1.3 S.F. for 10 HP and larger, calculated based on fan brake horsepower.

2.05 ELECTRICAL

- A. The air handler(s) shall be ETL and ETL-Canada listed by Intertek Testing Services, Inc. Units shall conform to bi-national standard ANSI/UL Standard 1995/CSA Standard C22.2 No. 236.
- B. Fan motors shall be manufacturer provided and installed, Open Drip Proof, premium efficiency (meets or exceeds EPart requirements), 1750 RPM, single speed, 460V / 60HZ / 3P. Complete electrical characteristics for each fan motor shall be as shown in schedule.
- C. Wiring Termination: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclosed terminal lugs in terminal box sized to NFPA 70.
- D. Manufacturer shall provide ASHRAE 90.1 Energy Efficiency equation details for individual equipment to assist Building Engineer for calculating system compliance.

- E. Installing contractor shall provide GFI receptacle within 25 feet of unit to satisfy National Electrical Code requirements.
- F. Air handler manufacturer shall provide, mount and wire ABB variable speed drive with electrical characteristics such as indicated on project schedule and shown on manufacturer's data sheets.

2.06 COOLING AND HEATING COILS

- A. Certification: Acceptable water cooling, water heating, steam, and refrigerant coils shall be certified in accordance with AHRI Standard 410 and bear the AHRI label. Coils exceeding the scope of the manufacturer's certification and/or the range of AHRI's standard rating conditions will be considered provided the manufacturer is a current member of the AHRI Forced Circulation Air-Cooling and Air-Heating Coils certification programs and that the coils have been rated in accordance with AHRI Standard 410. Manufacturer must be ISO 9002 certified.
- B. Water cooling coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not, factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.
 - 1. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.
 - 2. Fins shall have a minimum thickness of 0.0075-inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
 - 3. Coil tubes shall be 5/8-inch OD seamless copper, 0.020-inch nominal tube wall thickness, expanded into fins, brazed at joints. Soldered U-bends shall be provided to minimize the effects of erosion and premature failure having a minimum tube wall thickness of .025 inches.
 - 4. Coil connections shall be carbon steel, NPT threaded connection. Connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.
 - 5. Coil casing shall be a formed channel frame of stainless steel

6. All coils shall be provided with coating for inhibiting saltwater corrosion
- C. Water heating coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not, factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.
 1. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.
 2. Fins shall have a minimum thickness of 0.0075-inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
 3. Coil tubes shall be 5/8-inch OD seamless copper, 0.020-inch nominal tube wall thickness, expanded into fins, brazed at joints. Soldered U-bends shall be provided to minimize the effects of erosion and premature failure having a minimum tube wall thickness of .025 inches.
 4. Coil connections shall be carbon steel, threaded connection. Connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.
 5. Coil shall be furnished as an uncased stainless-steel track to allow for thermal movement and slide into a pitched track for fluid drainage.
 6. All coils shall be provided with coating for inhibiting saltwater corrosion

2.07 FILTERS

- A. Furnish angled filter section with 2-inch pleated MERV 8 filter with microbial resistant Intersept coating. Provide side loading and removal of filters.
- B. Filter media shall be UL 900 listed, Class I or Class II.
- C. Filter Magnehelic gauge(s) shall be furnished and mounted by others.

2.08 AIR PURIFICATIONS DEVICES

- A. Mount air purification device as noted in plans and schedules
- B. Devices shall be powered from local control circuit, and shall comply with all noted requirements in the plan schedules

2.09 ADDITIONAL SECTIONS

- A. Plenum section shall be provided and properly sized for inlet and/or discharge air flow (between 600 and 1500 feet per minute). The plenum shall provide single or multiple openings as shown on drawings and project schedule.
- B. Access section shall be provided for access between components. Floor options shall include .125-inch aluminum treadplate or drainpan as shown on project schedule.
- C. Economizer section shall be provided with left side outside air opening and end return air opening and right-side exhaust air opening with or without parallel low leak airfoil damper blades. Dampers shall be hollow core galvanized steel airfoil blades, fully gasketed and have continuous vinyl seals between damper blades in a galvanized steel frame. Dampers shall have stainless steel jamb seals along end of dampers. Linkage and ABS plastic end caps shall be provided when return and outside air dampers sized for full airflow. Return and outside air dampers of different sizes or very large dampers and exhaust dampers must be driven separately. Damper Leakage: Leakage rate shall be less than two tenths of one percent leakage at 2 inches static pressure differential. Leakage rate tested in accordance with AMCA Standard 500.

PART 3: EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's Installation & Maintenance instructions.

3.02 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been testing run under observation.

3.03 EXTRA MATERIALS

- A. Provide one extra set of fan belts and filters for each unit.

END OF SECTION 23 73 15

SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting and may be connected to ducts.

1.2 SUBMITTALS

- A. Product Data: For each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IESNA 90.1-2007 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2007, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.4 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace split-system air-conditioning units that fail in materials and workmanship within five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 EVAPORATOR-FAN UNIT

- A. Concealed Unit Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
 - 1. Insulation: Faced, glass-fiber duct liner.
 - 2. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1-2007.
 - 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.
- B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
- C. Evaporator Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
- D. Fan Motor: Multispeed.
- E. Filters: 1 inch thick, in fiberboard frames.

2.2 AIR-COOLED, COMPRESSOR-CONDENSER UNIT

- A. Casing steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- B. Compressor: Hermetically sealed reciprocating type with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - 1. Refrigerant: R-410a (unless otherwise indicated on the drawings).
- C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
- D. Fan: Aluminum-propeller type, directly connected to motor.
- E. Motor: Permanently lubricated, with integral thermal-overload protection.
- F. Low Ambient Kit: Permits operation down to 45 deg F.
- G. Mounting Base: Polyethylene.
- H. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1-2007, "Energy Standard for Buildings except Low-Rise Residential Buildings."

2.3 ACCESSORIES

- A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
- B. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
 - 1. Minimum Insulation Thickness: 1/2 inch thick.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- B. Install ground-mounted, compressor-condenser components on 4-inch- thick, reinforced concrete base; 4 inches larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.
- C. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
- D. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.
- E. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.
- B. Connect supply and return condenser connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
- C. Install piping adjacent to unit to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connection, and to assist in field testing. Report results in writing.
- B. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new components, and retest.
- D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 81 26

SECTION 23 82 20
FAN COIL UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Blower Coils
 - 1. Belt-Driven or Direct Drive Fan Coil Units

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 230900 – Direct Digital Control System.
- B. Section 260523 – Control Voltage Electrical Power Cables

1.3 RELATED SECTIONS

- A. Section 230900 – Direct Digital Control System.
- B. Section 260519 – Low Voltage Electrical Power Conductors and Cables.

1.4 REFERENCES

- A. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.
- B. UL 181 - Factory-Made Air Ducts and Connectors.
- C. UL 1995 - Heating and Cooling Equipment.
- D. NMFC item 180: Package Performance Testing in accordance with National Motor Freight Classification.
- E. ARI 260-2001 - Standard for Sound Rating of Ducted Air Moving and Conditioning Equipment.

1.5 QUALITY ASSURANCE

- A. ISO 9001 Certification.
- B. Unit designed and tested in compliance with ARI 430 air delivery ratings per ARI 430-1999.

- C. Unit designed and tested in compliance with ARI 260-2001.

1.6 SUBMITTALS

- A. Submit unit performance data including capacity, nominal and operating performance.
- B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.
- C. Submit shop drawings indicating overall dimensions as well as installation, operation and service clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.
- D. Provide fan curves with specified operating point clearly plotted.
- E. Submit data on electrical requirements. Include safety and start-up instructions.

1.7 REGULATORY REQUIREMENTS

- A. Unit shall be manufactured to conform to UL 1995 Standard and shall be listed by either UL/CUL or ETL. Units shall be provided with listing agency label affixed to unit.
- B. In the event the unit is not UL/CUL or ETL approved, the contractor shall, at his/her expense provide for a field inspection by a UL/CUL representative to verify conformance. If necessary, contractor shall perform modifications to the unit(s) to comply with UL/CUL or ETL as directed by the representative, at no additional expense to the Owner.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- B. Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags on each section to indicate location and orientation in direction of airflow. Each section shall have lifting points to allow for field rigging and final placement of section.
- C. Store in a clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- D. Deliver units to site with fan motors, sheaves, and belts completely assembled and mounted in units. If these components are not completely assembled, contractor shall be responsible for all expenses associated with installation, testing, and vibration balancing of fan(s).

1.9 START-UP AND OPERATING REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

1.10 WARRANTY

- A. The equipment manufacturer shall provide, at no additional cost, a STANDARD PARTS WARRANTY that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

PART 2 - PRODUCTS

- A. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to engineer prior to bid date for approval. Mechanical Contractor is responsible for expenses that occur due to exceptions made.

2.2 GENERAL UNIT DESCRIPTION

- A. Manufacturer shall provide unit arranged for draw-through application. Unit layout and configuration shall be as defined in project plans and schedule. Blow-through is only acceptable when consideration is given to capturing downstream moisture carryover. Considerations include downstream moisture eliminators and/or extended blank modules with condensate drain pans.

2.3 UNIT CASING MOTOR CHARACTERISTICS

- A. The entire air handler shall be constructed of galvanized steel. The removal of side panels shall not affect the structural integrity of the unit once the unit is installed. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.
- B. Access panels shall be on both sides of the unit in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance.
- C. Units shall ship as one or two modules completely factory-assembled including all coils, fans, motors, drives, dampers and filters.
- D. Access Panels: Removable access panels shall be provided on both sides of the unit to facilitate service access to drain pans, motors, drive components and bearings. Panels shall be gasketed. Access panel for filter removal shall be provided on both sides of the unit.

- E. Cabinet: Casing shall be manufactured of heavy gauge galvanized steel. All removable panels shall be gasketed to minimize air leakage.
- F. Insulation: High density, foil-faced - Interior surface of unit casing shall be acoustically and thermally lined. Insulation shall be installed with adhesive. Insulation shall have a minimum R-Value of 4, shall be UL listed, and shall meet ASTM C 665 Bacteriological Standard requirements. The installation shall comply with NFPA90A and B requirements. All exposed edges shall be sealed to prevent erosion of fibers into the airstream. If edges of fiberglass insulation are exposed, the manufacturer shall be responsible for sealing exposed edges with mastic sealer to prevent erosion into the airstream.

2.4 COILS

- A. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.
- B. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil are as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.
- C. Construct coil casings of galvanized steel. End supports shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.
- D. Hydronic Coils
 1. Supply and return header connections shall be clearly labeled on outside of units such that direction of coil water-flow is counter to direction of unit airflow.
 2. Coils shall be proof tested to 450 psig and leak tested to 300 psig air pressure under water.
 3. Headers shall be constructed of round copper pipe.
 4. Tubes shall be 1/2-inch O.D. minimum 0.016-inch-thick copper. Fins shall be aluminum.
 5. Coils shall be capable of being rotated in the field for left- or right-hand connection.

2.5 DRAIN PAN

- A. Drain Pan(s) shall be constructed of corrosion resistant material. Acceptable materials include polymer or 304 stainless steel. Units with cooling coils shall have drain pans under complete cooling coil section that extend beyond the air-leaving side of the coil to ensure capture of all condensate in section.
- B. Drain pan manufacturer shall either insulate bottom of drain pan with closed cell foam or provide double wall internally insulated construction to eliminate bottom sweating.
- C. Drain pan shall be sloped in two planes, pitched toward drain connections to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's installation

instructions. Units without drain pans sloped in two planes shall coat drain pans with anti-microbial treatment. Drain pan(s) shall have main and auxiliary drain connections with auxiliary outlet higher than the main connection.

- D. Coil(s) shall be mounted above the drain pan to facilitate easy and complete inspection, cleaning and removal. Coil(s) may not sit in drain pan.
- E. The drain pan shall be capable of being rotated in the field between right- and left-hand connections.

2.6 FANS

- A. Provide single-wheel, forward curved centrifugal fans as specified on the schedule. Fan shaft bearings shall be permanently sealed ball bearing with a minimum L50 design life of 200,000 hours.

2.7 MOTORS AND DRIVES

- A. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension unless of a direct drive configuration. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change. Fan sections without factory-installed motors shall have motors field installed by the contractor. The contractor shall be responsible for all costs associated with installation of motor and drive, alignment of sheaves and belts, run testing of the motor, and balancing of the assembly at no additional cost to the owner.
- B. Motors shall be open drip-proof with permanently sealed ball bearings.
- C. Motors shall be selected to operate continuously at 130 F (55 C) ambient without tripping on overloads. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.
- D. Manufacturer shall provide for each fan a nameplate with the following information to assist air balance contractor in start-up and services personnel in maintenance:
 - 1. Fan and motor sheave part number.
 - 2. Fan and motor bushing part number.
 - 3. Number of belts and belt part numbers.
 - 4. Fan design RPM and motor HP.
 - 5. Belt tension and deflection.
 - 6. Center distance between shafts.

2.8 FILTERS

- A. Provide removable one or two-inch-thick filters easily removable from either side of the unit. All units shall use standard filter sizes.

2.9 CONTROLS

A. Control Interface.

1. Unit shall be factory run tested and end devices shall be factory wired to terminal strip in an external junction box and tested for wiring continuity.
2. The thermostatic control package shall include the following: 24 VAC transformer, motor contactor(s), disconnect switch, and control box enclosure.

B. DDC Controls

1. DDC controller shall be supplied by the BAS contractor to be factory mounted by the fan coil unit manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that surfaces are ready to receive work and opening dimensions are as Indicated on shop drawings.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide units with shut-off valve on supply and lockshield balancing valve on return piping if factory packages are not factory provided.

3.3 CLEANING

- A. Clean work.
- B. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.
- C. Install new filters.

3.4 FAN COIL UNIT SCHEDULE

See plans for schedules

END OF SECTION 23 82 20

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1. All wire and cable shall be listed by an "approved" third-party testing agency.
2. Prior to energizing feeders, sub-feeders and service conductor cables shall be tested for electrical continuity and short circuits. A copy of these tests shall be sent to the State Construction Office, the engineer of record, and the owner.
3. Individual neutral wire shall be provided for each branch circuit. Shared neutrals will not be accepted.
4. All wire shall be new, manufactured within the last six months.
5. MC cable is NOT allowed.
6. Testing Reports should be included in project document notebook (along with completed copy of NFPA 72, Generator Load Bank Test, Ground Report, etc.) compiled by designer and *not mailed* into SCO Office.

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 1. Building wires and cables rated 600 V and less.
 2. Connectors, splices, and terminations rated 600 V and less.
 3. Sleeves and sleeve seals for cables.
- B. Related Sections include the following:

1. Division 27 Section "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For testing agency.
- C. Field quality-control test 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 member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Alcan Products Corporation; Alcan Cable Division.
 - 2. American Insulated Wire Corp.; a Leviton Company.
 - 3. General Cable Corporation.
 - 4. Senator Wire & Cable Company.
 - 5. Southwire Company.

- B. Copper Conductors: Comply with NEMA WC 70.

- C. Aluminum conductors are not allowed.

- D. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN and XHHW.

- E. Power and lighting circuits' minimum conductor size shall be #12 AWG, and maximum conductor size allowed shall be 500 Kcmil.

- F. Conductors for branch circuits shall be sized to prevent a voltage drop exceeding three percent (3%) at the farthest outlet of power, heating and lighting loads, or any combination of such loads. The maximum total voltage drop on both feeders and branch circuits to the farthest outlet shall not exceed five percent (5%).

- G. Power and lighting circuits #10 AWG and smaller shall have solid copper conductors. Conductor sizes #8 AWG and larger shall have Class B stranded copper conductors.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Hubbell Power Systems, Inc.
 - 3. O-Z/Gedney; EGS Electrical Group LLC.
 - 4. 3M; Electrical Products Division.
 - 5. Tyco Electronics Corp.

2.3 SLEEVES FOR CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Metraflex Co.
 - 4. Pipeline Seal and Insulator, Inc.
- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 1. Sealing Elements: EPDM NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 2. Pressure Plates: Carbon steel. Include two for each sealing element.
 - 3. 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.

PART 3. EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-THWN, single conductors in raceway.
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- E. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.
- F. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway
- H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- I. Branch Circuits Installed Below Raised Flooring: Type THHN-THWN, single conductors in raceway.
- J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- K. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- L. Class 2 Control Circuits: Type THHN-THWN, in raceway Power-limited cable, concealed in building finishes Power-limited tray cable, in cable tray.
- M. Power and lighting circuits' minimum conductor size shall be #12 AWG copper
- N. The maximum conductor size shall be 500 kcmil
- O. An individual neutral wire is required for each circuit.
- P. Conductors for branch circuits shall be sized to prevent a voltage drop exceeding three percent (3%) at the farthest outlet of power, heating and lighting loads, or any combination of such loads. The maximum total voltage drop on both feeders and branch circuits to the farthest outlet shall not exceed five percent (5%).

- Q. Where the conductor length from the panel to the first outlet on a 277-volt circuit exceeds 125 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG.
- R. Where the conductor length from the panel to the first outlet on a 120-volt circuit exceeds 50 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 - 2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- F. Cut sleeves to length for mounting flush with both wall surfaces.
- G. Extend sleeves installed in floors 2 inches above finished floor level.
- H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."
- L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
- M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground exterior-wall penetrations.

- B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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 Division 07 Section "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Perform tests and inspections and prepare test reports.
- C. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.
 - 2. Infrared Scanning: After Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
- D. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Completion.
- E. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- F. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- G. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.9 FEEDER INSULATION RESISTANCE TESTING

- A. All current carrying phase conductors and neutrals shall be tested as installed, and before connections are made, for insulation resistance and accidental grounds. This shall be done with a 500-volt megger. The procedures listed below shall be followed:
1. Minimum readings shall be one million (1,000,000) or more ohms for #6 AWG wire and smaller, 250,000 ohms or more for #4 AWG wire or larger, between conductors and between conductor and the grounding conductor.
 2. After all fixtures, devices and equipment are installed and all connections completed to each panel, the contractor shall disconnect the neutral feeder conductor from the neutral bar and take a megger reading between the neutral bar and the grounded enclosure. If this reading is less than 250,000 ohms, the contractor shall disconnect the branch circuit neutral wires from this neutral bar. He shall then test each one separately to the panel and until the low readings are found. The contractor shall correct troubles, reconnect and retest until at least 250,000 ohms from the neutral bar to the grounded panel can be achieved with only the neutral feeder disconnected.
 3. At final inspection, the contractor shall furnish a megger and show the engineers and State Construction Office representatives that the panels comply with the above requirements. He shall also furnish a hook-on type ammeter and voltmeter to take current and voltage readings as directed by the representatives.

END OF SECTION 26 05 19

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. This Section includes methods and materials for grounding systems and equipment, plus the following special applications:
 - 1. Overhead-lines grounding.
 - 2. Underground distribution grounding.
 - 3. Common ground bonding with lightning protection system.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Ground rings.
 - 4. Grounding arrangements and connections for separately derived systems.
 - 5. Grounding for sensitive electronic equipment.
- C. Qualification Data: For testing agency and testing agency's field supervisor.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
 - 1. Instructions for periodic testing and inspection of grounding features at test wells ground rings grounding connections for separately derived systems based on NFPA 70B.

- a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
- b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

- A. 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 to supervise on-site testing specified in Part 3.
- 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 UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 1. Solid Conductors: ASTM B 3.
 2. Stranded Conductors: ASTM B 8.
 3. Tinned Conductors: ASTM B 33.
 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch 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. Bare Grounding Conductor and Conductor Protector for Wood Poles:
 1. No. 4 AWG minimum, soft-drawn copper.
 2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.

- D. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches in cross section, unless otherwise indicated; with insulators.

2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4-inch by 10 feet in diameter.
- B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
 - 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
 - 2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Power and lighting circuits #10 AWG and smaller shall have solid copper conductors. Conductor sizes #8 AWG and larger shall have Class B stranded conductors.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum, or as indicated on the plans.
 - 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 and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 1 inch, 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, down to specified height above floor, and 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.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 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 as recommended by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.
 5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, 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.
- E. Removed Section.
- F. 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.
- G. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bus.
 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- H. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit. Ground ring system is to be a minimum of 30" below grade, if Lightning protection alternate is accepted.
- 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 Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
 - 1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install 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.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- B. Perform the following tests and inspections and prepare test reports:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. Report measured ground resistances that exceed the following values: Ground resistance shall be tested with a ground resistance tester.
1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 25 ohms.
 2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 25 ohms.
 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 25 ohms.
 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 25 ohm(s).
 5. Substations and Pad-Mounted Equipment: 25 ohms.
 6. Manhole Grounds: 25 ohms.

- D. Upon completion of installation of the electrical grounding and bonding systems, the ground resistance shall be tested with a ground resistance tester. Where tests show resistance-to-ground is over 25 ohms, appropriate action should be taken to reduce the resistance to 25 ohms, or less, by driving additional ground rods. (The compliance should be demonstrated by retesting.)

END OF SECTION 26 05 26

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.
- B. Related Sections include the following:
 - 1. Division 26 Section 260548 "Vibration and Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.
 - 2. Nonmetallic slotted support systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze hangers. Include Product Data for components.
 - 2. Steel slotted channel systems. Include Product Data for components.
 - 3. Nonmetallic slotted channel systems. Include Product Data for components.
 - 4. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 5. Channel Dimensions: Selected for applicable load criteria.
- B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- diameter holes at a maximum of 8 inches o.c., in at least 1 surface.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. Fabco Plastics Wholesale Limited.
 - d. Seasafe, Inc.
 3. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
 4. Fitting and Accessory Materials: Same as channels and angles.
 5. Rated Strength: Selected to suit applicable load criteria.
- C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- G. Power actuated fasteners are not permitted.

- H. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - b. 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 similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 5. Toggle Bolts: All-steel springhead type.
 6. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with single-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. To Steel: Beam clamps (MSS 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 meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
- F. Please add to the specifications that conduits installed on the interior of exterior building walls shall be spaced off the wall surface a minimum of 1/4-inch using "clamp-backs" or strut.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. 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 Division 03 Section "Cast-in-Place Concrete (Limited Applications)."
- C. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Related Sections include the following:
 - 1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.
- C. Raceways shall be metal except as specifically noted, or where non-metallic raceway is permitted by these specifications. A Green Grounding conductor shall be provided in all conduit except for telecommunications, data and audio conduits.
 - 1. Use heavy wall metal conduit (RMC) or intermediate metal conduit (IMC) for any conduit exposed below a height of 60".
 - 2. Electric metallic tubing (EMT) is permitted for most other general applications except for:
 - a. Where tubing, couplings, elbows and fittings would be in direct contact with the earth or underground (in/below slab-on-grade or in earth).
 - b. Any location outdoors where the tubing, etc., would be exposed to the elements.
 - c. Where exposed to severe corrosive influence and/or physical damage.
- D. Use flexible conduit for appropriate applications. Use galvanized type for dry locations and liquid-tight type for wet locations, or as noted. Flexible conduit shall be minimum 1/2" diameter. Liquid-tight flexible metal conduit shall be used for final connection to all motors, transformers, and other rotating or vibrating equipment. Flexible metal conduit shall be used for final connection to fluorescent lighting fixtures mounted in or on suspended ceilings, and similar applications with a maximum of 6' length. MC cable shall NOT be allowed to be used as a wiring method for branch circuits.

- E. Non-metallic raceway shall be minimum Schedule 40 PVC. In general, non-metallic raceway will be permitted for use underground or in poured concrete (including panel feeders, branch circuits, etc.), provided all 90 degree Ells up out of the floor are heavy wall rigid metal conduit (RMC), no exception. Non-metallic raceways will not be permitted for any exposed work or for raceways in ceiling spaces, etc.
- F. No raceway may be exposed in any finished space unless specifically so approved, in written form, prior to rough-in. Raceways exposed in finished spaces shall be of an appropriate type "wiremold" type surface raceway or approved equal. In the event of an accepted alternate that requires exposed conditions in a finished space, devices and fixtures shall be located to minimize exposure of raceway and maintain all required clearances, coverage, etc. Devices, fixture, etc. shall be positioned aesthetically/orthogonal to the orientation of the room.
- G. Minimum metal conduit size shall be 3/4" (interior) and 1" (exterior) for premises wiring system. Exception shall be 1/2" for switch legs, control circuits, signal wiring and applications for flexible metal conduits not exceeding four circuit conductors.
- H. Where installing conduit on interior surface of exterior walls, mount conduit minimum 1/4 -inch from wall with clamp-backs or strut.
- I. Branch circuits only are allowed to be direct buried in conduit.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. ENT: Electrical nonmetallic tubing, not allowed on this project.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. FMC: Flexible metal conduit.
- E. IMC: Intermediate metal conduit.
- F. LFMC: Liquidtight flexible metal conduit.
- G. LFNC: Liquidtight flexible nonmetallic conduit, not allowed on this project.
- H. NBR: Acrylonitrile-butadiene rubber.
- I. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Custom enclosures and cabinets.
 - 2. For handholes and boxes for underground wiring, including the following:
 - a. Duct entry provisions, including locations and duct sizes.
 - b. Frame and cover design.
 - c. Grounding details.
 - d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
 - e. Joint details.
- C. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For professional engineer and testing agency.
- E. Source quality-control test reports.

1.5 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. 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.
 6. Manhattan/CDT/Cole-Flex.
 7. Maverick Tube Corporation.
 8. O-Z Gedney; a unit of General Signal.
 9. Wheatland Tube Company.
- B. Rigid Steel Conduit: ANSI C80.1.
- C. IMC: ANSI C80. 6..5.
- D. PVC-Coated Steel Conduit: PVC-coated IMC.
1. Comply with NEMA RN 1.
 2. Coating Thickness: 0.040 inch, minimum.
- E. EMT: ANSI C80.3.
- F. FMC: Zinc-coated steel.
- G. LFMC: Flexible steel conduit with PVC jacket.
- H. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 2. Fittings for EMT: Steel, compression type.
 3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.
- I. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. 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. Arnco Corporation.
 4. CANTEX Inc.
 5. CertainTeed Corp.; Pipe & Plastics Group.
 6. Condux International, 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. ENT: Not allowed.
- C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- D. LFNC: Not allowed.
- E. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Arnco Corporation.
 2. Endot Industries Inc.
 3. IPEX Inc.
 4. Lamson & Sessions; Carlon Electrical Products.
- B. Description: Comply with UL 2024; flexible type, approved for plenum installation.

2.4 METAL WIREWAYS

- 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 sized and shaped as indicated, NEMA 250, Type 12, unless otherwise indicated.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type.
- E. Finish: Manufacturer's standard enamel finish.

2.5 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized metallic with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Thomas & Betts Corporation.
 - b. Walker Systems, Inc.; Wiremold Company (The).
 - c. Wiremold Company (The); Electrical Sales Division.

2.6 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.
 - 3. Erickson Electrical Equipment Company.
 - 4. Hoffman.
 - 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 - 6. O-Z/Gedney; a unit of General Signal.
 - 7. RACO; a Hubbell Company.
 - 8. Robroy Industries, Inc.; Enclosure Division.
 - 9. Scott Fetzer Co.; Adalet Division.
 - 10. Spring City Electrical Manufacturing Company.
 - 11. Thomas & Betts Corporation.
 - 12. Walker Systems, Inc.; Wiremold Company (The).
 - 13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

- D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- E. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular.
- F. Nonmetallic Floor Boxes: Nonadjustable, round.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.
- I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Plastic.
- J. Cabinets:
 - 1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. Description: Comply with SCTE 77.
 - 1. Color of Frame and Cover: See drawings.
 - 2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
 - 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 - 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 5. Cover Legend: Molded lettering, as indicated for each service.
 - 6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 - 7. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation.
 - d. NewBasis.

- C. 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.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Christy Concrete Products.
 - d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.

- D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Carson Industries LLC.
 - b. Christy Concrete Products.
 - c. Nordic Fiberglass, Inc.

2.8 SLEEVES FOR RACEWAYS

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.9 SLEEVE SEALS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Advance Products & Systems, Inc.
 2. Calpico, Inc.
 3. Metraflex Co.
 4. Pipeline Seal and Insulator, Inc.
- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 2. Pressure Plates: Carbon steel. Include two for each sealing element.
 3. 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.

2.10 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by a independent testing agency.
 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY INSTALLATION

- A. Underground runs, except under concrete floor slabs, shall have a minimum of 24" cover. Backfill shall be made in 6" layers – tamping each layer to a density of 95% of maximum possible.
- B. Raceways run external to building foundation walls, with the exception of branch circuit raceways, shall be encased with a minimum of 3" of concrete on all sides. Encased raceways shall have a minimum cover of 18", except for raceways containing circuits with voltages above 600 volts, which shall have a minimum cover of 30".

- C. All underground raceways shall be identified by underground line marking tape located directly above the raceway at 6" to 8" below finished grade. Tape shall be permanent, bright colored, continuous printed, metal compounded for direct burial not less than 6" wide and 4 mils thick. Printed legend on tape shall indicate general type of underground line below.

3.2 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit
2. Concealed Conduit, Aboveground: IMC (including elbows that turn up from below grade).
3. Underground Conduit: RNC, Type EPC- 80-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
6. Application of Handholes and Boxes for Underground Wiring:
 - a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
 - b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units, SCTE 77, Tier 8 structural load rating.
 - c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.

- B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: IMC.
7. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway.
8. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway.

9. Raceways for Concealed General-Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway.
 10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, nonmetallic in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

3.3 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- H. Raceways Embedded in Slabs:
1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.

- I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
 - 1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
 - 2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where otherwise required by NFPA 70.
- N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.
 - 1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
 - 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 the Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F temperature change.
 - 2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.
 - 3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

- O. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - 1. Use LFMC in damp or wet locations not subject to severe physical damage.
- P. 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.
- Q. Set metal floor boxes level and flush with finished floor surface.
- R. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.4 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

- 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.
- 2. Install backfill as specified in Division 31 Section "Earth Moving."
- 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
- 4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
- 5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
- 6. All underground raceways shall be identified by underground line marking tape located directly above the raceway at 6 to 8 inches below finished grade. Tape shall be permanent, bright-colored, continuous printed, plastic tape compounded for direct burial not less than 6 inches wide and 4 mils thick. Printed legend shall be indicative of general type of underground line below.

3.5 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes 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 conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.6 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 - 2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- F. Cut sleeves to length for mounting flush with both surfaces of walls.
- G. Extend sleeves installed in floors 2 inches above finished floor level.

- H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."
- L. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- M. Aboveground, Exterior-Wall 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.
- N. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.7 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground, exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.8 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.9 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:

- 1. Isolation pads.
- 2. Spring isolators.
- 3. Restrained spring isolators.
- 4. Channel support systems.
- 5. Restraint cables.
- 6. Hanger rod stiffeners.
- 7. Anchorage bushings and washers.

- B. Related Sections include the following:

- 1. Division 26 Section "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 DEFINITIONS

- A. The IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:

- 1. Site Class as Defined in the IBC: D
- 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: I
 - a. Component Importance Factor: 1.25
 - b. Component Response Modification Factor:

- c. Component Amplification Factor:
- 3. Design Spectral Response Acceleration at Short Periods (0.2 Second):
- 4. Design Spectral Response Acceleration at 1.0-Second Period:

1.5 SUBMITTALS

A. Product Data: For the following:

- 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
- 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
- 3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer, **Licensed in North Carolina**, responsible for their preparation.

- 1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
 - a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.
- 2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
- 3. Field-fabricated supports.
- 4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

- c. Preapproval and Evaluation Documentation: an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
- C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- D. Welding certificates.
- E. Qualification Data: For professional engineer and testing agency.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Ace Mountings Co., Inc.
 - 2. Amber/Booth Company, Inc.
 - 3. California Dynamics Corporation.
 - 4. Isolation Technology, Inc.
 - 5. Kinetics Noise Control.
 - 6. Mason Industries.

7. Vibration Eliminator Co., Inc.
 8. Vibration Isolation.
 9. Vibration Mountings & Controls, Inc.
- B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
1. Resilient Material: Oil- and water-resistant neoprene rubber hermetically sealed compressed fiberglass.
- C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Amber/Booth Company, Inc.
 2. California Dynamics Corporation.
 3. Cooper B-Line, Inc.; a division of Cooper Industries.

4. Hilti Inc.
 5. Loos & Co.; Seismic Earthquake Division.
 6. Mason Industries.
 7. TOLCO Incorporated; a brand of NIBCO INC.
 8. Unistrut; Tyco International, Ltd.
- B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an evaluation service member of ICC-ES OSHPD an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
- D. Restraint Cables: ASTM A 603 galvanized -steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
- E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.
- F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchors and studs.
- G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices.
- H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
- J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.3 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1. Powder coating on springs and housings.
 - 2. All hardware shall be galvanized. Hotdip galvanize metal components for exterior use.
 - 3. Baked enamel or powder coat for metal components on isolators for interior use.
 - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 APPLICATIONS

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

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Equipment and Hanger Restraints:
 - 1. Install restrained isolators on electrical equipment.
 - 2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

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

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
 6. Measure isolator restraint clearance.
 7. Measure isolator deflection.
 8. Verify snubber minimum clearances.
 9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust isolators after isolated equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 26 05 48

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Identification for raceway and metal-clad cable.
 - 2. Identification for conductors and communication and control cable.
 - 3. Underground-line warning tape.
 - 4. Warning labels and signs.
 - 5. Instruction signs.
 - 6. Equipment identification labels.
 - 7. Miscellaneous identification products.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.
- C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.
- E. ARC flash labeling is required after coordination study has been completed.

PART 2 - PRODUCTS

2.1 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Color for Printed Legend:
 - 1. Power Circuits: Black letters on an orange field.
 - 2. Normal Power = Black; Emergency = Red; UPS = Blue
 - 3. Legend: Indicate system or service and voltage, if applicable.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- C. Aluminum Wraparound Marker Labels: Cut from 0.014-inch- thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.
- D. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking nylon tie fastener.
- E. Write-On Tags: Polyester tag, 0.010-inch-thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.3 UNDERGROUND-LINE WARNING TAPE

- A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
 - 1. Not less than 6 inches wide by 4 mils thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend shall indicate type of underground line.

2.4 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7 by 10 inches.
- D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

- E. Warning label and sign shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
 3. Provide "ARC FLASH" warning labels on all switchboards, power panels, enclosed circuit breakers, ATS and other equipment where this hazard exists, as per NEC 110.16

2.5 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16-inch-thick for signs up to 20 sq. in. and 1/8-inch-thick for larger sizes.
1. Engraved legend with black letters on white face.
 2. Punched or drilled for mechanical fasteners.
 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 EQUIPMENT IDENTIFICATION LABELS

- A. Furnish and install engraved laminated phenolic nameplates for all safety switches, panelboards, and other electrical equipment supplied for the project for identification. Nameplates shall be securely attached to equipment with self-tapping stainless-steel screws; if the screw sharp end is protected; otherwise, rivets shall be used. Letters shall be approximately 1/2-inch-high minimum. Embossed, self-adhesive plastic tape is not acceptable for marking equipment. Nameplate material colors shall be:
- Blue surface with white core for 120/208-volt equipment
 - Black surface with white core for 277/480-volt equipment
 - Bright red surface with white core for all equipment related to fire alarm system.
 - Dark red (burgundy) surface with white core for all equipment related to security.
 - Green surface with white core for all equipment related to "emergency" systems.
 - Orange surface with white core for all equipment related to telephone systems.
 - Brown surface with white core for all equipment related to data systems.
 - White surface with black core for all equipment related to paging systems.
 - Purple surface with white core for all equipment related to TV systems.
- B. All outlet boxes, junction boxes and pull boxes shall have their covers and exterior visible surfaces painted with colors to match the surface color scheme outlined for nameplate materials. This includes exposed installations and covers on boxes above lift-out and other type accessible ceilings. Identification shall also include branch circuit designations.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength: 50 lb, minimum.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black, except where used for color-coding.

- B. Paint: Paint materials and application requirements are specified in Division 09 painting Sections.
 - 1. Exterior Concrete, Stucco, and Masonry (Other Than Concrete Unit Masonry):
 - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Exterior concrete and masonry primer.
 - 2) Finish Coats: Exterior semigloss acrylic enamel.
 - 2. Exterior Concrete Unit Masonry:
 - a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
 - 1) Block Filler: Concrete unit masonry block filler.
 - 2) Finish Coats: Exterior semigloss acrylic enamel.
 - 3. Exterior Ferrous Metal:
 - a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
 - 1) Primer: Exterior ferrous-metal primer.
 - 2) Finish Coats: Exterior semigloss alkyd enamel.
 - 4. Exterior Zinc-Coated Metal (except Raceways):
 - a. Semigloss Alkyd-Enamel Finish: One finish coat(s) over a primer.
 - 1) Primer: Exterior zinc-coated metal primer.
 - 2) Finish Coats: Exterior semigloss alkyd enamel.
 - 5. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):
 - a. Semigloss Alkyd-Enamel Finish: One finish coat(s) over a primer.
 - 1) Primer: Interior concrete and masonry primer.
 - 2) Finish Coats: Interior semigloss alkyd enamel.
 - 6. Interior Concrete Unit Masonry:
 - a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a block filler.

- 1) Block Filler: Concrete unit masonry block filler.
 - 2) Finish Coats: Interior semigloss acrylic enamel.
7. Interior Gypsum Board:
- a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.
 - 1) Primer: Interior gypsum board primer.
 - 2) Finish Coats: Interior semigloss acrylic enamel.
8. Interior Ferrous Metal:
- a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.
 - 1) Primer: Interior ferrous-metal primer.
 - 2) Finish Coats: Interior semigloss acrylic enamel.
9. Interior Zinc-Coated Metal (except Raceways):
- a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.
 - 1) Primer: Interior zinc-coated metal primer.
 - 2) Finish Coats: Interior semigloss acrylic enamel.
- C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws

PART 3 - EXECUTION

3.1 APPLICATION

- A. Raceways and Duct Banks More Than 600 V Concealed within Buildings: 4-inch- wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:
1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
 2. Wall surfaces directly external to raceways concealed within wall.
 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- B. Accessible Raceways and Metal-Clad Cables More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches high, with self-adhesive vinyl labels. Repeat legend at 10-foot maximum intervals.
- C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 100A: Identify with orange self-adhesive vinyl label.

- D. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands: Unless there is standard campus-wide color code, use the following Nameplate material colors shall be as follows:

Blue surface with white core for 120/208-volt equipment.
Black surface with white core for 277/480-volt equipment.
Bright red surface with white core for all equipment related to fire alarm system.
Dark red (burgundy) surface with white core for all equipment related to security.
Green surface with white core for all equipment related to "emergency" systems.
Orange surface with white core for all equipment related to telephone systems.
Brown surface with white core for all equipment related to data systems.
White surface with black core for all equipment related to paging systems.
Purple surface with white core for all equipment related to TV systems.

- E. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use metal tags. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.
- F. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.
- G. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.
- H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- I. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.

2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

K. Instruction Signs:

1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer or load shedding.

L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions: In Accordance with paragraph 3.1.D:

- a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where 2 lines of text are required, use labels 2 inches high.
- b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
- c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

2. Equipment to Be Labeled:

- a. Panelboards, electrical cabinets, and enclosures.
- b. Access doors and panels for concealed electrical items.
- c. Electrical switchgear and switchboards.
- d. Transformers.
- e. Electrical substations.
- f. Emergency system boxes and enclosures.
- g. Motor-control centers.
- h. Disconnect switches.
- i. Enclosed circuit breakers.
- j. Motor starters.
- k. Push-button stations.
- l. Power transfer equipment.
- m. Contactors.
- n. Remote-controlled switches, dimmer modules, and control devices.
- o. Battery inverter units.
- p. Battery racks.
- q. Power-generating units.
- r. Voice and data cable terminal equipment.

- s. Master clock and program equipment.
- t. Intercommunication and call system master and staff stations.
- u. Television/audio components, racks, and controls.
- v. Fire-alarm control panel and annunciators.
- w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
- x. Monitoring and control equipment.
- y. Uninterruptible power supply equipment.
- z. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.
- aa. Receptacle and Switch coverplates. Label is to include Panel and circuit number.

3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
- F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - 1. Color shall be factory applied or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.
 - 2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White
 - e. Ground: Green
 - 3. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.

- c. Phase C: Yellow.
 - d. Neutral: Grey
 - e. Ground: Green
4. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
- J. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

END OF SECTION 26 05 53

LIGHTING CONTROL DEVICES

PART 1 – GENERAL

1.1 SUMMARY

- A. Scope: The following specifications detail the minimum performance and related criteria for the Lighting Control System. Provide, connect, and furnish all necessary equipment for proper installation and service of the Lighting Control System indicated on the drawings and specified herein.

1.2 DESCRIPTION OF WORK

- A. The extent of lighting control system work is indicated by the drawings and the requirements of this section. The Lighting Control System as defined under this section includes all lighting control equipment, user interface devices, occupant and daylight sensors, and ancillary programming equipment. Types of equipment and wiring specified in this section include the following:
1. Programmable Light Energy Managers with time clock
 2. Multi-level drivers or Full dimmable
 3. Occupancy and Daylight Sensor Connectors
 4. Wall controllers
 5. Building Automation Interface
- B. Requirements are indicated elsewhere in these specifications for work including, but not limited to, raceways, electrical boxes, wire, lighting fixtures, and fittings required for installation of the lighting control system, which are not part of this section.
- C. It is the responsibility of the lighting supplier to meet the intent of these specifications. Where a specific piece of equipment cannot meet the requirements from the base design system, it is the manufacturer's responsibility to supplement the device in order to meet the intent with additional relays, graphical interface, switch controllers, etc.

1.3 SUBMITTALS

- A. Alternate and substituted equipment submittals shall provide a written line-by-line review of the specification.
- B. Submit the following according to the Conditions of the Contract, Division 1 and Division 16 Specification Sections.
1. Product data for each of the products specified. Include data on features, components, ratings, and performance. Include dimensioned drawings with isometric projections of components and enclosures.

2. Sample of the equipment, devices, and device plates (white) for color selection and evaluation of technical features, as required by Engineer.
3. Wiring diagrams detailing internal and interconnecting wiring for power signal, and control that distinguish between field-installed and factory-installed wiring.
4. Equipment Riser (one-line) Diagram with wire type details.
5. Complete details on BACnet connection to Building Automation System, including complete Protocol Implementation Conformance Statement (PICS).

1.4 APPROVALS

- A. Prior approval is required for alternate proposals in accordance with this project's specifications general requirements.
- B. Complete Catalog data, specifications, and technical information on alternate equipment must be furnished to the Engineer, Architect, and Owner on the bid date.
- C. System must utilize a passive detection technology. Ultrasonic sensor systems will not be allowed that interfere with the "Mimio" technology school system will be using. All control systems submitted shall have documentation stating non-interference.

1.5 QUALITY ASSURANCE

- A. Manufacturer experience: manufacturer of Lighting Control System shall have a minimum of 10 years of continuous experience in manufacturing lighting control products and luminaires.
- B. To insure a single source of responsibility, all switching, dimming, and related lighting control equipment described herein shall be supplied by the lighting manufacturer.
- C. Manufacturer shall have a nationwide network of factory trained and authorized service representatives capable of providing initial system commissioning, ongoing service contracts and on-site post-installation service support.
- D. Approvals – all primary equipment and related accessories shall be UL or CSA marked as appropriate.
- E. If requested, the contractor/manufacturer shall supply to the owner a written certification of compatibility to ensure that all components of the Lighting Control System, as defined in Section 1.3 and the remainder of this document, are fully compatible with each other for proper system functionality. This includes control electronics, sensors, drivers, and lamps.

1.6 WARRANTY

- A. The manufacturer shall provide at minimum, a full one-year warranty on all equipment supplied. A three-year warranty shall be furnished on all equipment supplied when system is installed with modular wiring. A five-year warranty shall be furnished on all compatible drivers.

1.7 COMMISSIONING (Required)

- A. System Checkout, programming, and training – A factory certified technician shall functionally test the system, program all settings and schedules per owner's specification,

and verify performance after contractor installation. It shall be the contractor's responsibility to coordinate with the owner and supply the necessary "as-installed" information and desired schedules to the manufacturer in a timely manner. The factory certified technician shall conduct a training session for the building operations personnel on the set-up, programming, operation and maintenance of the lighting control system. In addition to the commissioning and training, provide up to three visits to trouble shoot and set the systems. Full day visits, travel and expenses shall be included. Three additional full day visits shall be provided for post final/CO testing, refining and commissioning.

PART 2 - EQUIPMENT

PART 1 – GENERAL

1.01 SYSTEM DESCRIPTION

The lighting control system specified in this section shall provide time-based, sensor-based (both occupancy and daylight), and manual lighting control without the use of any centrally hardwired switching equipment (relay panels). The system's control shall be exerted by directly switching lighting loads on and off and/or dimming 0-10 VDC dimmable drivers.

1.02 MANUFACTURERS

This specification is based on the nLight® Control System from Sensor Switch, Inc. (800-727-7483, www.sensorswitch.com). Systems wishing to be substituted must be submitted no less than 5 days prior to bid date. An AutoCAD drawing of the facility showing coverage patterns and technical data must be provided with substitution request. All substitutions must clearly identify any and all exceptions to the specifications, with a detailed explanation as to the exception. If substitution is approved, the contractor shall bear the responsibility of a fully functional system to the owner's and an Architect's satisfaction. Acceptable equals:

1. nLight
2. Wattstopper DLM system.
4. Cooper Industries, Greengate.

1.03 QUALITY ASSURANCE

- 1.03.1 The installing contractor shall be responsible for a complete and functional system in accordance with all applicable local and national codes.
- 1.03.2 All applicable products must be UL and CUL or CSA Listed.
- 1.03.3 Product must be manufactured in the USA and be warranted for 5 years.

PART 2 – PRODUCTS

1.04 GENERAL SYSTEM SPECIFICATIONS

The following sections describe the features which the lighting control system shall possess as a complete operational system. Individual device features and specifications are listed in section 2.02.

1.04.1 SYSTEM ARCHITECTURE

- A All switching relays shall be located within either a sensor device, single gang wall switch device, or power (relay) pack device.
- B All switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e. not in a remotely located device).
- C System shall have a primary wall mounted network control “gateway” device that is capable of accessing and controlling all other system devices and linking into an Ethernet LAN.
- D System shall use “bridge” devices that route communication and distribute power for up to 8 lighting zones together for purposes of decreasing system wiring requirements.
- E System shall be able to utilize ZigBee[®] wireless mesh networking to facilitate communication with management software.
- F All devices within a single lighting zone shall be capable of being daisy-chain wired with CAT-5 low voltage cabling.
- G Communication and Class 2 system power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors. All cabling shall be installed by contractor providing lighting control system.
- H All system devices shall have at least two RJ-45 ports.
- I All wall mounted user control / gateway devices shall be low voltage, fit within a two-gang switch box, and have a backlit LCD panel. User control shall be made available via finger-touch buttons with no moving parts.
- J System must have a web-based software management program that enables system control, status monitoring, and creation of lighting control profiles.
- K Each control gateway device shall be capable of linking 400 devices to the management software.
- L Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure or the management software becoming unavailable.

1.04.2 LIGHTING CONTROL PROFILES

- A Changes to the operation of the system can be made in real-time or scheduled via lighting control profiles. These profiles are outlines of settings that direct how a collection of devices function for a defined time period.
- B Lighting control profiles shall be capable of being created and applied to a single device, zone of devices, or customized group of zones.
- C All relays and dimming outputs shall be capable of being scheduled to track or ignore information regarding occupancy, daylight, and local user switches via lighting control profiles.
- D Every device parameter (e.g. sensor time delay and photocell set-point) shall be configurable via a lighting control profile.
- E All lighting control profiles shall be stored on the network gateway device and on the software’s host server.

- F Lighting control profiles shall be capable of being scheduled to run according to the following calendar options: start date/hour/minute, end date/hour/minute, and sunrise/sunset +/- timed offsets.
- G Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.
- H Daylight savings time adjustments shall be capable of being performed automatically, if desired.
- I Lighting control profile schedules shall be capable of being given the following recurrence settings: daily, weekday, weekend, weekly, monthly, and yearly.
- J Software shall provide a graphical tool for easily viewing scheduled lighting control profiles.

1.04.3 MANAGEMENT SOFTWARE

- A Every device parameter (e.g. sensor time delay and photocell set-point) shall be available and configurable remotely from the software.
- B The following status monitoring information shall be made available from the software for all devices for which it is applicable: current occupancy status, current PIR Status, current Microphonics Status, remaining occupancy time delay(s), current photocell reading, current photocell inhibiting state, photocell transitions time remaining, current dim level, device temperature, and device relay state(s).
- C The following device identification information shall be made available from the software: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.
- D A printable network inventory report shall be available via the software.
- E Up to 40 simultaneous user sessions shall be capable of being supported.
- F Software shall require all users to login with a Username and Password.
- G Software shall provide at least three permission levels for users.
- H All sensitive stored information and privileged communication by the software shall be encrypted.
- I All device firmware and system software updates must be available for automatic download and installation via the internet.

1.04.4 COMMISSIONING FEATURES

- A To facilitate commissioning, all devices daisy-chained together (using CAT-5) shall automatically be grouped together into a functional lighting control zone.
- B All lighting control zones shall be able to function according to default settings once adequate power is applied and before any system software is installed.
- C Once software is installed, system shall be able to auto-discover all system devices without requiring any commissioning.
- D All system devices shall be capable of being given user defined names.
- E All devices within the network shall be able to have their firmware reprogrammed remotely and without being physically uninstalled for purposes of upgrading functionality at a later date.
- F Manufacturer shall commission final product including all programming, zone set up, and owner training sessions. Session training shall include up to (2) days of 8-hour training of facility personnel.

1.05 INDIVIDUAL DEVICE SPECIFICATIONS

The lighting control system outlined above shall consist of only devices of the following types: occupancy sensors, daylight (photocell) sensors, wall switches, dimming switches, power (relay) packs, power supplies, communication bridges, network control gateways. Panel based relay devices are not acceptable.

1.05.1 Occupancy & Photocell Sensors

A General Specifications

- i. Occupancy sensing technologies shall be completely passive meaning that they will not emit any radiation that is known to interfere with certain types of hearing aides, or electronic devices such as electronic white board readers. Passive Infrared (PIR) or PIR/Microphonic Dual Technology detection technologies shall be acceptable. Ultrasonic or Microwave based sensing technologies shall not be accepted.
- ii. Sensors shall be available with zero, one, or two integrated Class 1 switching relays.
- iii. Sensors shall be available with one or two occupancy “poles”, each of which provides a programmable time delay.
- iv. Sensors shall be available in multiple lens options which are customized for specific applications.
- v. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
- vi. All sensors shall have two RJ-45 ports.
- vii. Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.
- viii. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5 cabling.
- ix. Sensors shall be equipped with an automatic override for 100-hour burn-in of lamps. This feature must be available at any time for lamp replacements.

B Wall Switch Sensors

- i. Sensor shall recess into single-gang switch box and fit a standard GFI opening.
- ii. Sensor must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.
- iii. Sensor shall have optional features for photocell/daylight override, vandal resistant lens, and low temperature/high humidity operation.
- iv. Sensors shall be available in four colors (Ivory, White, Almond, Gray)

C Ceiling & Corner Mount Sensors

- i. Sensor shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.

- ii. Sensors with dimming control can control 0 to 10 VDC dimmable drivers by sinking up to 20 mA of Class 2 current (typically 40 or more drivers).
- iii. All sensors have at least one or two occupancy poles, each of which provides a programmable time delay

D Daylight (Photocell) Sensors

- i. Sensor shall provide for an On/Off set-point, and a deadband to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.
- ii. Sensors' set-point and deadband shall be automatically calibrated through the sensor's micro-controller by initiating the "Automatic Set-point Programming" subroutine. Further adjustment may be made manually if needed. Deadband setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
- iii. Sensors with dimming control can control 0 to 10 VDC dimmable drivers by sinking up to 20 mA of Class 2 current (typically 40 or more drivers).
- iv. Photocell sensor's set point shall be automatically calibrated through the sensor's micro-controller by initiating the "Automatic Set-point Programming" subroutine. Min and Max dim settings as well as set-point may be manually entered.
- v. Dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The second zone shall be controlled as an "offset" from the primary zone and shall be the zone farthest from the natural light source.

1.05.2 Power (Relay) Packs and Supplies

- A Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.
- B All devices shall have two RJ-45 ports.
- C Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.
- D Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.
- E When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.
- F Power Pack shall incorporate a Class 1 relay and contribute low voltage power to the rest of the system. Slave Packs shall incorporate the relay but shall not be required to contribute system power. Power Supplies shall provide system power only but are not

required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.

- G Class 1 Relays used in Power (Slave) Packs shall provide 16 Amp switching of all load types and be rated for 400,000 cycles.
- H Power packs shall be supplied with supplemental relays where HVAC interface is required.

1.05.3 Wall Switches & Dimmers

- A Devices shall recess into single-gang switch box and fit a standard GFI opening.
- B Devices shall provide user control via touch sensitive buttons that utilize no mechanical parts.
- C Devices shall be available with zero or one integrated Class 1 switching relay.
- D Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
- E All sensors shall have two RJ-45 ports.
- F All devices shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.
- G Devices shall be available in four colors (Ivory, White, Almond, Gray).
- H Devices with dimming control outputs can control 0 to 10 VDC dimmable drivers by sinking up to 20 mA of Class 2 current (typically 40 or more drivers).

1.05.4 Scene Controller

- A Device shall recess into single-gang switch box and fit a standard GFI opening.
- B Device shall provide user control via touch sensitive buttons which have no mechanical parts.
- C Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
- D All sensors shall have two RJ-45 ports.
- E Device shall have four touch sensitive buttons for selecting programmable lighting control profiles.
- F Device shall have four LEDs indicating current selection.
 - i.

1.05.5 Communication Bridges

- A Device shall surface mount to a standard 4" x 4" square junction box.
- B Device shall have either 4 or 8 RJ-45 ports.
- C Device shall be capable of aggregating communication with connected daisy-chains of system devices.
- D Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a CAT-5 cabled connection.
- E Device shall be capable of communicating with other system devices using the ZigBee® wireless mesh networking standard.
- F Provide (4) additional bridges for future use.
 - i.

1.05.6 Network Control Gateway

- A Device shall recess into a two-gang switch box.
- B Device shall provide user control via touch sensitive buttons which have no mechanical parts.
- C Device shall have a backlit LCD panel.
- D Device shall contain a real-time clock capable of synchronization with a network time authority.
- E Device shall be capable of communicating on an Ethernet network with a fixed or DHCP assigned IP address.
- F Device shall have three RJ-45 ports for connection to system devices and one RJ-45 port for connection to Ethernet network.
- G Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a CAT-5 cabled connection.

2.1 HARDWARE

A. LIGHT ENERGY MANAGER (LEM)

1. The LEM power supply shall be protected from power line surges per IEEE specification 62.41 for category A locations.
2. Each LEM shall support 8 independent configurations. It shall be possible for the user to program unique schedules and settings for each configuration. Each room may then be assigned to one of the configurations via the local wall station so that no knowledge of installation details (such as data wiring or power circuiting) shall be required for configuration. Advanced settings that may be configured via the LEM include:
 - a. Occupancy Sensor behavior:
 - 1) Manual ON/Automatic OFF (default)
 - 2) Automatic ON/Automatic OFF
 - 3) Set lights to minimum when no motion is detected during scheduled ON times and to OFF when no motion is detected during scheduled off times.
 - b. Wall station, photocell and occupancy sensors may be disabled by schedule
 - c. Time schedules may be temporarily suspended for 1, 2, 4, 8, 12, or 24 hours to accommodate special events. At the end of this period, the system shall automatically revert to the normal schedules.
3. Occupied Period Scheduling: The system shall support both fully adaptive and manually programmed time-of-day schedules.

- a. Adaptive Scheduling: the system shall have the ability to automatically adapt the time clock schedule to the actual use of each room in the space without requiring the use of occupancy sensors or manual programming of the system beyond setting the project location.
 - b. Manual Scheduling: the system shall also have the ability to have schedules manually programmed if required.
 - 1) The system shall support 8 independent schedules which may be programmed with the following events:
 - a) ON
 - b) OFF
 - c) Cancel Switch Timeouts
 - 2) Scheduled events may be programmed to occur at a fixed time of the day or at the calculated Sunrise and Sunset times. It shall also be possible to schedule an event to occur up to 120 minutes before or after Sunrise or Sunset.
 - 3) Schedule events may be programmed to occur on individual or multiple days of the week facilitating a rotating Monday through Sunday weekly operating scenario.
 - 4) Schedule events may also be assigned to occur on a holiday. Holiday events shall automatically supersede assigned weekday schedules based on a list of holiday dates. Holiday dates may be programmed to reoccur automatically each year or only on a specific year.
 - c. For both schedule types, of events shall be preceded by a warning sequence to warn the occupants of the impending of event. To maximize lamp life for loads with drivers, this warning sequence shall not turn off and re-strike the lamps, but rather dim them to minimum, then maximum, then return them to their previous level. The warning sequence shall turn non-dim loads off and then back ON again. It shall be possible to disable this warning sequence on a room by room basis if necessary to accommodate HID loads.
4. Load Shed Schedule: The LEM shall support a dedicated load shed schedule which allows the owner to shed from 1% to 85% of the lighting load on a time-of-day basis. When in effect, the load shed event shall proportionally subtract the programmed amount from the current occupant-set or schedule-set level. All other occupant and system controls shall remain operational during this time, but the actual level of the lights shall be the set level minus the load shed percentage.

5. Program Backup: The user program shall be stored in non volatile memory. The program memory shall be integrated into the device, be maintenance free, and not require batteries for retention of memory.
6. Pre-set load level “High Trim” for all classrooms. The commissioning agent or factory representative shall be able to adjust the driver factor or maximum percentage of input power that the connected smart junction box drivers will consume so that the lighting power density for a given space can be easily tailored by authorized personnel without changing the lighting fixture layout. The means to set this maximum input power percentage shall be located behind a hinged locking door and it shall not be possible for the occupants to adjust this setting.
7. Network Connections: The LEM shall be equipped with the following connections:
 - a. lighting control network
 - b. BACnet/IP over 10/100base-T Ethernet with two ports and integral switch.
 - c. EIA RS-485 port for connection to up to 16 SYRS series digital remote stations
 - d. EIA RS-232 port
 - e. Onboard modem for remote monitoring and programming of the system.
8. Low Voltage Inputs: The LEM shall be equipped with the following inputs:
 - a. Dry contact: programmable to accept maintained, momentary, normally-open, or normally-closed contacts.
 - b. Analog: 3 wire, 0-10V analog input with 24VDC supply compatible with Synergy LSA APS series photocells.

PART 3 EXECUTION

3.1 EQUIPMENT INSTALLATION AND DOCUMENTATION

- A. Installation – The control system shall be installed and connected as shown on the plans and as directed by the manufacturer. The contractor shall complete all electrical connections to all control circuits, network terminations, RS-232 connections, sensors and override wiring.
- B. Telephone Lines – The contractor shall arrange for all required telephone lines and touch-tone telephone override wiring as shown on the plans. All phone connections shall be terminated into a RJ-11 modular telephone connector. If multiple lines are required, they shall be installed on a rotating line such that when one line is busy the call will automatically switch to the next line.
- C. Documentation – Contractor shall provide accurate “as built” drawings to the owner indicating correct and latest program information.

- D. Operation and Service Manuals – Provide operation and service manuals for all components as indicated in the General Provisions.
- E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
 - a. Timed sensors shall be set to the midpoint of their range of the time limit setting.
 - b. Daylight sensors be set to 100% of the required lighting level for the room they are in, typical set marks classroom: 50fc, corridors: 30fc, multipurpose rooms: 50fc. Dimmable drivers shall be set at reductions according to manufacturer or 20% per setting.

3.2 PRODUCT SUPPORT AND SERVICE

- A. System Start-up
 - 1. Provide a factory authorized technician to verify the installation, test the system, and train the owner on proper operation and maintenance of the system. Before requesting start-up services, the installing contractor shall verify that:
 - a. The control system has been fully installed in accordance with manufacturer's installation instructions.
 - b. Phone lines have been checked for dial tone.
 - c. Low voltage wiring for overrides and sensors is completed.
 - d. Any schedules or settings specified by the owner have been fully documented and supplied to the factory at time start-up is scheduled.
 - 2. Proper notification of the impending start-up has been provided to the owner's representative.

3.3 FACTORY SUPPORT

- A. Factory telephone support shall be available at no cost to the owner for the life of the system. Factory Assistance shall consist of assistance in solving programming or other application issues pertaining to the control equipment. The Factory shall provide a toll-free number for technical support.

END OF SECTION 26 09 23

LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

General note: Transformers shall comply with the latest US DOE energy efficiency requirements.

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

- 1. Distribution transformers.

1.3 SUBMITTALS

- A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

- 1. Wiring Diagrams: Power, signal, and control wiring.

- C. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

- 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For testing agency.
- E. Source quality-control test reports.
- F. Field quality-control test reports.
- G. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- C. Source Limitations: Obtain each transformer type 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 C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

1.7 SUPPORT SYSTEMS

- A. The following minimum mounting and installation guidelines shall be followed for transformer support, unless specifically modified by the above referenced standards.
 - a. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.
 - b. Provide a letter of conformance for the support frame, signed and sealed by a Professional Engineer registered in the Project State.
 - c. Pre-engineered structures such as “GEARSTACKER” products, (www.gearstacker.com), will be acceptable provided the submittal contains complete documentation for the specific support application.
 - d. The E.C. is to coordinate any additional required wall bracing with G.C. prior to work beginning.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Products.
 - 2. General Electric Company.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices except for taps.
 - 1. Internal Coil Connections: Brazed or pressure type.
 - 2. Coil Material: Copper.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Cores: One leg per phase.
- D. Enclosure: Ventilated, NEMA 250, Type 2.
 - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- E. Enclosure: Ventilated, NEMA 250, Type 3R.
 - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- F. Transformer Enclosure Finish: Comply with NEMA 250.
 - 1. Finish Color: ANSI 49 gray.
- G. Taps for Transformers 7.5 to 24 kVA: Manufacturer's Standard
- H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- I. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- J. Energy Efficiency for Transformers Rated 15 kVA and Larger:
 - 1. Complying with EPA Act 2005, efficiency levels.
 - 2. Tested according to NEMA TP 2.
- K. 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.
 - 3. Shield Effectiveness:

- a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
 - b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
 - c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.
- L. Wall Brackets: Manufacturer's standard brackets.
- M. Sound-Level Requirements: NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.4 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution or buck-boost transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Brace wall-mounting transformers as specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- B. Remove and replace units that do not pass tests or inspections and retest as specified above.
- C. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.
- C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 22 00

PART 1 - GENERAL

1.1 GENERAL NOTES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. E.C. responsible for all Breaker Testing required.
- C. Gear manufacturer shall provide a full coordination study to the Engineer for approval during submittal process. Coordination Study is to be sealed by an engineer licensed in North Carolina.
- D. A. Switchboard shall be provided with painted "schematic" bus on front of enclosure to depict actual bus arrangement inside cubicles.
- E. Provide a laminated drawing of the building electrical riser next to each switchboard in the main electrical room framed and mounted under glass.
- F. Primary current injection testing of the GFPE equipment is required and a written record of the test should be included in final project documents per NEC 230.95 (C).
- G. Arc Reduction Method: Energy-reducing maintenance switching with local status indicator. On all breakers that can be adjusted or rated 1200A or higher.

1.2 SUMMARY

- A. Section Includes:
 - 1. Service and distribution switchboards rated 600 V and less.
 - 2. Transient voltage suppression devices.
 - 3. Disconnecting and overcurrent protective devices.
 - 4. Instrumentation.
 - 5. Control power.
 - 6. Accessory components and features.
 - 7. Identification.
 - 8. Mimic bus.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
 - 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
 - 6. Detail utility company's metering provisions with indication of approval by utility company.
 - 7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
 - 9. Include diagram and details of proposed mimic bus.
 - 10. Include schematic and wiring diagrams for power, signal, and control wiring.
 - 11. The engineer of record must seal and sign the manufacturers' Short-Circuit Analysis.
- C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
- D. Qualification Data: For qualified Installer.
- E. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- F. 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.
- G. Operation and Maintenance Data: For switchboards 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. Routine maintenance requirements for switchboards and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.5 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: Currently certified by NETA to supervise on-site testing.
- C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- D. 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.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Comply with NEMA PB 2.
- G. Comply with NFPA 70.
- H. Comply with UL 891.

1.6 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.

1.7 PROJECT CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Environmental Limitations:
 - 1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.
- C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet
- D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Architect 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 Architect's written permission.
 - 4. Comply with NFPA 70E.

1.8 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces.

Maintain required workspace clearances and required clearances for equipment access doors and panels.

- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: Five years from date of Substantial Completion of work.

1.10 EXTRA MATERIALS

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

- 1. 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 fewer than one of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

- 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.

- B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
 2. Branch Devices: Panel mounted.
 3. Sections front and rear aligned.
- C. Nominal System Voltage: as indicated on the drawings.
- D. Main-Bus Continuous: silver plated copper of the ampacity as indicated on the drawings.
- E. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- F. Indoor Enclosures: Steel, NEMA 250, Type 1.
- G. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- H. Barriers: Between adjacent switchboard sections.
- I. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.
- J. Cubical Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
 2. Space-Heater Power Source: Transformer, factory installed in switchboard.
- K. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.
- L. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- M. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.
- N. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- O. Pull Box on Top of Switchboard:
1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
 2. Set back from front to clear circuit-breaker removal mechanism.
 3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.

4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
 5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- P. Buses and Connections: Three phase, four wire unless otherwise indicated.
1. Phase- and Neutral-Bus Material: silver plated hard-drawn copper of 98 percent conductivity, copper feeder circuit-breaker line connections.
 2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 3. Ground Bus: 1/4-by-2-inch- hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 4. 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.
 5. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- Q. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- R. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
- S. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.2 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, fully rated to interrupt the short-circuit current available at terminals. Series ratings are not allowed.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.

- c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 6. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor 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. Communication Capability: Din-rail-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
 - g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - i. 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.
 - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixed circuit-breaker mounting.
 2. Two-step, stored-energy closing.
 3. Standard-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time time adjustments.
 - c. Ground-fault pickup level, time delay, and I^2t response.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Control Voltage: 120-V ac. Retain one of first two paragraphs below.

C. Breakers 600A or larger shall be a solid-state trip type.

2.3 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, tapped secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound type; double secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated: All values to be in true RMS.
 - a. Phase Currents, Each Phase: Plus, or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus, or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus, or minus 1 percent.
 - d. Megawatts: Plus, or minus 2 percent.
 - e. Megavars: Plus, or minus 2 percent.
 - f. Power Factor: Plus, or minus 2 percent.
 - g. Frequency: Plus, or minus 0.5 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus, or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus, or minus 2 percent; demand interval programmable from five to 60 minutes.
 - j. Phase current Demand.

- k. VA Demand.
 - l. VAR demand
 - m. Contact devices to operate remote impulse-totalizing demand meter.
 - n. 4 output relays and 4 isolated analog outputs that can replace transducers
 - o. The Power Meter shall have built-in data communications to allow Multi-point communication to multiple computer workstations, programmable controllers, and other host devices, at a minimum data rate of 9600 baud. The Power Meter shall be able to communicate with the Owners Tridium Niagara Software through the Network Area Controller, NAC, Panel for building management and/or other monitoring functions. The Power Meter shall be compatible with Modbus RTU Communications.
 - p. The Power Meter shall be able to perform Harmonic Analysis with trigger trace memory, waveform capture, event recorder and data logger.
2. Mounting: Display and control unit flush or semi flush mounted in instrument compartment door.

2.4 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.
- B. Not Used.
- C. Not Used.
- D. Not Used.
- E. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- F. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.5 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Not Used.
- C. Not Used.
- D. Not Used.
- E. Not Used.

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- 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.
- C. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
- D. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.
- E. Upon completion of installation, and prior to final inspection, the contractor shall reduce in size the "as-built" single line diagram (riser), frame diagram under glass, and mount in a conspicuous place adjacent to the switchboard.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section " Miscellaneous 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 equipment, 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 switchboards.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and 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, transient voltage suppression devices, and instrumentation.
1. Set field-adjustable switches and circuit-breaker trip ranges.
- H. Install spare-fuse cabinet.
- I. Comply with NECA 1.

3.3 CONNECTIONS

- A. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "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 Division 26 Section "Identification for Electrical Systems."

- D. Switchboards identified for use as service equipment shall be so labeled.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections as required by the equipment manufacturer to ensure all warranties are valid.
- 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. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Not used.
 - 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~~ Final Acceptance, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear 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~~ Final Acceptance.
 - 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.
 - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. The following tests shall be performed on the service circuit breakers and the distribution circuit breakers. Testing shall be performed by a qualified factory technician at the job site. All readings shall be tabulated:

- a. Phase tripping tolerance (within 20% of U/L requirements)
 - b. Trip time (per phase) in seconds.
 - c. Instantaneous trip (amps) per phase.
 - d. Insulation resistance (in megohms) at 100 volts (phase to phase, and line to load).
6. The ground fault protection on the new circuit breakers (if provided) shall be performance tested in the field and properly calibrated and set in accordance with the coordination study.
- F. Switchboard will be considered defective if it does not pass tests and inspections.
- G. 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. All tests shall be completely documented indicating time of day, date, temperature and all pertinent test information. All required documentation of readings indicated above shall be submitted to the engineer prior to, and as one of the prerequisites for final acceptance of the project.

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 indicated.

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, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

3.9 SHORT CIRCUIT STUDY

- a. A complete short circuit and protection coordination study with coordination plots for each medium and low voltage distribution system shall be provided. The studies shall include the power company's system and relay characteristics, the base quantities selected, impedance source data, calculation methods and tabulations, one-line diagrams, impedance diagrams, conclusions and recommendations. A ground fault study shall be provided for the low voltage system, which shall include the associated zero sequence

impedance diagrams. Short circuit momentary duties, when applicable, and interrupting duties shall be calculated on the basis of an assumed fault at each medium voltage switchgear line-up, low voltage switchgear line-up, switchboard, distribution panelboard, pertinent branch circuit panelboard, generator and other significant locations throughout the systems. The short circuit tabulations shall include the fault impedances, X to R ratios, asymmetry factors, KVA symmetrical and asymmetrical fault currents. This study is to be prepared and sealed by a professional engineer licensed in North Carolina.

- b. The coordination plots required shall graphically indicate the coordination proposed for the several systems centered on full scale log forms. The coordination plots shall include complete titles, representative one-line diagrams and legends, associated power company's relay or system characteristics, medium voltage fuses and relays, significant equipment starting characteristics, complete parameters for transformers, complete operating bands for low voltage switchgear or switchboard circuit breaker trip devices, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time dial settings and pick up settings required. The long-time region of the coordination plots shall indicate a complete tap scale for each medium voltage relay, full load current and 150, 400 or 600 percent full load current transformer parameters and designate the pickups required for the low voltage circuit breakers. The short time region shall indicate the medium voltage relay instantaneous elements, the magnetizing inrush, ANSI withstand thermal and mechanical transformer parameters, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault currents. Each primary protective device required for a delta-grounded wye connected transformer shall be selected so the characteristic or operating band is within the transformer parameters and shall include a parameter equivalent to 58 percent of the ANSI withstand point to afford protection for secondary line to ground faults. The transformer damage curve shall be included for each transformer. Low voltage power circuit breakers shall provide long time, long time delay, short time, short time delay, ground fault, ground fault delay, and I^2t in/out settings with coordination plots and shall be separated from each other and the associated primary protective device by a 16 percent current margin for coordination and protection in the event of secondary line to line or line to ground fault. Medium voltage relays shall be separated by a 0.4 second time margin when the maximum three phase fault flows, to assure proper selectivity. The protective device characteristics or operating band shall reflect the actual symmetrical and asymmetrical fault currents sensed by the device.
- c. The contractor shall note that the drawings and specifications indicate the general requirements for the equipment, the medium voltage and low voltage equipment, but additional specific characteristics of equipment furnished shall be determined in accordance with the results of the short circuit and protection coordination study. The equipment design discrepancies and the proposed corrective modifications, if required, shall be submitted with the short circuit and protection coordination study with any variations clearly noted on the subsequent shop drawings. Necessary field settings, adjustments and minor modifications for conformance with the approved short circuit and protection coordination study shall be accomplished by the particular manufacturer or by the Contractor without additional expense to the Owner. However, should equipment specified be outside the parameters required by this study, a change order to modify the equipment shall be issued if the engineer's review warrants such a change. Equipment

shop drawings shall not be submitted until the short circuit and protection coordination study has been reviewed by the Owner's engineer.

- d. Arc-Flash labels shall be printed per OSHA requirements and shall be installed by the contractor.

POINT SETTINGS:

- a. The Electrical Contractor shall set and calibrate all target points and settings indicated on the approved coordination study prior to energizing and testing the system.
- b. The study shall require the Electrical Contractor to provide the following information:
 - 1. Length, type, resistance, reactance of all cables both medium and low voltages.
 - 2. Fuse curves as required.
 - 3. Utility information.

END OF SECTION 26 24 13

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. E.C. responsible for all On-Site Breaker Testing required.
- C. Gear manufacturer shall provide a full coordination study to the Engineer for approval during submittal process. Coordination Study is to be sealed by an engineer licensed in North Carolina.
- D. E.C. is to label service equipment with maximum available fault current per NEC Art 110.24A

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Load centers.
 - 4. Transient voltage suppression panelboards.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. RFI: Radio-frequency interference.
- D. RMS: Root mean square.
- E. SPDT: Single pole, double throw.

1.4 SUBMITTALS

- A. Product Data: For each type of panelboard, overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

- B. Shop Drawings: For each panelboard and related equipment.
1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of panelboards and overcurrent protective devices.
 - d. Series Rated Breakers are not permitted.
 - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - f. 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.
 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:
1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For testing agency.
- E. Field quality-control test reports including the following:
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.
- F. Panelboard Schedules: For installation in panelboards.
- G. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

- A. 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.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- C. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.
- D. Product Options: Drawings indicate size, profiles, and dimensional requirements of panelboards and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- E. 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.
- F. Comply with NEMA PB 1.
- G. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: Not exceeding 104 deg F.
 - 2. Altitude: Not exceeding 6600 feet.
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet.

1.7 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Keys: Three spares for each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
 - a. Eaton Corporation; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical Distribution & Protection Div.
 - c. Siemens Energy & Automation, Inc.
 - d. Square D.

2.2 MANUFACTURED UNITS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Enclosures: Flush- and surface-mounted cabinets. NEMA PB 1, Type 1.
 - 1. Rated for environmental conditions at installed location.
 - a. Outdoor Locations: NEMA 250, Type 3R.
 - b. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - d. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 - 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 - 6. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.
 - 7. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.
 - 8. Directory Card: With transparent protective cover, mounted in metal frame, inside panelboard door.
- C. Phase, neutral, bolt-on circuit breakers and Ground Buses:
 - 1. Material: Copper.

2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
 3. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.
 4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
 5. Split Bus: Vertical buses divided into individual vertical sections.
- D. Conductor Connectors: Suitable for use with conductor material.
1. Main and Neutral Lugs: Compression type.
 2. Ground Lugs and Bus Configured Terminators: Compression type.
 3. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- E. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.
- F. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- G. The maximum number of breakers in a panelboard shall not exceed 42 poles.

2.3 PANELBOARD SHORT-CIRCUIT RATING

- A. Fully rated to interrupt symmetrical short-circuit current available at terminals.
- B. Series rated equipment is not allowed.

2.4 DISTRIBUTION PANELBOARDS

- A. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
- B. Main Overcurrent Protective Devices: Circuit breaker, see plans.
- C. Branch Overcurrent Protective Devices:
 1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
 2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.5 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- B. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.6 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: UL 489, with full rating to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 100 A and larger. A push-to trip button shall be provided on the cover for mechanically tripping the breaker. The breaker shall have reverse connection capability and be suitable for mounting and operating in any position.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic trip-unit circuit breakers shall have RMS sensing; field-replaceable rating plug; and with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. GFCI Circuit Breakers: Single- and two-pole configurations with [5] [30]-mA trip sensitivity.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
1. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
 3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 4. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
 5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second 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. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 10. Multipole units enclosed in a single housing or factory-assembled to operate as a single unit.
 11. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.

2.7 CONTROLLERS

- A. Motor Controllers: NEMA ICS 2, Class A, combination controller equipped for panelboard mounting and including the following accessories:
 - 1. Individual control-power transformers.
 - 2. Fuses for control-power transformers.
 - 3. Bimetallic-element overload relay.
 - 4. Indicating lights.
 - 5. Seal-in contact.
 - 6. 2 convertible auxiliary contacts.
 - 7. Push buttons.
 - 8. Selector switches.
- B. Contactors: NEMA ICS 2, Class A, combination controller equipped for panelboard mounting and including the following accessories:
 - 1. Individual control-power transformers.
 - 2. Fuses for control-power transformers.
 - 3. Indicating lights.
 - 4. Seal-in contact.
 - 5. 2 convertible auxiliary contacts.
 - 6. Push buttons.
 - 7. Selector switches.
- C. Controller Disconnect Switches: Fused switch Adjustable instantaneous-trip circuit breaker integrally mounted mounted adjacent to and interlocked with controller.
 - 1. Auxiliary Contacts: Integral with disconnect switches to de-energize external control-power source.
- D. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held general-purpose controller.
 - 1. Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 - 2. Control-Power Source: 120-V branch circuit.

2.8 ACCESSORY COMPONENTS AND FEATURES

- A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Furnish portable test set to test functions of solid-state trip devices without removal from panelboard.
- C. Fungus Proofing: Permanent fungicidal treatment for panelboard interior, including overcurrent protective devices and other components.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Mount top of trim 74 inches above finished floor, unless otherwise indicated.
- D. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- E. Install overcurrent protective devices and controllers.
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- F. Install filler plates in unused spaces.
- G. Stub five 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.
- H. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with engraved metal or laminated phenolic nameplate mounted with corrosion-resistant screws. Nameplate colors shall be consistent.

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit.
- B. Perform the following field tests and inspections and prepare test reports:
1. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Load Balancing: After Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
1. Measure as directed during period of normal system loading.
 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.
- D. Infrared Scanning: Completion, but not more than 60 days after Final Acceptance, perform an infrared scanning of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

E. FEEDER INSULATION RESISTANCE TESTING

1. All current carrying phase conductors and neutrals shall be tested as installed, and before connections are made, for insulation resistance and accidental grounds. This shall be done with a 500-volt megger. The procedures listed below shall be followed:
 - a. Minimum readings shall be one million (1,000,000) or more ohms for #6 AWG wire and smaller, 250,000 ohms or more for #4 AWG wire or larger, between conductors and between conductor and the grounding conductor.
 - b. After all fixtures, devices and equipment are installed and all connections completed to each panel, the contractor shall disconnect the neutral feeder conductor from the neutral bar and take a megger reading between the neutral bar and the grounded enclosure. If this reading is less than 250,000 ohms, the contractor shall disconnect the branch circuit neutral wires from this neutral bar. He shall then test each one separately to the panel and until the low readings are found. The contractor shall correct troubles, reconnect and

retest until at least 250,000 ohms from the neutral bar to the grounded panel can be achieved with only the neutral feeder disconnected.

c. At final inspection, the contractor shall furnish a megger and show the engineers and State Construction Office representatives that the phase, neutral, and ground bus within panels comply with the above requirements. He shall also furnish a hook-on type ammeter and voltmeter to take current and voltage readings as directed by the representatives.

F. GROUND SYSTEM TESTING

1. Upon completion of installation of the electrical grounding and bonding systems, the ground resistance shall be tested with a ground resistance tester. Where tests show resistance-to-ground is over 25 ohms, appropriate action should be taken to reduce the resistance to 25 ohms, or less, by driving additional ground rods. (The compliance should be demonstrated by retesting.)

G. CIRCUIT BREAKER TESTS

1. For services 1000 amperes and larger, the following tests should be performed on the service circuit breakers and the distribution circuit breakers. Testing shall be performed by a qualified factory technician at the job site. All readings shall be tabulated:

- Phase tripping tolerance (within 20% of U/L requirements).
- Trip time (per phase) in seconds.
- Instantaneous trip (amps) per phase.
- Insulation resistance (in megaohms) at 100 volts (phase to phase, and line to load).
- Set final trip functions to match the engineers approved overcurrent protection device coordination and arc flash study.
- Ground fault protection on circuit breakers shall be tested in the field in accordance with the NEC and properly calibrated and set to match the coordination and arc flash studies.
- List all breakers settings on the as-built drawings.

H. GROUND FAULT PROTECTION SYSTEM

1. The ground fault protection on the new circuit breakers (if provided) shall be performance tested in the field and properly calibrated and set in accordance with the coordination study.

I. DOCUMENTATION

1. All tests specified shall be completely documented indicating time of day, date, temperature and all pertinent test information.

2. All required documentation of readings indicated above shall be submitted to the engineer prior to, and as one of the prerequisites for, final acceptance of the project.

J. The ground fault protection on the new circuit breakers (if provided) shall be performance tested in the field and properly calibrated and set in accordance with the coordination study.

3.5 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.6 SHORT CIRCUIT STUDY

- A. A complete short circuit and protection coordination study with coordination plots for each medium and low voltage distribution system shall be provided. The studies shall include the power company's system and relay characteristics, the base quantities selected, impedance source data, calculation methods and tabulations, one-line diagrams, impedance diagrams, conclusions and recommendations. A ground fault study shall be provided for the low voltage system, which shall include the associated zero sequence impedance diagrams. Short circuit momentary duties, when applicable, and interrupting duties shall be calculated on the basis of an assumed fault at each medium voltage switchgear line-up, low voltage switchgear line-up, switchboard, distribution panelboard, pertinent branch circuit panelboard, generator and other significant locations throughout the systems. The short circuit tabulations shall include the fault impedances, X to R ratios, asymmetry factors, KVA symmetrical and asymmetrical fault currents.
- B. The coordination plots required shall graphically indicate the coordination proposed for the several systems centered on full scale log forms. The coordination plots shall include complete titles, representative one-line diagrams and legends, associated power company's relay or system characteristics, medium voltage fuses and relays, significant equipment starting characteristics, complete parameters for transformers, complete operating bands for low voltage switchgear or switchboard circuit breaker trip devices, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time dial settings and pick up settings required. The long-time region of the coordination plots shall indicate a complete tap scale for each medium voltage relay, full load current and 150, 400 or 600 percent full load current transformer parameters and designate the pickups required for the low voltage circuit breakers. The short time region shall indicate the medium voltage relay instantaneous elements, the magnetizing inrush, ANSI withstand thermal and mechanical transformer parameters, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault currents. Each primary protective device required for a delta-grounded wye connected transformer shall be selected so the characteristic or operating band is within the transformer parameters and shall include a parameter equivalent to 58 percent of the ANSI withstand point to afford protection for secondary line to ground faults. The transformer damage curve shall be included for each transformer. Low voltage power circuit breakers shall provide long time, long time delay, short time, short time delay, ground fault, ground fault delay, and I^2t in/out settings with coordination plots and shall be separated from each other and the associated primary protective device by a 16 percent current margin for coordination and protection in the event of secondary line to line or line to ground fault. Medium voltage relays shall be separated by a 0.4 second time margin when the maximum three phase

fault flows, to assure proper selectivity. The protective device characteristics or operating band shall reflect the actual symmetrical and asymmetrical fault currents sensed by the device.

- C. The contractor shall note that the drawings and specifications indicate the general requirements for the equipment, the medium voltage and low voltage equipment, but additional specific characteristics of equipment furnished shall be determined in accordance with the results of the short circuit and protection coordination study. The equipment design discrepancies and the proposed corrective modifications, if required, shall be submitted with the short circuit and protection coordination study with any variations clearly noted on the subsequent shop drawings. Necessary field settings, adjustments and minor modifications for conformance with the approved short circuit and protection coordination study shall be accomplished by the particular manufacturer or by the Contractor without additional expense to the Owner. However, should equipment specified be outside the parameters required by this study, a change order to modify the equipment shall be issued if the engineer's review warrants such a change. Equipment shop drawings shall not be submitted until the short circuit and protection coordination study has been reviewed by the Owner's engineer.

- D. Arc-Flash labels shall be printed per OSHA requirements and shall be installed by the contractor.

3.7 POINT SETTINGS

- A. The Electrical Contractor shall set and calibrate all target points and settings indicated on the approved coordination study prior to energizing and testing the system.

- B. The study shall require the Electrical Contractor to provide the following information:
 - 1. Length, type, resistance, reactance of all cables both medium and low voltages.
 - 2. Fuse curves as required.
 - 3. Utility information.

END OF SECTION 26 24 16

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Twist-locking receptacles.
 - 3. Receptacles with integral surge suppression units.
 - 4. Wall-box motion sensors.
 - 5. Isolated-ground receptacles.
 - 6. Snap switches and wall-box dimmers.
 - 7. Solid-state fan speed controls.
 - 8. Wall-switch and exterior occupancy sensors.
 - 9. Communications outlets.
 - 10. Pendant cord-connector devices.
 - 11. Cord and plug sets.
 - 12. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.
- B. Related Sections include the following:
 - 1. Division 27 Section "Communications Horizontal Cabling" for workstation outlets.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.

- F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Receptacles shall be industrial specification grade or heavy-duty grade meeting NEMA WD 1, NEMA WD 6, DSCC W-C-596G, UL-498 and shall be approved third-party listed.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5351 (single), 5352 (duplex).
 - b. Hubbell; HBL5351 (single), CR5352 (duplex).
 - c. Leviton; 5891 (single), 5352 (duplex).
 - d. Pass & Seymour; 5381 (single), 5352 (duplex).
 - 2. Receptacles shall have side wired terminals with brass screws and hex head grounding screw.
- B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; CR 5253IG.
 - b. Leviton; 5362-IG.
 - c. Pass & Seymour; IG6300.
 - 2. 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.
- C. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; TR8300.
 - b. Hubbell; HBL8300SG.
 - c. Leviton; 8300-SGG.
 - d. Pass & Seymour; 63H.

2.3 GFCI RECEPTACLES

- A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; GF20.
 - b. Pass & Seymour; 2084.
 - c. Leviton

2.4 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
 - 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.
- B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; IG2310.
 - b. Leviton; 2310-IG.
 - c. Pass & Seymour
 - d. Cooper
 - 2. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. 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.

2.5 PENDANT CORD-CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
 - 1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
 - 2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.6 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 - 1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.

2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
 - b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
 - c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
 - d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).
 2. Wall switches shall have a side wired terminal with brass screws and hex head grounding screw.
 3. Toggle switches shall have quiet operating mechanisms without the use of mercury switches. All switches shall be listed by an approved third-party agency, approved for the voltage and amperage indicated.
- C. Pilot Light Switches, 20 A:
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221PL for 120 V and 277 V.
 - b. Hubbell; HPL1221PL for 120 V and 277 V.
 - c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
 - d. Pass & Seymour; PS20AC1-PLR for 120 V.
 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
- D. Key-Operated Switches, 120/277 V, 20 A:
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221L.
 - b. Hubbell; HBL1221L.
 - c. Leviton; 1221-2L.
 - d. Pass & Seymour; PS20AC1-L.
 2. Description: Single pole, with factory-supplied key in lieu of switch handle.
- E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995.

- b. Hubbell; HBL1557.
 - c. Leviton; 1257.
 - d. Pass & Seymour; 1251.
- F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995L.
 - b. Hubbell; HBL1557L.
 - c. Leviton; 1257L.
 - d. Pass & Seymour; 1251L.

2.8 WALL-BOX DIMMERS

- A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
- B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.
- C. Incandescent Lamp Dimmers: 120 V; control shall follow square law dimming curve. On-off switch positions shall bypass dimmer module.
 - 1. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF."
- D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.9 FAN SPEED CONTROLS

- A. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.
 - 1. Continuously adjustable slider,
 - 2. Three-speed adjustable slider, 1.5 A.

2.10 OCCUPANCY SENSORS

- A. Wall-Switch Sensors:
 - 1. Products: Subject to compliance with requirements, provide one of the following:

- a. Cooper; 6111 for 120 V, 6117 for 277 V.
 - b. Hubbell; WS1277.
 - c. Leviton; ODS 10-ID.
 - d. Pass & Seymour; WS3000.
 - e. Watt Stopper (The); WS-200.
2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft.
- B. Wall-Switch Sensors:
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; AT120 for 120 V, AT277 for 277 V.
 - b. Leviton; ODS 15-ID.
 - c. Watt Stopper
 - 2. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft.
- C. Long-Range Wall-Switch Sensors:
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; ATP1600WRP.
 - b. Leviton; ODWWV-IRW.
 - c. Pass & Seymour; WA1001.
 - d. Watt Stopper (The); CX-100.
 - 2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1200 sq. ft.
- D. Long-Range Wall-Switch Sensors:
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; ATD1600WRP.
 - b. Leviton; ODW12-MRW.
 - c. Watt Stopper (The); DT-200.
 - 2. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft.
- E. Wide-Range Wall-Switch Sensors:
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; ATP120HBRP.
 - b. Leviton; ODWHB-IRW.
 - c. Pass & Seymour; HS1001.
 - d. Watt Stopper (The); CX-100-3.

2. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft.

F. Exterior Occupancy Sensors:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Leviton; PS200-10.
 - b. Watt Stopper (The); EW-100-120.
 - c. Hubbell
2. Description: Passive-infrared type, 120/277 V, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and 110-foot detection range. Minimum switch rating: 1000-W incandescent, 500-VA fluorescent.

2.11 COMMUNICATIONS OUTLETS

A. Telephone Outlet:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following: Cooper, Pass & Seymour, Hubbell, Leviton.
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3560-6.
 - b. Leviton; 40649.
 - c. Hubbell
 - d. Pass & Seymour
3. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e. Comply with UL 1863.

B. Combination TV and Telephone Outlet:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following: Cooper, Pass & Seymour, Hubbell, Leviton.
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3562.
 - b. Leviton; 40595.
 - c. Hubbell
 - d. Pass & Seymour
3. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

2.12 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: See the Plans.
 - 3. Material for Unfinished Spaces: See the plans.
 - 4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover and listed and labeled for use in "wet locations."
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant thermoplastic with lockable cover.

2.13 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: See the Plans.
- D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.
- E. Voice and Data Communication Outlet: See the Plans.

2.14 POKE-THROUGH ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hubbell Incorporated; Wiring Device-Kellems.
 - 2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
 - 3. Square D/ Schneider Electric.
 - 4. Thomas & Betts Corporation.
 - 5. Wiremold Company (The).
- B. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
 - 1. Service Outlet Assembly: Flush type with four simplex receptacles and space for four RJ-45 jacks.
 - 2. Size: Selected to fit nominal 4-inch cored holes in floor and matched to floor thickness.
 - 3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
 - 4. Closure Plug: Arranged to close unused 4-inch cored openings and reestablish fire rating of floor.

5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, 4-pair, Category 5e voice and data communication cables.

2.15 MULTIOUTLET ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the Cooper, Pass & Seymour, Hubbell, Leviton.
- B. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
- C. Raceway Material: Metal, with manufacturer's standard finish.
- D. Wire: No. 12 AWG.

2.16 SERVICE POLES

- A. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
 1. Poles: Nominal 2.5-inch- square cross section, with height adequate to extend from floor to at least 6 inches above ceiling, and with separate channels for power wiring and voice and data communication cabling.
 2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
 3. Finishes: Satin-anodized aluminum.
 4. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, 4-pair, Category 3 or 5 voice and data communication cables.
 5. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R units.
 6. Voice and Data Communication Outlets: Blank insert with bushed cable opening.

2.17 FINISHES

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
 1. Wiring Devices Connected to Normal Power System: See the Plans., unless otherwise indicated or required by NFPA 70 or device listing.
 2. Wiring Devices Connected to Emergency Power System: Red.
 3. TVSS Devices: Blue.
 4. Isolated-Ground Receptacles: As specified above, with orange triangle on face.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 - 1. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 - 4. Existing Conductors:
 - a. Cut back and pigtail or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pig-tailing existing conductors is permitted provided the outlet box is large enough.
- D. Device Installation:
 - 1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
 - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 - 4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
 - 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
 - 6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 - 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.

8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
10. Receptacles shall not utilize "push-in modular" connectors.

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 online 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, multi-gang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.

4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION 26 27 26

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
1. Cartridge fuses rated 600 V and less for use in switches panelboards switchboards controllers and motor-control centers.
 2. Spare-fuse cabinets.

1.3 SUBMITTALS

- A. Product Data: Include the following for each fuse type indicated:
1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 2. Let-through current curves for fuses with current-limiting characteristics.
 3. Time-current curves, coordination charts and tables, and related data.
 4. Fuse size for elevator feeders and elevator disconnect switches.
- B. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
1. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
- C. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - a. Let-through current curves for fuses with current-limiting characteristics.
 - b. Time-current curves, coordination charts and tables, and related data.

- c. Ambient temperature adjustment information.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain fuses from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NEMA FU 1.
- D. Comply with NFPA 70.

1.5 PROJECT 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.

1.6 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

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. Fuses: Quantity equal to 5 percent of each fuse type and size, but no fewer than 3 of each type and size.

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. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.
 - 3. Ferraz Shawmut, Inc.
 - 4. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

2.3 SPARE-FUSE CABINET

- A. Cabinet: Wall-mounted, 0.05-inch- thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 - 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
 - 2. Finish: Gray, baked enamel.
 - 3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
 - 4. Fuse Pullers: For each size of fuse.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Service Entrance: Class L, time delay J, fast acting J, time delay T, fast acting.
- B. Feeders: Class L, time delay J, time delay RK5, time delay.
- C. Motor Branch Circuits: Class RK5, time delay.
- D. Other Branch Circuits: Class RK1, time delay.

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).

3.4 IDENTIFICATION

- A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 26 28 13

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. This Section includes the following individually mounted, enclosed switches and circuit breakers:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Bolted-pressure contact switches.
 - 4. High-pressure, butt-type contact switches.
 - 5. Molded-case circuit breakers.
 - 6. Molded-case switches.
 - 7. Enclosures.

1.3 DEFINITIONS

- A. GD: General duty.
- B. GFCI: Ground-fault circuit interrupter.
- C. HD: Heavy duty.
- D. RMS: Root mean square.
- E. SPDT: Single pole, double throw.

1.4 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.

3. Short-circuit current rating.
 4. UL listing for series rating of installed devices.
 5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:
1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For testing agency.
- E. Field quality-control test reports including the following:
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.
- F. Manufacturer's field service report.
- G. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 2. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 QUALITY ASSURANCE

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

1.6 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.

1.7 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

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. Spares: For the following:
 - a. Potential Transformer Fuses: 3
 - b. Control-Power Fuses: 3
 - c. Fuses and Fusible Devices for Fused Circuit Breakers: 3
 - d. Fuses for Fusible Switches: 3
 - e. Fuses for Fused Power Circuit Devices: 3
 2. Spare Indicating Lights: Six of each type 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:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Manufacturers:
1. Eaton Corporation; Cutler-Hammer Products.
 2. General Electric Co.; Electrical Distribution & Control Division.
 3. Siemens Energy & Automation, Inc.
 4. Square D/Group Schneider.
- B. Fusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- C. Nonfusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two 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; and labeled for copper and aluminum neutral conductors.
 3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.3 FUSED POWER CIRCUIT DEVICES

- A. Bolted-Pressure Contact Switch: UL 977; operating mechanism shall use a rotary-mechanical-bolting action to produce and maintain high-clamping pressure on the switch blade after it engages the stationary contacts.
1. Manufacturers:
 - a. Boltswitch, Inc.

- b. Eaton Corporation; Cutler-Hammer Products.
- c. Pringle Electrical Mfg. Co.
- d. Siemens Energy & Automation, Inc.
- e. Square D/Group Schneider.

2.4 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Manufacturers:

- 1. Eaton Corporation; Cutler-Hammer Products.
- 2. Moeller Electric Corporation.
- 3. Siemens Energy & Automation, Inc.
- 4. Square D/Group Schneider.

B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

- 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- 3. Electronic Trip-Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I²t response.
- 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.
- 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
- 6. GFCI Circuit Breakers: Single- and two-pole configurations with 30-mA trip sensitivity.

C. Molded-Case Circuit-Breaker Features and Accessories:

- 1. Standard frame sizes, trip ratings, and number of poles.
- 2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
- 3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
- 4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
- 5. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."

6. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
 8. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 10. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
- D. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- E. Molded-Case Switch Accessories:
1. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and material of conductors.
 2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.
 3. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage. Provide "dummy" trip unit where required for proper operation.
 4. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay. Provide "dummy" trip unit where required for proper operation.
 5. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 6. Key Interlock Kit: Externally mounted to prohibit operation; key shall be removable only when switch is in off position.

2.5 ENCLOSURES

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
1. Outdoor Locations: NEMA 250, Type 3R.
 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

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.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

- A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.
- B. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems," and concrete materials and installation requirements are specified in Division 03.

3.3 INSTALLATION

- A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.
- B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.
- C. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Prepare for acceptance testing as follows:
 - 1. Inspect mechanical and electrical connections.
 - 2. Verify switch and relay type and labeling verification.
 - 3. Verify rating of installed fuses.
 - 4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.

- C. Perform the following field tests and inspections and prepare test reports:
1. Test mounting and anchorage devices according to requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 3. Infrared Scanning:
 - a. Initial Infrared Scanning: After Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
 - b. Follow-Up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Completion.
 - c. Instruments, Equipment and Reports:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.7 CLEANING

- A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.
- B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION 26 28 16

ENGINE GENERATORS - DIESEL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes packaged engine-generator sets for emergency power supply with the following features:
 - 1. Diesel engine.
 - 2. Unit-mounted cooling system.
 - 3. Unit-mounted control and monitoring.
 - 4. Performance requirements for sensitive loads.
 - 5. Load banks.
 - 6. Sound Attenuated Level 1 Outdoor enclosure.
- B. Related Sections include the following:
 - 1. Division 26 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.3 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 SUBMITTALS

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
 - 1. Thermal damage curve for generator.
 - 2. Time-current characteristic curves for generator protective device.

- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 4. Wiring Diagrams: Power, signal, and control wiring.
- C. Manufacturer Seismic Qualification Certification: Submit certification that engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For manufacturer and testing agency.
- E. Source quality-control test reports.
1. Certified summary of prototype-unit test report.
 2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
 4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 5. Report of sound generation.
 6. Report of exhaust emissions showing compliance with applicable regulations. Including compliance with US EPA emission restrictions for stationary emergency generators.
 7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- F. Field quality-control test reports.

- G. Operation and Maintenance Data: For packaged engine generators 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. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
- H. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 - 1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
 - 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles (321 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. 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), 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.
- D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- E. 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.
- F. Comply with ASME B15.1.
- G. Comply with NFPA 37.
- H. Comply with NFPA 70.
- I. Comply with NFPA 99.

- J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- K. Comply with UL 2200.
- L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
- N. GENERATOR AND COMPONENTS ARE TO BE PROVIDED AS A UL LISTED PIECE OF EQUIPMENT/SYSTEM.

1.6 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 Architect no fewer than two days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Architect's written permission.
- B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: -5 to 40 deg C.
 - 2. Relative Humidity: 0 to 95 percent.
 - 3. Altitude: Sea level to 1000 feet (300 m).
- C. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:

1.7 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators mounted on grade. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Division 07 Section "Roof Accessories."
- C. Emergency battery light fixture within the genset enclosure to illuminate the control should the engine/generator fail to operate.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period. This shall include all parts, labor, travel to and from job site and expenses and equipment necessary to perform replacement and/or repairs.
1. Warranty Period: 5 years from date of final inspection and acceptance.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
1. Caterpillar; Engine Div.
 2. Kohler Co.; Generator Division.
 3. Onan/Cummins Power Generation; Industrial Business Group.

2.2 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
 - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C. Capacities and Characteristics:
 - 1. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
 - 2. Output Connections: Three-phase, four wire.
 - 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance:
 - 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
 - 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
 - 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
 - 4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
 - 5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
 - 6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
 - 7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
 - 8. Start Time: Comply with NFPA 110, Type 10, system requirements. Maximum 10 seconds starting.
- E. Generator-Set Performance for Sensitive Loads:
 - 1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

- a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus, or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

- A. Fuel: Fuel oil, Grade DF-2.
- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
- D. Lubrication System: The following items are mounted on engine or skid:
 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

- E. Engine shall be water cooled, solid-injection type, either vertical in-line or v-type. The engine shall be equipped with fuel filter, lube oil filter, intake air filter, lube oil cooler, service meter, gear-driven water pump, and instruments, including a fuel pressure gauge, water temperature gauge, lubricating oil pump and pressure gauge, battery charging ammeter, and engine hour meter.
- F. Engine shall be provided with oil and water drains to exterior of enclosure with a bronze body ball valve installed on engine and plumbed to exterior coupling with high quality hose. Fumes disposal shall be extended to radiator discharge using an oil resistant high-quality hose.
- G. Engine Fuel System:
 - 1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 - 2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- H. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity. Engine shall be equipped with one jacket water heater with recirculating pump. Heaters and pump shall be a single assembly with a single point power feed connection.
- I. Governor: Adjustable isochronous, with speed sensing.
- J. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 - 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 - 3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 - 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 - 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- K. Muffler/Silencer: Critical Grade type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - 1. Minimum sound attenuation of 25 dB at 500 Hz.

2. Critical grade silencer shall be provided to reduce engine exhaust noise to a maximum dBA level of 85 at a distance of 10 feet.
 3. Terminate exhaust piping using a hinged cap on top of pipe to keep out rain. Exhaust piping and silencer shall be stainless steel to prevent rusting or be internally mounted. Exhaust pipe size shall be such that exhaust back pressure does not exceed maximum limitation required by engine manufacturer. Silencer shall provide a minimum of 32 dBA attenuation.
 4. Acoustic insulation shall reduce engine generator noise to an average of 79 dBA at 23 feet. Air intake and discharge inlets shall be supplied. Acoustic insulation material shall consist of sound absorbing material.
 5. Engine silencer shall be independently supported from the engine-generator.
- L. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- M. Air flow shall be away from engine. The radiator shall be protected by a strong grille or screen guard and the fan shall be provided with a screen guard.
- N. Starting System: 24-V electric, with negative ground.
1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 3. Cranking Cycle: As required by NFPA 110 for system level specified.
 4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging. Batteries shall be industrial grade lead acid with current limiting battery charger. Batteries shall be oversized for proper starting in temperature extremes. The battery charging system shall be automatic, solid state, current limiting and float equalizing and shall maintain the battery at normal capacity, recharge battery after cranking and be capable of recharging a completely discharged battery within 8 hours. System shall be capable of automatically switching from one charging rate to another to meet the needs of the battery. The battery charging system shall have a 120 volt input and shall also be equipped with overload protection, voltage surge suppressors, D.C. ammeter, D.C. voltmeter, low D.C. voltage alarm relay, battery charger malfunction alarm contact and have a minimum continuous output of 10 amperes D.C. and be third party listed.
 5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
 7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 6A minimum shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.
9. Engine shall have radio frequency suppression.

2.4 FUEL OIL STORAGE

- A. Comply with NFPA 30.
- B. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 2085 fuel oil tank. Features include the following:
 1. Tank level indicator.
 2. Capacity: Fuel for a minimum of 8 hours continuous operation at 100 percent rated power output
 3. Vandal-resistant fill cap.
 4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.5 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set. Generator parameters shall be able to be monitored through the Building Automation System (BAS) via LonWorks, Modbus, or approved equal.

- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
- D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel.
- E. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel features shall include the following:
 - 1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
 - 2. Switchboard Construction: Freestanding unit complying with Division 26 Section "Switchboards."
 - 3. Switchgear Construction: Freestanding unit complying with Division 26 Section "Low-Voltage Switchgear."
 - 4. Current and Potential Transformers: Instrument accuracy class.
- F. Indicating and Protective Devices and Controls:
 - 1. AC voltmeter.
 - 2. AC ammeter.
 - 3. AC frequency meter.
 - 4. DC voltmeter (alternator battery charging).
 - 5. Engine-coolant temperature gage.
 - 6. Engine lubricating-oil pressure gage.
 - 7. Running-time meter.
 - 8. Ammeter-voltmeter, phase-selector switch(es).
 - 9. Generator-voltage adjusting rheostat.
 - 10. Start-stop switch.
 - 11. Overspeed shutdown device.
 - 12. Coolant high-temperature shutdown device.
 - 13. Coolant low-level shutdown device.
 - 14. Oil low-pressure shutdown device.
 - 15. Fuel tank derangement alarm.
 - 16. Fuel tank high-level shutdown of fuel supply alarm.
 - 17. Generator overload.
 - 18. Overcrank.
 - 19. ATS in normal.
 - 20. ATS in emergency.

21. Low gas pressure.
22. Enclosure breach.

- G. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- H. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Division 26 Section "Electrical Power Monitoring and Control."
- I. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
1. Engine high-temperature shutdown.
 2. Lube-oil, low-pressure shutdown.
 3. Overspeed shutdown.
 4. Remote emergency-stop shutdown.
 5. Engine high temperature prealarm.
 6. Lube-oil, low-pressure prealarm.
 7. Fuel tank, low-fuel level.
 8. Low coolant level.
- J. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated. Panels, alarms, meters, etc., shall be appropriately labeled using laminated plastic labels, red letters on white background, professionally engraved. Contractor shall submit a drawing for approval showing layout prior to purchase or fabrication.
- K. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.
- L. The generator set shall have a digital control panel mounted on the unit with LCD readout and controls listed by the manufacturer as standard as well as those specified herein. Controls shall provide for automatic shutdown in case of high-water temperature, overspeed, overcrank, or low oil pressure. Include additional alarms for NFPA 110 and 99 compliance.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 2. Trip Settings: Selected to coordinate with generator thermal damage curve.
 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices. Furnish with auxiliary position contacts.
 4. Mounting: Adjacent to or integrated with control and monitoring panel.
- B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
 2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
 3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.
- C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Dripproof.
- G. Instrument Transformers: Mounted within generator enclosure.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent, maximum.

2.8 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, weatherproof, galvanized steel housing (minimum 14 gauge), wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure. Housing shall be painted aluminum, 14 gallon minimum, with access doors with panic hardware. Doors shall provide full access for operation and servicing and be lockable via in-handle lock tumblers.
- B. Coordinate first paragraph and subparagraphs below with Drawings showing features, construction details, and equipment arrangement.
- C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
 1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
- D. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
 1. AC lighting system and connection point for operation when remote source is available.
 2. DC lighting system for operation when remote source and generator are both unavailable.
 3. Provide battery backup emergency light within genset to illuminate control panel if normal power is de-energized and the generator fails to start.
 4. Provide a self-contained emergency light within enclosure to illuminate the control panel if normal power is lost and the generator fails to start. Minimum 90-minute backup, nicad battery.
- E. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

2.9 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of

sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Bridge-bearing neoprene, complying with AASHTO M 251.
2. Durometer Rating: 45.
3. Number of Layers: Two.

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of 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.

2.10 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Color shall be UNCC standard green finish over corrosion-resistant pretreatment and compatible primer.

2.11 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Full load run.
3. Maximum power.
4. Voltage regulation.
5. Transient and steady-state governing.
6. Single-step load pickup.
7. Safety shutdown.
8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of 1 inch. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Contractor shall provide a separate concrete pad for generator enclosure. Pads shall be a minimum of 12" beyond base x 12" deep with No.6 rebar on 12" centers in a horizontal grid pattern. Rebar should clear surfaces by 3" minimum in all directions. Concrete mixture shall be a 1:2:3 mixture of cement, sand, and aggregate with maximum of 4" slump and 28-day compressive strength of 3000psi.
- D. Install remote radiator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of [1 inch (25 mm)] on concrete base on grade.
- E. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and heat exchanger. Piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
- F. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
 - 1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."

- G. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Connect cooling-system water piping to engine-generator set and heat exchanger with flexible connectors.
- D. Connect engine exhaust pipe to engine with flexible connector.
- E. Connect fuel piping to engines with a gate valve and union and flexible connector.
 - 1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Division 23 Section "Facility Fuel-Oil Piping."
- F. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

- A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: All testing shall be demonstrated to the owner's commissioning agent.
- B. All testing shall be demonstrated to the owner's commissioning agent.
- C. Perform a 4 hour load bank test which shall be witnessed by owner's commissioning agent. On-site testing in the presence of the owner shall include testing of all safety devices and shall include a four hour running test first at 50% load for 1 hour, then at 75% load for 1 hour and last at 100% load for 2 hours. Then, after the cool down period the generator shall be started and after 10 seconds be applied 100% load for 30 minutes. The capability of the system to pick up full standby service load within 10 seconds of power outage shall also be demonstrated. Supplier shall furnish load bank.

- D. 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.
- E. 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.
- F. Tests and Inspections:
 - 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 - 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 - 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 - 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 - 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 - 7. Exhaust Emissions Test: Comply with applicable government test criteria. The Engine Generator must be able to meet Mecklenburg County emissions requirements (Tier 4).
 - 8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.
 - 9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 - 10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
- G. Coordinate tests with tests for transfer switches and run them concurrently.

- H. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- I. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- J. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- K. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- L. Remove and replace malfunctioning units and retest as specified above.
- M. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- N. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- O. Infrared Scanning: After Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 01 Section "Demonstration and Training."
- B. Supplier shall provide complete on-site training in the operation of the systems for the Owner at times chosen by the Owner to include all work shifts.
- C. Supplier shall provide, upon completion of installation but before final acceptance by Owner, three complete sets of operating instructions, maintenance manuals, and drawings, showing full details for care and maintenance of each item of equipment. In addition, a simplified set of step-by-step operating instructions, encased in a suitable frame for placing at the generator location, shall be provided with the operation and maintenance manuals.

END OF SECTION 26 32 13

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.
- B. Switch shall be 4-wire, 4-pole, 100% rated continuous

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switches.
 - 2. Remote annunciation systems.
 - 3. Remote annunciation and control systems.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
 - 1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
- C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For manufacturer and testing agency.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Features and operating sequences, both automatic and manual.
 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain automatic transfer switches through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NEMA ICS 1.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110.
- I. Comply with UL 1008 unless requirements of these Specifications are stricter.
- J. Transfer switch shall be completely assembled, wired, and tested at the factory prior to shipping and installation.

1.5 PROJECT CONDITIONS

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

1.6 COORDINATION

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Contactor Transfer Switches:
 - a. Zenith
 - b. ASCO
 - c. Russelectric.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location. The minimum withstand rating shall be 65,000 amps.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
 - 2. Switch Action: Double throw; mechanically held in both directions.
 - 3. Contacts: Silver plated copper. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Switching. Switching shall incorporate a time adjustable transition neutral position where the load is disconnected from both power sources.
- H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- I. 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.
- J. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
- K. 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.
- L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- M. Enclosures: General-purpose NEMA 250, Type 3R, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.
- N. All transfer switch coils, springs, and control elements shall be easily inspected and conveniently removable from the front of the transfer switch without major disassembly or disconnection of power conductors.
- O. All feeder lugs, relays, timers, control wiring, and accessories shall be front accessible.
- P. The control module and transfer switch shall be physically separate.
- Q. Controls shall be digital incorporating LCD backlit display visible while the enclosure door is closed.

2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: 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. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent flashover and shall be arranged so that the transfer switch can be manually operated under load, without opening the enclosure door.
- D. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- F. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
- G. Automatic Delayed -Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.
 - 1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
 - 2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
 - 3. Fully automatic break-before-make operation with center off position.
 - 4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.
- H. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
- I. Motor Disconnect and Timing Relay: Controls designate starters, so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

- J. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.
- K. Automatic Transfer-Switch Features:
1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
 5. Test Switch: Simulate normal-source failure.
 6. Switch-Position Pilot Lights: Indicate source to which load is connected.
 7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
 8. Unassigned Auxiliary Contacts: Timed auxiliary contacts. Two individually timed N.O.-N.C. contacts.
 9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
 10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
 11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
 12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
 13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

- a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is not available.
 - d. A selectable load/no-load digitally programmable exerciser shall be incorporated within ATS.
14. The switch shall automatically transfer to the emergency source in less than 10 seconds upon loss of utility power.
 15. Loss of utility power on any phase, or reduction of voltage on any phase below 80%, the transfer switch shall cause generator start.

2.4 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Floor-Mounting Switch: Anchor to floor by bolting.
 1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."
- C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Division 26 Section "Identification for Electrical Systems."
- E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary, to accommodate required wiring.

- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
 - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 - 5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

- g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.
- D. Testing Agency's Tests and Inspections:
1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
 5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.
- E. Coordinate tests with tests of generator and run them concurrently.

- F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- G. Remove and replace malfunctioning units and retest as specified above.
- H. Infrared Scanning: After 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. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 01 Section "Demonstration and Training."
- B. Coordinate this training with that for generator equipment.

END OF SECTION 26 36 00

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. 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 lightning protection for building elements. Specification is provided for performance specification and shall be used to provide a contract price for lightning protection system. Contractor shall provide a UL master label lightning protection system for the building including all required conductors, equipment, raceways and design.

1.3 DEFINITIONS

- A. LPI: Lightning Protection Institute.
- B. NRTL: National recognized testing laboratory.

1.4 SUBMITTALS

- A. Product Data: For air terminals and mounting accessories.
- B. Shop Drawings: Detail lightning protection system, including air-terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
- C. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.
- D. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.
- E. Field inspection reports indicating compliance with specified requirements.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who is an NRTL or who is certified by LPI as a Master Installer/Designer.
- B. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.6 COORDINATION

- A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
- B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Automatic Lightning Protection.
 - 2. ERICO International Corporation.
 - 3. Harger Lightning Protection, Inc.
 - 4. Heary Bros. Lightning Protection Co. Inc.
 - 5. Independent Protection Co.
 - 6. Robbins Lightning Inc.
 - 7. Thompson Lightning Protection, Inc.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Comply with UL 96.
- B. Roof-Mounting Air Terminals: NFPA Class I, aluminum, solid, unless otherwise indicated.
 - 1. Single-Membrane, Roof-Mounting Air Terminals: Designed for single-membrane roof materials.
- C. Stack-Mounting Air Terminals: Stainless steel.
- D. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Division 26 Section "Grounding and Bonding for Electrical Systems" and with standards referenced in this Section.

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 sharp bends and narrow loops.
- C. Conceal the following conductors:
 - 1. System conductors.
 - 2. Down conductors.
 - 3. Interior conductors.
 - 4. Conductors within normal view from exterior locations at grade within 200 feet of building.
 - 5. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.
- D. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.
- E. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- F. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.
- G. A counterpoise installation based on requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" may be used as a ground loop required by NFPA 780, provided counterpoise conductor meets or exceeds minimum requirements in NFPA 780.
 - 1. Bond ground terminals to counterpoise conductor.
 - 2. Bond grounded metal bodies on building within 12 feet of ground to counterpoise conductor.
 - 3. Bond grounded metal bodies on building within 12 feet of roof to counterpoise conductor.
- H. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

3.2 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.

3.3 FIELD QUALITY CONTROL

- A. UL Inspection: Provide inspections as required to obtain a UL Master Label for system.
- B. Provide an inspection by an inspector certified by LPI to obtain an LPI certification.

END OF SECTION 26 41 13

TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE
ELECTRICAL POWER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings 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 TVSSs for low-voltage power, control, and communication equipment.
- B. Related Sections include the following:
 - 1. Division 26 Section "Wiring Devices" for devices with integral TVSSs.
 - 2. Division 26 Section "Switchboards" for factory installed TVSSs.
 - 3. Division 26 Section "Panelboards" for factory installed TVSSs.

1.3 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. SVR: Suppressed voltage rating.
- C. TVSS: Transient voltage surge suppressor.
- D. SPD: Surge Protection Device

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating weights, operating characteristics, furnished specialties, and accessories.
- B. Product Certificates: For transient voltage suppression devices, signed by product manufacturer certifying compliance with the following standards:
 - 1. UL 1283.
 - 2. UL 1449.

- C. Qualification Data: For testing agency.
- D. Field quality-control test reports, including the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Failed test results and corrective action taken to achieve requirements.
- E. Operation and Maintenance Data: For transient voltage suppression devices to include in emergency, operation, and maintenance manuals.
- F. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.
- C. Product Options: Drawings indicate size, dimensional requirements, and electrical performance of suppressors and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits."
- F. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."
- G. Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Transient Voltage Surge Suppressors."

1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.
- B. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
 - 2. Operating Temperature: 30 to 120 deg F.
 - 3. Humidity: 0 to 85 percent, noncondensing.
 - 4. Altitude: Less than 20,000 feet above sea level.

1.7 COORDINATION

- A. Coordinate location of field-mounted surge suppressors to allow adequate clearances for maintenance.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within five years from date of final acceptance of work.
- B. Special Warranty for Cord-Connected, Plug-in Surge Suppressors: Manufacturer's standard form in which manufacturer agrees to repair or replace electronic equipment connected to circuits protected by surge suppressors.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Replaceable Protection Modules: One of each size and type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advanced Protection Technologies, Inc.
 2. Current Technology, Inc.
 3. Surge Suppression Incorporated.
 4. Cutler-Hammer, Inc.; Eaton Corporation.
 5. Entelec International.
 6. Intermatic, Inc.
 7. LEA International.
 8. Leviton Mfg. Company Inc.
 9. Liebert Corporation; a division of Emerson.
 10. Northern Technologies, Inc.
 11. Siemens Energy & Automation, Inc.
 12. Square D; Schneider Electric.
 13. Sutton Designs Inc.
 14. Transtector Systems, Inc.
 15. Tycor; Cutler-Hammer, Inc.
 16. United Power Corporation.

2.2 SERVICE ENTRANCE SUPPRESSORS

- A. Surge Protection Device Description: Non-modular, sine-wave-tracking type with the following features and accessories:
1. LED indicator lights for power and protection status.
 2. Audible alarm, with silencing switch, to indicate when protection has failed.
 3. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
- B. Surge Protection Device Description: Modular design with field-replaceable modules, sine-wave-tracking type with the following features and accessories:
1. Fuses rated at 200-kA interrupting capacity.
 2. Fabrication using bolted compression lugs for internal wiring.
 3. Integral disconnect switch.
 4. Redundant suppression circuits.
 5. Redundant replaceable modules.
 6. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
 7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 8. LED indicator lights for power and protection status.
 9. Audible alarm, with silencing switch, to indicate when protection has failed.

10. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
 11. Surge-event operations counter.
- C. Peak Single-Impulse Surge Current Rating: 240 kA per phase.
- D. Connection Means: Permanently wired.
- E. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:
1. Line to Neutral: 400 V for 208Y/120.
 2. Line to Ground: 400 V for 208Y/120.
 3. Neutral to Ground: 400 V for 208Y/120.
- F. Protection modes and UL 1449 SVR for voltages of 480, 3-phase, 4-wire, circuits shall be as follows:
1. Line to Line: 1000 V for 480 V.
 2. Line to Ground: 1000 V for 480 V.

2.3 PANELBOARD SUPPRESSORS

- A. Surge Protection Device Description: Non-modular, sine-wave-tracking type with the following features and accessories:
1. LED indicator lights for power and protection status.
 2. Audible alarm, with silencing switch, to indicate when protection has failed.
 3. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
- B. Surge Protection Device Description: Modular design with field-replaceable modules, sine-wave-tracking type with the following features and accessories:
1. Fuses rated at 200-kA interrupting capacity.
 2. Fabrication using bolted compression lugs for internal wiring.
 3. Integral disconnect switch.
 4. Redundant suppression circuits.
 5. Redundant replaceable modules.
 6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 7. LED indicator lights for power and protection status.
 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 9. One set of dry contacts rated at 5 A and 250-V, ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
 10. Surge-event operations counter.
- C. Peak Single-Impulse Surge Current Rating: 80 kA per phase.

- D. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:
 - 1. Line to Neutral: 400 V for 208Y/120.
 - 2. Line to Ground: 400 V for 208Y/120.
 - 3. Neutral to Ground: 400 V for 208Y/120.

- E. Protection modes and UL 1449 SVR for voltages of 480, or 600, 3-phase, 3-wire, delta circuits shall be as follows:
 - 1. Line to Line: 1000 V for 480 V.
 - 2. Line to Ground: 800 V for 480 V.

2.4 SUPPRESSORS FOR ELECTRONIC-GRADE PANELBOARDS

- A. Surge Protection Device Description: Sine-wave-tracking type, panel-mounted design with the following features and accessories:
 - 1. LED indicator lights for power and protection status.
 - 2. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 3. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
 - 4. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

- B. Peak Single-Impulse Surge Current Rating: 120 kA per phase.

- C. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:
 - 1. Line to Neutral: 400 V for 208Y/120.
 - 2. Line to Ground: 400 V for 208Y/120.
 - 3. Neutral to Ground: 400 V for 208Y/120.

- D. Protection modes and UL 1449 SVR for voltages of 480, or 600, 3-phase, 3-wire, delta circuits shall be as follows:
 - 1. Line to Line: 1000 V for 480 V.
 - 2. Line to Ground: 800 V for 480 V.

2.5 PLUG-IN SURGE SUPPRESSORS

- A. Description: Non-modular, plug-in suppressors with at least four 15-A, 120-V ac, NEMA WD 6, Configuration 15-15R receptacles, suitable to plug into a NEMA WD 6, Configuration 15-15R receptacle; with the following features and accessories:
 - 1. LED indicator lights for power and protection status.
 - 2. LED indicator lights for reverse polarity and open outlet ground.

3. Circuit breaker and thermal fusing. When protection is lost, circuit opens and cannot be reset.
 4. Circuit breaker and thermal fusing. Unit continues to supply power if protection is lost.
 5. Close-coupled direct plug-in.
 6. Rocker-type on-off switch illuminated when in the on position.
 7. One RJ11/12C telephone line protector, suitable for modem connection. Maximum clamping voltage 220 peak on pins No. 3 and No. 4.
- B. Peak Single-Impulse Surge Current Rating: 26 kA per phase.
- C. Protection modes and UL 1449 SVR shall be as follows:
1. Line to Neutral: 475 V.
 2. Line to Ground: 475 V.
 3. Neutral to Ground: 475 V.

2.6 ENCLOSURES

- A. NEMA 250, with type matching the enclosure of panel or device being protected.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE PROTECTION DEVICES

- A. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.
- B. Install devices for panelboard and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
1. Provide multipole, 60-A circuit breaker as a dedicated disconnect for suppressor, unless otherwise indicated.

3.2 PLACING SYSTEM INTO SERVICE

- A. Do not energize or connect panelboards to their sources until surge protection devices are installed and connected.

3.3 FIELD QUALITY CONTROL

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

1. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. Testing: Engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports:
- C. Testing: Perform the following field tests and inspections and prepare test reports:
 1. After installing surge protection devices, but before electrical circuitry has been energized, test for compliance with requirements.
 2. Complete startup checks according to manufacturer's written instructions.
- D. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

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

END OF SECTION 26 43 13

PART 1 - GENERAL

Refer to fixture schedule, on electrical plans, for more information.

1.1 SUMMARY**A. Section Includes:**

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 26 09 23 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.2 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.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product, arranged by designation.
- 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, and required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Green Globes Submittals:

1. Product Data for Credit IEQ 4.2: For paints and coatings, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit IEQ 4.2: For paints and coatings, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. Product Schedule: For luminaires and lamps.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved:
- B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
- C. Product Certificates: For each type of luminaire.
- D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 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 Final Inspection and acceptance.

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 and the luminaire will be fully operational during and after the seismic event."

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 for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. Recessed Fixtures: Comply with NEMA LE 4.
- E. CRI of 80. CCT of 4000 K.
- F. Rated lamp life of 50,000 hours.
- G. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- H. Internal driver.
- I. Nominal Operating Voltage: As circuited on the drawings.
 - 1. Lens Thickness: At least 0.125-inch (3.175 mm) minimum unless otherwise indicated.
- J. Mercury-free.

2.3 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.
 - 1. Acrylic: One hundred 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 (3.175 mm) minimum unless otherwise indicated.

2.4 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.

2.5 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm)
- D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 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: Sized and rated for luminaire weight.
- E. Flush-Mounted Luminaire Support: Secured to outlet box.
- F. Wall-Mounted Luminaire Support:
 1. Attached to structural members in walls.
 2. Do not attach luminaires directly to gypsum board.
- G. Ceiling-Mounted Luminaire Support:
 1. Ceiling mount with two 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length.

2. Ceiling mount with pendant mount with 5/32-inch diameter aircraft cable supports adjustable to 120 inches.

H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod 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 using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Secure with a screw at each corner to a MAIN ceiling runner.

J. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

K. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.2 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.

END OF SECTION 26 51 19

PART 1 - GENERAL

1.1 General Notes

- A. All exterior Light Poles, 12ft and taller, shall be UL listed or approved 3rd party listed.

1.2 RELATED DOCUMENTS

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

1.3 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.

1.4 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.

1.5 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.
 - 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.
- C. Delegated-Design Submittal: For luminaire supports.
1. Include design calculations for luminaire supports and seismic restraints.

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Luminaires.
 2. Structural members to which equipment and luminaires will be attached.
 3. Underground utilities and structures.
 4. Existing underground utilities and structures.
 5. Above-grade utilities and structures.
 6. Existing above-grade utilities and structures.
 7. Building features.
 8. Vertical and horizontal information.
- 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.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Product Certificates: For each type of the following:
1. Luminaire.
 2. Photoelectric relay.
- E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
- F. Source quality-control reports.
- G. Sample warranty.

1.7 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.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.
- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- E. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- F. Comply with IEEE C2, "National Electrical Safety Code."
- G. Comply with NFPA 70, "National Electrical Code."
- H. Comply with NECA/IESNA 501, "Standard for Installing Exterior Lighting Systems."
- I. Comply with UL 1598, "Standard for Luminaires."

- J. Comply with UL 8750, “Standard for Safety for Light Emitting Diode (LED) Equipment for Use in Lighting Products.”
- K. Comply with IESNA LM-79, “Electrical and Photometric Measurements of Solid-State Lighting Products”.
- L. Fixtures will be required to be DesignLights Consortium compliant (DLC). Fixtures specified must meet DLC certification or supplier will be responsible for submitting an “equal” fixture to the listed schedule fixture.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures, including luminaire support components.
 - b. Faulty operation of luminaires and accessories.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, product(s) indicated on Drawings.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

2.3 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires 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. CRI of minimum 80. CCT of 4000 K.
- E. L70 lamp life minimum of 50,000 hours.
- F. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- G. Internal driver. Provide a quick disconnect for driver and diode board.
- H. Mercury-free.
- I. 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.

2.4 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.
- C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.

- a. Color: Dark bronze.

- D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

- a. Color: As selected from manufacturer's standard catalog of colors.

2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 26 05 29 "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, 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. Wiring Method: Install cables in raceways. Conceal raceways and cables.
- G. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.
- H. Coordinate layout and installation of luminaires with other construction.
- I. Adjust luminaires that require field adjustment or aiming. [Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.]
- J. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

- A. Aim as indicated on Drawings.
- B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 30 00 "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

- B. Steel Conduits: Comply with Section 26 05 33 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 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. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s), as applicable to the specific luminaire use:
 - a. IES LM-5.
 - b. IES LM-50.
 - c. IES LM-52.
 - d. IES LM-64.
 - e. IES LM-72.
 - 2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- D. Luminaire will be considered defective if it does not pass tests and inspections.
- E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

3.9 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 26 56 19