SECTION 23 22 13 - STEAM AND CONDENSATE PIPING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following for LP steam and condensate piping:

1. Pipe, valves and fittings
2. Strainers
3. Safety valves
4. Thermostatic air vents and vacuum breakers
5. Expansion Joints and Guides

B. Related sections include:

1. Electric powered steam condensate pumps are specified in Section 23 21 23 "Pumps".

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures:

1. HP Steam Piping: above 80 psig (552 kPa)
2. LP Steam Piping: 0 through 80 psig (0 through 552 kPa)
3. HP Condensate Piping: above 80 psig (552 kPa)
4. LP Condensate Piping: 0 through 80 psig (0 through 552 kPa)
5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

B. Base expansion calculations on 50°F installation temperature and temperature of steam pressure for steam systems, plus 30% safety factor.

1.4 SUBMITTALS

A. Product Data: For each type of factory fabricated item indicated, include pressure ratings, construction materials, data sheets, performance characteristics.

B. Field quality-control test reports.

1.5 MANUFACTURER'S SUPERVISION / INSPECTION SERVICES

A. Expansion Joints, Offset Type: Provide service of manufacturer's authorized representative to inspect installation and to submit report of his inspection to Architect.

1.6 QUALITY ASSURANCE

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

B. Pipe Welding: Qualify processes and operators according to the following:

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

C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping" for systems operating at 15 psig (104 kPa) or less for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. Conform to Standards of Expansion Joint Manufacturer's Association.

PART 2 - PRODUCTS

2.1 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, Type, Grade, and Schedule as indicated in Part 3 "Piping Applications" articles.

B. Cast-Iron Threaded Fittings: ASTM A 126 gray iron. ASME B16.4 with ANSI B1.20.1 standard taper pipe threads; Classes 125, 150, and 300 as indicated in Part 3 "Piping Applications" articles.

C. Malleable-Iron Threaded Fittings: ASTM A 197 black malleable iron. ASME B16.3 with ANSI B1.20.1 standard taper pipe threads; Classes 150 and 300 as indicated in Part 3 "Piping Applications" articles.

D. Malleable-Iron Threaded Unions: ASME B16.39; Classes 250, and 300 as indicated in Part 3 "Piping Applications" articles. Brass to iron seat, ground joint union with brass seat ring pressed into head piece.

E. Forged Steel Socket Welding Unions: ASME B16.11, Class 3000. Steel to steel seat and ground joint.

F. Welding Fittings for Black Steel Pipe, 2 Inch (DN 50) and Smaller: Forged Steel Socket Welding Fittings. ASTM A 105 and ASME B16.11, wall thickness to match adjoining pipe. All elbows long radius.

G. Welding Fittings for Black Steel Pipe, 2-1/2 inch (DN 65) and Larger: ASTM A 234/A 234M and ASME B16.9, wall thickness to match adjoining pipe. All elbows long radius.

H. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts and nuts in accordance with applicable ASME standards.

I. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, as pipe in which installed, Schedule 80.

2.2 STAINLESS STEEL PIPE AND FITTINGS

A. Stainless Steel Pipe: ASTM A312, stainless steel, plain ends, Type, Class and Schedule as indicated in Part 3 piping applications articles.

B. Stainless Steel Fittings and Flanges: ASTM A403, Type, Class and Schedule as indicated in Part 3 piping application articles.

C. Welding Fittings for Stainless Steel Pipe: Branch connections two or more sizes smaller than main to be standard weight Weldolet, self-reinforced Type 316L stainless steel.

2.3 VALVES, GENERAL

A. Valves are specified by valve type. Where more than one valve type is listed for a service, use any of the listed types, unless otherwise specified or indicated, but selection must be consistent throughout the work.

B. Bronze Valves: NPS 2 (DN 50) and smaller with threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 2-1/2 (DN 65) and larger with flanged ends, unless otherwise indicated.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

F. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.
2. Gear Drive: For quarter-turn valves NPS 8 (DN 200) and larger.
3. Handwheel: For valves other than quarter-turn types.
4. Lever Handle: For quarter-turn valves NPS 6 (DN 150) and smaller.

G. Extended Valve Stems: On insulated valves.

H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

I. Valve Bypass and Drain Connections: MSS SP-45.

2.4 BRONZE ANGLE VALVES

A. Acceptable Manufacturers:

1. Type 2, Bronze Angle Valves:

a. NIBCO, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Milwaukee Valve Co.
d. Powell, Wm. Co.

B. Bronze Angle Valves, General: MSS SP-80, with ferrous-alloy handwheel.

C. Type 2, Class 150, Bronze Angle Valves: Bronze body with PTFE disc and union-ring bonnet. Dezincification-resistant bronze body, (Bronze ASTM B584 Alloy C84400 (Solder) or Bronze ASTM B62 Alloy C83600 (Threaded) or Bronze ASTM B61). Forged or yellow brass bodies will not be accepted. NIBCO T-335-Y

D. Type 2, Class 300, Bronze Angle Valves: Bronze body with regrinding seat and union-ring bonnet. Dezincification-resistant bronze body, (Bronze ASTM B584 Alloy C84400 (Solder) or Bronze ASTM B62 Alloy C83600 (Threaded) or Bronze ASTM B61). Forged or yellow brass bodies will not be accepted. NIBCO T- 375- B/Y; T- 376-AP.

2.5 CAST-IRON ANGLE VALVES

A. Acceptable Manufacturers:

1. Type II, Cast-Iron Angle Valves with Metal Seats:

a. NIBCO Inc.
b. Crane Co.; Crane Valve Group; Crane Valves
c. Milwaukee Valve Co.

B. Cast-Iron Angle Valves, General: MSS SP-85, Type II.

C. Class 125, Cast-Iron Angle Valves: Bronze mounted with gray-iron body and bronze seats. NIBCO F-818-B.

2.6 FERROUS-ALLOY BALL VALVES

A. Acceptable Manufacturers:

1. NIBCO Inc., Series listed, or equivalent product manufactured by:

a. Conbraco Industries, Inc.; Apollo Div.
b. Jamesbury, Inc.
c. Watts Industries, Inc.; Water Products Div.

B. Ferrous-Alloy Ball Valves: Fed Spec WW-V-35C, Type II, Class C, D, Style 1 and 3, 2000 psi (13770 kPa) W.O.G., 250 psi (1725 kPa) saturated steam, 2 inches (DN 50) and smaller. Carbon steel body. Stainless steel trim, latch lock handle, screwed ends, carbon filled, TFE seat, NIBCO T560 CS-R-66-FS-LL.

2.7 BRONZE CHECK VALVES

A. Acceptable Manufacturers:

1. Type 1, Bronze, Lift Check Valves with Metallic Disc:

a. NIBCO, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves. ((Import; No US foundry)
c. Powel Valve Co.

2. Type 3, Bronze, Swing Check Valves with Metallic Disc:

a. NIBCO, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves. (Import; No US foundry)
c. Powel Valve Co.

B. Bronze Check Valves, General: MSS SP-80. Dezincification-resistant bronze body, Bronze ASTM B584 Alloy C84400 (Solder) or Bronze ASTM B62 Alloy C83600 (Threaded) or Bronze ASTM B61, ball and / or trim. Forged or yellow brass bodies will not be accepted.

C. Type 1, Class 125, Bronze, Horizontal or Vertical Lift Check Valves: Bronze body with metallic disc and bronze seat. NIBCO T/S 480-Y.

D. Type 1, Class 300, Bronze, Horizontal or Vertical Lift Check Valves: Bronze body with metallic disc and bronze seat. Alternate: NIBCO T/S 473-B (can use Swing Check in Horizontal or Vertical position).

E. Type 3, Class 125, Bronze, Swing Check Valves: Bronze body with metallic disc and bronze seat. NIBCO T/S 413-B

F. Type 3, Class 300, Bronze, Swing Check Valves: Bronze body with metallic disc and bronze seat. NIBCO T/S 473-B

2.8 GRAY-IRON SWING CHECK VALVES

A. Acceptable Manufacturers:

1. Type I, Gray-Iron Swing Check Valves with Metallic Disc and Seats:

a. NIBCO, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.

c. Powell Valve Co.

B. Gray-Iron Swing Check Valves, General: MSS SP-71.

C. Type I, Class 125, gray-iron, swing check valves with metallic disc and seats. NIBCO F918-B.

D. Type I, Class 250 gray-iron, swing check valves with metallic disc and seats. NIBCO F968-B.

2.9 SPRING-LOADED, LIFT-DISC CHECK VALVES

A. Acceptable Manufacturers:

1. Type III, Globe Lift-Disc Check Valves:

a. NIBCO, Inc.
b. Metraflex Co.
c. Powell Valve Co.

2. Type IV, Threaded Lift-Disc Check Valves:

a. NIBCO, Inc.
b. Metraflex Co.
c. Mueller Steam Specialty.

B. Lift-Disc Check Valves, General: FCI 74-1, with spring-loaded bronze or alloy disc and bronze or alloy seat.

C. Type III, Class 125, Globe Lift-Disc Check Valves: Globe style with cast-iron shell and flanged ends. NIBCO F-910-W.

D. Type III, Class 250, Globe Lift-Disc Check Valves: Globe style with cast-iron shell and flanged ends. NIBCO F-960-W

E. Type IV, Class 125, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and threaded ends. NIBCO T-480

F. Type IV, Class 150, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and threaded ends. NICO T-480.

2.10 CAST-IRON GATE VALVES

A. Acceptable Manufacturers:

1. Type I, Cast-Iron, Rising-Stem Gate Valves:

a. NIBCO, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves
c. Powell, Wm. Co.

B. Cast-Iron Gate Valves, General: MSS SP-70, Type I.

C. Class 125, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, rising stem, and solid-wedge disc. NIBCO F-617-O

D. Class 250, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, rising stem, and solid-wedge disc. NIBCO F-667-O.

2.11 BRONZE GLOBE VALVES

A. Acceptable Manufacturers:

1. Type 2, Bronze Globe Valves with Nonmetallic Disc:

   a. NIBCO, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Powell, Wm. Co.

2. Type 3, Bronze Globe Valves with Renewable Seats:

   a. NIBCO, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Powell, Wm. Co.

B. Bronze Globe Valves, General: MSS SP-80, with ferrous-alloy hand wheel.

C. Type 2, Class 125, Bronze Globe Valves: Bronze body with PTFE disc and union-ring bonnet. NIBCO T/S-211-Y.

D. Type 3, Class 300, Bronze Globe Valves: Bronze body with renewable stainless steel seats and union-ring bonnet. NIBCO T-276-AP.

2.12 CAST-IRON GLOBE VALVES

A. Acceptable Manufacturers:

1. Type I, Cast-Iron Globe Valves with Renewable Metal Seats:

   a. NIBCO Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Powell Valve Co.

B. Cast-Iron Globe Valves, General: MSS SP-85.

C. Type I, Class 125, Cast-Iron Globe Valves: Gray-iron body with renewable bronze seats. NIBCO F-718-B; F-818-B (Angle).

D. Type I, Class 250, Cast-Iron Globe Valves: Gray-iron body with renewable bronze seats. NIBCO F-768-B; F-869-B (Angle Stop/Check/Globe).

2.13 STOP CHECK VALVES

A. Acceptable Manufacturers:

1. NIBCO, Inc.
2. Crane Co.
3. Lunkenheimer Valves.
4. A.Y. McDonald Mfg. Co.

B. Body and Bonnet: Malleable iron.

C. End Connections: Flanged.

D. Disc: Cylindrical with removable liner and machined seat.

E. Stem: Brass alloy.

F. Operator: Outside screw and yoke with cast-iron handwheel.

G. Packing: Polytetrafluoroethylene-impregnated packing with two-piece packing gland assembly.

H. Pressure Class: 250.

I. NIBCO F869-B.

2.14 STRAINERS

A. Y-Pattern Strainers:

1. Acceptable Manufacturers:

a. NIBCO, Inc.
b. Armstrong Machine Works
c. Hoffman Specialty, ITT
d. Illinois
e. Metraflex
f. Mueller Steam Specialty
g. Spirax-Sarco

2. Body: 2" and smaller: ASTM B584 or B62 bronze with threaded or solder; 2-1/2" and larger: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
3. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area. Net free area not less than 3 times the area of the inlet pipe.
4. Gaskets shall not contain asbestos.
5. Tapped blowoff plug.
6. CWP Rating: 250-psig (1725-kPa) working steam pressure.
7. NPS 2" and smaller: NIBCO: S / T – 221, S / T – 222

2.15 SAFETY VALVES

A. ASME labeled, rated and stamped, side outlet type relief valve with test lever.

B. Bronze or Brass Safety Valves:

1. Acceptable Manufacturers:

a. Armstrong International, Inc.
b. Farris
c. Kunkle Valve; a Tyco International Ltd. Company.
d. Spirax Sarco, Inc.
e. Watts Water Technologies, Inc.

2. Disc Material: Forged copper alloy.
3. End Connections: Threaded inlet and outlet.
4. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

C. Float and Thermostatic Traps:

1. Body and Bolted Cap: ASTM A 126, cast iron.
2. End Connections: Threaded.
3. Float Mechanism: Replaceable, stainless steel.
4. Head and Seat: Hardened stainless steel.
5. Trap Type: Balanced pressure.
6. Thermostatic Bellows: Stainless steel or monel.
7. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
8. Maximum Operating Pressure: 125 psig (860 kPa).

D. Thermodynamic Traps :

1. Body: Stainless steel with screw-in cap.
2. End Connections: Threaded.
3. Disc and Seat: Stainless steel.
4. Maximum Operating Pressure: 600 psig (4140 kPa).

E. Inverted Bucket Traps:

1. Body and Cap: Cast iron.
2. End Connections: Threaded.
3. Head and Seat: Stainless steel.
4. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
5. Bucket: Brass or stainless steel.
6. Air Vent: Stainless-steel thermostatic vent.
7. Pressure Rating: 250 psig (1725 kPa).

F. Thermostatic Traps:

1. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
2. Trap Type: Balanced-pressure.
3. Bellows: Stainless steel or monel.
4. Head and Seat: Replaceable, hardened stainless steel.
5. Pressure Class: 125.

2.16 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

1. Acceptable Manufacturers:

   a. Armstrong International, Inc.
   b. Barnes & Jones, Inc.
   c. Dunham-Bush, Inc.
   d. Hoffman Specialty; Division of ITT Industries.
   e. Spirax Sarco, Inc.
   f. Sterling.
2. Body: Cast iron, bronze or stainless steel.
3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: 125 psig (861 kPa)
7. Maximum Temperature Rating: 350 deg F

B. Vacuum Breakers:

1. Acceptable Manufacturers:

   a. Armstrong International, Inc.
   b. Dunham-Bush, Inc.
   c. Hoffman Specialty; Division of ITT Industries.
   d. Johnson Corporation (The).
   e. Spirax Sarco, Inc.
2. Body: Stainless steel.
3. End Connections: Threaded.
4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
5. O-ring Seal: EPR.
6. Pressure Rating: 125 psig (861 kPa)
7. Maximum Temperature Rating: 350 deg F

2.17 THERMOSTATIC DRAIN VALVE

A. Acceptable Manufacturers:

1. Armstrong International, Inc.
2. Spirax-Sarco Co.

B. Automatic drain valve, controlled by integral thermostatic element designed to open at approximately 75°F.

2.18 EXPANSION JOINTS

A. Flexible Ball Joints:

1. Acceptable Manufacturers:

a. Advanced Thermal Systems, Inc.
b. Hyspan Precision Products, Inc.

2. Carbon-steel assembly with asbestos-free composition packing, designed for 360-degree rotation and angular deflection, and 250 psig at 400 deg F (1725 kPa at 204 deg C) minimum pressure rating; complying with ASME Boiler and Pressure Vessel Code: Section II, "Materials", with ASME B31.9, "Building Services Piping", for materials and design of pressure-containing parts and bolting.

a. Angular Deflection for NPS 6 (DN 150) and Smaller: 30-degree minimum.
b. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

2.19 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

1. Acceptable Manufacturers:

a. Advanced Thermal Systems, Inc.
b. Hyspan Precision Products, Inc.

PART 3 - EXECUTION

3.1 LP STEAM AND CONDENSATE PIPING APPLICATIONS (0 THROUGH 80 PSIG (0 to 552 kPa))

A. LP Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Condensate piping above grade, NPS 2 (DN 50) and smaller: Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints

3.2 ANCILLARY PIPING APPLICATIONS

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Air-Vent Piping:

1. Inlet: Same as service where installed.
2. Outlet: Type K (A) annealed-temper copper tubing with soldered or flared joints.

C. Vacuum-Breaker Piping: Outlet, same as service where installed.

D. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.3 PIPING INSTALLATION

A. Refer to Section 23 05 00, "Common Materials and Methods for HVAC", for general piping installation requirements.

B. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

C. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow. Where condensate lines form a trap, provide vent loop over trapped section.

D. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

E. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe or at an angle of 45° above the centerline. Pitch branch connections from mains to risers, radiation or equipment up from mains, not less than 1 inch in 4 feet. Pitch branch connections from risers to radiation or equipment up from risers not less than 1 inch in 10 feet.

F. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 200 feet where pipe is pitched down in direction of steam flow and 150 feet maximum elsewhere.
2. Size drip legs same size as main. In steam mains NPS 6 (DN 150) and larger, drip leg size can be reduced, but to no less than NPS 4 (DN 100).

3.4 VALVE APPLICATIONS

A. Unless noted otherwise, use the following:

1. Shutoff Service: Ball or gate valves.
2. Throttling Service: Angle, ball (for liquid condensate service only, not to be used for throttling service on steam), or globe valves.
3. Condensate Pump Discharge: Spring-loaded, lift-disc check valves.

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

C. Select valves with the following end connections:

1. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

D. Low-Pressure Steam Piping: Use the following types of valves:

1. Angle Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 125, bronze.
2. Ball Valves, NPS 2 (DN 50) and Smaller: One piece, 2000 psi (13770 kPa) W.O.G., 250 psi (1725 kPa), saturated steam, ferrous alloy.
3. Swing Check Valves, NPS 2 (DN 50) and Smaller: Type 3, Class 125, bronze.
4. Gate Valves, NPS 2 (DN 50) and Smaller: Class 125, rising stem, bronze body, bonnet and solid wedge.
5. Globe Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 125, bronze.

E. Steam Condensate Piping: Use the following types of valves, pressure class suitable for system operating pressure:

1. Ball Valves, NPS 2 (DN 50) and Smaller: One-piece, 2000 psi (13770 kPa) W.O.G., 250 psi (1725 kPa) saturated steam, ferrous alloy.
2. Swing Check Valves, NPS 2 (DN 50) and Smaller: Type 3, Class 125, bronze, and Type 3, Class 300, bronze.
3. Spring-Loaded, Lift-Disc Check Valves, NPS 2 (DN 50) and Smaller: Type IV, Class 125 minimum 150.
4. Globe Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 125, bronze, and Type 3, Class 300, bronze

F. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

G. Thermostatic Drain Valves: Provide in condensate return to all steam coils subject to freezing air temperature.

H. Provide stainless steel valves in stainless steel piping, body and trim to match piping system.

3.5 VALVE INSTALLATION

A. Examination of Piping

1. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
2. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
3. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
4. Examine threads on valve and mating pipe for form and cleanliness.

5. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
6. Do not attempt to repair defective valves; replace with new valves.

B. Piping installation requirements are specified in this section. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Provide valves at locations shown, where specified and where required to properly control piping systems. Provide valves recommended or required by equipment manufacturers and codes for proper operation of equipment and shutoff valves to allow isolation of each main and branch service line, whether or not indicated or specified.

D. Provide valve ends to suit character of pipe in which installed. Provide valves designed for working pressure of at least 125% of maximum operating pressure of system in which installed, but not less than 250 psig (1725 kPa) on high pressure systems, and 125 psig (861 kPa) on low pressure systems.

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

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

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

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

I. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves (for condensate only): In horizontal position with hinge pin level.

J. Provide chromium plated valves in chromium plated piping. Provide steam valves in chromium plated piping with composition hand wheels which shall remain reasonably cool in service.

3.6 STRAINERS

A. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Strainers in steam piping to be installed on their side to reduce collecting condensate in strainer. Install NPS 3/4 (DN 20) nipple and shut-off valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

3.7 SAFETY VALVE INSTALLATION

A. Provide as required or shown on discharge of each steam regulating valve, on pressure equipment and in the steam piping systems. Install valve(s) furnished by boiler manufacturer if not factory installed. Aggregate relieving capacity as required by ASME Code. Pipe and extend discharge as indicated. Install in accordance with ASME B31.1 Code requirements.

B. Terminate vent lines from high and medium pressure relief valves outdoors. Provide drip pan elbow at valve discharge. From discharge drain and elbow, provide common 3/4 inch (DN 20) drain line with drain connection extended to discharge over nearest floor drain. Provide exhaust head at top of termination.

C. When several relief valve vents connect to one vent header, size header cross sectional area to equal the sum of individual vent outlet areas.

3.8 STEAM SYSTEM SPECIALTIES, STRAINERS AND ACCESSORIES

A. Steam Air Vents: Provide at the end of all steam mains and branch mains with 12 inch length of pipe below vent.

B. Steam Stop-Check Valve: Provide at or near steam nozzle of high pressure steam boiler.

C. Steam Strainer: Where strainer is not provided with a steam trap for drainage, turn strainer on its side to reduce collecting condensate in strainer.

3.9 EXPANSION JOINTS

A. Install in a neutral, pre-compressed or pre-extended condition as required for application.

B. Provide hangers and guides per manufacturer's recommendations.

C. Use only in accessible location, i.e., exposed or above lay-in ceilings, etc.

3.10 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections. Provide full size service to equipment with reducers at equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

D. Install a drip leg at coil outlet.

3.11 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping" and ASME B31.9, "Building Services Piping," and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Perform the following tests on steam and condensate piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Test hydrostatically. Maintain pressure for 4 hours with no drop in pressure. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. At the beginning of the pressure test, and periodically during the test, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
4. Unless otherwise required by Code, new branch piping connected to existing systems may be tested at normal operating pressure, providing new piping does not exceed 75 feet, or does not include more than 20 fittings.

C. Prepare written report of testing.

END OF SECTION 23 22 13

SECTION 23 30 00 – DUCTWORK AND DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Sheet metal ductwork and fittings
2. Sheet metal casings and plenums
3. Duct Accessories; including dampers, flexible connectors, flexible duct, access doors
4. Air volume control boxes
5. Diffusers, registers and grilles

B. Related Sections include the following:

1. Duct mounted smoke detectors are specified in Division 28
2. Airflow measuring stations are specified in Division 25
3. Motorized control dampers are specified in Division 25
4. Duct mounted filters are specified in Section 23 41 00, "Air Filtration"

1.3 DEFINITIONS

A. Duct Sizes: Inside clear dimensions. For acoustically lined ducts and casings, maintain sizes inside lining. For rectangular ductwork in plan, first dimension indicates width and second dimension indicates height.

B. Pressure Class: The numerical duct construction pressure classification that identifies permissible SMACNA Duct Construction Standards.

C. Seal Class: Identifies the extent of sealing of duct joints, seams and penetrations per SMACNA Duct Construction Standards.

D. Leakage Class: Identifies permissible leakage as described in SMACNA HVAC Air Duct Leakage Test Manual.

E. Low Pressure Ductwork: 3 inch wg (750 Pa) and less.

F. Medium Pressure Ductwork: 4 inch wg (1000 Pa) and 6 inch wg (1500 Pa).

1.4 REFERENCES

A. SMACNA: HVAC Duct Construction Standards – Metal and Flexible

B. SMACNA: HVAC Air Duct Leakage Manual

C. ARI 880: Air Volume Terminals

D. UL: Applicable Standards

1.5 SUBMITTALS

A. Product Data:

1. Provide booklet of Shop Standards, including the following:

a. Duct construction classification and fabrication, assembly, and installation details including SMACNA Tables and Figure numbers clearly marked to identify which are to be used.
b. Details of shop fabricated items, fittings, reinforcing details and spacing, seam and joint construction.
c. Installation details of duct mounted equipment and accessories, including dampers, coils, access doors, hangers and supports.
d. Product data for factory fabricated equipment, dampers, access doors, flexible duct, etc.

2. For each type of product indicated, include performance characteristics, rated capacities, data sheets, and furnished accessories.

B. Product Schedule or Lists: Include Diffuser, Register and Grille Schedule, indicating Drawing designation, room location, quantity, model number, size and accessories furnished.

C. Shop Drawings: Prepare CAD-generated shop fabrication drawings to a scale of not less than 3/8 inch per foot. Show complete ductwork and casing layout, including:

1. Duct layout indicating sizes and pressure classes.
2. Elevations of top and bottom of ducts.
3. Dimensions of main duct runs from building grid lines.
4. Fittings.
5. Clearly show all duct accessories, including access doors, dampers, diffusers and grilles.
6. Acoustical lining and thickness as applicable.
7. Prepare duct layout based on routing indicated on the drawings, and make reasonable modifications to layout without increasing duct system pressure drop in order to coordinate with other trades. Refer to "Layout and Coordination with other Trades" specified in Section 23 05 00. Do not submit duct shop drawings until multi-discipline coordination drawings specific in Division 1 are completed.
8. Clearly identify by circle and by note "Deviation" and/or "Interference" in large lettering any and all deviations from Drawings and any and all unresolved interference conditions and assume full responsibility for failure to do so.

9. Modify shop fabrication drawings in accordance with Architect's review comments, if any, and to show any subsequent shop or field changes. At completion of work, submit final shop fabrication drawings labeled "As-Built" to the Owner for record purposes.

D. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 3, "Duct System," for range hood ducts, unless otherwise indicated.

1.7 COORDINATION

A. Coordinate location of duct access doors to allow proper access to dampers, coils, fans, etc. Coordinate with General Contractor proper location of wall and ceiling access panels to permit access to duct access doors.

B. Coordinate location of duct mounted equipment (coils, humidifiers, smoke detectors) furnished in other Sections for installation under this Section. Provide duct transitions as required.

PART 2 - PRODUCTS

2.1 SHEET METAL 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: Lock-forming quality; zinc coating each side, complying with ASTM A 653/A 653M and having G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. PVC-Coated Galvanized Steel: Acceptable by authorities having jurisdiction for use in fabricating ducts with UL 181, Class 1 listing. Lock-forming-quality, galvanized sheet steel complying with ASTM A 653/A 653M and having G60 (Z180) coating designation. Factory-applied PVC coatings shall be 4 mils (0.10 mm) thick on sheet metal surfaces of ducts and fittings exposed to corrosive conditions and 2 mils (0.05 mm) thick on opposite surfaces.

D. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

E. Stainless Steel: ASTM A 480/A 480M, Type 304, and having a No. 2D finish for concealed ducts and No. 4 satin finish for exposed ducts. Use low carbon content material where welded joints are specified.

F. Aluminum Sheets: ASTM B 209 (ASTM B 209M), alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

G. Reinforcements: Structural shapes (channels, angles, and plates) shall be of galvanized steel where installed on galvanized ducts, and Type 304 stainless steel where installed on stainless steel ducts.

2.2 SEALANT MATERIALS

A. Acceptable Manufacturers:

1. United McGill Corp.
2. H.B. Fuller Co., Foster Products Division
3. Precision Adhesives
4. Carlisle Hardcast
5. General Electric Co.

B. General:

1. The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
2. Sealants for air distribution systems shall be of liquid and/or mastic type in accordance with SMACNA.

C. All sealants shall be UL Classified and meet NFPA 90A, Class 1 requirements when applied in a manner consistent with its intended use. Ratings shall not exceed a Flame Spread of 25 or a Smoke Developed of 50. All containers and shipping cartons shall bear the UL label indicating flame and smoke ratings and shall include Fire Hazard Classification. Labeling shall also include Hazard Statement required by the Consumers Product Safety Act, CFR Title 16, Chapter II, subchapter C, Federal Hazardous Substances Act Regulations, Part 1500, Section 1-272.

D. Sealants for air distribution systems shall be compatible with the materials, application and operating temperatures of the system. Sealants used for systems handling fumes and chemicals shall be confirmed suitable for the specific application. Sealants used for systems serving clean rooms shall be FDA approved silicone sealant. Sealants exposed to the weather, shall be ultraviolet light and ozone resistant and provide watertight seal.

E. Sealants shall be applied in accordance with manufacturer's instructions. Provide adequate ventilation and follow safety procedures as required. Adequate drying/curing time shall be allowed before operating or testing the systems.

F. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

G. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

H. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.

I. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

J. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.3 DUCT PRESSURE CLASSIFICATION AND CONSTRUCTION

A. Construct ducts for pressure class indicated (positive or negative), and seal all seams and joints to achieve Seal Class A, Leakage Class 6 for rectangular duct and Class 3 for round duct, according to the following:

1. Supply Ducts between AHU and Fire or Smoke Damper: 10-inch wg (2500 Pa) positive.
2. Supply Ducts between AHU and Reheat Coil: 4-inch wg (1000 Pa) positive.
3. Supply Ducts between Reheat Coil and Diffuser: 2-inch wg (250 Pa) positive.
4. Supply Ducts between Reheat Coil and Terminal Filter Diffuser: 3-inch wg (750 Pa) positive.
5. Supply Duct Systems without Reheat Coils: 2-inch wg (500 Pa) positive.
6. Outside Air Ducts: 2-inch wg (500 Pa) negative.
7. Return Duct between Return Fan and AHU: 4-inch wg (1000 Pa) positive.
8. Return Ducts between Return Fan and Reheat Coil: 3-inch wg (750 Pa) negative.
9. Return Ducts between Register or Grille and Reheat Coil: 2-inch wg (500 Pa) negative.
10. Return Duct System without Reheat Coils up to inlet of Return Fan: 2-inch wg (500 Pa) negative.

B. Material: All ducts shall be galvanized steel, except where specifically noted otherwise on drawings and as follows:

1. Ductwork at Humidifiers: Type 304 stainless steel 1 foot up stream and 4 foot down stream of humidifier. Welded seams and joints.

2.4 GENERAL DUCT FABRICATION

A. Detail and fabricate with the fewest possible joints in accordance with SMACNA standards and details, except where more stringent requirements are specified in this section, to keep resistance losses to a minimum.

B. Size round ducts installed in place of rectangular ducts, and vice versa, from ASHRAE table of equivalent rectangular and round ducts. Aspect ratio of rectangular ducts can be modified for coordination of layout, but in no case exceed 4 to 1, and without reducing free area of duct or increasing pressure drop.

C. Complete metal ducts within themselves with no single partition between ducts. Open corners are not acceptable.

D. Lap metal ducts in direction of air flow. Hammer down edges and slips to leave smooth duct interior.

E. Sleeves:

1. Construct sleeves of galvanized steel minimum 22 gauge unless noted otherwise.
2. Provide sleeves for fire dampers and combination fire/smoke dampers as specified in this Section "Fire and Smoke Dampers".

    a. Breakaway connections are not permitted except for pressure class 2-inch wg (500 Pa) and less.

F. Square heel and throat elbows, with vanes, are used on Drawings for drafting convenience only. Where space allows, construct tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible on rectangular ductwork, provide smooth radius elbows with full length splitter vanes designed and constructed in accordance with SMACNA Duct Design and Duct Construction Standard to produce a loss coefficient of 0.15 or less, except as follows:

1. Where R/W is such that a vaned radius elbow will not produce the specified loss coefficient and on exposed ductwork in finished areas, provide mitered elbows with square heel and throat and with double thickness turning vanes set into vane runners designed and constructed to produce a loss coefficient of 0.26 or less in accordance with above standards.
2. Increase/decrease duct sizes gradually, not exceeding 15° divergence/ convergence wherever possible. Maximum divergence upstream of equipment to be 30° and 45° convergence downstream.

G. Unless otherwise indicated or specified, fabricate branch connections as follows:

1. Rectangular duct branch connection to rectangular ductwork, 45° SMACNA entry/exit butt flange boot with corner filler pieces or proportional splits at Contractor's option. Where size of main duct is not large enough for a boot connection, fabricate ducts with proportional splits.
2. Round duct branch connection to low pressure round ductwork, conical tee or straight tee.
3. Round duct connection to rectangular duct on low pressure ductwork, bellmouth connection equal to Buckley BM or BMD or, for sizes 10 inches and smaller, straight connection equal to Buckley ATM or ATMD.
4. Where round duct is connected to rectangular duct and rectangular duct width shown is not equal to or larger than overall diameter of connecting end of round connector BENDING OF FLANGES OF ROUND CONNECTOR FOR CONNECTION TO RECTANGULAR DUCT IS NOT ALLOWED. Either increase rectangular duct width as required or provide a rectangular 45° SMACNA boot connection to the rectangular duct and a rectangular to round conversion for the round duct connection. For round connection to low pressure ductwork. Contractor may, at his option use a mini bellmouth connection equal to Buckley M-BM or M-BMD or a flat oval bellmouth equal to Buckley FOBM or FOBMD and an oval to round conversion for the round duct connection.
5. Spin-in, cinch lock or dovetail fittings not allowed except at duct connection to a transfer duct.

6. Connect branch to top, bottom or side of duct as indicated or as required, whether or not indicated, to suit surrounding conditions and avoid interferences.
7. Coordinate branch take-off locations with transverse joint spacing. Transverse joints interfering with branch take-offs will not be accepted. Modify joint spacing as required without exceeding maximum spacing.

H. Rigidly construct ducts with joints mechanically tight, substantially airtight without use of tape, braced and stiffened so as not to breathe, rattle, vibrate, or sag. Caulk duct joints and connections with sealant as ducts are being assembled. Where joints are not accessible for sealing, provide access doors and seal from inside.

I. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10% duct area, split into two ducts maintaining original duct area. No easements or penetrations allowed for medium or high pressure ductwork.

2.5 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Construct ducts of minimum 24 gauge.
2. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
3. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Flat Drive Joints: Flat drive joint constructed of not less than 24 gauge and specified static pressure in accordance with the limits of SMACNA will be accepted as Class A reinforcement for low pressure (2 inches w.g. (500 Pa) and less) ductwork located in shafts or furred spaces that do not have adequate clearance for factory fabricated or formed flanged joints.

C. Transverse Joints: Prefabricated slide-on joints, fastened to duct section with spot welds (do not use screws), and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement. Ductmate Industries, Inc., Nexus Inc., Ward Industries, Inc.

D. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details. Ductmate Industries, Inc., or Lockformer.

1. Use joint reinforcing for T-24 or T-25 joints and sheet metal gauges as recommended by SMACNA Standards as a minimum. Do not use lighter gauges shown in joint manufacturer's literature.

E. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant. Button punch snaplocks and pocket locks are not permitted for ducts constructed of 2 inch wg (500 Pa) or less.

F. Cross Breaking or Cross Beading: For duct pressure class 3 inch (750 Pa) or less, cross break or cross bead duct sides 18 inches and larger and 20 gauge thick or less, with more than 10 sq. ft. (0.93 sq. m) of nonbraced panel area unless ducts are lined.

2.6 ROUND DUCT AND FITTING FABRICATION

A. Acceptable Manufacturer: Factory fabricated or shop fabricated but equal in all respects to factory fabricated items specified herein:

1. McGill AirFlow Corporation.
2. SEMCO Incorporated.

B. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.

C. Round Duct and Fittings: Lock type spiral seam construction of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Stamped elbows and fittings. Gored (segmented) elbows and fitting only for sizes where stamped elbows and fittings not available. Adjustable elbows are not permitted.

D. Duct Joints:

1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances. Ductmate Industries, Inc., Lindab, Inc., or equal.
5. Flat-Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket. Ductmate Industries, Inc., McGill Airflow Corporation, SEMCO Incorporated, or equal.

E. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

G. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

H. Plastic coated where specified.

2.7 DOUBLE-WALL DUCT AND FITTING FABRICATION

A. Acceptable Manufacturers:

1. Lindab, Inc.
2. McGill AirFlow Corporation
3. SEMCO Incorporated

B. Ducts: Fabricate double-wall (insulated) ducts with an outer shell and an inner duct. Dimensions indicated are for inner ducts.

1. Outer Shell: Base metal thickness on outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner duct and insulation and in metal thickness specified for single-wall duct.
2. Insulation: 1-inch- thick fibrous glass, unless otherwise indicated. Terminate insulation where double-wall duct connects to single-wall duct or uninsulated components, and reduce outer shell diameter to inner duct diameter.

    a. Thermal Conductivity (k-Value): 0.26 at 75 deg F (0.037 at 24 deg C) mean temperature.

3. Solid Inner Ducts: Use the following sheet metal thicknesses and seam construction:

    a. Ducts 3 to 8 Inches in Diameter: 0.019 inch with standard spiral-seam construction.
    b. Ducts 9 to 42 Inches in Diameter: 0.019 inch with single-rib spiral-seam construction.
    c. Ducts 44 to 60 Inches in Diameter: 0.022 inch with single-rib spiral-seam construction.

4. Perforated Inner Ducts: Fabricate with 0.028-inch- thick sheet metal having 3/32-inch-diameter perforations, with overall open area of 23 percent.
5. Maintain concentricity of inner duct to outer shell by mechanical means. Prevent dislocation of insulation by mechanical means.

C. Fittings: Fabricate double-wall (insulated) fittings with an outer shell and an inner duct.

1. Solid Inner Ducts: Use the following sheet metal thicknesses:

    a. Ducts 3 to 34 Inches in Diameter: 0.028 inch.
    b. Ducts 35 to 58 Inches in Diameter: 0.034 inch.

2. Perforated Inner Ducts: Fabricate with 0.028-inch- thick sheet metal having 3/32-inch-diameter perforations, with overall open area of 23 percent.

2.8 FLEXIBLE DUCTWORK

A. Acceptable Manufacturers: Type numbers indicated are those of Thermaflex.

1. Thermaflex
2. Flexmaster, Inc.

B. UL listed under UL-181 as Class 1 Air Duct Connector and conforming to NFPA 90A and 90B.

C. Minimum Rating: 10 inch WG positive all uses, 2 inch WG negative for return or exhaust use, velocity of 4000 feet per minute.

D. For Heating Only Application: Type "SLP-10". Continuous galvanized spring wire helix having a cover of woven fiberglass, vinyl impregnated and coated or continuous corrugated aluminum for low pressure supply use only.

E. For Heating-Cooling or Cooling Only Application: Type "M-KC". Continuous galvanized spring wire helix having a cover of woven fiberglass fabric, vinyl impregnated and coated, or continuous corrugated aluminum for low pressure supply use only, and insulated with 1 inch thick fibrous glass insulation having outer moisture barrier consisting of reinforced metalized Mylar/ neoprene laminate with integral attaching devices. "U" factor at 75° F differential maximum 0.22 btu/sq.ft./° F/hour.

F. Attachment: Duct clamp stainless steel band with cadmium-plated hex screw to tighten band with a worm-gear action in size to suit duct size.

2.9 HANGERS AND SUPPORTS

A. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters. Perforated strap hangers are not allowed.
3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

B. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials. Hanger fasteners shall not pierce medium/high pressure (greater than 3 inches w.g.) ductwork under any circumstance.

C. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.10 FLEXIBLE CONNECTORS

A. Acceptable Manufacturers

1. Ductmate Industries, Inc.
2. Duro Dyne Corp.
3. Ventfabrics, Inc.
4. Ward Industries, Inc.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or stainless steel, or 0.032-inch- thick aluminum sheets. Select metal compatible with connected duct system. Comply with SMACNA requirements.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

E. 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. (810 g/sq. m).
2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

F. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

2.11 SHOP AND FIELD FABRICATED CASINGS

A. Fabricate casings according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible", except where more stringent requirements are specified herein.

B. Shop fabricate casings, to greatest extent possible, with a minimum number of joints and to minimize field fabrication and assembly.

C. Fabricate casings with standing seams and angle reinforcements. Reinforce casings with galvanized- or painted-steel angles. Seal joints with liquid-type, high-pressure duct sealant to eliminate air leakage.

D. Fabricate casings with reinforced and braced openings for hinged access doors at least 24 inches wide by 48 inches high and located for access to each item of equipment housed, or where shown on drawings for cleaning and inspection. Provide double wall access door when installed in insulated plenums.

E. Provide minimum 3 inch high reinforced concrete curb for floor mounted walls. At floor, rivet panels on 8 inch centers to steel angles.

2.12 FACTORY FABRICATED CASINGS

A. Acceptable Manufacturers:

1. Industrial Acoustics Company
2. Vibro-Acoustics, Co.
3. McGill Airflow Corporation

B. Double-wall, insulated, pressurized equipment casing.

C. Panel Fabrication: Solid, galvanized sheet steel exterior shell and solid, galvanized sheet steel interior shell; with 2- or 4-inch space between shells, as indicated.

1. Fabricate with a minimum number of joints.
2. Weld exterior and interior shells to perimeter; to interior, longitudinal, galvanized-steel channels; and to box-end internal closures. Paint welds.
3. Exterior Shell Thickness: 0.040 inch minimum.
4. Interior Shell Thickness: 0.034 inch minimum.
5. Interior Shell Thickness: 0.034 inch minimum, with 3/32-inch perforations at 3/16-inch staggered spacing for 23 percent open area.
6. Fabricate perimeter and interior, longitudinal channel members with galvanized-steel shapes.
7. Fill each panel assembly with insulating material that is noncombustible, inert, mildew resistant, and vermin proof, and that complies with NFPA 90A.
8. Fabricate panels with tongue-and-groove, continuous self-locking joints effective inside and outside each panel.

D. Trim Items: Fabricate from a minimum of 0.052-inch galvanized sheet steel, furnished in standard lengths for field cutting.

E. Access Doors: Fabricate personnel access doors at least 24 by 60 inches and other access doors in sizes indicated.

1. Fabricate doors of same thickness as panels, with a minimum 0.040-inch solid, interior and exterior, galvanized sheet steel shell.
2. Install a minimum of two ball-bearing hinges and two wedge-lever-type latches, operable from inside and outside. Install doors to open against air pressure differential. Install neoprene gaskets around entire perimeters of door frames.
3. Fabricate windows in doors consisting of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.

F. Structural Performance: Fabricate plenum to be self-supporting and capable of withstanding internal static pressures as scheduled, without any panel joint exceeding deflection of L/200 where "L" is the unsupported span length within completed casings.

G. Acoustic Performance: Certified by an independent acoustical testing agency listing sound-absorption and transmission-loss characteristics of panel assemblies.

H. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.

2.13 VOLUME DAMPERS

A. General: Factory fabricated, or shop fabricated but equal in all aspects to factory fabricated items, with required hardware and accessories in accordance with SMACNA duct standards except as noted herein.

B. Damper and damper frames shall be constructed of same material as duct in which they are installed. Fabricate single blade damper of minimum 20 gauge. Fabricate multi-blade damper of minimum 16 gauge.

C. Damper blades in rectangular ductwork shall be maximum 8 inches wide. Dampers having two or more blades shall be opposed action type with connecting bar and linkage. Multiple blade dampers shall be mounted in frames. Splitter dampers not allowed.

D. Provide for multiple section damper (larger sizes), appropriately sized jackshaft with bearing assemblies mounted on supports at each mullion and at each end of the multiple damper section. Provide appropriate length and number of mountings to connect linkage of each damper to the jackshaft.

E. Stiffen blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Device shall include indication of damper position. Provide end bearings and gaskets for damper components to seal duct consistent with pressure class.

F. Damper Hardware: Dampers shall be provided with all hardware including zinc plated, die-cast core with dial and handle made of 3/32 inch thick zinc plated steel, and a 3/4 inch hexagon locking nut. Include center hole to suit damper operating rod size. Include raised quadrant for mounting on insulated duct. Improvised shop or field fabricated hardware will not be accepted.

2.14 REMOTE CEILING DAMPER REGULATOR

A. Acceptable Manufacturers:

1. Young Regulator Model # TP-301 & TP-W

B. System specifically designed for remote manual adjustment of duct mounted volume damper.

C. Damper controller and cable shall be concealed above the ceiling and wall. Cable to consist of Bowden cable 0.054 inch stainless steel control wire encapsulated in 1/16 inch flexible galvanized spiral wire sheath. Maximum 50 feet length of cable distance between damper and control kit.

D. Damper:

1. Round damper constructed of heavy duty galvanized steel spiral shell design with rolled in stiffening beads for rigidity. Spiral shell shall have one crimped end and one straight end for ease of installation. Damper to include "V" style 20 gauge galvanized steel blade secured with 1/2 inch diameter steel shaft and Teflon bushings. Young Regulator Model 5020-CC.
2. Rectangular damper to be opposed blade type constructed of heavy duty extruded aluminum frame and blades. Damper blades to include individual blade bushings for smooth and quiet operation. Damper blades shall rotate between a matched pair of

formed and punched stainless steel connecting slide rails that facilitate blade movement and alignment. Young Regulator Model 830A-CC.

3. Damper shall include all necessary hardware to ensure compatibility with Bowden remote cable control system.

E. Control Shaft: Shall be D-styled flatted 1/4 inch diameter with 265 degree rotation providing graduations for positive locking and control, and 1-1/2 inch linear travel capability.

F. Control Kit: Shall consist of 2-5/8 inch diameter die cast aluminum housing with 3 inch diameter zinc plated cover plate, and 14 gauge steel rack and pinion gear drive converting rotary motion to push-pull motion. Control kit is designed to be concealed in the ceiling flush with the finished surface. Include wrench for damper adjustment. Young Regulator Model 270-301 or equal.

G. Control Kit: Shall be designed for use with internally or externally controlled round or rectangular dampers and shall consist of 14 gauge steel rack and pinion gear drive converting rotary motion to push-pull motion. Control kit mounting bracket can be field mounted on ceiling framework, behind grilles, on or inside plenum slot diffusers, or on diffuser back pan. Include wrench for damper adjustment. Young Regulator Model 270-275 or equal.

H. Control Kit: Shall consist of 2 5/8 inch diameter die cast aluminum housing with 3 inch diameter zinc plated cover plate, and 14 gauge steel rack and pinion gear drive converting rotary motion to push-pull motion. Control kit is designed to be concealed in the wall flush with the inside surface. Include wrench for damper adjustment. Young Regulator Model 270-302 or equal.

2.15 FIRE AND SMOKE DAMPERS

A. Acceptable Manufacturers:

1. Ruskin
2. Greenheck
3. Air Balance, Inc.

B. General: All dampers operable at pressures and velocities required by systems in which installed. Provide single or multiple framed assemblies as required for size of duct in which installed in order to maintain UL listing of entire damper assembly.

C. Fire Damper (FD):

1. General: Fire dampers shall be UL labeled, constructed in accordance with UL 555.
2. Rating: 1-1/2 hour for use in rated walls 2 hours and less, otherwise 3 hour.
3. Link: Provide replaceable fusible link rated for 165 deg F, except 212 deg F where indicated.
4. Materials: Galvanized steel, except stainless steel for installation in stainless steel, aluminum, or plastic coated ductwork. Provide rectangular to round adapter when installed in round duct.
5. Sleeve: Factory installed as part of damper assembly furnished by manufacturer, or field fabricated and installed. Construct sleeves for rigid connection to adjoining ductwork in accordance with UL 555 as follows:

a. Dampers less than 24 inches, 16 gauge
b. Dampers 24 inches and greater, 14 gauge
c. Use heavier gauges if required by SMACNA construction standards for pressure class indicated.

6. Type:

a. Fire dampers for transfer air application shall be shutter type for vertical mounting only.
b. Fire dampers for other than air transfer, and other than listed below, shall be curtain blade type with closure spring to assure positive closure for either horizontal or vertical mounting with "fans on". Blades retained in a recess out of the air stream, including multiple section applications.
c. Fire dampers with longest dimension less than 24 inch, or where UL sizing limitations will not permit the use of a curtain blade damper, or elsewhere as indicated, shall be multi-blade type spring loaded to assure closure for either horizontal or vertical mounting with "fans on". Blades shall be single skin 16 gauge with V-groove reinforcement. Damper linkage rod extended to outside of frame. Bearings shall be stainless steel sleeve in an extruded hole.

D. Smoke Damper (SD):

1. General: Smoke damper and motor assembly shall be UL labeled, constructed in accordance with UL 555S.
2. Materials: Galvanized steel, except stainless steel for installation in stainless steel, aluminum, or plastic coated ductwork. Factory installed sleeve as part of damper assembly.
3. Parallel airfoil blade type with 115 volt, single phase electric motor. Modulating motor, fail closed position upon loss of power.
4. Smoke dampers for air handling unit supply and return and elsewhere as indicated as having a damper end switch ("es") shall include factory mounted blade position switch.
5. Leakage Class: Class II, except Class I for smoke control systems and elsewhere as indicated

E. Combination Fire/Smoke Damper (FD/SD):

1. General: Combination fire and smoke damper shall be UL labeled, for 1-1/2 hour fire rating.
2. Materials: Galvanized steel, except stainless steel for installation in stainless steel, aluminum, or plastic coated ductwork. Factory installed sleeve as part of damper assembly.
3. Provide manually resettable electric heat sensing device rated for 165 deg F, except 212 deg F where indicated.
4. Parallel airfoil blade type with 115 volt, single phase electric motor. Modulating motor operation fail closed position upon loss of power.
5. Leakage Class: Class II, except Class I for smoke control system and elsewhere as indicated

2.16 DUCT SOUND ATTENUATORS

A. Acceptable Manufacturers:

1. Industrial Acoustics Company
2. Vibro-Acoustics Company
3. Dynasonics
4. Semco
5. Ruskin

B. General: Factory fabricated and tested, rectangular, round, or elbow duct silencer with performance characteristics as indicated.

C. Fire Performance: Adhesives, sealants, and packing materials shall have fire ratings not exceeding 25 for flame spread index and 50 for smoke developed index when tested according to ASTM E 84.

D. Rectangular and Round Units: Fabricate outer casing with a minimum 22 gauge solid galvanized steel, and inner casing with a minimum 26 gauge perforated galvanized steel. 1/8 inch diameter perforations for inner casing and baffles.

E. Elbow Units: Fabricate outer casing with a minimum 18 gauge solid galvanized steel, and inner casing with a minimum 22 gauge perforated galvanized steel.

F. Fabricate to form rigid unit that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Unit shall not experience air leakage up to differential pressure of 6 inch wg from inside to outside. Seams and joints lock formed and sealed or continuously welded. Do not use nuts, bolts, or sheet metal screws for unit assemblies.

G. Fill Material: Provide with the following as indicated:

1. Inert and vermin-proof fibrous material, packed under not less than 5 percent compression, mylar lined resistant to erosion.
2. Moisture proof non-fibrous material.
3. Resonate chamber with no media fill "packless" type.

H. Source Quality Control: Factory test according to ASTM E 477. Record acoustic ratings, including dynamic insertion loss and self-noise power levels with an airflow of at least 2000 fpm (10 m/s) face velocity. Test methods shall eliminate effects due to test room conditions. Published performance data shall include all octave bands (63 Hz to 8000 Hz).

2.17 ACCESS DOORS

A. General: Factory fabricated double wall access doors in accordance with SMACNA standards except as specified herein. Improvised shop or field fabricated access doors will not be permitted.

B. Fabricate doors airtight and suitable for duct pressure class. Access doors shall be double wall constructed of the same material as the ductwork in which they are installed except that doors located in ducts constructed of plastic, FRP and PVC coated steel shall be constructed of Type 304 stainless steel.

C. Rectangular Duct: Provide door with closed cell full sealing gaskets and quick turn fastening locking device. Provide hinged doors with butt or piano hinge and 2 cam latches. For medium and high pressure duct, hingeless with minimum 4 cam latches and factory installed retaining cable.

D. Round Duct: Provide double wall insulated and gasketed door with minimum 2 compression latches.

E. For insulated ductwork, fabricate double wall with insulation fill and thickness not less than adjacent duct insulation. Provide raised hinge type.

F. Construct access doors in grease duct in accordance with the more stringent requirements of NFPA 96 and SMACNA.

G. Access door size 16 inches by 20 inches unless otherwise indicated. Where size of duct will not accommodate this size, provide size as large as possible, minimum 12 inch by 6 inch. Provide view window where indicated.

2.18 INSTRUMENT TEST HOLES

A. Cast iron or cast aluminum to suit duct material, including screw cap and gasket and a flat mounting gasket. Size to allow insertion of pitot tube and other testing instruments and provide in length to suit duct insulation thickness. Ventlock 699 by Ventfabrics, or approved equal.

2.19 AIR VOLUME CONTROL BOXES

A. Acceptable Manufacturers:

1. Price Industries
2. Anemostat
3. Krueger
4. Titus

B. General:

1. Factory fabricated assembly consisting of casing, damper, airflow sensor and other accessories as specified herein.
2. The assembly operation shall be pressure independent and shall reset to any airflow throughout entire operating range.
3. Performance ratings shall be certified in accordance with ARI 880 and shall bear the ARI seal. Sound ratings calculated in accordance with ARI 885.
4. Identification: Provide label on each box indicating identification number shown on drawings, maximum and minimum airflow range, scheduled airflow and calibration curve.
5. Units listed and labeled as defined in NFPA 70 by a testing agency applicable to authorities having jurisdiction, and marked for intended use.

C. Configuration:

1. Boxes shall be suitable for electric powered pressure independent air volume control system and temperature control system furnished by Division 25 as specified in this Section. Boxes shall include airflow sensor and damper with extended shaft compatible with unit mounted controller.
2. Division 25 Contractor will ship controller to box manufacturer who shall install controller and damper actuator at factory prior to shipment.
3. Provide integral power transformer 120/24 volt of each air volume control box.

D. Casing:

1. Minimum 22 gauge galvanized steel housing. Inlet collar minimum 2 inch depth for securing duct connection. Outlet slip and drive connection.
2. Provide insulated double wall access door or removable panel for access to all interior components and coil cleaning.
3. Provide sheet metal frame in box casing and gasket seal to obtain specified maximum leakage.
4. Standard casing: Construct and seal casing and access panel for leakage not to exceed 2% of unit rated airflow, or 10 CFM, whichever is greater, at 1.5 inch wg static pressure.
5. Low leakage casing: Construct and seal casing and access panel for leakage not to exceed 1% of unit rated airflow, or 5 CFM, whichever is greater, at 1.5 inch wg pressure.

E. Insulation:

1. Fibrous glass: 3/4 inch thick 1-1/2 pound density fibrous glass insulation, coated with a durable fire and damage resistant surface to prevent erosion complying with ASTM C 1071; secured with adhesive. All exposed edges shall be coated.
2. Polymer foam: 3/4 inch thick closed cell polymer foam, complying with UL 181 erosion requirements, and having maximum flame spread index of 25 and maximum smoke developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
3. The unit insulation shall be fully enclosed with solid 22 gauge galvanized sheet metal or equivalent gauge aluminum liner. All edges sealed within metal nosing or with NFPA 90A approved sealant.

F. Damper:

1. Damper constructed of two heavy gauge metal plates sandwiched around gasketed blade seal with solid one piece aluminum shaft rotating in self lubricated bearings extended outside of unit casing. Construct of materials that cannot corrode and do not require periodic servicing. Hollow metal shaft is not permitted.
2. Provide damper blade seals and shaft bearing bushings to satisfy required leakage. Damper shaft shall include an integral marker at the end of shaft to indicate damper position.
3. Damper leakage for closed damper shall not exceed 1% of the nominal catalog rating at 3 inch wg inlet pressure. ARI 880 rated.

G. Air Flow Sensor:

1. Center tapped cross flow averaging sensor located in inlet collar, constructed of stainless steel, reinforced to prevent damage.

2. Sensor shall amplify pressure signal by a factor of not less than 1.75 and shall maintain control accuracy within plus or minus 5% throughout operating range with the same size inlet duct in any configuration. Sensor shall not require any minimum length of straight duct to maintain control accuracy.
3. Sensor shall have a minimum of 16 pressure measurement points on all inlet sizes. Pressure sensing tubes shall be extended to the outside of casing for connection to the airflow controller. Tubing secured to casing with grommets.
4. Sensor shall be aerodynamically designed with negligible pressure drop or noise contribution.

H. Hot Water Heating Coil:

1. Factory mounted, copper tubes 1/2 inch OD, 0.017 inch thick tube wall mechanically expanded into 0.0045 inch thick aluminum fins. Minimum 0.03 inch galvanized steel casing.
2. Coils tested and certified in accordance with ARI 410. Leak test coil with 250 psi hydrostatic pressure.
3. Provide access door or removable panel for access upstream of coil.

I. Sound Attenuator: Factory mounted discharge section, minimum 3 feet long. Casing and lining constructed same as unit construction.

J. Dual Duct Inlet: Provide hot deck/cold deck dual inlet collar box. Dual inlet box shall have air volume damper, airflow sensor and controls for each inlet constructed same as unit construction. Box shall maintain pressure independence during all modes of operation.

K. Control Package: Factory mount damper actuator and controller furnished by Division 25. Coordinate for direct attachment of damper actuator to shaft. Additional linkages, swivels, or levels are not acceptable. Include all required accessories to accomplish sequence of operation specified in Division 25.

L. Control Package:

1. Provide factory mounted electric DDC damper motor for air volume control and velocity reset controls for pressure independent operation throughout entire operating range.
2. Include all required accessories and box controls to accomplish sequence of operation specified in Division 25.
3. Submittals shall clearly indicate accessories, normal damper position (open or closed), etc., for sequences specified, in plain English, without the need for interpretation of manufacturer's part number or model number to determine what is being provided.
4. Box manufacturer shall be fully responsible for coordinating and verifying compatibility of air volume control box with sequences specified in Division 25.
5. Coordinate for direct attachment of damper actuator to shaft. Additional linkages, swivels, or levels are not acceptable.
6. Electric Controls: Provide electrically operated pressure independent air volume control and temperature control system.

    a. Damper Actuator: 24 volt AC, powered closed, powered open.
    b. Provide transformer to step down incoming voltage to 24 volt, service disconnect switch, low voltage fuse and fuse block, line voltage disconnect switch, and line voltage fuse and fuse block.

c. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain airflow dictated by thermostat with 5 percent of set point while compensating for inlet static pressure variations up to 4 inch (1000 Pa); shall be suitable for either reverse acting or direct acting and field adjustable for either normally open or normally closed damper position. The controller shall have auxiliary flow setpoint to be referenced through contact input, and provide line velocity readout.

d. Thermostat: Wall mounting electronic thermostat, with concealed cover latches to prevent tampering and adjustable stops for locking or limiting temperature setpoint slider movement.

7. DDC Controls: Provide DDC operated pressure independent air volume control and temperature control system. Factory mounted and calibrated.

a. Damper Actuator: 24 volt AC, powered closed, powered open.

b. Provide transformer to step down incoming voltage to 24 volt, service disconnect switch, low voltage fuse and fuse block, line voltage disconnect switch, and line voltage fuse and fuse block.

c. Unit Controller: Preprogrammed with appropriate control application and specified zone setpoints, complete with full operational readiness checks prior to delivery to jobsite. Compatible with pneumatic tube inlet airflow sensor. Factory calibrate to maximum and minimum airflows, and include the following:

1) Proportional, plus integral control of room temperature.
2) Time proportional reheat coil control.
3) Occupied and Unoccupied heating mode.
4) Remote reset of airflow or temperature setpoints.
5) Adjust and monitoring with portable terminal.
6) Communication interface with temperature control system specified in Division 25.

d. Room Temperature Sensor: Wall mounted with temperature setpoint adjustment and access for data port connection of portable operator terminal.

2.20 DIFFUSERS, REGISTERS, AND GRILLES

A. Acceptable Manufacturers:

1. Diffusers, Registers, and Grilles, except Laminar Flow Diffuser:

a. Titus
b. Price Industries
c. Krueger

2. Laminar Flow Diffusers:

a. Price Industries
b. Precision Air Products
c. Krueger

B. General:

1. Provide terminals of type and quantity as indicated on the drawings. Sizes and deflection patterns are shown for general guidance. Approved manufacturer shall be responsible for adjusting sizes to meet noise and throw performance requirements for CFM indicated.
2. Provide air terminals that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size and type device as listed in manufacturer's current data. Rate in accordance with ADC standards and certify catalogued performance.
3. Provide blow direction to direct air away from walls, columns or other obstructions within radius of supply air terminal operation.

C. Performance requirements: Base selection on maximum residual air velocity in breathing zone of 35 feet per minute and on space noise level of NC 35 unless otherwise indicated.

D. Ceiling and Wall Compatibility:

1. Refer to architectural drawings and general specifications for types of ceiling and wall systems and coordinate the specific ceiling and wall type at the location where air terminals are to be installed. Provide border styles compatible with ceiling and wall type that are specifically manufactured to fit into ceiling module with accurate fit and adequate support.
2. Air terminals installed in T-bar grid framed ceilings: Provide panel type frame sized to fit within lay-in tile grid system. For tegular tile ceilings, provide drop face terminal to align with ceiling surface.
3. Air terminals installed in Spline, or inverted T-bar, grid framed ceilings: Provide drop face panel type sized to fit within lay-in tile grid system and aligning with ceiling surface.
4. Air terminals installed in hard gypsum ceilings: Provide frame with gasket seal suitable for attachment to gypsum ceiling.
5. Air terminals installed in walls: Provide wall mounted terminals suitable for installation in concrete block or drywall partition.

E. Square Plaque Diffuser (SPD)

F. Laminar Flow Diffuser: (LFD):

1. The diffuser shall be suitable for surface mounting type or lay-in type as indicated.
2. Laminar type air distribution system constructed of extruded aluminum with continuous weld to form an airtight shell. Frame contains 2 separate plenums, air being admitted to initial plenum through a collar, having control mechanism to meter air volume; then, air passes through a plate, into lower plenum and then by pressure displacement through perforated plate. Perforated distribution plate of 14 gauge aluminum, perforated with 16% free area in square pattern, held to frame with aluminum mounting frame and retained to frame by quarter turn fasteners. Vinyl coated stainless steel cable prevents accidental drop of perforated plate assemblies during disassembly.
3. Diffuser functions with zero aspiration at face of perforated plate and velocities in the plane of the perforated plate vary no greater than 10%.
4. Individual diffuser mounting frame constructed of extruded aluminum with integral vinyl gasket and hold down clips.
5. Gasketed Holding Frame Grid System:

a. Where diffuser occurs in plaster drywall ceiling, provide fully gasketed mounting frame for diffuser and lights suitable for single or multiple modules as applicable. Diffuser and holding frame shall be of the same manufacturer.
b. Refer to architectural reflected ceiling plan for locations of mounting frames.
c. Be responsible to coordinate grid and frame dimensions with Division 26, who will provide lights suitable for installation in mounting frame.
d. Holding frame shall be 1/8 inch thick extruded aluminum welded construction, white baked epoxy.
e. Provide manufacturers blank off panels matched to the grid in sections where no diffuser or light is shown.

6. Provide closed cell neoprene gasket full perimeter of frame.
7. Finish: as scheduled

G. Registers and Grilles:

1. Provide outlets and intakes indicated as registers with adjustable key operated, multi shutter, streamlined contour, opposed blade dampers adjustable from face of register. Provide outlets and intakes indicates as grilles of same construction as registers except without dampers.
2. Fabricate of steel with minimum 20 gauge frame and 22 gauge blades, or aluminum of equivalent gauge. Fabricate entire assembly of stainless steel where indicated. Provide countersunk fastening screws on frame.
3. Intakes: Fabricate with streamlined, horizontal fixed bar grille face with bars set straight for ceiling installation and set at 40 deg angle, turned down for low sidewall and turned up for high sidewall.
4. Outlets: Fabricate with streamlined, individually adjustable, double deflection grille faces with horizontal face bars.
5. Finish: as scheduled

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated, for the specified duct pressure classification with the fewest possible joints.

B. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.

C. Install fabricated fittings for changes in directions, size, and shape and for connections.

D. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

E. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. On ductwork subject to internal condensation, pitch horizontal runs towards equipment, or source of moisture, minimum 1/8 inch per foot slope.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

K. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

L. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Firestopping materials and installation methods are specified in Division 07.

M. Install ducts with hangers and braces in accordance with Division 23 "Vibration Isolation and Seismic Restraints for HVAC Systems".

N. Paint interiors of metal ducts that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.2 SEAM AND JOINT SEALING

A. Seal all duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated, and SMACNA's "HVAC Leakage Test Standards" for leakage and seal class indicated.

1. For pressure classes 2-inch wg (500 Pa) and lower, seal transverse joints.

B. Seal ducts before external insulation is applied. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

3.3 FLEXIBLE DUCT INSTALLATION

A. Use only where shown on the drawings, installed in accordance with SMACNA's "HVAC Duct Construction Standards" except as specified herein.

B. Do not install flexible duct on return or exhaust ductwork unless specifically noted on drawings.

C. Minimum length 48 inches and maximum length of 72 inches. Install runs with minimum centerline radius of bends not less than twice duct diameter and with no more offsets than an equivalent 90° elbow. Provide band strap hangers with saddle supports under flexible duct run to keep supports from sagging and kinking. Stretch duct enough to smooth out internal corrugations.

D. Connect both ends to collar of rigid ductwork and air delivery device with "3M Brand" EC800 or approved equal adhesive, and secure with sheet metal screws in addition to an approved stainless steel worm gear draw band. Plastic tie straps are not permitted.

3.4 FLEXIBLE CONNECTORS INSTALLATION

A. Provide flexible connections immediately adjacent to fans and externally isolated air handling units, to isolate and prevent transmission of vibration to ductwork and casings.

B. Connections shall be made with a 3 inch space between duct and equipment collars, installed in line, and with 1-1/2 inch excess material folded so as not to interfere with airflow through connection. Flexible connectors are not permitted as a means for correcting misalignment.

C. Do not install flexible connectors on grease duct systems.

3.5 FIRE AND SMOKE DAMPER INSTALLATION

A. Install dampers complete with required perimeter mounting angles and sleeves, in accordance with installation instructions furnished by manufacturer, conforming to installation required of UL as a condition of listing.

B. Install in such a manner to be accessible for testing and reset. Coordinate size and location access door. Increase duct size to accommodate minimum door size of 12 inch by 8 inch as applicable.

C. Furnish additional fusible links, one fusible link for every five dampers installed, to Owner.

3.6 ACCESS DOORS INSTALLATION

A. Install duct access doors to allow inspecting, adjusting and cleaning duct mounted accessories where shown on drawings and as follows:

1. Upstream and downstream of coils, filters, fans, humidifiers, control dampers, airflow measuring devices.
2. Downstream of air volume control boxes.
3. Adjacent to fire and fire/smoke dampers, providing adequate access to reset or reinstall fusible link.
4. Adjacent to fire/smoke dampers, providing adequate access to damper actuator/motor.
5. As required by NFPA requirements for duct cleaning.

B. Where access doors are required within shaft enclosures or above inaccessible ceilings, coordinate with General Contractor and advise proper location of access panel.

C. Identify all fire damper access doors by stenciling with bright red paint the words "FIRE DAMPER ACCESS". For spring closure dynamic curtain type fire dampers use the words "CAUTION – DYNAMIC FIRE DAMPER ACCESS".

3.7 AIR VOLUME CONTROL BOX INSTALLATION

A. Install connecting piping to allow access to unit mounted controller and access panel.

B. Connecting tubing and/or wiring for box installed in return air plenum ceiling to be "plenum rated" of type approved by applicable building code and local authority having jurisdiction for installation in ceiling air plenum.

C. Install straight run, minimum of 2-1/2 duct diameters of rigid duct connection to inlet, full size of inlet connection. Fan powered units shall be connected with flexible connections on inlet and outlet. Inlet flexible connection shall be located upstream of straight run section, not at box collar connection.

D. Provide hanger support for air volume control boxes independent of ductwork.

3.8 AIR TERMINAL INSTALLATION

A. After installing terminal in ceiling grid, provide 12 gauge support wire fastened independently to structure. One wire for each device weighing 10 pounds or less, two wires (opposite corners) for device weighing 11 to 55 pounds, four wires for device weighing greater than 55 pounds. Wire shall not be in tension to lift device out of grid, but with minimal slack to allow device to sit on grid.

3.9 SOUND ATTENUATOR INSTALLATION

A. Install sound attenuator with rigid duct connections in accordance with manufacturer's installation instructions.

B. Where multiple silencer units are grouped together in parallel within duct system, seal between units airtight with 3M Company EC-800 sealant.

3.10 DUCT HANGERS AND SUPPORTS INSTALLATION

A. Suspend and support ductwork, casings, and equipment in accordance with requirements of SMACNA Duct Construction Standards and as specified further in Sections 23 05 00 and 23 05 48, except as specified herein.

B. No hangers shall be attached to or suspended from any type of metal deck. Attachments made beneath metal deck areas may be made by fastening to building structural members (excluding bridging and bracing) in conjunction with the use of miscellaneous auxiliary structural steel. All such steel shall conform to ASTM A36.

C. Whenever the distance between the top of duct and overhead supporting member is greater than 36 inches, the hangers shall be of structural angles or channels and shall include cross bracing as required to prevent sway. Do not use straps or rods.

D. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection. Support vertical ducts at a maximum interval of 12 feet and at each floor.

E. Hangers must be arranged to allow the duct insulation to pass through without insulating any part of the hanger.

F. Unless combined pipe/duct racks are shown on the drawings, provide dedicated hangers for support of ductwork.

3.11 CLEANING AND PROTECTION

A. Thoroughly clean all air stream surfaces of all equipment, devices and accessories in the air distribution systems and all air stream surfaces of ductwork, casings and plenums and maintain in a clean condition as the work progresses. Clean ductwork piece by piece, section by section as installed.

B. Protect openings of all equipment, devices and accessories with polyethylene film or another covering to prevent entrance of moisture, dust or debris until final ductwork/casing/plenum connections are made. Similarly protect openings in ductwork, casings and plenums.

C. After installation, either force air at high velocity through systems or use high power vacuum machines to remove accumulated dust. Protect equipment which may be harmed by dirt with filters, or bypass during cleaning. Provide adequate access into ductwork/casings/plenums for cleaning.

D. Clean external surfaces of all of the above of foreign substances which might cause corrosive deterioration of metal or, where to be painted, might interfere with painting or cause paint deterioration.

E. Wipe clean all air terminal units from dust entrained on face during construction.

3.12 FIELD QUALITY CONTROL

A. Perform duct leakage testing and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports.

B. Test all high and medium pressure ductwork during installation and before application of any exterior insulation or enclosing of ductwork.

C. Test all low pressure ductwork during installation and before application of any exterior insulation or enclosing of ductwork.

D. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

E. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. Do not pressurize systems above maximum design operating pressure.

F. Conduct tests in the presence of General Contractor. Give seven days' advance notice for testing.

G. Maximum Allowable Leakage: Total leakage for pressure class shall not exceed permissible leakage for specified seal and leakage class.

H. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

END OF SECTION 23 30 00

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SECTION 23 41 00 - AIR FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Particulate Air filter(s) mounted in ductwork systems.

B. Air filter draft gauge.

C. Equipment Furnished by This Section for Installation Under Other Sections

1. Furnish filters located in ductwork, to Contractor for installation by that section.

1.3 DEFINITIONS

A. MERV: Minimum Efficiency Reporting Value.

B. HEPA: High-efficiency Particulate Air.

1.4 REFERENCES

A. ASHRAE-52.2 Methods of Testing Air-cleaning Devices used in General Ventilation for Removing Particulate Matter

B. IEST Institute of Environmental Sciences and Technology

C. NFPA Applicable standards

D. UL Applicable standards

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data including flow capacity, initial and final pressure drop at rated airflow, efficiency and test methods, dust holding capacity, fire classification and installation instructions.

B. Shop Drawings: Include plan, elevations, sections and details to illustrate component assemblies and attachments. Show filter holding frame assembly details dimensions and materials. Identify means for filter removal and change out.

C. Source Quality Test Reports: Submit factory certified test reports for each HEPA filter.

1.6 QUALITY ASSURANCE

A. The manufacturer shall submit ASHRAE 52.2 test reports for each grade of filter being offered. The report shall be prepared by an independent laboratory using test equipment, method and duct section as specified by ASHRAE Standard 52.2. The filter shall be required to meet the same MERV-A value when tested per Appendix J of ASHRAE Standard 52.2-2007. Filters with a MERV-A value lower than the MERV value are not acceptable.

B. All filter holding frames and filter media packs shall be equipped with full perimeter gasketing to prevent air bypass. Completely seal full perimeter of holding frame and inside surface of air handling unit or duct. Provide safing as required.

C. Provide additional support bracing and/or reinforce filter holding frames to be capable of withstanding manufacturer's maximum recommended filter pressure drop without deformation of holding frame assembly.

D. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

E. Comply with NFPA 90A and NFPA 90B.

1.7 DELIVERY, STORAGE AND HANDLING

A. Store and handle filters and accessories in accordance with manufacturer's recommendations.

B. Filters shall be stored in original containers until all construction on site is completed. Storage shall be in a dry location, away from direct construction activity. Do not store any equipment or parts on top of filter containers that may dent or damage filters. Do not install any filters that have been damaged or become wet. Replace in kind.

PART 2 - PRODUCTS

2.1 PARTICULATE AIR FILTERS

A. Acceptable Manufacturers:

1. Camfil-Farr Co.
2. American Air Filter Co., Inc.
3. Flanders
4. Purolator
5. Viledon

B. General: Select filter media that is UL listed, Class I or Class II, as approved by local authorities. Filter shall have a Minimum Efficiency Reporting Value (MERV) in accordance with ASHRAE 52.2 and shall have minimum efficiency values listed for specified particle sizes.

C. High Efficiency Particulate (HEPA) Filter

1. Filters shall be absolute grade HEPA filters consisting of pleated media packs assembled in a V-bank configuration, polyurethane sealant, anodized aluminum enclosure and seamless sealing gasket
2. HEPA Filter Construction: Filter media shall be micro fiber glass formed into minipleat pleat-in-pleat V-bank design. The media packs shall be potted into the enclosing frame with fire retardant polyurethane sealant. An enclosing frame of 304 stainless steel shall form a rugged and durable enclosure. A 3/4" channel with silicone sealant shall be included on the downstream side of the filter to form a positive seal upon installation. Filter must be listed as UL 586 and UL 900 Class 2 per Underwriters Laboratories. Initial resistance target shall not exceed 0.90 inch w.g. at 600 FPM approach velocity.
3. HEPA Filter Holding Frame: 14 gauge stainless steel with sealing grooves and gaskets, locking clips, and provision for front mounted prefilter and front or rear removal of filter media as required.
4. Assembly Housing: Side access absolute filter housing shall be constructed of 304 stainless steel and shall include dual access doors, challenge injection port, door gasketing and swing bolt filter retainers. It shall be reinforced with channel bracing to withstand 8.0" w.g. positive or negative pressure. Standing flanges shall be provided to ductwork.
5. HEPA Filter Efficiency: Each filter shall be individually tested and certified to a minimum efficiency at 0.3 micron of 99.99% using a near monodispersed thermally generated challenge when evaluated according to the current edition of IEST-RP-CC-001. Each filter shall be individually tested, certified and labeled as to tested performance.
6. DOP (Dioctyl Phthalate) shall not be used in the testing of HEPA filters.

2.2 AIR FILTER DRAFT GAUGE

A. Acceptable Manufacturers:

1. Dwyer Instruments, Inc.
2. American Air filter, Co., Inc.
3. Ellison Instrument Division

B. Provide at each air filter section with taps upstream and downstream of filter located in an easily visible location.

C. Magnehelic type, shutoff cock to atmosphere for checking zero setting, shutoff cocks in lines to points where draft is measured, white background scale with heavy black divisions and figures, not less than 4-1/2 inches in diameter Graduations as follows:

Differential	Maximum Graduations	Equivalent Dwyer Model No.
1 inch	.02 inch	2001 [and 250.5-AF]
2 inches	.05 inch	2002 [and 252-AF]
3 inches	.10 inch	2003 [and 209-AF]
4 inches	.10 inch	2004 [and 350-AF, vertical scale]

PART 3 - EXECUTION

3.1 GENERAL

A. Install all equipment as indicated and as recommended by manufacturer.

3.2 ALL EQUIPMENT WITH FILTERS

A. If equipment is required to operate during construction, provide temporary filters for use during construction of Minimum Efficiency Reporting Value (MERV) of 8 when evaluated under guidelines of ASHRAE 52.2. Do not operate unit until filters (temporary or permanent) are in place. Replace all temporary filters used during construction with specified filters before turning equipment over to Owner. Provide new filters as specified for air balancing work. Provide Owner with one additional spare set of all filters.

3.3 CERTIFICATION TESTING FOR HEPA FILTERS

A. Provide the owner labeled factory certification report for all HEPA filters. Contractor to provide an independent field integrity testing certification in accordance with IEST Recommended Practices for all HEPA filters.

3.4 INSTALLATION OF PARTICULATE AIR FILTERS

A. Install filter frames according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Install filter draft gage for each filter bank.

E. Install filter gage static-pressure tips upstream and downstream from filters to measure pressure drop through filter. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling unit installations.

END OF SECTION 23 41 00

SECTION 23 84 13 - HUMIDIFIERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Duct Mounted Humidifier
2. Vaporizing Steam Generator
3. Room Humidifier

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

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

B. Comply with ARI 640, "Commercial and Industrial Humidifiers."

1.5 COORDINATION

A. Coordinate location and installation of humidifiers with manifolds in ducts and air-handling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 PANEL TYPE HUMIDIFIER

A. Acceptable Manufacturers:

1. Armstrong International, Inc.
2. DRI-STEEM Humidifier Company
3. Nortec Industries Inc.
4. Pure Humidifier Company

B. Packaged panel assembly of steam dispersing tubes connected to a steam supply header/separator and, if required by manufacturer's design and construction, a condensate return header, all constructed of Type 316 stainless steel and contained within a galvanized metal casing. Tubes fitted with nonmetallic steam discharge tublets with steam orifices. Panel designed and constructed for "clean steam" application.

C. Provide insulated dispersion tube. Insulation shall be suitable for use in wet/hot humidifier applications.

D. Select panel size, tube spacing and number of orifices for maximum absorption distance at scheduled face velocity. Absorption distance 18 inches maximum at 52° DB and 90% RH supply air with panel face velocity up to 1500 ft. per minute. Air pressure loss not to exceed 0.26 inches w.g. at panel face velocity of 1500 ft. per minute.

A. Provide manufacturer's full modulating electric valve properly orificed, inlet strainer and steam trap(s), all constructed of Type 316 stainless steel and shipped loose for field installation. Provide pilot positioner if humidifier has turn down ratio of less than 20 to 1.

B. Include with submittal factory published/calculated absorption distance and air pressure drop for actual installed velocity at maximum and minimum flow conditions and design temperature conditions at 90% minimum duct relative humidity.

C. Accessories:

1. Wall and supply-duct-mounted humidistat
2. Duct-mounted, high-limit humidistat
3. Airflow switch for preventing humidifier operation without airflow

2.2 HOT ELEMENT CABINET STEAM GENERATOR

A. Acceptable Manufacturers:

1. Dri Steem
2. Armstrong
3. Nortec

B. Factory tested packaged steam generator assembly with separate vaporizing and control section contained in a wall mounting, heavy gauge steel cabinet with baked enamel finish. Include microprocessor with history and diagnostic capabilities, operating light and switches and

diagnostic signals. Incorporate terminals for electric power supply, controlling thermostat, duct high limit thermostat, fan interlock and alarm circuit.

C. Vaporizing chamber, fittings and accessories, including float and float valve, constructed of Type 316 stainless steel.

D. Electric heating element either Incoloy alloy sheathed or stainless steel sheathed immersion type. Provide magnetic contactor for each heater, control circuit transformer, fuse for each heating element, modulating control to provide 0% to 100% of maximum capacity, safety cutouts, door interlock, numbered terminal strip and other safety and control devices as specified or required factory mounted and wired in control section.

E. Vaporizing chamber and heating element(s) easily accessible for cleaning, repair, replacement. Provide automatic drain with drain valve open and fill valve closed after 72 continuous hours without a call for humidity.

F. Maintain quality of water in vaporizer by one of the following means:

1. Disposable ionic bed cartridges to attract solids from boiling water, float type makeup valve, drain/flush cycle based on operating history, or
2. Electronic water level control system with three teflon coated stainless steel probes, factory set surface skimmer, drain/flush cycle based on water conductivity and operating history.

G. Provide steam distribution system consisting of room blower unit with adjustable speed control. Supplemental air blower shall operate 15 minutes after humidifier unit shutdown. Steam input shall be through bottom of unit. Distribution unit constructed as part of humidifier cabinet and wired and controlled from the humidifier unit.

H. Provide panel type steam humidifier as specified hereinbefore, except without control valve, strainer and trap(s), for installation in supply air ductwork.

I. Unit UL and CSA approved.

J. Include with submittal factory published/calculated absorption distance and air pressure drop for actual installed velocity and design temperature conditions at 90% minimum duct relative humidity.

2.3 INSTALLATION

A. Examine duct layout at location of humidifier, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Install humidifiers with required clearance for service and maintenance.

C. Seal humidifier manifold duct or plenum penetrations with flange.

D. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

E. Install stainless steel drain pan under each manifold mounted in duct.

1. Construct drain pans to comply with ASHRAE 62.
2. Connect to condensate trap and drainage piping.
3. Extend drain pan upstream and downstream from manifold a minimum of 24 inches or as recommended by manufacturer.

F. Install manifold supply piping pitched to drain condensate back to humidifier.

G. Install drip leg upstream from steam trap a minimum of 12 inches tall for proper operation of trap.

H. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to humidifiers to allow service and maintenance.
2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.

I. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.

J. Install piping from safety relief valves to nearest floor drain.

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."

2.4 FIELD QUALITY CONTROL

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

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

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

2.5 DEMONSTRATION

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

END OF SECTION 23 84 13

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SECTION 25 09 00 - INSTRUMENTATION AND CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to Division 23 for general provisions, installation requirements and additional HVAC equipment control information.

C. All electrical work shall be in accordance with Division 26 Specification Sections.

D. Related Sections include the following:

1. Refer to Division 1 Section "TESTING, ADJUSTING, AND BALANCING FOR HVAC" for additional work related to system testing and balancing.
2. Refer to Division 23 Section "Hydronic Piping Systems" for water flow measuring devices that relates to this Section.
3. Refer to Division 23 Section "Steam and Condensate Piping Systems" for steam flow measuring devices that relates to this Section.

1.2 SUMMARY

A. This Section includes all labor, materials, equipment, and service necessary for a complete and operating control system for all HVAC equipment including control of units not supplied with factory-wired controls and installation and wiring of loose controls shipped with equipment.

B. All new HVAC equipment to be provided with Direct Digital Controls (DDC) controlled thru the existing Automated Logic Building Automation System (BAS).

C. Furnish all labor, materials, equipment, and service necessary for a complete and operating Building Automation System (BAS), utilizing a high speed peer to peer network of interoperable Direct Digital Controls (DDC), Graphical User Interface (GUI) with color graphic displays available on at least 64 client computers, and electronic interfaces and actuation devices, as shown on the drawings and as described herein.

D. The new BAS system shall be fully compatible with the existing campus control system. All new controls shall be fully accessible through the existing operator's terminals. Division 25 contractor is responsible for determining compatibility prior to submitting bid

E. Owner presently has an existing Automated Logic Building Automation System as part of past projects. The intent of this specification is to extend and interoperate with this system and to provide a peer-to-peer, networked control system for the control work that is part of this project. All components, software and operation shall be interoperable with the existing building automation system. The installed system will interface directly with the existing system. The existing software and database will be modified to accept the new equipment being installed

under this project to maintain integrity for centralized scheduling, trending, programming and alarming. PC Desktop icons that "link" to a separate system are not acceptable. Any costs associated with connecting to the existing energy management system, including licensed software, programming, training etc., shall be part of the controls contractor's bid. The contractor must demonstrate their ability to perform the integration to the existing systems prior to submittal acceptance. All systems as described in the sequence of operation will be shown via dynamic graphics with all pertinent system alarms for proper operation and maintenance. The use of separate PC workstations, gateways, metalinks, replacement of existing controllers and control devices and additional software graphic packages to accomplish this integration will not be accepted.

F. Provide surge and over-voltage protection of all electronic controllers serving HVAC equipment. This shall include protection of all controllers provided with equipment where this protection is not factory installed.

1.3 DEFINITIONS

A. BAS: Building Automation System

B. Control Contractor: Contractor for this section

C. DDC: Direct digital control

D. I/O: Input/output

E. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

F. MS/TP: Master slave/token passing

G. NIST: National Institute of Standards and Technology

H. PC: Personal computer

I. PID: Proportional plus integral plus derivative

J. OWS: Operator Work Station

K. RTD: Resistance temperature detector

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.

4. Object Scan: Transmit change of state and change of analog values to control units or work station within six seconds.
5. Alarm Response Time: Annunciate alarm at work station within 45 seconds. Multiple work stations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values or update changes and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within minimum tolerances as follows:

    a. Water Temperature: Plus or minus 1 deg F (0.5 deg C)
    b. Water Flow: Plus or minus 5 percent of full scale
    c. Water Pressure: Plus or minus 2 percent of full scale
    d. Space Temperature: Plus or minus 0.5 deg F (0.3 deg C)
    e. Ducted Air Temperature: Plus or minus 0.5 deg F (0.3 deg C)
    f. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C)
    g. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C)
    h. Relative Humidity: Critical Areas plus or minus 1 percent
    i. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale
    j. Airflow (Terminal): Plus or minus 10 percent of full scale
    k. Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa)
    l. Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa)
    m. Electrical: Plus or minus 5 percent of reading

1.5 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator work station equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

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. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices. Contractor's detailed installation drawings will not be accepted in lieu of schematic flow diagrams.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.

5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. All data sheets shall indicate accessories and options included.
9. DDC System Hardware:

    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator work station and control unit locations.

10. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
11. Controlled Systems:

    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Written description of sequence of operation including schematic diagram.
    c. Points list.

C. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for DDC work stations and control systems.

D. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

E. Qualification Data: For Installer and manufacturer.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device.
2. Index sheet, listing contents in alphabetical order.
3. Manufacturer's equipment parts list of all functional components of the system, Auto-CAD disk of system schematics, including wiring diagrams.
4. Description of Sequence of Operations.
5. As-built interconnection wiring diagrams.
6. Operator's manuals.
7. Trunk cable schematic showing all remote electronic panel locations, and all trunk data wiring runs.
8. Copies of all graphic screens.
9. Keyboard illustrations and step-by-step procedures indexed for each operator function.

10. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
11. Calibration records and list of set points.

1.6 WARRANTY

A. Provide all services, materials and equipment necessary for the successful operation of the entire system for a period of one year after acceptance. The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices. Provide cost for second year.

B. The on-line support services shall allow the system supplier to dial out over telephone lines to monitor and control the facility's building automation system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.

C. If the problem cannot be resolved on-line by the local office, the national office of the building automation system manufacturer shall have the same capabilities for remote connection to the facility. If the problem cannot be resolved with on-line support services, the system supplier shall dispatch the appropriate personnel to the job site to resolve the problem within 3 hours of the time that the problem is reported.

1.7 QUALITY ASSURANCE

A. Installer Qualifications

1. Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.
2. The system shall be installed, commissioned, and serviced by manufacturer employed, factory trained personnel.
3. Installer of control system shall have a branch office within 100 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment.

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

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate location of control panels, dampers, valves, and devices such that clearance can be maintained for proper access to all components.

C. Coordinate equipment and wiring with Division 26 requirements to achieve compatibility of communication interfaces, drives, motor starters and annunciation devices.

D. Coordinate equipment with Division 28 to achieve compatibility with equipment that interfaces with Fire Alarm system.

E. Coordinate and assist Testing, Adjusting and Balancing (TAB) Contractor with proper set up and operation of HVAC Systems.

F. The minimum quantity of DDC/ATC panels are located on the contract documents. Provide additional panels as required. All panel locations must be approved by the Owner and Architect and coordinated with all trades prior to installation. If approval and/or coordination are not completed, then panels shall be relocated at no cost to owner.

G. Do not locate DDC panels above ceilings. Panels shall be located in mechanical rooms or in equipment systems rooms.

H. Automatic temperature control valves and thermowells furnished by Control Contractor shall be installed by Division 23 Contractor under the supervision of Control Contractor.

I. Smoke detectors in ducts and at air handling units shall be wired into the Fire Alarm System by Division 28. Required power for those smoke detectors shall also be provided by Division 28. Provide wiring from smoke detectors/interface modules to respective air handling unit(s) and fan(s) for shutdown in the event of smoke conditions. Contractor for Section 23 30 00 will install detectors in ductwork where shown or where required.

J. Furnish Contractor**(s)** for Section 01 91 00 approved temperature control technical data and shop drawings, information relating to changes or revisions in work, and all other information required for proper balancing, adjusting and commissioning of systems.

K. Through-penetration fire-stop systems at penetrations through floors or fire or smoke rated walls and partitions will be provided by Division 07. Control Contractor shall be responsible to coordinate quantity and locations of all penetrations.

L. Provide all power wiring and devices required for electric/electronic operators/actuators and all air tubing and devices required for pneumatic operators/actuators.

M. All deviations from specifications shall be documented separately. Obtain approval for deviations prior to fabrication or installation. Include all costs, including delays to other trades, to remedy deviations in fabrication, installation or other issues. All issues shall be reviewed.

N.

O. All mechanical equipment sent with loose controls shall be mounted and wired by Division 25.

P. Control Contractor shall provide all conduit, trays, etc., required for power and control wiring to his devices.

Q. Control Contractor shall interlock fans or pumps through hard wiring where indicated on contract documents; software interlocks shall not be acceptable.

R. Coordinate equipment with Division 26 "Network Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

S. Provide communication cards or ports to interface with equipment such as drives, chillers, boilers, etc. as required by the contract documents.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

A. Acceptable Manufacturer: Subject to compliance with requirements, provide system by the following:

1. Siemens

B. Provide a direct digital control (DDC) system consisting of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems and to perform functions as specified.

C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator work station permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

D. Provide extension of existing control system consisting of sensors, controllers, indicating devices, interface equipment, other apparatus, and accessories to operate mechanical equipment and to perform functions as specified. Update all existing data bases and incorporate new graphics.

E. Provide all materials and field work necessary for a complete system.

F. Provide electric operator for each damper and valve to be controlled, unless one is specified elsewhere.

G. Unless specified otherwise, provide fully modulating components.

H. Unless specified otherwise, provide proportional/integral/inverse derivative components for variable air volume controls, proportional/integral components for air handling unit discharge control, and fully proportional/integral components elsewhere.

I. Motors that respond to incremental "pulse" signals or do not fail to the specified position shall not be acceptable.

J. Provide all electrical wiring, communication cabling, relays or other devices for interlocking of equipment as described in Sequence of Operations or as shown on drawings.

K. DDC system shall be capable of operating in environmental conditions of 30 deg F to 120 F and 10% RH to 90% RH noncondensing. Sensors and final control elements shall be capable of operating in environment in which they are installed.

L. Graphics: New global graphics to provide a user friendly interface to the new and existing detail graphics. Provide an overall riser diagram page which will allow instant access to new floor plan graphic pages, individual air handling units and central plants. An individual floor plan graphic will be provided for each floor of the building. The floor plan will show air handling zone layout and provide a link to the associated air handler graphic within each zone. Each space temperature available on the DDC system shall be interactively displayed on the floor plan. Provide sub-area graphics as required to fit all temperatures.

2.2 DDC CONTROLLER INTEGRATION TO EXISTING BAS NETWORK

A. Prior to physically connecting the new DDC Controllers to the existing system, the BAS contractor shall print a predefined report listing any points that are failed, in alarm, or overridden in the system. Once the integration is complete, verify through the same reports that no additional existing points are failed, in alarm, or overridden.

B. Once the new DDC controllers are commissioned, the BAS contractor shall assist the Owner's rep to make the physical connection to the existing network.

C. Once the tie-in is complete, the BAS contractor shall confirm communication with the server.

D. Upload all data to the server.

E. Verify there are no new failed existing points on the system. If so, take corrective action to resolve discrepancies.

F. Create graphics that represent the new systems, including but not limited to AHU layouts, navigation, screens, and room graphics.

G. Map all alarmable points into the existing remote notification software installed on the server.

2.3 BAS TO COMMUNICATE TCP/IP OVER ETHERNET (Owner's Backbone)

A. The owner's representative shall furnish and install cables, switches, and signal repeaters to connect the new project to the existing workstations/server.

B. The BAS contractor shall coordinate: node names, IP addresses, access privileges, and system configuration with the owner prior to startup.

C. The owner's representative shall provide a modular 8-pin, Category 5 information outlet at all DDC controllers and shall terminate the cable inside the field panel at the information outlet. A patch cable shall be provided by the BAS contractor to connect the field panel to the information outlet.

2.4 DDC EQUIPMENT

A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator work station or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

    a. Global communications.
    b. Discrete/digital, analog, and pulse I/O.
    c. Monitoring, controlling, or addressing data points.
    d. Software applications, scheduling, and alarm processing.
    e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Application Programs:

    a. Include control programs capable of performing functions as described in Sequence of Operations.
    b. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
    c. Remote communications.
    d. Maintenance management.
    e. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator work station or diagnostic terminal unit.
5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator work station or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

    a. Global communications
    b. Discrete/digital, analog, and pulse I/O
    c. Monitoring, controlling, or addressing data points

3. Local operator interface provides for download from or upload to operator work station or diagnostic terminal unit.
4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators. Floating type actuators are permitted only on terminal devices such as reheat coils, VAV boxes and unit heaters. Floating type actuators are not permitted on air handling units, for central plant controls or for reheat coils upstream of humidifiers serving high humidity spaces or spaces with tight control tolerances.
7. Universal I/Os: Provide software selectable binary or analog outputs.

D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

E. Power Line Filtering: Internal or external transient voltage and surge suppression for work stations or controllers with the following:

1. Minimum dielectric strength of 1000 V
2. Maximum response time of 10 nanoseconds
3. Minimum transverse-mode noise attenuation of 65 dB
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz

2.5 DDC CONTROLLERS

A. General

1. DDC controllers shall be capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
2. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.

3. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
4. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

B. Each DDC controller shall be provided for control of each of the following types of equipment. DDC controllers shall reside on a peer to peer network.

1. DDC controllers shall be a minimum of 16-bit stand-alone, multitasking, multiuser, real-time digital control processors.
2. Each primary networked DDC controller shall house a minimum of 32 MB RAM and 8 MB Flash ROM to support its own operating system, databases, and stand-alone software functions including:

    a. Control Processes
    b. Energy Management Applications
    c. Mathematical Modeling, Equipment Learning, Part Load Curve Updating Functions to support advanced algorithms for energy reduction.

        1) Provide capabilities for mathematical modeling of VAV air delivery systems to optimize static pressure setpoints and reduce fan energy while maintaining cooling and ventilation constraints in each of the areas served by the VAV system.
        2) Provide capabilities for equipment learning such that load and part load curves are built for equipment controlled to optimize equipment selection at given loads.

    d. It shall be possible for the controller to determine equipment degradation from internal plotting of load curves to schedule maintenance.
    e. Alarm Management Applications including custom alarm messages for each level alarm for each point in the system.
    f. Historical/Trend data for points specified.
    g. Maintenance support applications.
    h. Custom Processes.
    i. Operator I/O
    j. Remote Communications

3. DDC controllers shall provide a communication port for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals.
4. DDC controllers shall be provided with digital input and output LED status indication for visual confirmation of point conditions.
5. The operator shall have the ability to manually override automatic or centrally executed commands at the Networked DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.

6. DDC Controllers shall be provided with communication ports for the control and monitoring of application specific controllers to coordinate control of major mechanical equipment with downstream terminal equipment.
7. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication to alert facility personnel of failure.
8. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

    a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
    b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
    c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power.
    d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max) isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:

        1) IEEE Standard 587-1980.
        2) UL 864 Supply Line Transients
        3) Voltage Sags, Surge and Dropout per EN 61000-4-11 (EN 1000-4-11)

9. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC controllers to prevent the loss of database or operating system software. Nonvolatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

    a. Upon restoration of normal power, the DDC controller shall automatically resume full operation, incorporating time delays to prevent surges, without manual intervention.
    b. Should DDC controller memory be lost for any reason, the user shall have the capability of reloading the DDC controller via the local communication port, via telephone line dial-in or from a network work station PC.

10. Controllers shall be provided with the capability to communicate TCP/IP directly over Ethernet, without the use of an external network interface card. Devices must:

    a. Auto-sense 10/100 Mbps networks.
    b. Receive an IP Address from a Dynamic Host configuration Protocol (DHCP) Server or be configured with a Fixed IP Address. (Owner shall provide IP addresses and relevant network information for each DDC controller provided under this specification.)
    c. Resolve Name to IP Address for devices using a Domain Name Service (DNS) Server on the Ethernet network.
    d. Allow access using Telnet.

C. Each Application Specific Controller (ASC) shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multitasking, real-time digital control

processor. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.

1. Provide for control of each piece of equipment, including, but not limited to, the following:

   a. Air Volume Control Boxes (AVCB)
   b. Booster Fan
   c. Humidifiers

2.6 CONTROL PANELS

A. Provide panels of unitized cabinet type for each system.

B. Enclosure: Fabricate panels from 12 gauge steel or aluminum with baked enamel finish, with hinged key lock door and UL listing as NEMA 1. All panel locks shall be keyed alike.

C. Mount all relays, clocks, switches, transmitters and controllers within cabinet. Mount temperature indicators, pressure gauges, pilot lights, pushbuttons and switches flush on cabinet face.

D. Provide engraved plastic nameplates for instruments and controls inside cabinet and on cabinet face. Nameplates shall be white with black center core.

2.7 FIELD HARDWARE PANELS (FHP)

A. Provide field hardware panel whenever interfaces between field equipment and DDC panels are necessary. Devices such as transducers (current to pressure, pressure to current), relays, contactors, and other devices shall be labeled for quick identification.

B. Provide power from the same source as DDC panels.

C. Provide plastic engraved nameplates for instruments and controls inside cabinet and on cabinet face.

2.8 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Humidity Sensors: Bulk polymer sensor element on Humidicap ®.

1. Acceptable Manufacturers:

   a. Siemens
   b. Vaisala

2. Accuracy: Critical areas 1 percent full range with linear output; non-critical areas 3 percent full range with linear output.

3. Room Sensor Range: 20 to 80 percent relative humidity.
4. Room Sensor Cover Construction: Manufacturer's standard locking covers.

   a. Set-Point Adjustment
   b. Color: Standard.
   c. Orientation

5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.

2.9 STATUS SENSORS

A. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

B. Current Switches

1. The current switch shall be a Veris Industries Hawkeye Current Sensor.
2. The current sensor shall be induce powered from the monitored load.
3. The current sensor shall provide on/off status indication of electrical loads from 1.5 to 200 amperes.
4. The selected switch shall match current VFD System output requirements.
5. The current sensor shall be capable of providing accurate status at temperatures from -15° to 60° C.
6. The current sensor shall be isolated to 600 VAC rms.
7. The current sensor output shall be N.O. solid-state 1.0 ampere at 30 VAC/DC.
8. The current sensor shall be a self-gripping split-core type.
9. The current sensor shall detect drive belts slipping, breaking, or pump couplings shearing.

C. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

D. 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.

2.10 HUMIDISTATS

A. Acceptable Manufacturers:

1. Vaisala
2. Siemens

B. Duct-Mounted Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

2.11 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 "Electrical Requirements for HVAC Equipment."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
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. Acceptable Manufacturers:

    a. Belimo Aircontrols (USA), Inc.

2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. 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.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24- or 120-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.

9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: 40 to 104 deg F (5 to 40 deg C).
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F (Minus 30 to plus 121 deg C).
12. Run Time: 120 seconds.

2.12 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. Hydronic system valves shall have the following characteristics:

1. NPS 2 (DN 50) and Smaller:

a. Globe Valve: Class 125 bronze body, bronze trim, stainless steel rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure. Replaceable plugs and stainless-steel or brass seats. Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
b. Ball Valve: Class 125 bronze body with full-port, chrome-plated bronze ball; TFE seats and packing; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem. Threaded ends.

2. Sizing:

a. Two Position: Line size; ball or butterfly valve.
b. Two-Way Modulating: 3-psig (21-kPa) maximum pressure drop at design flow rate; globe or ball valve.
c. Three-Way Modulating: Line size; globe, ball or butterfly valve.
d. Differential Pressure: Typically 50% of pump head with full pump flow.
e. Valves which are sized 6 inch and larger shall be butterfly type.

3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
4. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating equal to pump dead head (zero flow) pressure for two-way valves and 100 percent of pressure differential across valve for three-way valves.
5. One third and two thirds of total capacity is design and actual split will be the ratio of each valve's Cv to the total Cv.

C. Steam system valves shall have the following characteristics:

1. NPS 2 (DN 50) and Smaller:

a. Globe Valve: Class 125 bronze body, bronze trim, rising stainless steel stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure. Replaceable plugs and stainless-steel seats. Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

b. Ball Valve: Fed Spec WW-V-35C, Type II, Class C, D, Style 1 and 3, 2000 psi W.O.G., 250 psi saturated steam. Carbon steel body. Stainless steel trim, screwed ends, carbon filled, TFE seat and packing, blowout-proof stem.

2. Sizing: For pressure drop based on the following services:

a. Two Position: Line Size; ball or globe valve.
b. Modulating 15-psig (103-kPa) Steam: As indicated on drawings – 5-10 psig; globe valve.

3. Flow Characteristics: Modified linear characteristics.
4. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of operating (inlet) pressure.
5. For equipment requiring a steam flow rate greater than 1,000 pounds/hour, two control valves shall be required.

D. Terminal Unit Control Valves: Globe Valve, 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.

2.13 LIMIT SWITCHES

A. Separate independent position switches shall be installed on dampers including smoke isolation, as needed. The DPST switches shall change state in response to a damper that has modulated beyond 95% full open or closed as dictated by the application.

B. Limit switches shall be the flexible spring-return rod type, with a mechanical endurance of 30 x 10^6 cycles.

C. The contacts shall be rated for 10A at 120VAC.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pneumatic piping and duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. General

1. Install software in control units and operator work station(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
2. Connect and configure equipment and software to achieve sequence of operation specified.
3. Furnish automatic control dampers to Division 23 Section "Duct and Duct Accessories" for installation.
4. Install damper motors on outside of duct in tempered areas, not in locations exposed directly to outdoor temperatures.
5. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."
6. Coordinate location of hydronic instrument wells, valves, and other accessories installed by Division 23 Section "Hydronic Piping Systems."
7. Coordinate location of steam and condensate instrument wells, valves, and other accessories installed by Division 23 Section "Steam and Condensate Piping Systems."

B. Thermostats and Temperature Sensors

1. Verify location of thermostats and/or temperature sensors where shown on drawings and room interior elevations. Coordinate location with other wall mounted devices.
2. Install space thermostats and/or temperature sensors 48 inches above finished floor.
3. Provide insulation pads for thermostats and/or temperature sensors mounted on exterior walls and columns.
4. Install averaging elements in ducts and plenums in serpentine, crossing or zigzag pattern across the area of duct or plenum in order to sense true average temperature. Secure averaging elements in such a manner as to prevent vibration from causing element fatigue.
5. Secure duct mounted sensors to ductwork in a vibration free area.
6. Furnish thermal wells for sensors to be installed in piping. Furnish extension necks where installed in insulated piping. Material for wells shall be compatible with material of piping where installed.

C. Humidistats and Humidity Sensors

1. Verify location of humidistats and/or humidity sensors where shown on drawings and room interior elevations. Coordinate location with other wall mounted devices.
2. Install space humidistats and/or humidity sensors 48 inches above finished floor.
3. Secure duct mounted sensors to ductwork in a vibration free area.

D. Control Valves

1. Tag each valve with brass or aluminum tag with corresponding number on control drawings. Tag shall identify valve number and be attached to valve with non ferrous metal chain.

E. Control Panels

1. Mount control panels adjacent to associated equipment either on walls or freestanding on steel supports. Mounting on ductwork or air handling units will not be permitted. Panels shall be free from vibration.
2. Panels shall be securely mounted with vertical and lateral bracing.

F. Current Switches

1. Shall be installed such that core is securely in place.
2. Shall be adjusted such that calibration trip point will detect drive belts slipping, breaking, or pump coupling shear.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Provide signal and power wiring to all panels and devices furnished under the contract and signal and safety device wiring to all equipment controlled under this contract, except power wiring to air compressor will be provided by Division 26.

B. Provide all interlock wiring between equipment being sequenced as required to accomplish the sequence of operations, which shall include supply and return air fans, exhaust fans, coil circulating pumps, chilled and condenser water pumps, cooling tower fans and chiller control panels, flow switches, etc.

C. Mount and wire all loose control components provided with packaged equipment.

D. Provide all required power wiring and conduit for all panels furnished by the contractor for the project. All panels shall be circuited to the nearest emergency essential equipment panel and utilize 20 amp single pole spare circuit breaker in panelboard. Refer to electrical documents to ascertain exact location of nearest emergency essential equipment panelboard. Multiple panels may use same circuit within the electrical limitations. Indicate panelboard name and circuit number for each panel on shop drawings.

E. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

F. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

G. Install signal and communication cable according to Division 26 Section "Communications Horizontal Cabling."

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway.
3. Install concealed cable in raceway.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

H. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

I. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 FIELD QUALITY CONTROL

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

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

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
5. Test each point through its full operating range to verify that safety and operating control set points are as required.
6. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
7. Test each system for compliance with sequence of operation.
8. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.6 TESTING, ADJUSTING AND BALANCING

A. Testing, adjusting and balancing of air and water systems will be provided under Division 01 "Testing, Adjusting and Balancing of HVAC Systems".

B. Cooperate with testing, adjusting and balancing Contractor in coordination and scheduling of testing, balancing and adjusting work, as well as determining appropriate set point adjustments required for proper system operation.

C. Provide notice upon completion of all preparatory work and all initial operational testing required as part the Work. Perform additional operational testing on equipment, or systems, as directed and to extent and for duration deemed necessary, to demonstrate that systems are performing properly and delivering quantities in accordance with the requirements of the Contract Documents.

D. BAS Contractor shall set up and calibrate the mass flow control devices to the design contract values. BAS Contractor shall adjust the AVCB control so that final setup does not deviate more than plus or minus 5 percent from the design value.

E. BAS Contractor shall index the system configuration as requested by the TAB Contractor.

F. BAS Contractor shall obtain static pressure readings from TAB Contractor at the various points in the system for programming and tuning final set point conditions.

3.7 DEMONSTRATION

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

B. Upon completion of all work and tests, operate systems for a sufficient length of time to demonstrate to Owner, mode of operation and definitively determine whether the system as a whole is in first class working condition. Before systems are turned over to Owner, a final demonstration test of 48 continuous hours, during which systems shall operate without adjustment, shall be performed.

C. Before installation is accepted, provide certification to Owner and Architect that control system and equipment have been inspected and found to be properly installed and functioning satisfactorily.

END OF SECTION 25 09 00

SECTION 26 05 00 - COMMON MATERIALS AND METHODS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section is intended to describe the basic materials and installation methods for electrical work; it applies in general to all Sections under DIVISION 26. All materials and equipment specified and/or shown on Drawings are new unless noted otherwise.

B. All new materials, equipment and systems shall be listed and labeled by a licensed nationally recognized testing laboratory as defined by OSHA and used for the specific purpose, environment or application for which it was tested and approved. No field modifications and/or noncompliant installation whatsoever shall be made to any materials, equipment and systems that would violate the listing and labeling.

C. This section includes the following:

1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Grout.
5. Common electrical installation requirements.

1.3 DEFINITIONS

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

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

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

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

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

F. EPDM: Ethylene-propylene-diene terpolymer rubber.

G. NBR: Acrylonitrile-butadiene rubber.

1.4 REFERENCES

A. Provide work in accordance with all applicable international, state and local, codes, rules, regulations, and standards, including but not limited to, requirements of the following:

1. California Building Code, 2013 Edition
2. California Electrical Code, 2013 Edition
3. California Code of Regulations, Title 24, Part 6, California Energy Code, 2013
4. Underwriters' Laboratories, Inc. (UL).
5. National Electrical Manufacturer's Association (NEMA).
6. National Electrical Contractors Association (NECA)
7. The Institute of Electrical and Electronics Engineers, Inc. (IEEE)
8. Applicable NFPA Codes and Standards
9. National Electric Safety Code, ANSI C2
10. State of California Office of Statewide Health Planning and Development (OSHPD).

B. Conflicts

1. Nothing stated or shown in Specifications or on Drawings is intended to conflict with the above standards and regulations. Should Contractor find any apparent conflict, it shall be his responsibility to notify Architect before any of the work in question is performed or material purchased.

1.5 SUBMITTALS

A. Provide Product List of factory fabricated items, in accordance with Section 016000 "Product Requirements", including name of proposed manufacturer, for all products specified in various sections of Division 26.

B. Provide submittals in accordance with Section 013300 "Submittal Procedures" in sufficient detail to verify full compliance with the requirements of the Contract Documents.

C. Product Data: Provide for each type of factory-fabricated product indicated.

D. Submit testing reports.

1.6 WARRANTY AND CONTRACT CLOSEOUT

A. Comply with warranty and contract closeout requirements specified in Division 01, GENERAL REQUIREMENTS.

B. Provide Special Warranties and/or warranty service in accordance with Section 016000 "Product Requirements" where specified in the various sections of Division 26.

C. Provide manufacturer's certificates of supervision and startup service as specified in the various sections of Division 26.

D. Upon completion of work and tests, and at a time mutually agreed to by Contractor, Architect and Owner, operate all systems installed, in all parts, at Contractor's expense for sufficient length of time to demonstrate the mode of operation and definitely determine whether systems as a whole are in first class working condition. Defects and malfunctions that may develop during this period of operation shall be immediately corrected by Contractor at his own expense, and systems placed in first class working condition before being finally turned over to Owner.

E. Include information for all products specified in the operation and maintenance manual.

F. Provide electrical certificate(s) from electrical inspection agency - see Article titled "Inspections".

G. Provide manufacturer's certification and warranty of system operation - see Article titled "Tests".

1.7 QUALITY ASSURANCE

A. The specifications for certain products and alternative materials may appear in more than one section of Division 26. Work of Division 26 shall be coordinated for all sections of Division 26 to assure that where two or more items of any given product are furnished under Division 26 that they are of the same manufacturer and type and that alternative materials are consistent throughout the work of Division 26.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle all material and equipment in accordance with manufacturer's instructions and recommendations. Such instructions and recommendations are hereby made part of these specifications.

B. Deliver products and equipment properly labeled and tagged. Maintain products in original shipping containers and store in a dry area until ready for installation.

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

1.9 PHASE ARRANGEMENT

A. Exercise great care in maintaining a uniform and consistent arrangement of phase conductors on all systems. Throughout the entire wiring systems, each phase conductor must always be in the same physical position with respect to the other phase wires at equipment terminals.

B. Identify phase wires by color coded conductors and match the existing hospital facility guidelines.

1.10 INSPECTIONS

A. Before starting any Work under this Contract, file for inspection with the Office of Statewide Health Planning and Development (OSHPD) or other certified agency. Upon completion of the work, furnish electrical certificates from said agency for all electrical equipment and systems installed or furnished and installed as part of the work.

B. Electrical equipment or systems that are modified in the field shall be reinspected. Furnish a new electrical certificate covering such modifications.

1.11 GENERAL COORDINATION.

A. The electrical systems are indicated on the Electrical Drawings. Certain pertinent information and details required by the electrical work appear on the Architectural, Structural, Mechanical, and other drawings submitted with the overall drawing package. Become familiar with all drawings and specifications and incorporate all pertinent requirements.

B. Drawings are diagrammatic and indicate general arrangement of systems and requirements of the Electrical work. Do not scale the drawings to obtain dimensional requirements. Exact locations of equipment must be coordinated and obtained from the architectural drawings or the architect prior to starting the work.

C. Coordinate scheduling, sequencing, movement and positioning of large equipment into the building during construction.

D. Coordinate installation of identification devices with completion of covering and painting of surfaces where identification devices are to be applied.

E. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

F. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

G. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

H. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

I. The contractor shall visit the site, including all areas indicated on the drawings. They shall thoroughly familiarized themselves with any and all existing conditions and by submitting a bid, accept the conditions under which they shall be required to perform the work.

1.12 ELECTRICAL WORK ASSOCIATED WITH OTHER DIVISIONS

A. WORK NOT REQUIRED BY DIVISION 26

1. Unless otherwise noted or specified, setting of mechanical equipment and associated safety and control devices will be done by Division 22 and 23 Contractors.
2. Control devices provided under Division 22 or 23 will include, but are not necessarily limited to the following:

    a. Limit Switches: Aquastats, thermostats, air, gas and water pressure
    b. Sensing Devices: Air, gas and water flow and their presence in atmosphere
    c. Flow Switches: Air, medical gas, water
    d. Valve Operators: Electric or air motors or pistons

3. Magnetic motor starters and their associated auxiliary contacts, pushbutton stations, selector switches, pilot lights and control switches that are integral with factory prewired packaged equipment.
4. Unless otherwise noted or specified, setting of mechanical equipment and associated safety and control devices will be done by Division 22 and 23 Contractors.
5. Automatic Temperature Control System including all necessary power wiring.
6. Motors for mechanical equipment.
7. Field wiring, other than power wiring, for electrical accessories furnished as an integral part of equipment furnished under Division 22 and 23.
8. Furnishing, installing and wiring of pilot switches, relays and other control devices required for the proper sequence, electrical or pneumatic control of the apparatus furnished under Division 22 and 23, and not specified or shown on Drawings as being furnished under Automatic Temperature Control System or under Division 26 of the Specifications.
9. Packaged room air conditioning units.
10. Variable frequency drives (VFD) and associated filters, furnished by Division 23 that are integral with factory prewired packaged equipment.

B. WORK REQUIRED BY DIVISION 26

1. Provide all labor, materials, equipment, components and tools for required wiring and connections to control devices and instruments, as specified herein.

2. Provide all recording, indicating devices, contactors, time switches, photoelectric devices and lighting dimming equipment, as specified.
3. Install, completely wire and connect all systems specified herein in accordance with details on drawings and manufacturer's instructions.
4. Install and adjust all mechanical and electrical interlocks. Repair or replace faulty equipment.
5. Install, wire and connect electric heater non-integral thermostats.
6. Provide magnetic and manual motor starters for equipment furnished by others except where starters and controllers are furnished as an integral part of prewired packaged equipment.
7. Provide power wiring to starters and from starters to motor including all connections. Wire capacitors when they are provided by Division 23. Exception: When motors, starters, controllers, etc., are furnished as an integral part of any equipment furnished under Division 23, only power wiring to power terminals on said equipment shall be included herein.
8. Provide Motor Starters including integral pushbuttons, pilot light, control switches, auxiliary contacts and the like, required for proper sequence and control function specified under Division 23.
9. Provide and wire all manual motor switches as required and specified.
10. Provide motor and circuit disconnect safety switches, both fusible (fuse size per equipment nameplate) and non-fusible types, as shown or as required by the CEC. Integral disconnect switches for power roof ventilators will be included under Division 23.
11. Provide all interlock and control wiring shown or referred to on the Electrical and Mechanical Drawings. Provide minimum 3/4-inch conduit for wiring.
12. Provide 120V circuit(s), including conduit and wiring, to any requiring Division 22 or 23 equipment
13. Provide grounded convenience outlet, or grounded junction box for solid connection when required, for each electric water cooler. Locate properly so connection is not visible.
14. Installation of variable frequency drives (VFD) and all associated line reactors and harmonic filters. Provide power wiring to VFD and from VFD to motor including all connections. Obtain manufacturer's installation instructions and wiring diagrams from Division 22 and 23.

C. Plumbing, Gas and Fire Protection System Controls

1. All plumbing system control equipment and devices will be provided under Division 22, with the exception of any devices so indicated or specified otherwise under Division 26.

2. The following controls will be furnished and installed by Division 22 Contractor and wired and connected by Division Contractor indicated:

   a. Aquastats, float and pressure switches integral with a given system equipment piping - Division 22 or Equipment Supplier; individual devices installed at construction site - Division 26.
   b. Pressure switches, flow and OS&Y indicating valve switches for fire protection – Division 26. When these devices are installed concealed above ceiling construction, provide local space mounted condition pilot lights as indicated.
   c. Control transformers for Plumbing and Fire Protection System if integral with equipment Division 21 or 22, respectively; otherwise - Division 26.
   d. Medical Gas alarm panels and remote devices – Division 26.

3. Coordinate all plumbing, gas and fire protection control equipment, devices, location of and test with the respective sections of Division 23.

D. Automatic Temperature Controls (ATC)

1. All temperature control equipment and devices will be provided under Division 25, with the exception of any devices indicated or specified otherwise under Division 26.
2. The following controls will be furnished and installed by Division 23, and as noted herein, wired and connected by Division Contractor indicated.

    a. Line Voltage Thermostats – Division 25
    b. Air Flow Switches, Float and Pressure Switches – Division 25
    c. Pneumatic Electric (P.E.) and Electric Pneumatic (E.P.) Switches – Division 25
    d. Duct Mounted Smoke Detectors - Furnished and wired to Fire Alarm System - Division 28. Installed and wired to dampers, fan controls and other mechanical devices – Division 25
    e. Initiating Alarm Contacts for Supervisory (Surveillance) Alarm Wiring - Division 28
    f. Control Transformers for HVAC Control Equipment - Division 25; exception control transformers in Motor Control Centers provided under Division 26.
    g. Selector Switches for indexing spare chilled and condenser water pumps to primary pump service - provided by Division 25, wired by Division 26

3. Coordinate all temperature control equipment device locations and test with the respective Division 23 Contractor.

E. Air Volume Control Box Wiring

1. Unless otherwise noted in the Panelboard Schedule, connect no more than ten (10) air volume control boxes on a 20A, 120V branch circuit.
2. Connect all air volume control boxes to the nearest normal 208/120V power panelboard within the respective electrical circuit zone, unless the air handler that serves the air volume control box is on emergency power and/or indicated in the air volume control box schedule shown on the mechanical drawings. Air volume control boxes requiring emergency power shall be connected to the nearest 208/120V emergency panel that is fed by the same automatic transfer switch (emergency branch) that supplies power to the respective air handler.
3. Refer to Mechanical Drawings for quantity and locations of air volume control boxes.

F. Smoke and Combination Fire/Smoke Damper Wiring

1. Unless otherwise noted in the Panelboard Schedule, connect no more than ten (10) smoke and/or combination fire/smoke dampers on a 20A, 120V branch circuits.
2. Connect all smoke and/or combination fire/smoke dampers to the nearest normal 208/120V power panelboard within the respective electrical circuit zone, unless the air handler that serves the smoke and/or combination fire/smoke damper is on emergency power. Smoke and/or combination fire/smoke dampers requiring emergency power shall be connected to the nearest 208/120V emergency panelboard that is fed by the same automatic transfer switch (emergency branch) that supplies power to the respective air handler. Circuits shall be arranged as follows:

a. Dampers located in riser shafts shall be circuited vertically to other dampers served by the same air handler.
b. Dampers located in areas, other than riser shafts shall be circuited horizontally to the nearest panel board (as described above) within the respective electrical circuit zone. Coordinate circuiting arrangement with Division 23 contractor, prior to commencement of work, to limit the quantity of control relays associated with each fan.

3. Refer to mechanical drawings for quantity and locations of smoke and/or combination fire/smoke dampers.

G. Overhead Door Wiring

1. Install controller, push-buttons, limit switches, safety bars and key-operated stations for each overhead door. Provide branch circuit and control wiring, and circuit disconnect as required for each door.
2. Locate key-operated control station on the exterior of the building or where directed. Seal conduit after conductor installation.
3. Confirm all locations and electrical characteristics with supplier prior to installing electrical work.

H. Power Door Wiring

1. Perform the following work for power operated and power held doors furnished under other divisions of this specification.
2. Provide branch circuit/feeder and disconnect switches or devices at each location as shown or as required. Key switches if required will be furnished by others; install and connect.
3. Investigate and determine exact requirements for each power operated and held door specified or shown, for location of conduits, switches, controllers, etc., and type of connections. Coordinate all this data before making installation and provide as required to comply with manufacturer's requirements, details of installation and materials supplied.

I. Electric Door Lock and Monitor Wiring

1. Perform the following work for the electric door lock and monitor systems specified and furnished under another section of this specification and as indicated.
2. Provide 120 Volt branch circuits required for each system specified, to a low voltage transformer and controller by others, as shown or required. Install and wire all electric door locks, contact devices, control switches and control devices for a complete operable system.
3. In addition to the local interior door systems, the following exterior doors with lock release system shall be equipped with a relay interwired with door security system circuit (specified by Division 28). When these doors are operated remotely, security status alarm will be bypassed (with time delay) during authorized door opening:
4. Investigate and determine exact requirements for each door lock system specified, for location of conduit, switches, wiring, etc., and type of connection, before installing any work and comply with manufacturer's requirements for details of installation and materials used.

J. Cath Lab Equipment Wiring

1. Provide all power supply and control wiring and conduit, switches, circuit breakers, transformers, boxes and fittings, for Cath Lab equipment as shown.
2. Conductors and raceways shall be as shown and/or as recommended by Cath Lab Equipment Manufacturer.
3. Cath Lab equipment will be furnished and set in place, connections made and tested by Cath Lab Equipment Contractor.
4. Protective lead shielding behind recessed or surface mounted boxes and devices will be provided under General Construction Section.
5. Investigate and determine exact characteristics of Cath Lab equipment and auxiliary equipment as to locations, connections, capacities and safety requirements. Coordinate all this prior to installing same and comply with manufacturer's requirements, details of installation and materials to be used.

1.13 EQUIPMENT LOCATIONS

A. Locations are subject to changes in order to avoid obstacles in building construction. Verify all dimensions and conditions at site. Check layout for sizes and clearances, so that the apparatus and material may be installed and operated satisfactorily in space provided. Install equipment and raceways to preserve headroom and to keep openings and passageways clear.

B. Install equipment, boxes and outlets in accessible locations. Obtain final locations of all outlets and equipment from details on drawings and from Architect. Examine drawings of other trades and avoid interferences with their work.

C. In case of conflict in location of flush outlets, architectural details shall take precedence.

D. Install conduit to avoid mechanical and/or structural obstructions, minimizing crossovers.

E. Install all exposed conduits parallel or perpendicular to building lines.

F. Keep raceways at least 6 inches away from parallel runs of cable trays (side, top, and bottom or top of light fixtures (unless otherwise noted), and 12 inches from heat sources such as flues and steam or hot-water pipes.

G. Mounting heights of outlets and equipment shall be as indicated on "Mounting Height" Schedule, or as specified herein.

H. Verify all door swings before installing switch boxes. In case of conflict between drawings, Architectural details shall take precedence.

I. Architect reserves the right to change, without additional cost, location of any luminaire, wall switch, receptacle or power outlet, provided such changed location is not more than 10 feet, and is ordered changed before said work is completely "roughed in".

J. Locations of electrical equipment and connections to all other equipment are approximately correct, and are subject to such modifications as are required at time of installation, in order to meet field conditions or the dimensions of equipment actually being supplied.

K. No changes are to be made in the original design without written approval by Architect.

1.14 SEISMIC REQUIREMENTS

A. Seismic Design

1. All new and impacted existing Electrical systems (equipment and raceways) shall be provided with seismic restraints in accordance with the requirements of the 2013 California Building Code, Section and Section 260548 "Vibration Isolation and Seismic Controls for Electrical Systems".
2. Refer to Structural Drawings Division 01 for seismic criteria to be used for this project.
3. Use a Component Importance Factor, Ip, of 1.5 for all electrical systems and components.
4. Employ a Professional Engineer registered in the jurisdiction for which the project is located to design all restraints necessary to meet the seismic requirements. Said Engineer shall sign and seal all drawings and calculations prepared for this purpose.
5. The contractor shall have anchoring calculations performed for all electrical equipment or components by a structural engineer licensed in state of California (equipment/component exceptions: weight is less than 20 pounds or weight is less than 400 pounds with a center of gravity below 4 feet). Details on attachments, locations, methods, and spacing shall be included. Calculations and seismic anchoring details shall be submitted as a separate submittal and must be signed and sealed by a structural engineer licensed in state of California.
6. Prior to first Application for Payment, provide a complete listing of all components and elements that are to be seismically restrained and/or braced.
7. It is the entire responsibility of the equipment manufacturer to design their equipment so that the strength and anchorage of the components of the equipment exceeds the force level used to restrain and anchor equipment itself to the supporting structure. Factory manufactured and/or field or shop fabricated equipment shall be designed to safely accept and resist, at its points of anchorage or suspension without failure or permanent displacement of the equipment, earthquake generated external forces required by the code.
8. The preparation and submittal of product data and shop drawings to the Architect for review shall constitute a representation by the manufacturer, contractor and vendor that all components comply with the above requirements.
9. The functional and physical interrelationship of components and their effect on each other shall be installed so that failure of an essential or nonessential architectural, mechanical, electrical component shall not cause the failure of nearby essential architectural, mechanical, or electrical components.

B. Seismic Requirements

1. All new and impacted existing Electrical systems (equipment and raceways) shall be provided with seismic restraints in accordance with the requirements of the 2013 California Building Code, Section and Section 260548 "Vibration Isolation and Seismic Controls for Electrical Systems".
2. Refer to Structural Drawings Division 01 for seismic criteria to be used for this project.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

C. Coordinate sleeve selection and application with selection and application of fire stopping specified in Division 07 Section "Penetration Firestopping"

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

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

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

2. 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.
3. Pressure Plates: Plastic. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. General

1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.
6. Furnish, deliver, erect, connect and finish in every detail, all materials, equipment and accessories required for the Work. Select and arrange to fit properly into the building spaces.
7. Perform all work in accordance with the drawings, specifications, including manufacturer's installation instructions, all applicable codes and NECA's Standard of Installation guidelines.
8. Include in the Work and in the bid proposal minor details not shown or specified, but manifestly necessary for the proper installation and operation of the various systems, as if specified or shown.
9. Position and install all material and equipment to permit proper access and in such a manner that maintenance, adjustment, calibration, inspection, repair and replacement of the material and equipment can be accomplished with minimum effort and cost.
10. Perform the installation, wiring, cleaning, testing, calibration and startup of all material and equipment in accordance with the manufacturers' instructions and recommendations. Such instructions and recommendations are hereby made a part of these Specifications.
11. If any departures from Contract Documents are deemed necessary, submit details of such departures and the reasons there for to Architect for approval.
12. Pull and junction boxes shall be located and sized by the electrical contractor in accordance with CEC, EIA/TIA, utility company requirements and/or owner standards, unless otherwise noted on the drawings.

B. Layout and Coordination

1. Lay out all work from approved building and property lines and benchmarks. Verify and be responsible for the correctness of all measurements in connection with work. Any change made in major overall dimensions as shown which affect the physical size, shape, or location of any part of the Work, whether due to field check or changes due to the use of equipment of a manufacturer other than that used as the basis of design shall not cause any interference with other work.
2. Examine the drawings of other trades and initiate cooperation and coordination of the Work with the work of other trades to insure that the Work can be installed properly as designed and planned without interference with other work or delay. Furnish all

necessary templates, patterns, measurements, etc., for installing work and for the purpose of making adjoining work conform; furnish setting plans and shop details to other trades as required.

3. Investigate the structural and finish conditions affecting the Work. Offsets, bends or other items required by the Work may not be shown due to the small scale of the drawings; provide such offsets, bends or other items as required to meet structural or finish conditions.
4. Coordinate and be responsible for the required clearances of the Work in shafts, chases, double partitions and suspended ceilings. Coordinate and cooperate with the trades responsible for constructing such spaces, together with other trades sharing such spaces, and advise other trades of the requirements of the Work. Immediately submit for review space requirements that exceed those shown.
5. Install material and equipment as high as possible; at minimum, to clear the top of all doors, windows and other structural openings. Maintain maximum headroom and space conditions in every case. Where headroom or space conditions appear inadequate, notify the Architect before proceeding with the installation.
6. Install conduit, fittings, etc., to provide not less than 1/2 inch between their finished covering and the structure or adjacent work of any kind.
7. Electrical equipment shall not interfere in any way with other material or equipment and shall be provided with adequate working space; see the CEC working space requirements.
8. Make reasonable modifications in the layout of the Work, as directed, to provide proper clearances or accessibility, or to prevent conflict with the work of other trades, at no increase in the Contract sum.
9. Cooperate fully with the Contractor for General Construction in regard to location of electrical equipment and work progress schedules. Notify him of all flush panelboard locations so that wall of proper thickness is provided.
10. Prepare large scale composite working drawings, including such section views and details as are necessary to clearly show how the Work is to be installed in relation to the work of other trades. Issue such drawings to the other trades for coordination of their work. Where such drawings show deviations from the Contract Drawings or conflict with other trades, detail and submit such deviation or conflicts to the Architect for review.
11. Locate wall switches at strike side of doors (where possible) and at height indicated on "Mounting Height" schedule. Review all door swings with Contractor for General Construction prior to rough-in.
12. Locate receptacles at heights indicated in "Mounting Height" schedule. Mount receptacles vertically, ground pole at top. In special areas such as kitchens, laboratories, utility areas, coordinate locations with counters, benches and casework.
13. All devices and wiring are to be concealed where possible. Where specifically shown or where approved by the Architect, install exposed outlet boxes and branch circuit wiring in finished areas in formed metallic surface raceway systems using suitable factory fabricated fittings and devices as specified herein.
14. Fire-resistance-rated walls and ceilings: Device outlet boxes shall only penetrate one face of a fire-resistance-rated assembly. Steel electrical boxes shall not exceed 16 square inches (i.e. a typical 4 inch x 4 inch outlet box), and the sum of such penetrations shall not exceed 100 square inches within 100 square feet of wall or ceiling space. Additionally, electrical boxes on opposite sides of the walls must either be separated by a distance of 24 inches, by a distance not less than the depth of a wall cavity when filled with insulation, by solid fireblocking, by listed putty pads, or by other approved listed materials and methods. Contractor can utilize a shallow (4 inch x 4 inch x 1-1/2 inch)

depth box to meet the above criteria if volume of the box meets the minimum conductor fill requirements of the CEC and box is of sufficient depth to accommodate the device and terminations.

15. If work is installed before coordinating with all other trades and Owner's work, or so as to cause interference with the work of other trades, or so as not to provide proper access for maintenance or repair, make necessary changes in work to correct the condition at no cost to the Owner.

C. Cutting and Patching

1. Except where specified otherwise in Division 26, provide cutting, patching and refinishing work in accord with the requirements of Division 01, GENERAL REQUIREMENTS.
2. Horizontal chases shall not be cut into existing walls or partitions without approval of Architect.

D. Painting

1. Except where specified otherwise in Division 26, general painting will be provided under Division 09, FINISHES.
2. Touch up or paint out damage done to items having a factory applied finish, and which are installed under Division 26, utilizing materials and methods specified in Division 09. FINISHES.

E. Access Doors and Panels

1. Access doors and panels shown on the Architectural Drawings will be provided under Division 05, METALS.
2. Furnish other access panels required under Division 26 for installation under the General Construction Sections.
3. Furnish access panels for access to concealed junction/pull boxes, cabinets, terminal boxes and other equipment where other means of access is not available. Access panels shall be adequate in size for the service requirements, and shall not have a clear opening of less than 16 inches x 16 inches. Final size and location of access panels shall be subject to approval of the Architect. Cooperate with other trades so that the equipment will be accessible through the access panels.
4. Access panels shall be of steel construction, prime coated; have front panel fitted flush with the frame, with concealed hinge and latches; and shall be Inryco/Milcor, Style DW, K or M, to suit the construction and location.

F. Sleeves, Fire-stops and Waterseals

1. Provide each raceway or cable passing through a masonry or concrete wall, floor or partition with a sleeve made from standard weight steel pipe with smooth edges, securely and neatly cemented in place. Provide each raceway or cable passing through a wood or metal partition with a sleeve made from No. 22 gauge galvanized sheet metal, securely fastened in place.
2. Set floor sleeves flush with floor surface in finished areas; 1 inch above the finished floor in kitchens, cafeterias and similar service areas, mechanical rooms, pipe chases, pipe spaces and other unfinished areas, unless otherwise indicated, and flush with the

underside of slabs. Wall and partition sleeves shall be flush with each surface unless otherwise indicated or specified.

3. Sleeves shall be 2 pipe sizes larger than the conduit or cable size unless otherwise required by the sealing method selected by the Contractor for Division 07, THERMAL AND MOISTURE PROTECTION. Coordinate with the Contractor for that section to determine requirements for sleeves, clearances, etc. Remove sleeve if required by UL listing for system selected.
4. Place sleeves in concrete floor or wall forms before concrete is poured. Sleeves shall have integral waterstop flanges, where they are to receive either watertight or hydrostatic seals.
5. Insure proper location and alignment of all sleeves for electrical work before and during concrete placement.
6. Where sleeves penetrate exterior walls, fill and seal ends around conduits and/or cables with duct sealant compound equal to Solorite KN-1146, or Link Seal. Install seals in accordance with the manufacturer's recommendations to provide airtightness above ground and hydrostatic sealing below grade. Caulking or other type mastic is not acceptable.
7. Provide fire-stop systems in accordance with Division 07, THERMAL AND MOISTURE PROTECTION.

G. Flashing and Counterflashing:

1. For conduit penetrating built-up roofing membranes, provide a flashing fitting located approximately 1 foot above the roof and extend the conduit to the required height. Flashing fitting shall be J. R. Smith 1750 or equivalent. For sizes when manufactured fittings are not available, the flashing fitting shall consist of a drilled and threaded standard cast iron or malleable iron cap, galvanized, one size larger than conduit and screwed to form a counterflashing or rainguard. Extend conduit through the cap and provide with a coupling for extension. Flashing under the Roofing Section will terminate at the flashing fitting. Apply two coats of asphalt base emulsion to the entire fitting and for a minimum of 6 inches up the conduit extension, to provide a completely weathertight installation.

3.2 PROTECTION OF WORK

A. Protect all conduit, fittings, panelboards, switchgear, transformers and other equipment before and during installation and keep clean.

B. Protect factory finished equipment, luminaires, panels switchgear and devices with approved temporary protective material where these items are subject to accidental damage or abuse. Electrical equipment and switchgear shall be stored indoors or otherwise securely protected and kept free of condensation by adequate electric heat. Contractor shall remove all temporary protective material at the conclusion of the Work or as directed.

C. The Contractor shall assume full responsibility for the cost of repairing or replacing any damaged Work or material caused by employees working under this Division.

3.3 TESTS

A. Test equipment, including switchgear, motor starters, motors, panelboards and all other equipment to verify that items are free from unintended grounds, short circuits, and open circuits and that equipment will operate as specified. Test feeders for insulation resistance; for load balance of the final installation, and for overall operation of systems. Furnish labor and material required for making such tests and make corrections necessary to balance the load and to obtain proper operation.

B. Measure secondary voltages after energizing transformers and adjust transformer taps to provide rated voltages listed on drawings and/or specifications. After building is in use, measure these voltages during a period of "normal load" and "light load". Report results to Architect, who will advise Contractor whether or not further adjustment of voltages is required. Make changes as directed.

C. Test all wiring systems up to 600 volts, for insulation resistance with a megger in accordance with the NEC. Determine values with switchboards, panelboards, fuseholders, switches, receptacles and overcurrent devices in place.

D. Determine ampere rating of thermal overload relays in motor starters and compare with equipment nameplate and actual current measurement of the motor. If overload relays are found to be incorrect, provide proper size. Provide proper motor rotation.

E. Arrange for each system to be fully tested and adjusted by manufacturer or his authorized representative. Each element of each system shall be individually operated to insure that it will function as intended. Furnish all labor and material required to correct all defects.

F. Submit to the Architect a letter from manufacturer (or authorized representative) of each system, attesting to the fact that all necessary tests and adjustments have been made and that the entire system is functioning properly in every respect.

G. This article shall not be construed as deleting other tests specifically outlined in other sections of this Specification.

3.4 WORKMANSHIP

A. Electrical equipment shall be installed in a neat and workmanlike manner in accordance with latest and best practices of the trade.

B. Only mechanics skilled in this type of Work shall be employed and utilized by Contractor for this Division in the execution of this Work.

3.5 REFINISHING

A. All surfaces of boxes, cabinets and equipment shall have suitable lacquer, enamel or plated finishes. Touch up any finishes marred during construction. Supports and other metal work not furnished with a protective coating shall be given two coats of approved paint after completion of the work.

3.6 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07, THERMAL AND MOISTURE PROTECTION.

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07, THERMAL AND MOISTURE PROTECTION.

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

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

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.7 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.8 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07, THERMAL AND MOISTURE PROTECTION.

3.9 CONTINUITY OF EXISTING SERVICES

A. Perform alterations and connections to existing facilities with a minimum of interruption. Where interruption is necessary, prepare a time schedule for same, coordinate with Architect, Owner and other sections, and obtain prior written clearance from Owner. Provide and place notices in affected areas, and on luminaires or equipment, etc., which will be temporarily out of use. Remove notices when interruption has been completed.

3.10 DEMOLITION

A. Disconnect and cap existing DIVISION 26 services to demolished areas of existing and new building(s) as required. Cap services at points where required. Contractor for Division 2 will remove abandoned DIVISION 26 services between capped services and demolished areas.

3.11 ALTERATIONS AND CONNECTIONS TO EXISTING FACILITIES

A. Make all necessary alterations to existing DIVISION 26 systems extending these systems to permit existing systems to remain in use whether indicated or not. New materials used to alter existing systems shall match existing materials unless otherwise indicated. Record modifications for Owner's future use.

B. Where equipment, ductwork and piping is removed or disconnected under DIVISION 26, perform the work in such a manner that no damage is done to the structure or remaining portions of the systems.

C. Remove exposed conduit, hangers and supports made obsolete due to this modification.

D. Where existing concealed conduit is not to be reused, abandon same in place unless otherwise indicated or specified.

E. Unless otherwise specified, all materials and equipment removed or disconnected by Contractor which are not to be reused shall be turned over to the Owner for his future use.

3.12 COMMISSIONING

A. Commissioning will be provided as specified in Division 01 Section "Commissioning". All contractors and subcontractors of the various sections of this specification shall cooperate and participate in the commissioning work in accordance with requirements of Division 01 Section "Commissioning".

B. Ensure participation of major equipment manufacturers or their representatives.

C. Equipment and systems/subsystems installed under this section are expected to be in full compliance with the design intent by the commissioning phase. Notify the Commissioning Agent when any specific piece of equipment or specific system/subsystem is ready for commissioning. Be prepared to demonstrate system readiness.

D. Equipment or systems/subsystems having incomplete work or exhibiting problems related to noncompliance with the design intent shall require commissioning. The contractor for this section shall be fully responsible to make all necessary corrections to incomplete or non-complying work at their own expense and shall pay the Commissioning Agent per diem rate for recommissioning such incomplete or non-complying work.

END OF SECTION 26 05 00

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SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

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 the CEC, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

C. Comply with the CEC.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

B. Coordinate wall and floor penetrations with appropriate UL listed fire stopping systems.

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. Conductor Insulation: Comply with NEMA WC 70 for Types THHN/THWN-2.

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.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

C. Feeders in Cable Tray: Type THHN/THWN-2, single conductors in raceway.

D. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

F. Branch Circuits in Cable Tray: Type THHN/THWN-2, single conductors in raceway.

G. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

H. Class 1 Control Circuits: Type THHN/THWN-2, in raceway.

I. Class 2 Control Circuits: Type THHN/THWN-2, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Division 26, Section "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables through raceways.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

G. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

H. Multi-wire branch circuits will not be allowed. A separate neutral conductor shall be provided for each branch circuit.

I. The continuity of a neutral conductor shall not be dependent upon device and luminaire connections, where removal of such device would interrupt the continuity of circuit.

J. All conductors of a parallel feeder shall be of the same length.

K. Insulated conductors and cables installed in underground enclosures or raceways shall be listed for use in wet locations and shall comply with CEC Article 310.10(C). Any connections or splices in an underground installation shall be approved for wet locations.

L. For branch circuits, a maximum of three 1-pole circuits shall be permitted to be installed within a single raceway. All other circuits shall be run in individual raceways.

M. The smallest size conductors permitted are No. 12 AWG, unless otherwise noted. Branch circuits rated 20 amperes, 120-277 volts and longer than 100 circuit feet from panelboard shall be #10 AWG minimum (150 feet away shall be #8 AWG). Branch circuits rated 20 amperes, 277 volts+ and longer than 150 circuit feet from panelboard shall be #10 AWG (250 feet away shall be #8 AWG).

N. All branch and feeder conductors shall be installed with a ground conductor sized per the CEC as a minimum.

O. Metal-Clad and other flexible cables are not allowed.

P. For branch circuits, a maximum of three 1-pole circuits shall be permitted to be installed within a single raceway. All other circuit types shall be run in individual raceways.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.