

SECTION 23 09 93

BAS SEQUENCE OF OPERATIONS

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.
- B. Related Sections include the following:
 - 1. Division 23 Section "Building Automation System" for control equipment and devices and for submittal requirements.

1.03 DEFINITIONS

- A. DDC: Direct digital control.
- B. VAV: Variable air volume.

1.04 HEATING CONTROL SEQUENCES

- A. Refer to the attached control sequences and points schedule for required Building Automation Systems work.

PART 2: PRODUCTS (Not Applicable)

PART 3: EXECUTION (Not Applicable)

CONTROL SEQUENCE AND POINTS SCHEDULE

FOR: Make-Up Air and Exhaust Systems

1. GENERAL

A. Air Handling Systems: All equipment indicated shall be controlled by the same software defined occupied/unoccupied schedule through the Building Automation System.

1. AREA SERVED:

Make-up Air Unit MAU-1
Exhaust Fans EF-1

B. Make-up air units are indirect gas fired and are complete with all factory installed controls including control dampers. Refer to specification section 23 73 39.

C. Provide all required programming, wiring, all devices to incorporate the factory control panel and sequences indicated herein into the District's existing front-end control system.

D. Install and wire the factory provided make-up air unit controls in accordance with all manufacturer's instructions and guidelines.

E. Provide and wire all electrical interlocks to other equipment associated with this system, as indicated or otherwise necessary for proper system operation.

2. CONTROL SEQUENCE

A. Occupied

1. The system shall be indexed to the occupied mode by a timeclock schedule determined through the Building Automation System software (District's existing front-end).

2. Make-up air unit MAU-1 and exhaust fans EF-1 shall be controlled as a single zone based on an enable/disable command from the District's front-end.

3. The make-up air unit shall operate on its own internal controls to maintain unit discharge air temperature setpoint. The front-end system shall send the factory controller a space temperature setpoint (operator adjustable) that will adjust the DA temperature setpoint through the factory controller.

4. The motorized damper for each exhaust fan shall prove fully open before the exhaust fan and make-up air unit are allowed to start.

B. Unoccupied Mode

1. Exhaust systems shall be off. The make-up air unit shall start to maintain a night set-back temperature initially set as 55°F (operator adjustable through the District's front-end).

C. Safeties

1. Smoke - Transmit alarm to EMCS when smoke is detected in duct system.

2. High Discharge Air Temperature - De-energize fan and transmit alarm to EMCS when the discharge air temperature exceeds 100.0 degrees.

3. Low Discharge Air Temperature - De-energize fan and transmit alarm to EMCS when the discharge air temperature drops below 38.0 degrees.

3. ALARMS

- A. Generate an alarm when one of the following devices trips:
 - 1. Duct Smoke Detectors
- B. Generate an alarm if the make-up air unit is in fault alarm.
- C. Generate an alarm if the exhaust fan is indicated to run but its status is off.

4. POINTS SCHEDULE

Provide at a minimum the following control points for each system and as required to accomplish the control sequences. All points shall be part of the front-end graphics.

- (AO)Space Temperature Setpoint
- (DO)MAU-1 Control
- (DI) MAU -1 Fault
- (AI) Space Temperature
- (AI) Outside Air Temperature
- (DO)Exhaust Fan Control
- (DO)Exhaust Fan Damper Control
- (DI) Exhaust Fan Damper End Switch
- (DI) Exhaust Fan EF-1 Status
- (AI) Discharge Air Temperature

CONTROL SEQUENCE AND POINTS SCHEDULE

FOR: Central Heating Plant

1. GENERAL

- A. Install and wire the boiler management panel provided by another Div. 23 section. Provide a 4-20 mA signal to the high efficiency condensing boiler management system provided with the boilers to reset the supply water setpoint. Coordinate requirements with boiler manufacturer and provide all wiring and control components required to accomplish the setpoint reset function.
- B. Provide a push button switch at each boiler room exit at 7'-0" AFF to function as an emergency boiler shut-off. Tie into existing water heaters, boilers, and new boilers. Label with a red plastic laminate sign with white lettering "Emergency Boiler Shut-off".
- C. Provide 3-way control valve for existing boiler B-1 primary loop control. Installation by another Division 23 section.
- D. Provide interface with existing boiler B-1 control panel for enable/disable and failure alarm. Modify panel as required.
- E. Provide new combustion air fan control for the existing boiler B-1 and Environex fan. Boiler operation is locked out until the fan proves on.

2. CONTROL SEQUENCE

A. Boiler Plant Control

- 1. The central plant shall be indexed to heating mode manually or by the Building Automation System when outdoor air temperature drops below a user-definable setpoint. The central plant control module shall broadcast a "heating available" signal across the network to the various system control modules.
- 2. High efficiency boilers B-2 and B-3 shall be controlled as the lead boilers. Upon lead boiler failure or if they cannot maintain secondary loop temperature, boiler B-1 shall be enabled.
- 3. Primary boiler pumps P-3, P-4, and P-5 shall be controlled such that they run when the respective boiler is enabled.
- 4. The boilers shall operate on their internal burner firing controls as controlled by their boiler management system. The boiler supply water temperature setpoint for the high efficiency boilers shall be reset through a 4-20 mA signal on the same reset schedule as the secondary loop outside air temperature reset. The boiler management system will stage each boiler on to maximize plant efficiency.
- 5. Provide a secondary loop supply water temperature reset schedule: reset linearly between the endpoint as follows.

<u>Supply Temperature</u>	<u>Outside Air Temperature</u>
180°F	0°F and lower
110°F	60°F and greater

- 6. Provide a supply and return water temperature sensor for all boilers. Boiler B-1 fires on its own internal controls. Provide a 3-way control valve and PID loop for supply water temperature control. Modulate the 3-way control valve to maintain the secondary loop temperature setpoint. Override valve control to maintain a minimum 140°F return water temperature.

7. Control secondary pumps P-1 and P-2 on a lead/lag basis. The lag pump shall automatically start upon lead pump failure. The lead pump designation shall rotate on a software-defined schedule. The lead pump shall be interlocked with the boiler operation.

B. Pool Heating Mode

1. When the EMCS is not indexed to heating mode, the central plant shall be in pool heating mode.
2. The boilers shall operate on their internal burner firing controls as controlled by their boiler management system. The boiler supply water temperature shall initially be set to 110°F (operator defined). The BAS contractor shall provide a PID control loop to reset the supply water temperature based on the pool supply and return water temperatures (refer to Control Sequence for HX-1). The boiler management system will stage each boiler on to maximize plant efficiency.

3. SAFETIES

- A. Wire the boiler safety shut-off switches to shut down all boilers and the existing water heaters when activated.
- B. Coordinate installation of boiler mounted disconnect with electrical.

4. ALARMS

- A. Generate an alarm upon boiler B-2 or B-3 general failure.
- B. Generate an alarm upon boiler B-1 failure.
- C. Generate an alarm when the secondary loop temperature is +/- 10°F off setpoint for a period greater than 20 minutes.
- D. Generate an alarm if any pump is enabled but its status is off.
- E. Generate an alarm if boiler B-1 is enabled and return water temperature is less than 140°F for a period greater than 15 minutes.

5. POINTS SCHEDULE

- A. Provide at a minimum the following control points for each system and as required to accomplish the control sequences indicated.

(DI) B-1 Status	(AI) Secondary Hot Water Supply Temperature
(DO) B-1 Control	(AI) Secondary Hot Water Return Temperature
(DI) B-1 Failure	(AO) Secondary Loop Setpoint
(AI) B-1 Inlet Temperature	(DO) Pump P-5 Control
(AI) B-1 Supply Temperature	(DI) Pump P-5 Status
(DO) B-2 Control	(DO) Pump P-1 Control
(DI) B-2 Status	(DI) Pump P-1 Status
(DI) B-2 Failure	(DO) Pump P-2 Control
(AI) B-2 Inlet Temperature	(DI) Pump P-2 Status
(AI) B-2 Supply Temperature	(DO) Pump P-3 Control
(AO) B-2 and B-3 Setpoint	(DI) Pump P-3 Status
(DO) B-3 Control	(DO) Heating Mode
(DI) B-3 Failure	(AI) Outside Air Temperature
(AI) B-3 Outlet Temperature	
(AI) B-3 Inlet Temperature	
(AO) B-1 Valve Modulation	

CONTROL SEQUENCE AND POINTS SCHEDULE

FOR: Pool Heat Exchanger HX-1

1. GENERAL

- A. Provide temperature sensor wells and control sequence for HX-1.
- B. Provide heating control valves and electric valve actuators; installed as work of another Division 23 Section.
- C. HX-1 shall be capable of indexing between occupied and unoccupied modes by a timeclock schedule through the EMCS system.
- D. Provide all required relays, interlocks, and components required for system operation.
- E. Temperature sensor well on pool supply water side shall be located within the pool filter room.

2. CONTROL SEQUENCE

- A. Occupied Mode
 - 1. Pump P-6 shall be enabled anytime the system is indexed to heat.
 - 2. Modulate the HX-1 control valve to maintain a pool water temperature initially set for 85°F.
- B. Unoccupied Mode
 - 1. Pump P-6 shall be enabled anytime the system is indexed to heat.
 - 2. Modulate the HX-1 control valve to maintain a pool water setback temperature initially set for 75°F.

3. ALARMS

- A. Generate an alarm when the pool water supply temperature is below setpoint for a 5-minute duration.
- B. Generate an alarm when the pool water return temperature is below setpoint for a 5-minute duration.
- C. Generate an alarm when the secondary pool heating water Pump P-6 is enabled but its status is off.

4. POINTS SCHEDULE

- A. Provide at a minimum the following control points for each system and as required to accomplish the control sequences indicated.
 - (DI) Pump P-6 Status
 - (DO) Pump P-6 Control
 - (AO) Heating Valve Modulation
 - (AI) Pool Water Supply Temperature
 - (AI) Pool Water Return Temperature

END OF SECTION 23 09 93

SECTION 23 11 23

NATURAL-GAS PIPING

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

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

1.03 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, 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 Space: A space that does not have an opening through its boundary to allow the free passage of air to an occupied space. The opening size and location within the space boundary required for a space to be considered non-concealed is at the discretion of the Engineer and the plumbing inspector. The measure of a space that is defined as non-concealed is that odors from a potential gas leak will be readily detected by a building occupant.

1.04 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: 65 psig minimum unless otherwise indicated.
- B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 2 psig, and is reduced to secondary pressure of 0.5 psig or less.

1.05 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Corrugated, stainless-steel tubing with associated components.
 - 3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.

4. Pressure regulators. Indicate pressure ratings and capacities.
 5. Dielectric fittings.
 6. Mechanical sleeve seals.
 7. Escutcheons.
- B. Welding certificates.
- C. Field quality-control reports.
- D. Operation and Maintenance Data: For motorized gas valves and pressure regulators to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

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

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

1.08 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.

1.09 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

PART 2: PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - 4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
- B. Galvanized Steel Pipe and Fittings: Conform to ASTM A53/A 53M, Type E or S, Grade A or B, Schedule 40.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
 - 3. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
- C. Drawn-Temper Copper Tube: Comply with ASTM B 88, Type K.
 - 1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
 - 2. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
 - a. Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - b. Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
- D. Annealed-Temper Copper Tube: Comply with ASTM B 88, Type K.
 - 1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.

2.02 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches.

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

E. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

F. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.03 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

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

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.04 MANUAL GAS SHUTOFF VALVES

- A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
1. CWP Rating: 125 psig.
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
- B. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig
 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 4. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BrassCraft Manufacturing Company; a Masco company.
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 2. Body: Bronze, complying with ASTM B 584.
 3. Ball: Chrome-plated bronze.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 8. CWP Rating: 600 psig.
 9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

D. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lee Brass Company.
 - b. McDonald, A. Y. Mfg. Co.
2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.05 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Actaris.
 - b. American Meter Company.
 - c. Eclipse Combustion, Inc.
 - d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
 - e. Invensys.
 - f. Maxitrol Company.
 - g. Richards Industries; Jordan Valve Div.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Optional Features:
 - a. Overpressure Protection Device: Factory mounted on pressure regulator.
 - b. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - c. Maximum Inlet Pressure: 2 psig.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Canadian Meter Company Inc.
 - b. Eaton Corporation; Controls Div.
 - c. Harper Wyman Co.
 - d. Maxitrol Company.
 - e. SCP, Inc.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 2 psig.

2.06 DIELECTRIC FITTINGS

A. Dielectric Unions:

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

B. Dielectric Flanges:

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

C. Dielectric-Flange Kits:

1. Minimum Operating-Pressure Rating: 150 psig.
2. Companion-flange assembly for field assembly.
3. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.07 SLEEVES

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

2.08 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
 2. Pressure Plates: Stainless steel.
 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

2.09 ESCUTCHEONS

- A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.

PART 3: EXECUTION

3.01 PIPE APPLICATIONS

- A. Within Building: Install steel pipe with welded joints for all pipe sizes. Steel pipe with threaded joints or copper pipe with brazed joints, may be installed for 2" and smaller piping where routed in locations not defined as a concealed space.
- B. Outside Building: Install galvanized steel pipe with threaded joints and fittings.

3.02 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves for pipe sizes NPS 2 and smaller shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.
- B. Valves for pipe sizes NPS 2-1/2 and shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.
 - 3. Cast-iron, nonlubricated plug valve.

3.03 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints:
 - 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

3.04 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.05 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to State Code to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with State Code requirements for prevention of accidental ignition.

3.06 OUTDOOR PIPING INSTALLATION

- A. Comply with State Code for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
 - 1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.
- C. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to coating on pipe as recommended in writing by protective coating manufacturer.
- D. Install fittings for changes in direction and branch connections.
- E. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 - 2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
- F. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- G. Install pressure gage downstream from each service regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.07 INDOOR PIPING INSTALLATION

- A. Comply with State Code for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install escutcheons at penetrations of interior walls, ceilings, and floors. Escutcheons in areas exposed to view shall have a chrome plated finish.
- K. Seal space outside of sleeves in concrete slabs and walls with grout.
- L. Install sleeves that are large enough to provide ¼-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.
- M. Install sleeve materials according to the following applications:
 - 1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
 - 2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.
 - a. Extend sleeves 2 inches above finished floor level.
 - b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
 - 3. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe.
 - 4. Sleeves for Piping Passing through Exterior Concrete Walls:
 - a. Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).
 - b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
 - c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
 - 5. Sleeves for Piping Passing through Interior Concrete Walls:
 - a. Steel pipe sleeves for pipes smaller than NPS 6.
- N. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- O. Verify final equipment locations for roughing-in.
- P. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

- Q. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- R. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- S. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- T. Concealed Space: In accordance with the definition in Part 1, the following conditions are considered to be concealed spaces. The following is not intended to be a complete list of all concealed conditions within the building. All piping in a concealed space shall have welded joints and fittings. Mechanical fittings, valves, and unions are not allowed.
1. Above-Ceiling Locations: That are not return plenums or do not have a reasonably sized and located opening to allow free passage of air to the occupied space below.
 2. Piping In Partitions: Piping routed in partition walls shall be open to a non-concealed ceiling space and allow the free passage of air for the entire height of the partition.
- U. Prohibited Locations: Do not install gas piping in or through a circulating air duct, clothes chute, chimney or gas vent, ventilating duct, dumb waiter, elevator shafts within poured concrete floors, or below grade within the building perimeter.
- V. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- W. Connect branch piping from top or side of horizontal piping.
- X. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- Y. Do not use natural-gas piping as grounding electrode.
- Z. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- AA. Install pressure gage downstream from each line regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.08 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- C. Install a code approved shut-off valve in the gas main in an accessible location, just inside the building, before the first branch line.

3.09 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Copper Tube Max. Span – Ft.	Min. Rod Dia. – Inches
Up to ¾	8	7	3/8
1	8	7	3/8
1¼	9	7	3/8
1½	9	8	3/8
2	9	8	3/8
2½	10	9	½
3	10	10	½
3½	10	10	½
4	10	10	½

- C. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.10 CONNECTIONS

- A. Install piping adjacent to appliances to allow service and maintenance of appliances.
- B. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- C. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.11 LABELING AND IDENTIFYING

- A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.12 PAINTING

- A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.

3.13 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test, inspect, and purge natural gas according to State Code and authorities having jurisdiction.
- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 23 11 23

SECTION 23 21 13

HYDRONIC PIPING

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Hot-water heating piping.
 - 2. Makeup-water piping.
 - 3. Blowdown-drain piping.
 - 4. Air-vent piping.
 - 5. Safety-valve-inlet and -outlet piping.
- B. Related Sections include the following:
 - 1. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.03 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
 - 1. Hot-Water Heating Piping: 150 psig at 200 deg F.
 - 2. Makeup-Water Piping: 80 psig at 150 deg F.
 - 3. Blowdown-Drain Piping: 200 deg F.
 - 4. Air-Vent Piping: 200 deg F.
 - 5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.04 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 - 2. Air control devices.
 - 3. Chemical treatment.
 - 4. Hydronic specialties.
- B. Welding certificates.
- C. Qualification Data: For Installer.
- D. Field quality-control test reports including reports on flushing procedures and hydrostatic pressure testing.

- E. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.
- F. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site and recommendation of the chemical treatment consultant.

1.05 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

1.06 EXTRA MATERIALS

- A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup.

PART 2: PRODUCTS

2.01 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Wrought-Copper Fittings: ASME B16.22.

2.02 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.03 JOINING MATERIALS

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

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

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

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

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

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BA9-1, silver alloy for joining copper with bronze or steel.

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

2.04 DIELECTRIC FITTINGS

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

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:

1. Factory-fabricated union assembly, for 250-psig minimum working pressure at 300 deg F.

D. Dielectric Flanges:

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

E. Dielectric-Flange Kits:

1. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures

F. Dielectric Couplings:

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

G. Dielectric Nipples:

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

2.05 VALVES

A. Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Pumps, Inc.
 - b. Flow Design Inc.
 - c. Gerand Engineering Co.
 - d. Griswold Controls.
 - e. Taco.
 - f. Nibco
 - g. Tour & Andersson; available through Victaulic Company of America.
2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

C. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Pumps, Inc.
 - b. Flow Design Inc.
 - c. Gerand Engineering Co.
 - d. Griswold Controls.
 - e. Taco.
 - f. Tour & Andersson; available through Victaulic Company of America.
 - g. Nibco
2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.

10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F

2.06 AIR CONTROL DEVICES

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

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

B. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

C. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

2.07 CHEMICAL TREATMENT

A. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

2.08 YDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.

3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

D. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

E. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

F. Expansion fittings are specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

PART 3: EXECUTION

3.01 PIPING APPLICATIONS

A. Hydronic Piping (unless otherwise specified here-in):

1. Up to 2½": Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. 1½" and Larger: Schedule 40 steel pipe with welded joints and fittings.

B. Makeup-water piping:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

C. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

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

E. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

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

3.02 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install a ball valve with memory stop in the by-pass leg of all three way control valves at each heating and cooling coil.
- E. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- F. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01, for installation requirements.

3.03 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping.
- P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

- R. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- S. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."
- T. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."
- U. Install all temperature sensors and flow switches at the direction of the Building Automation System Contractor.

3.04 HANGERS AND SUPPORTS

- A. Comply with requirements in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment" for pipe hanger and support products and installation.
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: MSS Type 1, adjustable, steel clevis hangers.
 - 3. Multiple, Straight, Horizontal Piping Runs: Field fabricated, heavy duty trapeze. Fabricate from steel shapes required for loads.
- B. Support vertical piping and tubing at base and at each floor.
- C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.
- D. Install supports for vertical copper tubing every 10 feet.
- E. Install supports for vertical steel piping every 15 feet.
- F. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Copper Tube Max. Span – Ft.	Min. Rod Dia. - Inches
Up to 3/4	7	5	3/8
1	7	6	3/8
1-1/4	7	7	3/8
1-1/2	9	8	3/8
2	10	8	3/8
2-1/2	11	9	1/2
3	12	10	1/2
3-1/2	13	11	1/2
4	14	12	1/2
5	16	13	5/8
6	17	14	3/4
8	19	16	7/8
10	22	18	7/8
12	23	19	7/8

- G. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.05 PIPE JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems

- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.06 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

3.07 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

3.08 CHEMICAL TREATMENT

- A. Provide the services of a chemical treatment consultant to perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics. Test the water at a minimum of four different sample points throughout the system as selected by the Engineer. Submit a report to the Engineer to include the initial water analysis and the consultants recommendations.
 - 1. pH: 8.0 to 10.0

2. "P" Alkalinity: 100 to 500 ppm.
 3. Boron: 100 to 200 ppm.
 4. Chemical Oxygen Demand: Maximum 100 ppm. Modify this value if closed system contains glycol.
 5. Corrosion Inhibitor:
 - a. Sodium Nitrate: 1000 to 1500 ppm
 6. Soluble Copper: Maximum 0.20 ppm
 7. Tolyriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
 8. Total Suspended Solids: Maximum 10 ppm.
 9. Ammonia: Maximum 20 ppm.
 10. Free Caustic Alkalinity: Maximum 20 ppm.
 11. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maximum 1000 organisms/ml.
 - b. Total Anaerobic Plate Count: Maximum 100 organisms/ml.
 - c. Nitrate Reducers: 100 organisms/ml.
 - d. Sulfate Reducers: Maximum 0 organisms/ml.
 - e. Iron Bacteria: Maximum 0 organisms/ml.
 12. "Fe" Iron: Equal to make-up water.
 13. "PO₄" Phosphate: Equal to make-up water.
 14. "TDS" Total Dissolved Solids: 1500-1750 ppm, (as CaCO₃)
- B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, install new filter in the bypass feeder and refill with fresh water. Provide all additional valves, fitting, temporary piping, piping connections and pumps required to isolate sections of pipe intended to be cleaned and flushed from existing or previously cleaned and finished. Test for oil and grease and do not proceed until the oil and grease levels are within acceptable tolerances.

3.09 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 3. 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.
 4. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
 5. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens and install new filter in the bypass feeder. Notify the Owner and Engineer one week prior to performing flushing procedures such that procedures can be witnessed.

6. Prepare a written report of flushing procedures indicating the date of flushing and signed by the person performing the procedures validating it has been completed.
- B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing indicating the date of testing, the specific procedures and test pressures, and signed by the person performing the work. Submit the report to the Engineer.
 7. Provide at the Engineer's discretion a water quality test by an independent agency to validate flushing procedures have been completed and the chemical treatment has been completed to maintain water quality within the specified ranges.
- C. Perform the following before operating the system:
1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.
 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Set temperature controls so all coils are calling for full flow.
 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 7. Verify lubrication of motors and bearings.
 8. Remove and clean or replace strainer screens and install new filter in the bypass feeder.

END OF SECTION 23 21 13

SECTION 23 21 23

HYDRONIC PUMPS

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

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

1.03 DEFINITIONS

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

1.04 SUBMITTALS

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

1.05 QUALITY ASSURANCE

- A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.06 DELIVERY, STORAGE, AND HANDLING

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

- E. Comply with pump manufacturer's written rigging instructions.

1.07 COORDINATION

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

1.08 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Mechanical Seals: One mechanical seal for each pump.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - 1. Inline Pumps
 - a. Armstrong Pumps Inc.
 - b. Bell & Gossett; Div. of ITT Industries.
 - c. Peerless Pump; a Member of the Sterling Fluid Systems Group.
 - d. Taco, Inc.
 - e. Weinman; Div. of Crane Pumps & Systems.

2.02 SEPARATELY COUPLED, HORIZONTAL, IN-LINE CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.
- B. Pump Construction:
 - 1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded companion-flange connections.
 - 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
 - 3. Pump Shaft: Stainless steel.
 - 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
 - 5. Pump Bearings: Permanently lubricated ball bearings.
- C. Shaft Coupling: Molded rubber insert with interlocking spider capable of absorbing vibration.
- D. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and resiliently mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment", including, but not limited to, efficiency and power factor correction requirements.

2.03 PUMP SPECIALTY FITTINGS

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

PART 3: EXECUTION

3.01 EXAMINATION

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

3.02 PUMP INSTALLATION

- A. Comply with manufacturer's written instructions and guidelines.
- B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

3.03 ALIGNMENT

- A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.
- B. Comply with pump and coupling manufacturers' written instructions.
- C. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.04 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install check valve and throttling valve on discharge side of pumps.
- F. Install suction diffuser and shutoff valve on suction side of pumps.

- G. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.
- H. Install check valve and gate or ball valve on each condensate pump unit discharge.

3.05 STARTUP SERVICE

- A. Complete pump start-up procedures in accordance with the manufacturer's instructions and guidelines. At a minimum perform the following:
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.06 DEMONSTRATION

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

END OF SECTION 23 21 23

SECTION 23 31 13

DUCTWORK

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Section Includes:

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

- B. Related Sections:

- 1. Section 01 45 43 "Testing, Adjusting and Balancing" for testing, adjusting, and balancing requirements for metal ducts.
- 2. Division 23 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
- 3. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.03 PERFORMANCE REQUIREMENTS

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

- 1. Static-Pressure Classes:

- a. Supply Ducts (non-variable air volume systems): 2-inch.
- b. Return Ducts (Negative Pressure): 1-inch wg.
- c. Exhaust Ducts (Negative Pressure): 1-inch wg.

1.04 SUBMITTALS

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

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

- B. Shop Drawings

- 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
- 2. Factory- and shop-fabricated ducts and fittings.
- 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.

4. Elevation of top of ducts.
 5. Dimensions of main duct runs from building grid lines.
 6. Fittings.
 7. Reinforcement and spacing.
 8. Seam and joint construction.
 9. Penetrations through fire-rated and other partitions.
 10. Equipment installation based on equipment being used on Project.
 11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
 12. Hangers and supports, including methods for duct and building attachment and vibration isolation.
- C. Coordination Drawings: Refer to requirements in Section 23 05 00 "Common Work Results for HVAC."
- D. Welding certificates.
- E. Field quality-control reports.

1.05 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
 3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. Leakage Tests: Perform tests as directed by the Testing Agent and submit reports.

PART 2: PRODUCTS

2.01 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.03 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- D. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.04 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - 2. Tape Width: 4 inches.
 - 3. Sealant: Modified styrene acrylic.

4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
- C. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C 920
1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.05 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:

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

PART 3: EXECUTION

3.01 DUCT APPLICATIONS

A. Fabricate ducts with galvanized sheet steel except as follows:

1. Pool Filter and Locker Rooms as noted on drawings:
 - a. Aluminum
 - b. Welded seams and flanged joints with EPDM gaskets.

B. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

C. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.

- 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
- b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Welded.
- D. Branch Configuration:
- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
 - 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

3.02 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- K. Where ducts pass through fire-rated or smoke-rated interior partitions and exterior walls, install fire or fire/smoke dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers. Provide firestopping material as required to maintain fire rating and smoke rating. Comply with all firestopping manufacturer's installation guidelines.

- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines Advance Cleanliness Level."

3.03 SEAM AND JOINT SEALING

- A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements," unless otherwise indicated.
 - 1. For static-pressure classes 1- and 1/2-inch wg, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class C, except as follows:
 - a. Systems for residential occupancy.
 - b. Ducts that are located directly in zones they serve.
 - c. Ducts that have short runs from volume-control boxes to diffusers.
 - d. Return-air ceiling plenums.

3.04 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- G. Hangers shall not be attached to metal roof deck.

3.05 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.06 PAINTING

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

3.07 FIELD QUALITY CONTROL

- A. Perform tests and inspections to ensure a fully sealed system in compliance with SMACNA's standards.
- B. Duct system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 23 31 13

SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Manual volume dampers.
2. Control dampers.
3. Flange connectors.
4. Turning vanes.
5. Duct-mounted access doors.
6. Flexible connectors.
7. Flexible ducts.
8. Duct accessory hardware.

B. Related Sections:

1. Division 23 Section "Air Handling" for roof-mounted ventilator caps.
2. Division 28 Section "Digital Addressable Fire Alarm Systems" for duct-mounted fire and smoke detectors.

1.03 SUBMITTALS

- A. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control damper installations.
 - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
 - e. Duct security bars.

- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

- C. Source quality-control reports.

- D. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.04 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with AMCA 500-D testing for damper rating.

PART 2: PRODUCTS

2.01 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Aluminum Sheets: Comply with 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.
- D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.02 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Standard leakage rating.
 - 2. Suitable for horizontal or vertical applications.
 - 3. Frames:
 - a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
 - 4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized-steel, 0.064 inch thick.
 - 5. Blade Axles: Galvanized steel.

6. Bearings:
 - a. Oil-impregnated bronze or Molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 7. Tie Bars and Brackets: Galvanized steel.
- B. Standard, Aluminum, Manual Volume Dampers:
1. Standard leakage rating.
 2. Suitable for horizontal or vertical applications.
 3. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
 4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
 5. Blade Axles: Stainless steel or Nonferrous metal.
 6. Bearings:
 - a. Oil-impregnated bronze or Molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 7. Tie Bars and Brackets: Aluminum.
- C. Jackshaft:
1. Size: 1-inch diameter.
 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
- D. Damper Hardware:
1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
 2. Include center hole to suit damper operating-rod size.
 3. Include elevated platform for insulated duct mounting.

2.03 TURNING VANES

- A. Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel or of material to match required duct system; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vaness and Vane Runners," and 2-4, "Vane Support in Elbows."
- C. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.04 DUCT-MOUNTED ACCESS DOORS

- A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
 - 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal or of material to match require duct system with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel or of material to match require duct system, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
 - d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.05 FLEXIBLE CONNECTORS

- A. Materials: Flame-retardant or noncombustible fabrics.
- B. Coatings and Adhesives: Comply with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd..
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.

- 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..
 - 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F.

- F. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - 1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - 2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.06 FLEXIBLE DUCTS

- A. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
 - 1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 20 to plus 175 deg F.

- B. Flexible Duct Connectors:
 - 1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.07 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3: EXECUTION

3.01 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Coordinate subparagraphs below with Division 23 Section "Metal Ducts." Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Downstream from manual volume dampers, control dampers, turning vanes, and equipment.
 - 3. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 4. At each change in direction and at maximum 50-foot spacing.
 - 5. Upstream of turning vanes.
 - 6. Elsewhere as indicated.
- H. Install access doors with swing against duct static pressure.
- I. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body plus Ladder Access: 25 by 17 inches.
- J. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- K. Install flexible connectors to connect ducts to equipment.
- L. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

- M. Connect diffusers to low-pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- N. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- O. Install duct test holes where required for testing and balancing purposes.
- P. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.
- Q. Install duct smoke detectors.

3.02 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.
 - 2. Inspect locations of access doors and verify that purpose of access door can be performed.
 - 3. Inspect turning vanes for proper and secure installation.

END OF SECTION 23 33 00

SECTION 23 34 16

AIR HANDLING

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following:

- 1. Centrifugal roof ventilators.

1.03 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on sea level.

- B. Operating Limits: Classify according to AMCA 99.

1.04 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

- 1. Certified fan performance curves with system operating conditions indicated.
- 2. Certified fan sound-power ratings.
- 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
- 4. Material thickness and finishes, including color charts.
- 5. Dampers, including housings, linkages, and operators.
- 6. Roof curbs.
- 7. Fan speed controllers.

- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

- 1. Wiring Diagrams: Power, signal, and control wiring.
- 2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
- 3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

- C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

- 1. Roof framing and support members relative to duct penetrations.
- 2. Ceiling suspension assembly members.
- 3. Size and location of initial access modules for acoustical tile.

4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.08 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Belts: One set(s) for each belt-driven unit.
- B. Furnish replacement drives and sheaves for each type of fan in quantity greater than one and not less than 20% of the total number of each fan type. Exact sizes provided shall be at the direction of the Testing and Balancing Contractor as required to achieve design air flows. Labor for installation is specified in Part 3 of this section.
- C. Furnish replacement motors for each type of fan in a quantity greater than one and not less than 20% of the total number of each fan type. Exact motor hp shall be at the direction of the Testing and Balancing Contractor as required to achieve design air flows. Assume for the purposes of bidding that each fan motor will increase a maximum of one hp size. Labor for installation is specified in Part 3 of this section.

PART 2: PRODUCTS

2.01 CENTRIFUGAL ROOF VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Acme Engineering & Mfg. Corp.
 2. Aerovent; a Twin City Fan Company
 3. Ammerman; General Resource Corp.
 4. Carnes Company HVAC.
 5. Delhi Industries Inc.
 6. Greenheck.
 7. Loren Cook Company.
 8. Penn Ventilation.
 9. Twin City Fan and Blower Co.
- B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories. Provide all aluminum hardware.
- C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
 2. Hinged Subbase: Aluminum hinged arrangement permitting service and maintenance.
- D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 4. Fan and motor isolated from exhaust airstream.
- F. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent. Provide on all direct drive fans and as noted on the drawings.
 2. Disconnect Switch: For single phase motors, provide nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit for three phase motors, a combination starter/disconnect will be provided by Division 26.
 3. Bird Screens: Removable, 1/2-inch mesh, aluminum.
 4. Dampers: All aluminum counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
 5. Motorized Dampers: All aluminum parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

- G. Roof Curbs: Fully Aluminum; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
 - 1. Configuration: Self-flashing without a cant strip, with mounting flange or built-in raised cant and mounting flange as required for roofing type.
 - 2. Overall Height: 18 inches.
 - 3. Metal Liner: Aluminum

2.02 MOTORS

- A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment", including, but not limited to, efficiency and power factor correction requirements.
- B. Enclosure Type: Totally enclosed, fan cooled.
- C. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.

2.03 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3: EXECUTION

3.01 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Secure roof-mounting fans to roof curbs with hardware compatible with all aluminum construction as recommended by manufacturer. Refer to Division 07 and architectural details of construction for installation of roof curbs.
- C. Install units with clearances for service and maintenance.
- D. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.02 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Label fans according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.03 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
1. Verify that shipping, blocking, and bracing are removed.
 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 3. Verify that cleaning and adjusting are complete.
 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Adjust belt tension.
 6. Adjust damper linkages for proper damper operation.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature-control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.04 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Refer to Division 1 Section "Testing, Adjusting, and Balancing " for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

3.05 PROJECT CLOSEOUT

- A. Replace fan drives and sheaves as directed by the Engineer as required for systems to perform to the intended design conditions. The Contractor's bid shall include labor and materials required to replace the quantity of drives and sheaves specified in Part 1.0 "Extra Materials".
- B. Replace fan motors as directed by the Engineer as required for systems to perform to the intended design conditions. The Contractor's bid shall include all material and labor required to replace the quantity at motors, specified in Part 1.0 "Extra Materials".

3.06 DEMONSTRATION

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

END OF SECTION 23 34 16

SECTION 23 37 13

DIFFUSERS, REGISTERS, AND GRILLES

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Related Sections:

1. Division 08 Section "Louvers" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2: PRODUCTS

2.01 MANUFACTURERS

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

1. Anemostat
2. Carnes
3. Krueger
4. Titus
5. Metalaire
6. Nailor
7. Price
8. Tuttle and Bailey

2.02 CEILING AIR DIFFUSERS

- A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

- C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.
- D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule. The following requirements shall apply to nomenclature indicated on schedule:
 - 1. Diffuser Faces:
 - a. Round: Round housing, core of concentric rings, round duct connection.
 - b. Square: Square housing, core of square concentric louvers, square or round duct connection.
 - c. Linear: Extruded aluminum continuous slot, single or multiple.
 - 2. Diffuser Mountings:
 - a. Lay-in: Diffuser housing sized to fit between ceiling exposed suspension tee bars and rest on top surface of tee bar.
 - b. Duct-mounted.
 - 3. Diffuser Patterns:
 - a. Fixed: Fixed position core with concentric rings or louvers for radial air flow around entire perimeter of diffuser.
 - b. Adjustable: Manual adjustable core with concentric rings or louvers, fully adjustable for horizontal to vertical air flow.
 - 4. Diffuser Dampers:
 - a. Opposed Blade: Adjustable opposed blade damper assembly, key operated from face of diffuser.
 - b. Integral: Combination volume control and pattern adjustment for linear diffusers.
 - 5. Diffuser Accessories:
 - a. Equalizing Deflectors: Adjustable parallel blades in frame for straightening air flow.
 - b. Blank-Off Baffles: Arc segments designed to fit into diffuser housing to divert air flow from impinging on obstruction, and to create directional pattern.
 - c. Operating Keys: Tools designed to fit through diffuser face and operate volume control device and/or pattern adjustment.
 - 6. Diffuser Finishes:
 - a. White Enamel: Semi-gloss white enamel prime finish.

2.03 WALL REGISTERS AND GRILLES

- A. General: Except as otherwise indicated, provide manufacturer's standard wall registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide wall registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

- C. **Wall Compatibility:** Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction which will contain each type of wall register and grille.
- D. **Types:** Provide wall registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule. The following requirements shall apply to nomenclature indicated on schedule:
 - 1. **Register and Grille Materials:**
 - a. **Steel Construction (ST):** Manufacturer's standard stamped sheet steel frame and adjustable blades.
 - b. **Aluminum Construction (AL):** Manufacturer's standard extruded aluminum frame and adjustable blades.
 - 2. **Register and Grille Faces:**
 - a. **Horizontal Straight Blades:** Horizontal blades, individually adjustable, at manufacturer's standard spacing.
 - b. **Vertical Straight Blades:** Vertical blades, individually adjustable, at manufacturer's standard spacing.
 - c. **Horizontal 45⁰ Fixed Blades:** Horizontal blades, fixed at 45⁰, at manufacturer's standard spacing.
 - 3. **Register and Grille Patterns:**
 - a. **Single Deflection:** 1 set of blades in face.
 - b. **Double Deflection:** 2 sets of blades in face, rear set at 90⁰ to face set.
 - 4. **Register and Grille Dampers:**
 - a. **Opposed Blade:** Adjustable opposed blade damper assembly, key operated from face of register.
 - 5. **Register and Grille Accessories:**
 - a. **Operating Keys:** Tools designed to fit through register or grille face and operate volume control device and/or pattern adjustment.
 - 6. **Register and Grille Finishes:**
 - a. **White Enamel:** Semi-gloss white enamel prime finish.

2.04 SOURCE QUALITY CONTROL

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

PART 3: EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

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

3.03 ADJUSTING

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

END OF SECTION 23 37 13

SECTION 23 52 16

CONDENSING BOILERS

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, pulse-combustion, fire-tube, water-tube, water-jacketed condensing boilers, trim, and accessories for generating hot water.

1.03 SUBMITTALS

- A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, 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 boilers to include in emergency, operation, and maintenance manuals.
- E. Warranty: Special warranty specified in this Section.

1.04 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. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
- C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- D. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.05 COORDINATION

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

1.06 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Pulse-Combustion Boilers:

- a. Heat Exchanger Damaged by Thermal Shock: 10 years from date of Substantial Completion.
 - b. Heat-Exchanger Corrosion: Prorated for five years from date of Substantial Completion.
2. Warranty Period for Fire-Tube Condensing Boilers:
- a. Leakage and Materials: 10 years from date of Substantial Completion.
 - b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated for five years from date of Substantial Completion.
3. Warranty Period for Water-Jacketed Condensing Boilers:
- a. Leakage and Materials: Eight years from date of Substantial Completion.
 - b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated for five years from date of Substantial Completion.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Pulse Combustion Boilers
 - a. Fulton Boiler Works, Inc.
 2. Fire Tube Condensing Boilers
 - a. AERCO International.
 3. Water-Jacketed Condensing Boilers
 - a. Viessmann Manufacturing Co. (US) Inc.

2.02 MANUFACTURED UNITS – PULSE COMBUSTION CONDENSING BOILER

- A. Description: Factory-fabricated, -assembled, and -tested, pulse-combustion condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.
- B. Heat Exchanger: Carbon steel with corrosion resistant coated primary and secondary combustion chamber.
- C. Pressure Vessel: Carbon steel with welded heads and tube connections.
- D. Exhaust Decoupler: Fiberglass composite material in a corrosion-resistant steel box.
- E. Burner: Natural, Propane gas, self-aspirating and self-venting after initial start.

- F. Blower: Centrifugal fan to operate only during start of each burner sequence.
 - 1. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- G. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
- H. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
- I. Casing:
 - 1. Jacket: Sheet metal, with snap-in or interlocking closures.
 - 2. Control Compartment Enclosure: NEMA 250, Type 1A.
 - 3. Finish: Baked-enamel protective finish.
 - 4. Insulation: Minimum 2-inch-thick, mineral-fiber insulation surrounding the heat exchanger.
 - 5. Draft Hood: Integral.
 - 6. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
 - 7. Mounting base to secure boiler to concrete base.
- J. Mufflers: Carbon-steel intake muffler and stainless-steel exhaust.
- K. Condensate Trap: Cast-iron body with stainless-steel internal parts.
- L. Characteristics and Capacities:
 - 1. Heating Medium: Hot water.
 - 2. Design Water Pressure Rating: 150 psig.
 - 3. Safety Relief Valve Setting: 45 psig and maximum temperature equal to boiler rating.
 - 4. Minimum Efficiency (AFUE): 95%

2.03 MANUFACTURED UNITS – FIRE TUBE CONDENSING BOILER

- A. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.
- B. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber.
- C. Pressure Vessel: Carbon steel with welded heads and tube connections.
- D. Burner: Natural, Propane gas, forced draft.
- E. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
 - 1. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- F. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
- G. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

H. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Baked-enamel protective finish.
4. Insulation: Minimum 2-inch- thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

I. Condensate Trap: Stainless steel body with stainless-steel internal parts.

J. Characteristics and Capacities:

1. Heating Medium: Hot water.
2. Design Water Pressure Rating: 160 psig.
3. Safety Relief Valve Setting: 45 psig and maximum temperature equal to boiler rating.
4. Minimum Efficiency (AFUE): 95%

2.04 MANUFACTURED UNITS – WATER-JACKETED BOILERS

A. Description: Factory-fabricated, -assembled, and -tested, water-jacketed condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; water supply, return, and condensate drain connections; and controls. Water heating service only.

B. Heat Exchanger: Stainless-steel primary and secondary combustion chamber.

C. Pressure Vessel: Carbon steel with welded heads and tube connections where not in contact with combustion or flue gases.

D. Burner: Natural gas, forced draft; swing-open front and burner observation port.

E. Blower: Centrifugal fan, forced draft. Include prepurge and postpurge of the combustion chamber.

1. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Gas Train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.

G. Ignition: Electric-spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

H. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Powder-coated protective finish.
4. Insulation: Minimum 4-inch- thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

I. Characteristics and Capacities:

1. Heating Medium: Hot water.
2. Design Water Pressure Rating: 30 psig.
3. Safety Relief Valve Setting: 45 psig and maximum temperature equal to boiler rating.

4. Minimum Efficiency (AFUE): 95%

2.05 MOTORS

- A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment", including but not limited to, efficiency and power factor correction requirements.
 1. Motor Sizes: Minimum sizes as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

2.06 TRIM

- A. Aquastat Controllers: Operating and high limit.
- B. Safety Relief Valve: ASME rated.
- C. Pressure and Temperature Gage: Minimum 3-1/2-inch- diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
- D. Boiler Air Vent: Automatic.
- E. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

2.07 CONTROLS

- A. Refer to Division 23 Section "Building Automation System."
- B. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms.
 1. Hardwired Points:
 - a. Monitoring: On/off status, common trouble alarm, low water level alarm.
 - b. Control: On/off operation, hot water supply temperature set-point adjustment.
 2. A BACnet communication interface with building management system shall enable building management system operator to remotely monitor the boiler management system from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building management system.
- E. Boiler Management System
 1. Boiler Management System shall be capable of optimizing boiler plant energy performance of multiple boiler plants. The controller shall be capable of varying the firing rate of each individual boiler through its full modulating range to maximize condensing capability and thermal efficiency output of the entire heating plant.
 2. The boiler header temperature shall be reset through the automation system by a 4-20mA signal. The plant shall be enabled/disabled through the automation system.
 3. Provide non-volatile memory back-up of all control parameters.
 4. Refer to Section 23 09 00 "Building Automation System" for additional interface requirements.

2.08 ELECTRICAL POWER

- A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 - 1. House in NEMA 250, Type 1 enclosure.
 - 2. Wiring shall be numbered and color-coded to match wiring diagram.
 - 3. Install factory wiring outside of an enclosure in a metal raceway.
 - 4. Field power interface shall be to fused disconnect switch.
 - 5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
 - 6. Provide each motor with overcurrent protection.

2.9 VENTING KITS

- A. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
- B. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.10 SOURCE QUALITY CONTROL

- A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
- C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3: EXECUTION

3.01 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
 - 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 BOILER INSTALLATION

- A. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.
- B. Install gas-fired boilers according to NFPA 54.
- C. Assemble and install boiler trim.
- D. Install electrical devices furnished with boiler but not specified to be factory mounted.
- E. Install control wiring to field-mounted electrical devices.

3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to boiler to allow service and maintenance.
- C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
- D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 Section "Common Work Results for HVAC."
- E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
- F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
- G. Install piping from safety relief valves to nearest floor drain.
- H. Install piping from safety valves to drip-pan elbow and to nearest floor drain.
- I. Boiler Venting:
 - 1. Install flue venting kit and combustion-air intake.
 - 2. Connect full size to boiler connections. Comply with requirements in Division 23 Section "Breechings, Chimneys, and Stacks."

3.04 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
 - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Remove and replace malfunctioning units and retest as specified above.

D. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.
 - a. Test for full capacity.
 - b. Test for boiler efficiency at low fire 40, 60, 80, and 100 percent of full capacity. Determine efficiency at each test point.
4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

3.05 DEMONSTRATION

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

END OF SECTION 23 52 16

SECTION 23 57 00

HEAT EXCHANGERS FOR HVAC

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes shell-and-tube heat exchangers.

1.03 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- 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. Design Calculations: Calculate requirements for designing bases.
 - 2. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
- C. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Tube-removal space.
 - 2. Structural members to which heat exchangers will be attached.
- D. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of heat exchangers and are based on the specific equipment indicated. Refer to Division 01 Section "Product Requirements."
- B. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
- C. Registration: Fabricate and label shell-and-tube heat exchangers to comply with the Tubular Exchanger Manufacturers Association's standards.
- D. UL listed for portable water.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 SHELL-AND-TUBE HEAT EXCHANGERS

A. Manufacturers:

1. Armstrong Pumps, Inc.
2. ITT Industries; Bell & Gossett.
3. Taco, Inc.

B. Configuration: U-tube with removable bundle.

C. Shell Materials: Carbon steel.

D. Head:

1. Materials: Carbon steel with removable cover.
2. Flanged and bolted to shell.

E. Tube:

1. Double wall 90/10 Copper-Nickel.
2. Tube diameter is determined by manufacturer based on service.
3. Vented leak ports.

F. Tubesheet Materials: Carbon steel tubesheets.

G. Baffles: Steel.

H. Piping Connections:

1. Shell: Threaded or Flanged outlet fluid connections, threaded drain, and vent connections.
2. Head: Threaded or Flanged inlet and outlet fluid connections.

I. Support Saddles:

1. Fabricated of material similar to shell.
2. Foot mount with provision for anchoring to support.

J. Construction: ASME for 125 psi design pressure at 375°F.

PART 3: EXECUTION

3.01 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

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

3.02 HEAT-EXCHANGER INSTALLATION

A. Install shell-and-tube heat exchangers on saddle supports. Fabricate steel support structure to mount Min. 5' above finished floor. Locate with required tube bundle removal clearance.

3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of heat exchangers.
- C. Install shutoff valves, unions, thermometers at heat-exchanger inlet and outlet connections.
- D. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.
- E. Install vacuum breaker at heat-exchanger steam inlet connection.
- F. Install hose end valve to drain shell.

3.04 FIELD QUALITY CONTROL

- A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.05 CLEANING

- A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.06 DEMONSTRATION

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

END OF SECTION 23 57 00

SECTION 23 73 39

INDIRECT GAS-FIRED HEATING AND VENTILATING UNITS

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes direct-fired H&V units.

1.03 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories.
- 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. Prepare the following by or under the supervision of a qualified professional engineer:
 - 1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Coordination Drawings: Roof-mounted units and roof-curb mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Size and location of rooftop unit mounting rails and anchor points and methods for anchoring units to curb.
 - 2. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.
- D. Startup service reports.
- E. Operation and Maintenance Data: For direct-fired H&V units to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of direct-fired H&V units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.05 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: One set(s) for each unit.
 - 2. Fan Belts: One set(s) for each unit.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Modine Mfg. Co.; Commercial HVAC&R Division.
 2. Titan Air Incorporated.
 3. ICE
 4. Reznor.
 5. Greenheck
 6. Trane Co.

2.02 PACKAGED UNITS

- A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, factory starter, filters and direct-fired gas furnace to be installed as indicated on the drawings.

2.03 CABINET

- A. Cabinet: Double-wall galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. The cabinet shall be fully weatherized for outside installation where indicated on the drawings to be installed.
- B. Access Panels Piano hinged with cam-lock fasteners for furnace and fan motor assemblies on both sides of unit.
- C. Internal Insulation: Fibrous-glass duct lining, comply with NFPA 90A and UL181 applied on complete unit .
1. Thickness: 1 inches
 2. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.
- D. Finish: Heat-resistant, baked enamel.
- E. Discharge: Horizontal-or vertical pattern as indicated on the drawings, galvanized-steel assembly with diffusers incorporating individually adjustable vanes.
- F. Roof Curb: Full-perimeter curb of sheet metal minimum 18" high, with wood nailor, neoprene sealing strip, and welded z-bar flashing.

2.04 SUPPLY-AIR FAN

- A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings. When available, otherwise pillow block bearings rated for L50 or 200,000 hours with external great fittings.
- B. Motor: Open dripproof single -speed motor.
- C. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.
- D. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with spring isolators.

2.05 AIR FILTERS

- A. Comply with NFPA 90A.

- B. Disposable Panel Filters: 2-inch- thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1.
 - 1. Media: Interlaced glass fibers.
 - 2. Frame: Galvanized steel.

2.06 OUTDOOR AIR INTAKE

- A. Outdoor Air Hood: Galvanized steel with rain battles bird screen, and finish to match cabinet, size to supply 100 percent of supply air volume. The hood shall be the full width of the unit. Provide with 1 inch thick cleanable metal mesh filters for winter operation.

2.07 DAMPERS

- A. Outdoor-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. of damper area, at differential pressure of 2-inch wg. Return air dampers shall be the same construction where noted on the drawings.
- B. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.08 INDIRECT-FIRED GAS FURNACE

- A. Description: Factory assembled, piped, and wired of the capacity and configuration indicated on the drawings comply with ANSI Z83.4, "Direct Gas-Fired Make-Up Air Heaters" ; ANSI Z83.18, "Direct Gas-Fired Industrial Air Heaters" ; and NFPA 54, "National Fuel Gas Code."
- B. Inside Unit External Housing: Steel cabinet with integral support inserts.
- C. Burners: Stainless-steel heat exchange
 - 1. Control Valve: Modulating with minimum turndown ratio of 8:1.
 - 2. Fuel: Natural gas.
 - 3. Pilot: Electrically ignited by hot-surface ceramic igniter.
- D. Safety Controls:
 - 1. Gas Manifold: Safety switches and controls to comply with ANSI standards and Michigan code of requirements.
 - 2. Purge-Period Timer: Automatically delays burner ignition and bypasses low-limit control.
 - 3. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
 - 4. Manual-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - 5. Gas Train: Redundant, automatic main gas valves, electric pilot valve, electronic-modulating temperature control valve, main and pilot gas regulators, main and pilot manual dual shutoff valves, main and pilot pressure taps, and high-low gas pressure switches.
 - 6. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
 - 7. Control Transformer: Integrally mounted 24-V ac.
 - 8. Disconnect: Non-fused door interlocked.

2.09 CONTROLS

- A. Provide factory controls with capability of integrating into the Tridium-based Building Automation System utilizing BACnet Open Protocol Standard Language. Include all required factory-supplied communication cards to ensure complete interface.
- B. DDC Controller:
 - 1. Controller shall have volatile-memory backup.
 - 2. Safety Control Operation:
 - a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire alarm control panel.
 - b. Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F enters unit.
 - c. Fire Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Division 28 Section "Fire Detection and Alarm."
 - d. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 40 deg F.
 - 3. Scheduled Operation: Receive an enable/disable signal from the Building Automation System for time of day scheduled operation.
 - 4. Supply Fan Operation:
 - a. Occupied Periods: Run fan continuously.
 - b. Unoccupied Periods: Cycle fan to maintain setback temperature.
 - 5. Gas Furnace Operation:
 - a. Occupied Periods: Control burner to maintain space or discharge air setpoint. Refer to Specification Section 23 09 93 "BAS Sequence of Operations".
 - b. Unoccupied Periods: Cycle burner to maintain setback temperature.
 - 6. Economizer Outdoor-Air Damper Operation:
 - a. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
- C. Interface Requirements for Building Automation System:
 - 1. Refer to Specification Section 23 09 93 "BAS Sequence of Operations" for interface requirements. Provide at a minimum the following:
 - a. Enable/Disable.
 - b. Unit fault.
 - c. Outside air damper minimum position control.
 - d. Freezestat input.
 - e. Modulating temperature input.

2.10 MOTORS

- A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment", including, but not limited to, efficiency and power factor correction requirements.
 - 1. Motor Sizes: Minimum sizes as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

PART 3: EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation of direct-fired H&V units.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
- B. Install controls and equipment shipped by manufacturer for field installation.

3.03 CONNECTIONS

- A. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.
 - 1. Gas Piping: Comply with requirements in Division 23 Section "Natural-Gas Piping ." Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.
- B. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and ducts to direct-fired H&V units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories."
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1. Inspect for visible damage to furnace combustion chamber.
 - 2. Inspect casing insulation for integrity, moisture content, and adhesion.
 - 3. Verify that clearances have been provided for servicing.
 - 4. Verify that controls are connected and operable.
 - 5. Verify that filters are installed.

6. Purge gas line.
 7. Inspect and adjust vibration isolators.
 8. Verify bearing lubrication.
 9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 10. Adjust fan belts to proper alignment and tension.
 11. Start unit according to manufacturer's written instructions.
 12. Complete startup sheets and attach copy with Contractor's startup report.
 13. Inspect and record performance of interlocks and protective devices; verify sequences.
 14. Operate unit for run-in period recommended by manufacturer.
 15. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
 - a. Measure gas pressure on manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
 16. Calibrate thermostats.
 17. Adjust and inspect high-temperature limits.
 18. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
 19. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 20. Measure and record airflow. Plot fan volumes on fan curve.
 21. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
 - a. High-limit heat.
 - b. Alarms.
 22. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
- C. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.
- D. Prepare written report of the results of startup services.

3.05 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- 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 two visits to Project during other-than-normal occupancy hours for this purpose.

3.06 DEMONSTRATION

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

END OF SECTION 23 73 39