

SECTION 23 00 00 - HVAC SYSTEM

PART 1 GENERAL

1.1 DESCRIPTION

- A. The work covered by this Section of the specifications includes the furnishing of labor, materials, equipment, transportation, permits, inspections and incidentals and the performing of operations required to install the heating and ventilating systems indicated.

1.2 RELATED DOCUMENTS

- A. The drawings and the specifications including SECTION 23 05 00 "Common Work Results for HVAC" are hereby made a part of the work of this section.

1.3 SUBMITTALS

- A. Substitutions: Your attention is directed to Section 23 05 00-"Substitutions", relative to competition and the (ONLY) notation. Familiarity with this section should be achieved before reading the PRODUCTS section of this specification.

- B. The items for which the submittals paragraph in Section 23 05 00, Common Work Results for HVAC, apply are as follows:

1. Piping materials.
2. Fittings for steel pipe.
3. Hangers.
4. Valves.
5. Piping, valve and equipment identification.
6. Hydronic specialties.
7. Gas-fired boilers.
8. Finned tube radiation.
9. Finned tube radiation schedule of all elements, room by room.
10. Unit heaters/cabinet unit heaters/wall heaters.
11. Fans.
12. Energy recovery ventilators.
13. Circulating pumps.
14. Chemical Batch Feeders
15. Brazed plate heat exchanger (radiant and snow-melt systems).
16. Seismic connectors.

PART 2 PRODUCTS

2.1 PIPING MATERIALS

- A. Hot Water Heating Piping: Type L hard copper tubing and cast bronze or wrought copper solder fittings or Schedule 40 carbon steel pipe with threaded joints and malleable iron fittings, or Schedule 40 carbon steel pipe with rolled or cut grooves and rigid couplings or flexible coupling where required for expansion. Piping 1" and smaller may be PEX.

2.2 FITTINGS FOR STEEL PIPE

- A. Fittings in sizes 1/2" through 2": Steel or malleable iron with requirements as follows:
1. Steel fittings socket welding or screwed type conforming to ANSI B16.11.
 2. Malleable iron fittings screwed type conforming to ANSI B16.3.
 3. Victaulic rolled or cut grooves with rigid couplings and flexible couplings where required for expansion.
- B. Fittings in sizes 2-1/2" and larger:
1. Butt welding type conforming to ANSI B16.9.
 2. Flanged type conforming to ANSI B16.5.
 3. Victaulic rolled or cut grooves with rigid coupling and flexible couplings where required for expansion.
- C. Steel Flanges: Forged steel, welding type conforming to ANSI B16.5. Bolting and gaskets shall be as follows:
1. Bolting: Material used for bolts and studs shall conform to ASTM A 307, Grade B, and material for nuts shall conform to ASTM A 194, Grade 2. Dimensions of bolts, studs, and nuts shall conform to ANSI B18.2.1 and ANSI B18.2.2 with threads conforming to ANSI B1.1 coarse type, with Class 2A fit for bolts and studs, and Class 2B fit for nuts. Bolts or bolt-studs shall extend completely through the nuts.
 2. Gaskets: Gasket material for flanged joints for steam application under saturated conditions shall be composition asbestos or copper. Gaskets shall be of a material that resists attack by the fluid or gas in the pipeline and shall be suitable for the pressure and temperature ranges encountered. Gaskets shall be as thin as the finish of surfaces will permit. Raised-face steel flanges shall have ring gaskets with an outside diameter extending to the inside of the bolt holes. Gaskets shall have an inside diameter equal to or larger than the port openings.
- D. Butt Weld Joints: Shall conform to ANSI B31.1. The use of backing rings shall conform to ANSI B31.1. Ferrous rings shall be of weldable quality and shall not exceed 0.05 percent sulfur. Backing rings shall be of the continuous machined or split band type.
- E. Grooved Joint Couplings: Couplings shall be self centering and shall engage and lock in place the grooved or shouldered ends of pipe and pipe fittings in a positive watertight couple. The couplings shall provide some degree of angular pipe deflection, contractions, and expansion. The coupling clamp shall be malleable iron conforming to ASTM A 536, Grade 65-45-12. The gasket shall be molded rubber conforming to ASTM D 2000, the "line call-out" number shall be suitable for a water temperature of 230 degrees F. Coupling nuts and bolts shall be steel conforming to ASTM A 183. Grooved fittings shall be malleable iron conforming to ASTM A47, Grade 32510 or ductile iron conforming to ASTM A 536, Grade 65-45-12. Mechanical couplings and fittings shall be of the same manufacturer. Before couplings are assembled, pipe ends and outside of gaskets shall be lightly coated with lubricant approved by the coupling manufacturer to facilitate installation.

2.3 HANGERS

- A. Adjustable Swivel Hanger: Pipe Sizes 2" and Less: Carpenter and Paterson Fig. 800 conforming to MSS-SP-58, oversize for insulated piping systems. Pipe Sizes Larger Than 2": Carpenter and Paterson Fig. 100, oversize for insulated piping systems.
- B. Riser Clamp: Carpenter and Paterson Fig. 126 and Fig. 126 CT conforming to MSS-SP-58, provide copper plated clamps on copper pipes.
- C. Insulation Shields: 18 ga. galvanized steel, 180° wrap, Carpenter and Paterson Fig. 265P, Type H.
- D. All piping 20' upstream and downstream of pumps shall also have Mason Industries PC30N precompressed double deflection spring isolators installed.

2.4 VALVES

- A. Ball Valves: Apollo 70-100 and 70-100-07 series, Watts, Nibco, or equal bronze body with stationary seat ring and chromium plated or stainless steel floating ball per Federal Specification WW-V-35B. Blowout proof stem, reinforced PTFE seal, 600 psig WOG. Sizes 1½" and larger shall have threaded ends and lever handles. For sizes 1¼" and smaller, provide steel tee handles. Provide with stem extension as required to allow operation without interfering with pipe insulation.
- B. Gate Valves: Nibco Model S-113 or T-113, bronze body Fed. Spec. WW-V-54, wedge disc, rising stem, screwed connection for steel pipe, sweat connection for copper tube, 150-pound class.
- C. Check Valves: Nibco Model S-413 or T-413, bronze body Fed. Spec. WW-V-51, regrinding swing check type, 200 pound class.
- D. Butterfly Valves: Centerline or Norris, valves shall conform with MSS-SP67, Type I 150 psig - Tight shut off valve, ends shall be flangeless or grooved, cast iron body, type 300 series corrosion resistant steel stems and corrosion resistant or bronze discs with molded elastomer disc seals. Valves shall have throttling handles with a minimum of 7 locking positions. Valves shall be suitable for water temperatures up to 220 degrees F.

2.5 PIPING, VALVE AND EQUIPMENT IDENTIFICATION

- A. Pipe Identification: Provide plastic "wrap around" identification markers indicating flow direction and fluid flowing for the following:

Hot Water Supply Piping
Hot Water Return Piping

1. Markers shall be placed 30-50 ft. apart for piping in accessible areas.
2. Markers shall be placed outside the pipe insulation and in the most obvious location for viewing. Markers shall not be installed in exposed areas except in the mechanical rooms.

B. Valve Tags:

1. Attach to each valve a 1-1/2" round or octagonal brass tag with 1/2" indented numerals filled with a durable black compound. In addition to the valve numbers, each tag shall identify the system it controls. Service stop valves exposed in finished areas need not be tagged.
2. Tags shall be securely attached to stems of valves with copper or brass "S" hooks, or chains.
3. Valve charts shall be provided for each piping system and shall consist of schematic drawings of piping layouts, showing and identifying each valve and describing its function. Upon completion of the work, one (1) copy of each chart, sealed to rigid backboard with clear lacquer placed under glass and framed, shall be hung where directed. Two (2) additional unmounted copies shall be delivered to the Architect.
4. Tags and charts shall be coordinated with Section 22 00 00 Plumbing and when completed this work shall have been done sequentially.

C. Equipment Identification:

1. Provide laminated plastic nameplates for boilers, pumps, and air handling units. Laminated plastic shall be 0.125-inch thick melamine plastic conforming to Fed. Spec. L-P-387, black with white center core. Surface shall be a matte finish, corners shall be square. Accurately align lettering and engrave into the white core. Minimum size of nameplates shall be 1.0 inch by 2.5 inches. Lettering shall be minimum of 0.25-inch high normal block lettering.

2.6 HYDRONIC SPECIALTIES

- A. Thermometers: Trerice Model V80445 or Ashcroft Series 600A-04, dial type, Mil Spec MIL-T-9955, 4-1/2" diameter face. Hot water system thermometers shall have a range of 30°F to 240°F with 2° increments. Provide with brass thermometer wells projecting a minimum of 2" into the pipe with extension to face of insulation. Provide with heat transfer fluid to fill the sealed interstitial space between bulb and well. Evidence of the transfer fluid leaking shall be cause for refilling and sealing the well.
- B. Pressure Gauges: Trerice Series 800 or Ashcroft Type 1005, Grade B, ANSI B40.1, 3-1/2" diameter face installed with shut off petcock and restrictor. Pressure range: 0-50 psig with 5 psi graduations, 0-100 psig with 10 psi graduations for chilled water pumps.
- C. Expansion Tanks (Captive Air Type) (ET): Taco Model as scheduled, tank shall be of capacity indicated and shall be welded steel, constructed and tested hydrostatically in accordance with Section VIII of the ASME Boiler Pressure Vessel Code. The tank bladder shall be butyl rubber and shall be removable for inspection. Tank shall have air charging and system connections, and shall be factory pressurized.
- D. Strainers: Watts Model 77S, MIL-S-16293, 125 psig minimum rating wye strainers, cast iron or bronze body, screen shall be stainless steel, monel or bronze with 20 mesh perforations. Provide with blowdown ball valve and 3/4" hose connection.

- E. Automatic Air Vents: Armstrong No. 1-AV, float type to vent air in hydronic systems. Vent constructed with cast iron body and stainless steel internals and with NPT male inlet and outlet for 1/4 inch overflow for safe water connection. 150 psi working pressure, 250°F maximum temperature.
- F. Tangential Air Separator (AS): Taco model 4900-AD, or Spirovent, as scheduled, steel construction, designed for not less than 125 psig and constructed and tested in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code. Tank shall have fabricated connections, screwed for sizes 2" and smaller, flanged for sizes 2-1/2 inches and larger. Separators shall be factory prime-painted. Each air separator shall have an internal design suitable for creating the required conditions for optimal air separation and microbubble removal. Provide fittings for connection of automatic air vent and for connection of manual blow-down valve.
- G. Manual Air Vents: Brass body, fiber discs, 125 psi working pressure, 240°F maximum temperature, adjustable for quick venting at system start-up.
- H. Circulator (inline) (CP): Taco model indicated, pumps shall be inline cartridge-type or close coupled pump of capacity and performance indicated with cast-iron body and bronze-fitted, 175 psig rated working pressure, 220°F maximum water temperature, carbon Ni-resist mechanical seal, flexible coupling, resilient-mounted drip-proof sleeve bearing motor. The pumps shall be factory tested, cleaned, and painted with machinery enamel. A set of installation instructions shall be included with the pump. Provide high efficiency motors if available as an option of the manufacturer. If high efficiency motors are not available as an option of the manufacturer, submit a certification stating same. Main hot water supply circulators shall be provided with inverter-duty motors for use with variable frequency drives.
- I. Circulator (base mounted, close-coupled): Taco model indicated, Bell and Gossett, Patterson, or approved equal, base mounted pumps shall be single stage, vertical split case end suction design, cast iron body bronze fitted construction. The impeller shall be of the enclosed type, dynamically balanced, keyed to the shaft and secured with a locknut. Pump seal shall be single mechanical seal with carbon seal ring and ceramic (or tungsten steel) seat. A replaceable shaft sleeve shall be furnished to cover the wetted area of the shaft under the seal. The bearing frame assembly of the pump shall be fitted with regreasable ball bearings. The pump and motor shall be mounted on a common steel baseplate with welded cross members and open grouting area. The pumps shall be factory tested, cleaned, and painted with machinery enamel. A set of installation instructions shall be included with the pump. Following the completion of testing and balancing, provide pump impeller trim to match impeller size to the operating conditions. Motors shall be premium high efficiency type, open drip-proof or TEFC by Baldor, Magnetek or Toshiba. Motor efficiencies shall comply with the Consortium for Energy Efficiency Standard and be inverter-duty rated. Base-mounted pumps shall have the impellers trimmed to match system design parameters as determined by the Balancing Contractor and Commissioning Agent.
- J. Manual Circuit Balance Valves: Taco "Accu-Flo".
 - 1. Bronze or brass body and internals, teflon seats, 300 psi working pressure, 250°F working temperature. Balancing devices shall be adjustable and shall have provisions for connecting a portable differential pressure gauge. Each balancing device shall be sized to provide a differential pressure reading between 2 and 5 feet with the valve full open at design flow rates.

2. Install per manufacturer's recommendations for adjacent length of straight pipe.
 3. Shop drawings shall indicate gpm, size, wide open differential pressure meter reading, and actual water pressure drop.
 4. At the Contractor's option, balancing valves with combination shut-off - balancing - drain provisions may be used in lieu of the individual components indicated. The balancing valve shall be furnished with a memory stop feature so that the valve can be correctly returned to the balance position after serving the stop function
- J. Water Pressure Reducing Valve: Pressure Reducing Valves: Watts Regulator series U5-Z3 bronze body, bronze and stainless steel internals, 300 psi working pressure, 160°F maximum temperature, adjustable pressure range of 25-75 psig, with inlet strainer (screen). Valves used for make-up water applications shall have suffix "LP" and be rated for an adjustable pressure range of 10-35 psig.
- K. Flexible Connectors at Pumps and at Coils: Multi-layer neoprene-nylon cord fabric twin-sphere connectors with flange ends, rated at 150 psig at 220°F. Sizes 1-1/2" to 2-1/2": 6" long, sizes 3" to 6": 9" long, line size. Provide pump connectors at the suction and discharge piping of each base-mounted pump. Pump connectors shall have tie rods.
- L. Temperature and Pressure Test Ports: Peterson Equipment Co. Model 110 "Pete's Plugs" temperature and pressure test capability, brass body, 1/4" NPT fitting, Nordel valve cores, 275°F maximum temperature, 500 psig maximum pressure. Provide with (1) pressure and temperature test kit.
- M. Automatic Flow Control Valves: Flow Design, Inc., Autoflow Model AC (up to 2") and Model WS (larger than 2"), Nexus "UltraMatic", Griswold, or approved equal. The valves shall be factory set to maintain the specified flow rates within +/- 5% over an operating range of 2-32 psid. Each valve shall have a five (5) year warranty and free first year cartridge exchange. The internal wear surfaces of the valve cartridge shall be electroless nickel or stainless steel. The valve body shall be forged brass and permanently marked with the flow rate and spring range. Minimum pressure and temperature ratings shall be 400 psig at 250EF. Valve accessories shall include a union, ball valve and integral strainer. Installation shall be in accordance with the manufacturer's recommendations. The ball valve shall have a teflon packing, brass packing nut and blowout-proof stem, large diameter plated ball and a full size steel handle with vinyl grip.
- N. Triple Duty (Multi-Purpose Valves): Shall be Taco MPV, Armstrong or Bell and Gossett. The multi-purpose valves shall incorporate a combination gate valve, metering valve, balancing valve and non-slam check valve in one valve body. Construction shall be cast-iron body, stainless steel stem sleeve, cast iron, non-lubricated plug and brass seat with "O" ring seal. The design working pressure shall be 175 psig and temperature rating shall be 240°F.
- O. Batch Chemical/Glycol Feeders: Shall be J.L. Wingert Co. Model DB-18HD, Northeast Mechanical Model SF-25, Cemline, Ace or approved equal, 18 gallon minimum capacity, 3/4" inlet and outlet threaded tappings as required, mild carbon steel construction with primed exterior, 125 psig construction with valved and capped funnel fill and 3/4" drain valve with hose connection. Furnish with ball valves, unions, bushings and leg supports.
- P. Seismic Connectors: Seismic connectors shall be FlexHose "TriFlex Loop", or approved equal, UL536-listed.

- Q. Suction Diffuser: Victaulic 731-series, Taco Model RSP or Bell and Gossett. Stainless steel start-up strainer and magnetic insert shall have a total free area equal to 2 times the area of the pump suction. Remove the start-up strainer after 72 hours of continuous operation.

2.7 GAS-FIRED BOILER/BURNER UNITS

- A. Boilers shall be high efficiency, sealed combustion, direct vent condensing type. The manufacturer shall be Hydrotherm "KN", Aerco "Benchmark", or approved equal suitable for natural gas (2" w.g.). The minimum rated working pressure shall be 75 psig. Boiler-burners shall be Model and size as scheduled. Thermal efficiency shall be a minimum of 90%. Direct vent boilers shall be Energy Star compliant.
- B. Provide AL29-4C stainless steel venting and Schedule 40 PVC condensate drain piping installed in accordance with the manufacturers' recommendations.
- C. Accessories shall include floor support stand or reinforced concrete pad, 75 psig ASME rated pressure relief valves, thermostatic, operating aquastat, insulated combustion air intake ductwork, low water cut-off, condensate neutralization kit and flow switch and associated wiring.
- D. Provide boilers with packaged controls system capable of coordinating two (2) boilers, boiler circulating pumps, main circulating pumps, indirect fired water heater pumps, outdoor air reset, pump relay for freeze protection. Packaged controls shall include 2-line, 16-character LCD display and shall be capable of displaying number of cycles, hours of operation and time since last service. (See Specification Section 230900 for control sequence).
- E. The boiler/burner units shall be started and adjusted by a factory representative who shall submit an efficiency report for Engineer review.
- F. Provide firestats, emergency shut-off switches, and service switches as required by NFPA 54, including associated wiring.

2.8 FINNED TUBE RADIATION (FTR-#)

- A. Finned tube radiation (FTR) shall be of manufacturer, type, size, and capacity scheduled.
- B. Finned Tube Radiation (Wall Hung and Pedestal): Heating elements shall have aluminum fins with integral fin collars mechanically bonded to the tube. Provide element mounting system consisting of wall mounted mounting brackets and pipe cradles on 4' centers. Cradles shall run on nylon guides for noiseless operation. Enclosures shall be 18 gauge steel or as indicated, shall be continuous, and shall mount to a continuous channel mounting strip at the top of the enclosure. The bottom of the enclosure shall fasten to the pipe mounting brackets. Provide a continuous urethane gasket between the top mounting channel and the wall to prevent dust streaking. Provide end caps, corner pieces, access panels and enclosure extensions as required. Provide factory enamel finish - color by Architect.
- C. Finned tube radiation located in "wet" environments" such as bathrooms or laundry areas shall have aluminum cover similar to Sterling DesignLine Series.

- D. Manufacturer's local representative shall provide a schedule of all elements for the project. The room by room schedule shall include the design information, heating outputs (btuh) with all correction factors included, element lengths, cover lengths and accessories.

2.9 WALL HEATERS (WH-#)

- A. WH 1 Shall be Smith's Environmental Products, or approved equal, Model KS2008, 7.9 MBH with 1.0 GPM, 180F. EWT, 65F. EAT, 120V.
- B. WH2 shall be Smith's Environmental Products, or approved equal, Model PSU 23, fan convector, 12.1 MBH with 2.0 GPM, 180F. EWT, 65F. EAT, 120V., low speed operation.
- C. Provide low temperature aquastats and two-speed fan switches.

2.10 FANS (SF-#, EF-#)

- A. Shall be model indicated. The fan shall include housing, fan wheel, shaft, bearings, inlet shroud, motor, mounting support and mounting frame as a factory-assembled unit. An OSHA-approved belt guard shall be included. The fan drive shall have a 1.5 service factor for the maximum rated horsepower. Each fan shall incorporate a backdraft damper or one shall be installed at the discharge (louver).
- B. Bearings shall be precision, flange-mounted self-aligning ball bearings at inlet and discharge. Grease lines shall extend to the exterior of the fan housing.
- C. Submit sound power data for inlet and discharge sound.
- D. Submit fan curves for each fan with the design operating point clearly marked.
- E. Furnish accessories as noted on drawings.
- F. Roof fans and duct penetrations thru the roof shall have 12" high insulated pre-fabricated and self-flashing insulated curbs by Conn-Fab, or approved equal. Provide a suitable foam gasket between the curb and fan base to seal airtight.

2.11 CABINET UNIT HEATERS (CUH-#)

- A. Construction:
 - 1. Cabinet unit heaters shall be manufactured by the Trane Co., Sterling, Vulcan or American Air Filter. Unit configuration shall be inverted airflow, ceiling-mounted, wall-mounted or floor-mounted as indicated. Cabinets shall be surface-mounted, semi-recessed or fully-recessed, as indicated. Coils shall be copper tube mechanically expanded into aluminum fins and pressure rated at 200 psig at 250°F. Fans shall consist of multiple squirrel cage blowers on a common shaft. Coils shall be certified in accordance with ARI Standard 410. Casings shall be galvanized steel. Cabinets shall be finish painted in a factory-applied baked enamel with color selection by the Architect.
 - 2. Furnish units with a 3-speed fan switch, disconnect switch and throwaway dust filter (with 2 spare sets per unit).

- B. Performance:
 - 1. Performance and capacity shall be as scheduled.

2.12 X-PUMP BLOCK (SNOWMELT SYSTEM)

- A. The snowmelt system shall consist of a Taco Model XPB-1 heat exchanger and variable speed pump package designed for use with and filled with 50% propylene glycol and water. Furnish with electronic controls designed for snowmelt applications.
- B. Furnish with expansion tank and pressure relief valve for the system (snowmelt) side.

2.13 RADIANT MIXING BLOCK (RADIANT FLOOR SYSTEM)

- A. The radiant floor system shall include a Taco Model RMB-1 variable speed pump package designed for use with radiant floor heating systems. Furnish with electronic controls designed for radiant floor applications.

2.14 TOTAL ENERGY HEAT RECOVERY EQUIPMENT (ERV-#)

- A. Shall be Greenheck, Semco, DesChamps, or approved equal, with capacities and performance as scheduled. The heat recovery equipment shall be a factory assembled and tested package, constructed and rated in accordance with ARI, AMCA and UL. System components shall include fan(s), air-to-air heat exchangers, dampers, hot water heating coil, filter sections, motor starters, electric preheat defrost system, welded structural steel base, non-fused disconnect switches, roof curb, modulating wheel control, unit control package and double-wall, insulated airtight casing with interior sheetmetal liner. The casing shall have 1" thick (minimum) 3.0 pcf fiberglass thermal insulation. A minimum of ten (10) feet of separation shall be provided between the outside air intake and exhaust outlet.
- B. The air-to-air "total energy" heat recovery units shall be a rotating enthalpy wheel (molecular sieve design or desiccant) or static plate core capable of sensible and latent energy transfer. Rotating wheel exchangers and drives shall include a purge section and a five (5) year replacement warranty for materials and labor. The exterior casing shall be constructed of galvanized steel, weathertight, phosphatized and painted with a finish coat of epoxy paint (Greenheck "Permatecor", or approved equal).
- C. Fans shall be DWDI forward curved or airfoil blade or plenum fan with variable pitch belt drives selected at 1.5 times the maximum rated motor horsepower. Motors shall be mounted on an adjustable slide base. Motors shall be premium high efficiency, inverter-duty rated. Motor performance shall comply with the 2009 American Recovery and Reinvestment Act. Fan bearings shall be regreasable tapered roller pillow block bearings with an L10 life of 200,000 hours. Provide extended lubrication lines for each bearing. Fans shall have seismic rated 2" static deflection spring vibration isolators. All serviceable components shall be readily accessible via hinged (stainless steel) and latched fully gasketed quick release access doors.
- D. Supply and exhaust prefilters shall be 2" thick, 80-85% efficient (MERV13) extended surface pleated media disposable type by Farr, or approved equal. Furnish a total of two (2) complete sets of filters for each filter bank.

- E. Drain pans shall be insulated double-sloped stainless steel with drain connections. Provisions shall be made for bypassing the heat exchanger, reducing the speed of the wheel (VFD) or otherwise reducing the recovered heat on a call for cooling of the supply airstream (economizer cycle).
- F. Dampers shall be galvanized steel, airfoil blade, Ruskin Model CD60, or approved equal, "ultra low leak" type. Blade seals shall be neoprene and jamb seals shall be compressible aluminum or stainless steel. Insulated, motorized backdraft dampers and actuators with end switches shall be provided for the supply and exhaust fans.
- G. Electrical work shall be in accordance with the National Electrical Code (NFPA 70) and shall include motor starters and junction boxes. Wiring shall be in galvanized steel or liquidtight conduit. A single point electrical connection shall be provided.
- H. Controls shall include the following: enthalpy economizer controller, wheel rotation sensor, electric preheat wheel frost control, dirty filter sensor for outdoor and exhaust filters and modulating wheel discharge control. The controller shall be a direct digital controller (DDC) with BacNet, Modbus or LonWorks interoperability protocol and communications with the Building Automation System (BAS).
- I. The heat recovery units shall be started up and their operation verified by an authorized representative of the equipment manufacturer and the commissioning agent during the commissioning process.
- J. Coils: Capacities and pressure drops shall be rated in accordance with ARI 410. Coils shall be pressure tested at 300 psig and shall be suitable for 150 psig service.
 - 1. Heating and Cooling Coils: Copper tubes, aluminum fins and copper headers. Casings shall be 16 gage galvanized steel.
 - 2. Provide internal piping connections for rooftop installations.
- K. Provide space in the unit cabinet for a future DX cooling coil for dehumidification and a hot gas reheat coil, upstream of the hot water heating coil.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

- A. Inspection:
 - 1. Prior to work of this Section, carefully inspect the installed work of other trades and verify that such work is complete to the point where this installation may properly commence.
 - 2. Verify that the heating system may be installed in accordance with pertinent codes and regulations and the reviewed Submittals.

3.2 INSTALLATION OF PIPING

- A. In general, piping shall be run concealed above ceilings in occupied areas. Piping in other areas may be run exposed. Piping shall not be exposed in occupied spaces unless written authorization is given by the Architect.

- B. Provide and erect in accordance with the best practice of the trade piping shown on the Drawings and as required to complete the intended installation. Make offsets as shown or required to place piping in proper position to avoid other work and to allow the application of insulation and finish painting to the satisfaction of the Architect.
- C. The size and general arrangements, as well as the methods of connecting piping, valves, and equipment, shall be as indicated, or so as to meet the requirements of the Architect.
- D. Piping shall be erected so as to provide for the easy and noiseless passage of heating fluid under working conditions. Inverted eccentric reducing fittings shall be used whenever water pipes reduce in size.
- E. Water mains shall be run level or pitch slightly upward so that no air pockets are formed in the piping. The mains shall be set at elevations such that the runouts feeding equipment shall have no pockets where air can collect except where vents are provided. Provide drains at low points in the piping systems.
- F. High points in water piping shall be provided with manual vents.
- G. In the erection of water piping, make proper allowances for expansion and contraction. Piping shall be anchored as necessary to control expansion. Hot water runouts to units shall be the size as indicated on the Drawings and shall come off the main downward or off the side with a minimum of two 90° elbows provided on runout from main.
- H. Install stop valves and unions to facilitate isolation and removal of equipment. Provide final connections for hydronic specialties furnished under other sections of the Specifications.
- I. Steel piping with screwed connections. Threads on piping shall be full length and clean-cut with inside edges reamed smooth to the full inside bore. Close nipples shall not be used. Pipe threads: standard pipe threads, machine cut and full length. Pipe: reamed to remove burrs and up-ended and rapped to dislodge dirt and scale. Joint compound shall be applied to male thread only. If it is necessary to back off a screwed joint after it is made, the thread shall be cleaned and new compound applied. Caulked threads will not be permitted.
- J. Connections between copper and steel piping shall be made with bronze fittings.
- K. Install thermometer wells for temperature gauges and sensors, projecting a minimum of 2" into the pipe with extension to face of insulation. Piping 1-1/2" and smaller shall be enlarged to 2" where wells are installed. Wells shall be installed in active sections of piping. Fill wells with heat transfer fluid.
- L. Solder joints shall be made with non-lead solder. Clean surfaces to be soldered and use a paste flux. Wash joints with sodium bicarbonate and water to remove corrosive effects of heated solder paste. Hot wipe solder at each fitting.
- M. PVC piping shall have solvent welded joints except at connections to equipment and valves which shall be screwed for sizes 2" and smaller and flanged for sizes 2-1/2" and larger. Solvent welded joints: Pipe ends deburred, and beveled. Pipe end and fitting: Cleaned and dried, primed to soften bonding surfaces. Pipe end: Apply even full layer of solvent cement after priming. Before cement starts to set, insert pipe end into fitting and turn 1/4 turn to

evenly distribute cement. Hold joint together until cement sets-up, wipe excess cement off joint.

- N. Pipe penetrations through walls, floors and ceilings shall be in accordance with Section 23 05 00 "Common Work Results for HVAC". Traverse points of piping shall be escutcheoned with split chrome floor and ceiling plates and spring anchors, where visible to occupancy.
- O. Automatic Air Vents: Shall be installed with a manual isolation valve. The vent discharge shall be piped to a local floor drain.

3.3 PIPE HANGERS

- A. Impact driven studs are not acceptable.
- B. Pipes (copper or steel) shall be supported at intervals and rod sizes as follows, double nuts on hangers and on beam clips.

Pipe Size	Hanger Intervals	Rod Sizes
1/2"	5'	3/8"
3/4"	6'	3/8"
1"	7'	3/8"
1-1/4"	8'	3/8"
1-1/2"	9'	3/8"
2"	10'	3/8"
2-1/2"	11'	1/2"
3"	12'	1/2"

- C. Verticals: Supported at the base and at intervals as follows by use of clamp hangers:

Steel Pipe: Not more than 16 ft.

Copper Pipe and Tubing:

1-1/2" and larger - Not more than 12 ft.

1-1/4" and smaller - Not more than 6 ft.

- D. Provide welded steel saddles at each hanger on steel piping systems 4" and larger.
- E. PVC Piping: Supported at 4' intervals.
- F. Spring Isolators: All piping within 20' upstream and downstream of the pumps.

3.4 INSTALLATION OF BOILERS

- A. Assemble boiler sections, jacketing, burner, combustion controls, operating controls, and safety controls per NFPA-54 and manufacturer's instructions. Provide boiler interconnecting power and control wiring. Hydrostatically test the boiler for leaks prior to installation of jacketing. Repair leaks and retest as required.
- B. The boiler/burner units shall be started and adjusted by a factory representative in the presence of the Architect. The factory representative shall provide a field efficiency report to

the Engineer at the completion of the start-up. The report shall include, but not be limited to:

- CO₂ reading (%).
- Stack draft (in W.G.).
- Stack temperature, room temperature.
- Combustion efficiency (%).

Incorporate the field test results in the "Operations and Maintenance" manuals.

Charge hot water heating system with corrosion inhibitor per manufacturer's recommendations. Concentrations shall be based on a system temperature of 200°F and shall be the high end of the manufacturer's recommended concentration range.

3.5 CLOSING IN WORK

- A. Cover up or enclose work after it has been properly and completely tested and reviewed.
- B. No additional cost to the Owner will be allowed for uncovering or recovering any work that is covered or enclosed prior to required test and review.

3.6 TEST AND ADJUST

- A. Piping Systems: Test with water to a pressure of 75 psi and hold for a period of two hours. Repair any leaks and retest the piping system; repeat process until systems are leak-free. Test piping before it is insulated.
- B. Before operating any system, flush the piping to remove oil and foreign materials.
- C. After the installation is complete and ready for operation, test the system under normal operating conditions in the presence of the Architect and demonstrate that the system functions as designed.
- D. Demonstrate that the HVAC systems have free and noiseless circulation of water, that all air has been purged and that systems are watertight.
- E. Correct defects which develop in operational testing, conduct additional testing until defect free operation is achieved.
- F. Provide balancing and adjusting of terminal devices in accordance with Specification Section 23 05 93.

3.7 CLEANUP AND CORROSION PREVENTION

- A. Piping and equipment shall be thoroughly cleaned. Dirt, dust, and debris shall be removed and the premises left in a clean and neat condition.
- B. Before covering is applied to piping systems, clips, rods, clevises and other hanger attachments, and before uncovered piping is permitted to be concealed, corrosion and rust shall be wire brushed and cleaned and in the case of iron products, a coat of approved protective paint applied to these surfaces. When corrosion is from the effects of hot solder paste, the areas shall be cleaned and polished and a wash of bicarbonate of soda and water used to neutralize the acid condition.

3.8 INSTRUCTIONS

- A. On completion of the project, instruct the Owner's representative in the care and operation of the system. The total period of instruction shall not exceed four (4) hours. The time of instruction shall be arranged with the Owner. In addition to the prime Mechanical Contractor, the control system Contractor, Balancing Contractor, and Owner's representative shall be present and participate in the Owner's instruction.

* END OF SECTION *