

---

SECTION 15700 - 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, ventilating and air conditioning systems indicated.

1.2 RELATED DOCUMENTS

- A. The drawings and the specifications including SECTION 15000 "SUPPLEMENTAL MECHANICAL GENERAL REQUIREMENTS" are hereby made a part of the work of this section.

1.3 SUBMITTALS

- A. Substitutions: Your attention is directed to Section 15000-"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 15000, Supplemental Mechanical General Requirements, apply are as follows:

1. Piping materials.
2. Fittings for steel pipe.
3. Hangers.
4. Piping, valve and equipment identification.
5. Valves.
6. Hydronic specialties and expansion joints.
7. Gas-fired boilers.
8. Hot water and chilled water circulating pumps.
9. Unit Heaters, kickspace heaters and wall heaters.
10. Cabinet unit heaters.
11. Fans.
12. Mini-Split-System air conditioning units (SAC-1.2 and SCU-1.2).
13. Vibration isolation and sound attenuation.
14. Fintube radiation.
15. Firestopping materials and methods.
16. Air-cooled chiller.
17. Air-cooled condensing unit (CU-1) (Alternate No. 3).
18. Spring vibration isolation hangers.
19. Packaged total energy recovery units (ERV1, 2, 3).
20. Propylene glycol antifreeze.
21. Electric heat trace.
22. Chilled water storage tank.
23. Electric heating equipment.

---

PART 2 PRODUCTS

2.1 PIPING MATERIALS

- A. Hot Water Heating Piping: 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, or Schedule 05 carbon steel pipe up to 2" with the Victaulic "Pressfit" fitting system. Type "L" copper tube with soldered joints is an acceptable alternate.
- B. Drain Pan Condensate Piping: Type L hard copper tubing and cast bronze or wrought copper solder fittings or Schedule 40 PVC.
- C. Chilled Water Piping (above grade): Type SDR 26 pressure-rated (160 psig rated working pressure) PVC with solvent-welded joints and Schedule 80 fittings
- D. Refrigeration Piping: See Paragraph 3.2.
- E. PEX piping: Wirsbo, or approved equal, cross-linked polyethylene plastic.
- F. Generator Exhaust Piping: Schedule 40 carbon steel with welded joints.

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.
  - 4. Victaulic "Pressfit" system.
- 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. Above Grade Hot water piping only: 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 (Hot water and chilled water piping only): 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.
- 2.4 VALVES
- A. Ball Valves: Hammond or Apollo 70-100 Series, bronze body, Fed. Spec. WW-V-35, Type II, Class A (bronze), Style 3, blow-out proof stem, 600 pound W.O.G., screwed connection for steel pipe, sweat connection for copper tube. Provide stem extension to allow operation without interfering with pipe insulation. Provide Tee handles for valves thru 2" pipe size.
- B. Gate Valves: Hammond or 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. Outside Screw and Yoke (OS&Y) Gate Valves: Hammond or Nibco Model F-617-0, iron body, Fed. Spec. WW-V-58 with bronze trim, 125 pound class.
- D. Check Valves: Hammond or Nibco Model S-413 or T-413, bronze body Fed. Spec. WW-V-51, regrinding swing check type, 200 pound class.
- E. Butterfly Valves: Hammond, 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 by Seton or Setmark indicating flow direction and fluid flowing for the following:

Hot Water Supply Piping	Chilled Water Return Piping
Hot Water Return Piping	
Refrigerant piping	
Chilled Water Supply 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.
3. Piping identification shall be color-coded and in accordance with ANSI.

- B. 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.

- C. 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 Resident.
4. Tags and charts shall be coordinated with Section 15400 Plumbing and when completed this work shall have been done sequentially.

## 2.6 HYDRONIC SPECIALTIES AND EXPANSION JOINTS

- A. Thermometers: Tel-Tru Model D5A-series battery operated, or Ashcroft, 5" round dial, adjustable angle, Type 304 stainless steel case. The digital display shall include 1" high LCD digits. The thermometer display shall be in <sup>0</sup>F. and have a minimum battery life of five (5) years. Accuracy shall be +/- 1% of the displayed value or 1<sup>0</sup>, whichever is greater. 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: Tel-Tru, or Ashcroft Type 1005, Grade B, ANSI B40.1, 3-1/2" diameter face installed with shut off petcock and restrictor. Pressure range: 0-60 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 to 18 psig.
- 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 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 tangential (ONLY) connections, screwed for sizes 2" and smaller, flanged for sizes 2-1/2 inches and larger. Each air separator shall have an internal design suitable for creating the required vortex and subsequent air separation. 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 premium high efficiency motors. 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.
- I. Circulator (base mounted): Taco model indicated, 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. A flexible coupler, shall be provided between the pump and motor, and shall be equipped with a suitable coupling guard. 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.

- 
- J. Suction Diffuser: Taco. Start-up strainer and magnetic insert shall have free area equal to 5 times the area of the pump suction. Remove the start-up strainer after 72 hours of continuous operation.
- K. Circuit Balance Valves: Taco "Accu-Flo" circuit setter.
1. Bronze or brass body and internals, teflon seats, 175 psi working pressure, 250°F working temperature. Balancing devices shall be adjustable and shall have provisions for connecting a portable differential pressure gauge for flow measurement. 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. Circuit balance valves shall be suitable for tight shut-off with memory stop feature.
- L. Water Pressure Reducing Valve: Watts Regulator series U5LP bronze body, bronze internals, 200 psi working pressure, 180°F maximum temperature, adjustable pressure range 10-35 psig. Provide with inlet strainer (screen).
- M. Flexible Connectors at Pumps: 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. Furnish with control rods if recommended by the manufacturer.
- N. 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.
- O. Flexible Connections at Coils: Mason type BSS line size with male nipples for 2" and smaller, flanged for 2-1/2" and larger. Provide series EM-RF-150 for application of extreme movement (3/4") or misalignment (1-1/2").
- P. Automatic Flow Control Valves: Flow Design, Inc., Autoflow Model AC (up to 2") and Model WS (larger than 2"), 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 250°F. Valve accessories shall include a union and pressure and temperature test ports. 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. Provide an automatic flow control valve for each terminal heating and cooling unit as indicated on the drawings.
- Q. Triple Duty Valve: Taco MPV, cast-iron body, 200 psig rating, lockable in position and incorporating a non-slam silent operating check valve, flow measuring ports and positive shut-off valve with position indication.
- R. Expansion joints: Shall be Proco Model 240 / 242, non-metallic expansion joints with an engineered molded style twin sphere designed bellows. Construction shall be EPDM rubber with stainless steel flanges, suitable for maximum operating temperatures of 230°F.

- S. Batch Chemical/Glycol Feeders: Shall be Griswold Model CBF-10GE, Cemline, Ace or approved equal, 10 gallon minimum capacity, 3/4" inlet and outlet threaded tappings as required, mild carbon steel construction with primed exterior, 125 psig ASME construction with valved and capped funnel fill and 3/4" drain valve with hose connection. Furnish with valve and pedestal support stand package.
- T. Spring Vibration Isolation Hangers: Shall be Mason Industries Model PC30N, Vibration Mountings and Controls or Amber-Booth.

## 2.8 GAS-FIRED BOILER/BURNER UNITS

- A. Boiler(s) shall be pressurized wet base cast iron sectional, type and model indicated. The manufacturer shall be H.B. Smith, Weil-McLain or Burnham. The rated working pressure shall be 70 psig. The natural gas burners shall be Webster, "fully modulating" control, flame retention type. Furnish with UL-listed gas train sized for the available gas pressure.
- B. Primary controls shall include flame detection circuit with manual reset and modulating firing rate controller with fuel-air control. Safety controls shall include a McDonnell-Miller manual reset electronic probe-type low water cut-off, Series 750 (150 psig), 20,000 ohms sensitivity with test switch, NEMA 1 enclosure, and manual and automatic reset high limit aquastats.
- C. The boiler/burner unit(s) shall be furnished with a factory fabricated burner mounted control panel (mounted on top of the burner) housing control components and terminal strip including: programming control, service switch, low fire hold switch, manual reset high limit, fused power supply and control power transformer. Provide an interface for remote alarms for flame failure and low water. The burner programming control shall provide a fully modulating firing sequence. The burner management / firing rate controller shall be Autoflame Mark VI microprocessor-based and designed to maximize the fuel to air ratio.
- D. Accessories shall include 70 psig ASME rated pressure relief valves, theraltimeter, operating aquastat, boiler return yoke and barometric dampers.
- E. Furnish stack thermometer with stainless steel bulb and 4" minimum scale, range of 50-750°F.
- F. The boiler/burner unit(s) shall be started and adjusted by a factory representative who shall submit an efficiency report for Engineer review.
- G. Provide firestats, emergency shut-off switches, and service switches as required by NFPA 54.

## 2.9 CABINET UNIT HEATERS

- 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, wall-mounted, ducted 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 250F. 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.

2.10 HORIZONTAL UNIT HEATERS

- A. Horizontal unit heaters shall be manufactured by the Trane Co., Sterling, Vulcan or American Air Filter. Coils shall be copper tube mechanically expanded into aluminum fins and pressure rated at 200 psig at 250F. Fans shall consist of a single blower. 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.
- B. Furnish with factory-mounted disconnect switch.

2.11 TOTAL ENERGY HEAT RECOVERY EQUIPMENT

- A. Shall be Greenheck, AEX, 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, filter sections, drain pans, motor starters, defrost system, welded structural steel base, non-fused disconnect switches 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. Floor openings shall have safety grates.
- 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 inside and out (Greenheck "Permatector", 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. 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 gasketted quick release access doors.
- D. Supply and exhaust prefilters shall be 2" thick, 30-35% efficient extended surface pleated media disposable type by CamFarr, or approved equal. Furnish a total of three (3) complete sets of filters for each filter bank. Provide Dwyer "Magnehelic" differential air pressure gauges across 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 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. Motorized backdraft dampers and actuators with end switches shall be provided for the supply and exhaust fans. Intake and exhaust duct connections shall be provided.

- G. Electrical work shall be in accordance with the National Electrical Code (NFPA 70) and shall include motor starters, junction boxes, duplex weatherproof GFCI receptacles, and vapor-tight marine lights in each compartment. Provide switches with pilot lights. Wiring shall be in galvanized steel or liquidtight conduit. A single point electrical connection shall be provided.
- H. Controls shall include the following: enthalpy controller, wheel rotation sensor, modulating wheel frost control, "unoccupied" cycle recirculation damper(s) and controls, dirty filter sensor for outdoor and exhaust filters. Furnish each unit with remote panel(s) with indicator lights, programmable electronic time switch and "summer-winter" switches.
- I. Coils, fans and other individual ferrous and aluminum components shall be coated with a baked phenolic (Heresite) corrosion resistant coating suitable for a marine environment.
- J. 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.
- K. The heat recovery units shall be in compliance with ASHRAE/IESNA Standard 90.1-2001, "Energy Standard for Buildings Except Low-rise Residential Buildings" and all current addenda based on standard rating conditions per ARI Standard 340/360.

#### 2.12 FANS

- A. Shall be model indicated. Fan manufacturers shall be Greenheck, Cook or equal. The fans 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 for each fan shall be included. The fan drive shall have a 1.5 service factor for the maximum rated horsepower. Provide a disconnect switch for each fan. Roof fans shall have a factory-applied epoxy coating with color selection by the Architect. Provide gravity-operated backdraft dampers for all exhaust fans.
- B. Bearings shall be precision, flange-mounted self-aligning ball bearings at inlet and discharge. Minimum average L50 design life shall be 200,000 hours at maximum catalogued operating conditions. 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. Spring Type Vibration Isolators: Mason Industries Model HS, select for 1.5" static deflection. Provide for all fans that are not curb-mounted.

#### 2.13 AIR-COOLED CHILLER

- A. The chiller shall be McQuay, or approved equal, 480v.-3 phase, with capacities, dimensions and performance as scheduled, based on a 35% mixture of propylene glycol and water. The unit shall be a complete package suitable for mounting outdoors on a structural steel frame. The unit shall ship with a full charge of refrigerant and oil. Panels, structural elements and control boxes shall be constructed of 12 gauge galvanized steel, mounted on a welded structural steel base. The unit shall be finished with a weather-resistant baked on finish. The air-cooled chiller shall be supported by prefabricated structural equipment rails by ConnFab or Kees, galvanized steel, 12" high.
- B. The evaporator shall be a tube-in-shell heat exchanger design with internally finned copper tubes expanded into the tube sheet. The evaporator shall be designed, stamped and tested in accordance with ASME for a refrigerant side working pressure of 300 psig. The evaporator shall be rated at 215 psig

working pressure. The evaporator shall be insulated with a 3/4" thickness of Armaflex II insulation. A heat tape and thermostat shall be provided for freeze protection.

- C. The air-cooled condenser shall have aluminum fins mechanically bonded to internally finned seamless copper tubing. The condenser shall be provided with an integral subcooling circuit and provide oil cooling for the compressor bearing and injection oil. The condenser shall be factory proof and leak tested to 506 psig. The condenser fans shall be direct-drive vertical discharge and be dynamically balanced. Fan motors shall be 3-phase with permanently lubricated ball bearings and internal thermal overload protection. The unit shall be capable of starting and operating at ambient temperatures as low as 25°F.
  - D. The scroll or reciprocating compressor(s) shall be hermetic, direct-drive, 3600 rpm, oil pump and oil heater. The motor shall be suction gas cooled, hermetically sealed, two-pole squirrel cage induction type. The oil separator and filtration devices shall be separate from the compressor.
  - E. A minimum of two(2) independent refrigerant circuits shall be provided. Each circuit shall include a compressor suction and discharge service valve, liquid line shutoff valve, removable core filter drier, liquid line sight glass with moisture indicator, charging port and electronic expansion valve to provide capacity modulation.
  - F. Controls shall be factory installed and tested and the entire electrical system UL-listed. Operating controls shall be microprocessor-based and be capable of interfacing with the Building Automation System (BAS) for "Enable-Disable-Status". Control functions shall include start-up and shut down, leaving chilled water temperature control, compressor and electronic expansion valve modulation, fan sequencing, anti-recycle logic, automatic lead/lag compressor starting and load limiting. Safety controls shall include loss of chilled water flow, evaporator freezing, loss of refrigerant, low refrigerant pressure, high refrigerant pressure, reverse rotation, compressor starting and running over current, phase loss, phase imbalance, phase reversal and loss of oil flow. A digital display and keypad shall provide access to all information and values.
  - G. The motor starter shall be solid state, reduced voltage or part-winding type located in a weathertight enclosure. The unit shall have a single point electrical service. Sound performance shall be rated in accordance with ARI 370, "Sound Rating of Large Outdoor Refrigeration and Air Conditioning Equipment".
  - H. Accessories shall include a non-fused disconnect switch, housed galvanized or coated spring isolators, acoustical package, extended warranty, Building Automation System interface and low ambient lockout. A factory-authorized service company shall provide start-up and field testing of the chiller.
  - I. The condenser fins shall be copper or be coated with "Heresite" baked phenolic anti-corrosion coating, suitable for a marine environment.
  - J. The chiller and rated EER and IPLV shall be in compliance with ASHRAE/IESNA Standard 90.1-2001, "Energy Standard for Buildings Except Low-rise Residential Buildings" and all current addenda based on standard rating conditions for air conditioning equipment per ARI Standard 340/360.
- 2.14 WALL HEATERS (WH)
- A. Wall heaters shall be VRV Products Model KS 2008, Beacon-Morris, or Embassy, 100 CFM, 7,960 BTUH at 1.0 GPM, 180°F. EWT, 65°F. EAT. Wall heaters shall be fully recessed or surface-mounted, as indicated, 120V. with pipe-mounted aquastat. The wall heater covers shall be painted with an enamel paint.

2.15 SPLIT SYSTEM AIR CONDITIONING UNITS (SAC-1.2 and SCU-1.2)

- A. The split system air conditioning unit shall be Mitsubishi Model MS12NN wall mounted indoor units with Model MU12NN outdoor unit, or approved equal by Sanyo. Cooling capacity shall be 12,600 Btuh with entering conditions of 75<sup>0</sup>F. EDBT, 67<sup>0</sup>F. EWBT and 95<sup>0</sup>F. ambient. The indoor unit shall operate on 120V. and the outdoor unit shall operate on 208V.-1 phase power. Furnish with refrigerant piping, wiring and condensate piping as recommended by the manufacturer. The air conditioning units shall be suitable for operation at 0<sup>0</sup>F. outside ambient.

2.16 FINTUBE RADIATION

- A. Fintube radiation (FTR-1) shall be Sterling "Versaline" Model JVK-S11, or Vulcan, low profile sloped top with an output rating of 700 BTUH/ft. with 180<sup>0</sup>F. average water temperature, 65<sup>0</sup>F. entering air temperature and a 2.0 GPM water flow rate. The finned element shall be 3/4" copper tube with aluminum fins at 40 fins per foot. The enclosure shall be 16 gauge cold rolled steel, 3½" deep X 11" high with factory enamel finish and color selection by the Architect. Installation including mounting height shall be per the manufacturer's recommendations unless indicated otherwise on the drawings.
- B. Fintube radiation (FTR-2) shall be Sterling "Versaline" Model JVK-PM, or Vulcan, pedestal-mounted with an output rating of 650 BTUH/ft. with 180<sup>0</sup>F. average water temperature, 65<sup>0</sup>F. entering air temperature and a 2.0 GPM water flow rate. The finned element shall be 3/4" copper tube with aluminum fins at 40 fins per foot. The enclosure shall be 16 gauge cold rolled steel with extruded aluminum grille. Color selection by Architect.
- C. Where indicated, fintube radiation shall be "radiused" to match the curved wall.

2.17 AIR-COOLED CONDENSING UNIT (CU-1) (ALTERNATE NO. 3)

- A. Shall be McQuay, or approved equal with capacities, dimensions and performance, as scheduled. The condensing unit shall be factory assembled and wired. The structural frame shall be constructed of minimum 14 GA. welded galvanized steel with a phosphatized and painted finish. A decorative steel grille shall protect the condenser coils from physical damage. The condensing unit shall be supported by prefabricated structural equipment rails by ConnFab or Kees, galvanized steel, 12" high.
- B. The compressors shall be multiple scroll compressors, suction gas-cooled, direct-drive, operating at 3600 RPM. The unit shall have a centrifugal oil pump, oil charging valve and oil level sightglass.
- C. The condenser coil(s) shall have configured aluminum fins with a baked phenolic coating or copper fins, suitable for a marine environment, mechanically bonded to copper tubing with an integral subcooler. The condensers shall be factory leak-tested at 450 psig. The fans shall be direct-drive vertical discharge, statically and dynamically balanced. Three-phase motors shall have permanently lubricated ball bearings and thermal overload protection. A minimum of two (2) independent circuits and four (4) compressors shall be provided.
- D. A factory provided 115v. control circuit shall include fusing and control power transformer. Factory-wired magnetic contactors shall be provided for the compressors and fans with 3 leg solid-state overload protection and high-low pressure cut-outs. Charge isolation, reset relay and anti-recycle compressor timer(s) shall be provided.
- E. The condensing unit shall include a five (5) year compressor warrantee for parts and labor and a non-fused disconnect switch. Furnish with neoprene "rubber-in-shear" vibration isolators.

- F. The condensing units and rated EER and IPLV shall be in compliance with ASHRAE/IESNA Standard 90.1-2001, "Energy Standard for Buildings Except Low-rise Residential Buildings" and all current addenda based on standard rating conditions for air conditioning equipment per ARI Standard 340/360.

2.18 ELECTRIC HEAT TRACE

- A. Shall be Thermon XL trace or Chemelex, 208V.-1Ph.
- B. Electric heat trace shall be applied to piping systems where indicated for freeze protection.
- C. Heat trace shall be self-limiting electric heat trace, 208V, 4 W/ft. designed to maintain a pipe temperature of 50°F or as indicated.
- D. Furnish and install a UL listed system of electric self regulating heating cable and components for freeze protection of piping. The cable shall utilize a radiation crosslinked conductive polymer as the heating element, and the cable shall be specifically designed, manufactured, and UL listed for freeze protection service.
- E. Submittals:
1. Copy of UL file indicating the heating cable is specifically listed to provide supplementary heating to hot water service supply systems utilizing thermally insulated metal or plastic pipe.
  2. Manufacturer's catalog cuts showing materials and performance data.
  3. Project list of at least 20 projects, installed for at least 5 years, with at least 2000' (600 m) of heating cable in each project.
- F. Construction: The self regulating heating cable shall consist of two (2) 16 AWG (1.2 mm) nickel coated copper bus wires embedded in a radiation crosslinked conductive polymer core. It shall be covered by a radiation crosslinked, polyolefin, dielectric jacket surrounded by a polymer coated aluminum wrap, and 2 enclosed in a tinned copper braid of 14 AWG (2.5 nun equivalent wire size. The braid shall be covered with a (nominal) 40 mil (1 mm) polyolefin outer jacket, color coded for easy identification.
- G. Mechanical: The cable shall have a minimum cut through resistance of 600 lb. per CSA 22.2 0.3 cutting test 4.14. The cable shall have a minimum impact resistance of 251 lb per UL 1588.11. The cable shall withstand a glancing impact of 221 lb per UL 1581.590. The cable shall have a minimum abrasion resistance of 7000 cycles per UL 719.19. The cable shall withstand a crush resistance of 4500 N per IEEE 515 Deformation Test 5.1.5.
- H. Operating Temperatures: The system shall maintain a nominal temperature of 50 °F (15°C) at 208V.
- I. Maintenance Temperature: Each piping system temperature shall be maintained using only one product. Temperatures shall be maintained with straight runs of heating cable on the pipe.
- J. Power Control (self regulating index): The slope of the power/temperature curve shall be such that the power of the heating cable shall increase with decreasing temperature at a rate of at least 0.028 W/ft°F (0.16 W/m°C) from 50°F (10°C) to 100°F (38°C).
- K. Long Term Thermal Stability (as determined by accelerated testing): The power retention of the heating cable shall be at least 90% after 300 cycles between 50°F (10°C) and 212°F (100°C).

- L. High Temperature Withstand: The heater shall not decrease in resistance, overheat, or burn when powered at 208 V and exposed to 400°F (205°C) in an oven for 30 minutes.
- M. Experience: The manufacturer shall have more than ten years experience with self regulating heating cables for freeze protection service.
- N. Acceptable Manufacturer: Thermon or Raychem Corporation.
- O. Installation: The system shall be installed according to the drawings and the manufacturer's instructions. The installer shall be responsible for providing a functional system, installed in accordance with applicable national and local code requirements. Each circuit shall be protected with a 30 mA ground fault protection device, with the appropriate load rating.
- P. Testing:
  - 1. Procedure: Measure the heater circuit continuity and the insulation resistance between the braid and bus wires with a 2500 Vdc megohmmeter (megger).
  - 2. Timing: The tests shall be performed after the pipe insulation has been installed and prior to installation of wall or ceiling panels, and shall be witnessed by the Resident and the manufacturer or the manufacturer's representative.
  - 3. Acceptable Results: The heater circuit shall be continuous and megger readings shall be at least 20 megohms regardless of heater length. Circuits yielding unacceptable readings shall be repaired or replaced.
  - 4. Submittal of Results: Submit records of the test data to the Resident.
  - 5. Labels indicating "electrically heat-traced" shall be applied to the insulation jacket in accordance with the manufacturer's recommendations.

#### 2.19 PROPYLENE GLYCOL

- A. Shall be Dowfrost, or approved equal, with long-life corrosion inhibitors suitable for closed hydronic heating and cooling systems.

#### 2.20 CHILLED WATER STORAGE TANK

- A. The chilled water tank shall be ACE or Cemline, 125 psig ASME construction, carbon steel, primed exterior, tappings as indicated. The tank shall have approximate dimensions of 30" diameter x 78" high (vertical) with ring base stand and manway. Provide interior baffles, as indicated on the drawings.

#### 2.21 ELECTRIC HEATING EQUIPMENT

- A. Shall be Markel or Chromalox, 208V-1PH., with capacities as indicated on the drawings with low voltage thermostats, control transformers, disconnects, contactors and limit devices, UL-listed. Electric heating equipment shall have a baked enamel finish.
- B. Installation shall be in accordance with the manufacturers recommendations and the National Electrical Code.

---

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 and cooling systems 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 Resident.
- 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 Resident.
- 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 shall have screwed or welded 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. Steel Piping 2-1/2" and larger shall have welded connections or Victaulic couplings (water piping only).
  1. Welded Joints:

- a. Welding Procedure Specifications: Before any welding is performed, submit copies of welding procedure specification for metals included in the work together with proof of qualification as outlined in ANSI B31.1.
- b. Performance Qualification Record: Before any welder or operator shall perform any welding, submit 2 copies of the Welder's Performance Qualification Record in conformance with ANSI B31.1 showing that the welder was tested under the approved procedure specification submitted. In addition also submit each welder's assigned number, letter, or symbol which shall be used to identify the work of the welder, affixed to the joint immediately upon completion of the weld. Welders making defective welds after passing a qualification test shall be given a requalification test and upon failing to pass the test shall not be permitted to work this contract.
- c. Previous Qualification: Welding procedures, welders and welding operators previously qualified by test may be accepted for this contract without requalification subject to approval and provided that the conditions specified in ANSI B31.1 are met before a procedure can be used.
- d. Surface Conditions: Welding shall not be done when the atmospheric temperature is less than 0 degrees F, when the surfaces are wet, when rain or snow is falling or moisture is condensing on the surfaces to be welded, nor during periods of high wind, unless the welder and the work are protected properly. At temperatures between 32 degrees and 0 degrees F, the surfaces for an area within 3 inches of the joint to be welded shall be heated with a torch to a temperature warm to the hand before welding. Surfaces to be welded shall be free from loose scale, slag, rust, paint, oil and foreign material. Joint surfaces shall be smooth, uniform, and free from fins, tears and other defects which might affect proper welding. Slag shall be removed from flame cut edges to be welded by grinding, temper colors need not be removed. Each layer of weld metal shall be cleaned thoroughly by wire brushing prior to inspection and deposition of additional weld metal.
- e. Base Metal Preparation: Preparation of pipe ends shall be done by machining and/or grinding, except that oxygen or arc cutting will be permitted on carbon steel pipe only if the cut is reasonably smooth, true and heavy oxide is thoroughly cleaned from the flame cut surfaces by grinding.

The ends of pipe-to-pipe, and pipe-to-fitting, joints shall be aligned accurately within a tolerance of twenty percent of the pipe thickness. Alignment shall be maintained during welding by suitable clamps, jigs, tack welds, or other devices. If tack welds are used to maintain alignment, they shall be kept below the outside surfaces of the pipe and shall not exceed twice the pipe thickness in length or two thirds the pipe thickness in depth, shall be the same quality as the final welds, and shall be fused thoroughly in the final weld. Defective tack welds shall be removed before the final weld is made.

- f. Quality of Welds: The quality of welds shall be in accordance with ANSI B31.1. The surface of the finished welds shall have a bright metallic luster after cleaning, shall be fairly smooth with regular, even ripples, and shall be uniform in contour. Except as necessary to correct defects, the surfaces shall not be dressed, smoothed, or finished for improving their appearance. Welds shall be sound throughout and fused thoroughly, and shall be free from gas pockets, oxides, slag inclusions, and surface porosity, except that very small pores or specs of oxides or slag will be allowed if dispersed widely and if not larger or more numerous than those produced in passing qualification tests. Welds shall be free from

- overlaps, undercuts and excessive convexity. The inside of the pipe shall be free from blobules of weld metal which would restrict the pipe area or might become loose.
- g. Correction of Defects: Defective or unsound welds shall be corrected by removing and replacing the welds with new welds, or as follows:
- 1) Excessive convexity - chip or grind weld to required size.
  - 2) Undercutting, shrinkage cracks, craters, blowholes, and excessive porosity - chip or grind weld to sound weld and base metal and deposit additional weld metal.
  - 3) Undersize and excessive concavity - clean weld and deposit additional weld metal.
  - 4) Overlapping and lack of fusion - remove weld by chipping or grinding and reweld.
  - 5) Slag inclusions - chip or grind weld to remove slag and fill with weld metal.
  - 6) Removal of adjacent base metal during welding - chip or grind weld to sound base and weld metal and form full size by depositing additional weld metal. Pipe or fittings which cannot be rewelded satisfactorily shall be replaced with new pipe or fittings at the Contractor's expense. Caulking of welds shall not be done. Before adding weld metal or rewelding, the surfaces shall be cleaned thoroughly. The removal of weld metal from a defective weld shall not extend into the base metal beyond the weld penetration. Where incomplete fusion is disclosed by chipping or grinding to correct defects, the part of the weld shall be removed and rewelded. In chipping or grinding welds, the weld or base metal shall not be nicked or undercut.
2. Victaulic Joints:
- a. Pipe Preparation: Pipe shall be prepared in accordance with the latest published Victaulic specifications.
- 1) Standard Weight Pipe: Shall be roll grooved without metal removal or square cut grooved.
  - 2) Plain End for "Pressfit": pipe ends shall be thoroughly cleaned on the OD, for 1" from the pipe end to remove pipe coatings, mill scale, rust and raised weld beads, OD burrs and sharp edges shall be removed. Pipe shall be marked 1-1/2" from the end, and pipe end configuration shall be in conformance with Victaulic specifications.
- b. Assembly: Couplings, fittings, valves and pipe shall be assembled in accordance with latest published manufacturer's instructions.
- 1) Pipe: pipe shall be checked to be certain it is sufficiently free of indentations, projections, grooves, weld seams, or roll marks on the exterior of the pipe over the entire gasket, that pipe ends are square cut and that preparation (grooving, cleaning, hole cutting) is in accordance with Victaulic pipe preparation standards.
  - 2) Gasket: gaskets shall be of the central cavity pressure-responsive design. Gasket style and elastomeric material (grade) shall be checked to be certain gasket supplied is suited for the intended service.

- 3) Lubrication: Use manufacturer's recommended lubricant. Lubrication shall be used for proper coupling/fitting assembly as follows: A thin, uniform coat of Victaulic Lubricant shall be applied by brush or by hand by: 1) brushing lubricant on the gasket lips (ID) and the entire exterior of the gasket; 2) brushing lubricant on the pipe ends around the entire pipe circumference and inside with coupling housing.
- K. Connections between copper and steel piping shall be made with brass fittings.
- L. 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.
- M. 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.
- N. 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.
- O. Pipe penetrations through walls, floors and ceilings shall have pipe sleeves of the same material as the pipe and in accordance with Section 15000 "Supplemental Mechanical General Requirements" and BOCA. Pipe sleeves shall be suitable for firestopping in accordance with the firestopping manufacturers recommendations. Traverse points of piping shall be escutcheoned with split chrome floor and ceiling plates and spring anchors, where visible to occupancy.
- P. Automatic Air Vents: Shall be installed with a manual isolation valve. The vent discharge shall be piped to a local floor drain.
- Q. Refrigeration Piping
1. Provide and install refrigeration piping, hangers, and accessories as specified and required. The piping installation shall be performed by a qualified refrigeration mechanic under the direct supervision of the equipment manufacturer. Submit records of tests.
  2. Refrigeration piping shall be Type ACR copper tube with brazed joints, nitrogen-charged equal to BCUP-2 Classification of American Welding Society.
  3. The refrigeration system shall be tested as follows:

High pressure Side	300 psi
Low Pressure Side	150 psi
  4. Support risers, offsets, and equipment, in an acceptable manner.
  5. Piping shall be installed to meet Codes and regulations, applicable to the installation and in accordance with the best practice of the trade. Brazing shall be accomplished while sweeping piping with nitrogen.

6. Refrigerant accessories shall include required valves and fittings to provide a complete installation. Refrigerant suction piping shall be insulated with 1/2" thick Armaflex Type AP, or equal, elastomeric unicellular insulation.
7. Parts of the system not factory charged and field installed piping of components shall be evacuated to within .10 MM/Mercury of a perfect vacuum. Break the vacuum to 0 psig with oil-free nitrogen before charging. Hold vacuum overnight for leak test.
8. Provide complete charges of refrigerant and oil to be maintained for the guarantee period.
9. Elbows shall be long radius.
10. The installation shall be in accordance with the above, with equipment manufacturer's instructions, and with established recommended practices.
11. System installation shall include the following:
  - a. Pitch lines down in direction of flow a minimum of 1/2 inch per 10 feet.
  - b. Trap suction risers as verified with the equipment manufacturer.
  - c. Provide service valves on liquid and suction piping at air cooled condensing units.
  - d. Maximum filter-dryer pressure drops:  
1 psi for liquid line filter-dryer.
  - e. Liquid line solenoid valve on each refrigeration circuit.
  - f. Thermal expansion valve on each refrigeration circuit.

### 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.

### 3.4 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.

### 3.5 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 Resident 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.

### 3.6 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.

### 3.7 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 per building. 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.

3.8 FIRESTOPPING

- A. Firestopping shall be performed in accordance with Specification Section 07840 "Firestopping and Smoke Barrier Caulking". All penetrations of fire-rated assemblies including walls and floors by mechanical system components (piping, ductwork, conduits, etc.) shall be firestopped as specified.

\* END OF SECTION \*