

SECTION 23 73 33

HEATING, VENTILATING, AND COOLING SYSTEM

01/07

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASSOCIATION OF HOME APPLIANCE MANUFACTURERS (AHAM)

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 210 (2007) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 310/380 (2017) Packaged Terminal Air-Conditioners and Heat Pumps

AHRI 710 (2004) Standard for Performance Rating of Liquid-Line Driers

AHRI DCAACP (Online) Directory of Certified Applied Air-Conditioning Products

ARI 410 (1991) Forced-Circulation Air-Cooling and Air-Heating Coils

ARI 430 (1999) Central-Station Air-Handling Units

ARI 590 (1992) Positive Displacement Compressor

ARI 880 Water-Chilling Packages
(1998) Air Terminals

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15 (2001) Safety Standard for Mechanical Refrigeration System

ASHRAE 52.1 (1992; Interpretation 1 2007) Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

ASME INTERNATIONAL (ASME)

ASME B16.18 (2012) Cast Copper Alloy Solder Joint Pressure Fittings

ASME/ANSI B16.22 (1995) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.23 (2002; Errata 2003; R 2006) Cast Copper Alloy Solder Joint Drainage Fittings - DWV

ASME/ANSI B16.26 (1988) Cast Copper Alloy Fittings for Flared Copper Tubes

ASME B31.1 (2018) Power Piping

ASME/ANSI B31.5 (2001) Refrigeration Piping and Heat Transfer Components

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003 (2001; Errata, 2003) Performance Requirements for Water Pressure Reducing Valves

ASTM INTERNATIONAL (ASTM)

ASTM A 525 (1991; Rev. B) Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

ASTM A 653/A 653M (2001a) Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock-Forming Quality

ASTM B 32 (2008) Standard Specification for Solder Metal

ASTM B 42 (2002e1) Standard Specification for Seamless Copper Pipe, Standard Sizes

ASTM B 88 (2009) Standard Specification for Seamless Copper Water Tube

ASTM B 306 (1999) Copper Drainage Tube (DWV)

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR-USC (2002) List of Approved Backflow Prevention Assemblies

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58 (2009) Standard for Pipe Hangers and Supports - Materials, Design and Manufacture

MSS SP-67 (2002a; R 2004) Standard for Butterfly

Valves

- MSS SP-69 (2003; R 2004) Standard for Pipe Hangers and Supports - Selection and Application
- MSS SP-70 (2006) Standard for Cast Iron Gate Valves, Flanged and Threaded Ends
- MSS SP-71 (2005) Gray Iron Swing Check Valves, Flanged and Threaded Ends
- MSS SP-80 (2008) Bronze Gate, Globe, Angle and Check Valves
- MSS SP-85 (2002) Standard for Cast Iron Globe & Angle Valves, Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- NEMA ICS 6 (1993; R 2011) Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 70 (2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14; TIA 17-15; TIA 17-16; TIA 17-17) National Electrical Code
- NFPA 90A (2018) Standard for the Installation of Air Conditioning and Ventilating Systems

NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)

- NRCA R&W Manual (2001, 5th Ed) NRCA Roofing and Waterproofing Manual

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

- SMACNA HVAC Duct Const Stds (1995; Addenda Nov 1997; 6th Printing 2001) HVAC Duct Construction Standards - Metal and Flexible
- SMACNA Leakage Test Mn1 (1985; 6th Printing 1997) HVAC Air Duct Leakage Test Manual

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

UNDERWRITERS LABORATORIES (UL)

- UL Bld Mat Dir (updated continuously online) Building Materials Directory

UL 181 (1996; Rev Dec 1998) Factory-Made Air Ducts and Air Connectors

UL 555 (1999; Rev thru Jan 2002) Fire Dampers

1.2 SYSTEM DESCRIPTION

Provide new and modify existing heating, ventilating, and cooling (HVAC) systems complete and ready for operation. HVAC systems include equipment, ducts, and piping which is located within, on, under, and adjacent to buildings.

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00, "Submittal Procedures."

SD-02 Shop Drawings

Temperature control systems

Mechanical Rooms, Mechanical Yard

SD-03 Product Data

Dehumidifer Units

Packaged terminal Heat Pumps

Unit heaters

Pumps, including performance curves for each impeller size

Exhaust fans

Dedicated Outside Air Unit

Fire dampers

Expansion and Buffer Tanks

Dirt-Air separators

Heat Tape

Pipe hangers and supports

Flexible pipe connectors

Dampers

Diffusers, registers, and grilles

Outside air intake louvers

Duct

Flexible round ducts

Valves

Pipe and fittings

Hydraulic Separator

SD-06 Test Reports

Air-handling units: greater than 2,000 cfm.

SD-07 Certificates

Certification of welders' qualifications

SD-08 Manufacturer's Instructions

Installation manual

SD-10 Operation and Maintenance Data

Packaged Dedicated Outside Air Unit, Data Package 3

Packaged air-handling units, Data Package 3

Unit heaters, Data Package 2

Pumps, Data Package 2

Exhaust fans, Data Package 2

Fire dampers, Data Package 1

Submit in accordance with Section 01 78 23, "Operation and Maintenance Data."

SD-11 Closeout Submittals

Air filter inventory

1.3.1 Temperature Control Systems

Drawings shall include point-to-point electrical wiring diagrams.

1.3.3 Equipment layout drawings

Submit drawings showing equipment layout including foot print, piping, conduit, control cabinets, door swings, and power disconnects.

1.3.3 Installation Manual

Provide for each item of equipment.

1.3.4 Certification of Welders' Qualifications

Submit copy of Welder Qualification Tests (Form QW-482) prior to site welding.

1.3.5 Air Filter Inventory

Submit an inventory of sizes and quantity of air filters required to be replaced. Inventory shall indicate location of each piece of equipment. Include sketches of drawings.

PART 2 PRODUCTS

2.1 EQUIPMENT

Dehydrate, purge, and charge refrigerant circuit with refrigerant and oil at factory. Factory oil and refrigerant charge shall be full amount required for operation, if within limits permitted by the Department of Transportation; otherwise, a holding charge shall be furnished. Field charging, where only a holding charge is shipped, shall be accomplished without breaking permanent refrigerant connections. Equipment using R-11, R-12, R-13, R-113, R-114, R-115, R-500, or R-502 as a refrigerant will not be permitted. Refrigerants shall have an Ozone Depletion Factor (ODF) of 0.05 or less. The ODF shall be in accordance with the "Montreal Protocol On Substances That Deplete The Ozone Layer," September 1987, sponsored by the United Nations Environment Program. Refrigerants that operate any where in the cycle below 20 psia will not be permitted. Efficiency of equipment shall meet the minimum's of Table 15701-1.

2.1.1 Dehumidifer Units

Provide commercial rated, UL or ETL listed, dehumidifier units with a minimum 5 year manufacturer parts warranty on the sealed refrigerant system, capable of continuous operation, equipped with replaceable or washable filter media, designed to operate continuously without emptying a tank, and able to remove a minimum of 150 pints/day of moisture at room conditions of 80 degrees F and 60% relative humidity. Unit shall be hardwired to an appropriately rated electric circuit. Each unit shall be capable of gravity drain of condensate via hose to a floor drain or equipped with a condensate pump capable of continuous condensate discharge via a hose to a floor drain. Install clean filter media following installation. Provide 5 additional filter media in the factory sealed packaging and left in the mechanical room for each unit installed. Provide a dehumidifier with ability to control humidity setpoint in 5% RH increments or provide remote mounted humidistat to control the dehumidifier as indicated on the plans.

2.1.5 Air-Handling Units

Provide units factory assembled, designed, tested, and rated in accordance with ARI 430. Units shall be ARI certified for cooling. Provide heating and cooling units including hot water coils and chilled water coils. Unit shall include fan section, coil section with drain pan, variable frequency motor controller, filter section and access panels. Insulate interior of casing with manufacturer installed closed-cell foam insulation. Provide nylon bushings for dampers.

- a. Fan section: Provide draw-through fan section including motor, starter, and drives.
- b. Coil section: Provide ARI 410 coils and slope for drainage. Provide insulated drain pans under cooling coils and valves.
- c. Filter section: Provide UL listed throwaway 1 inch thick fiberglass filters, standard dust-holding capacity, 500 fpm maximum face velocity. Provide gasketed hinged access panel with quick opening half-twist latches at end of filter rack. Filter rack(s) shall accept 2 inch or thicker filters as required to achieve a maximum 500 fpm filter face velocity.
- d. Space temperature controls: Provide controls including adjustable programmable thermostats with COOL-OFF-HEAT system switch and AUTO-ON fan switch. Thermostats shall be furnished by unit manufacturer. Provide relays, transformers, contactors, and control wiring between thermostats and unit.
- g. Special corrosion protection: Provide heating and cooling coils constructed of copper tubes and plate copper fins or copper tubes and plate aluminum fins with phenolic coating factory applied to entire coil by immersion dipping and baking to 1.5 mil minimum dry film thickness. Rating of units shall be after application of phenolic coating.
- h. Equipment selection: Air-handling unit (AHU) manufacturer shall certify the capability of the AHU to perform between the cumulative design minimum and maximum airflows of the variable air volume (VAV) terminals. The AHU submittal selection shall be supported by fan curves clearly annotated showing operating points of the minimum and maximum airflow of connected VAV terminals.

2.1.1.7 Air-Cooled Water Chillers

Provide single package units factory assembled, designed, tested, and rated in accordance with ARI 590 with air-cooled condensers. Provide not less than two independent refrigerant circuits for multicompressor units. Provide direct expansion shell and tube design, refrigerant circuits, including electric-motor-driven refrigerant compressors with integral crankcase heater, air-cooled condenser, receiver, chiller, piping, controls, and accessories mounted in a cabinet. Provide refrigerant, internal pressure relief device, solenoid valve, combination liquid-line strainer-drier, expansion valve, and service valves. Condenser discharge air shall be in vertical direction. Provide guards to protect condenser fins from mechanical damage. Provide equipment guards around base of unit. Crankcase heaters are not required when scroll compressors are provided. Provide a 5 year compressor parts warranty and, if available, a 5 year la.

Controls: Provide factory-wired digital electronic controls including adjustable programmable thermostat for chilled water temperature control, high-low pressure control, low water temperature safety thermostat, ON-OFF unit switch, and nonrecycling pump-down relay. Controls shall also include maximum operating pressure expansion valves and programming of microprocessor chiller controls or high temperature controller for operation of compressors in cool down mode for start-up or changeover when entering water temperature is in 60 to 90 degree F range. Provide electrical interlock between water chiller and

chilled water pump to prevent chiller from operating unless pump is running. Provide flow switch or flow sensors in chilled water return piping to stop compressor in event of water flow failure. Condenser fan electric motors shall be drip-proof, with built-in three-phase overload protection, mounted inside the casing. Compressor motor stoppage due to thermal and pressure overload shall require manual restart. Provide control and interlock wiring. Provide thermostat controlled electric heater cable around chiller and exterior piping for freeze protection down to 0 degree F air temperature, to operate when ambient exterior air temperature falls below 40 degrees F. [Provide low ambient control to 35 degrees F

- b. Weatherproof casing: Provide removable gasketed panels designed to exclude driving rain and hail for access to compressors, motors, and controls.
- c. Condenser coils: Provide all coils on air-cooled chillers with ASTM B117 6000-hour rated salt spray corrosion protection. Rating of units shall be after application of coil protective coating.

2.1.12 Packaged Terminal Heat Pumps

Provide units factory assembled, designed, tested, and rated in accordance with AHRI 310/380. Units shall be ARI certified or rated in AHRI DCAACP. Units shall include refrigeration section, additional heating section (where indicated), separate outdoor weatherproof anodized aluminum louvers, forced ventilation, room cabinet, fans and motors, controls, wall sleeves, filters, dampers, grilles, subbases, leveling device, and power connections. Wall sleeves and installation shall be designed to exclude driving rain. Insulate interior of unit with manufacturer's standard insulation. Unit shall have slide-out chassis easily removed through room cabinet opening. Provide adjustable deflection inside air supply grille. Fan motors shall be permanent-split capacitor type. Provide wall mounted units.

- a. Filters: Provide permanent washable air filters or UL listed throwaway fiberglass filters, standard dust-holding capacity; removable through access door or panel.
- b. Safety controls: Provide compressor motors with thermal and overload protection, 5 minute anti-recycle timer, start capacitor kit, and crankcase heater. The above safety controls are not required when scroll compressors are provided.
- c. Supplemental heating section: Provide UL listed electric resistance heaters including internal fusing integral with unit; fan shall run until heater cools. Provide controls to operate heater only when indoor thermostat is in heating mode and outdoor thermostat indicates outside temperature is below 35 degrees F or unit balance point, whichever is higher; and when unit is in defrost mode at any outside temperature.
- d. Space temperature controls: Provide controls including adjustable COOLER-WARMER temperature control thermostats with COOL-OFF-HEAT system switch and HIGH-MEDIUM-LOW fan switch, and FAN ONLY switch.
- e. Anti-Ligature Cover: Provide Sloped top, 3/32" on 3/16" staggered center, laser cut perforated. Floor Mounting: Offset floor angles

are provided loose. Floor-mounted units with openings low in front for make-up air flow. Vertical Wall Mounting: 90 Degree, powder coated cold rolled steel provided loose. Visible mounting hardware is self drilling zinc plated torx head security screw.

Enclosure Material: CR, 12 Gauge cold rolled steel,
Grille Material: SS, 11 Gauge stainless steel
First Coating - Zinc Rich Primer
Second Coating - Hybrid-Epoxy, Loss Gloss, White
Accessories: Screw Down Access Doors (torx head) security machine screws

2.1.1 Unit Heaters

Provide factory-assembled, propeller or blower type fan unit heaters arranged for horizontal air discharge. Each unit shall include hot water coil or natural gas heat furnace, fan, electric motor, housing, and air discharge vanes or diffusers. Horizontal discharge type units shall have adjustable deflectors for control of horizontal and vertical airflow. Each unit shall be provided with threaded mounting holes for attaching threaded hanger rods. Fan motor shall be controlled by wall-mounted adjustable thermostat (+/- 2 degrees F).

2.1.2 Pumps

Provide chilled and heating hot water pumps as either Option 1 or Option 2 below.

2.1.6.1 Option 1 - Vertical Twin In-Line Pumps

Provide pumps constructed of manufacturer's standard materials suitable for chilled water and hot water heating systems. Pumps shall have mechanical seals and drip-proof electric motors. Pump suction diffuser shall have internal straightening vanes dependent upon inlet flow, strainer with minimum 0.25-inch openings, and auxiliary disposable fine mesh strainer which shall be removed 30 days after start-up. Provide warning tag for operator indicating scheduled date for removal.

2.1.6.2 Option 2 - Base Mounted End Suction Pumps

Provide pumps constructed of manufacturer's standard materials suitable for chilled water and hot water heating systems. Pumps shall have mechanical seals and drip-proof electric motors. Pump suction diffuser shall have internal straightening vanes dependent upon inlet flow, strainer with minimum 0.25-inch openings, and auxiliary disposable fine mesh strainer which shall be removed 30 days after start-up. Provide warning tag for operator indicating scheduled date for removal. Casing shall have connection sizes to match pump suction and pipe sizes, and be provided with adjustable support foot or support foot boss to relieve piping strains at pump suction. Blowdown port and plug shall be provided on unit casing. Provide a magnetic insert to remove debris from system.

2.1.3 Exhaust Fans

AMCA 210 with AMCA seal. Provide centrifugal type exhaust fans with aluminum housing, fan wheel, and bird screen. Motors shall be

completely shielded from the airstream. Provide exhaust opening and gravity closing type automatic backdraft dampers.

2.1.8 Dedicated Outside Air Unit

Unit shall include outdoor supply fan, exhaust air fan, recovery plate, 2-inch thick outdoor air and exhaust air filters, and outdoor and exhaust shut off dampers with chilled water and hot water reheat coils. Furnish flat panel filter section with 2-inch pleated MERV 8 filter. Provide side loading and removal of filters.

2.1.8.1 Unit Casing

A. Fabricate unit with heavy gauge channel posts and panels secured with mechanical fasteners. All panels, access doors, and ship sections shall be sealed with permanently applied bulb-type gasket. Shipped loose gasketing is not allowed.

B. Panels and access doors shall be constructed as a 2-inch nominal thick; thermal broke double wall assembly, injected with foam insulation with an R-value of not less than R-13.

1. The inner liner shall be constructed of G90 galvanized steel.
2. The outer panel shall be constructed of G90 galvanized steel.
3. The floor plate shall be constructed as specified for the inner liner.
4. Unit will be furnished with solid inner liners.

C. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, maximum 5 inches of positive or 6 inches of negative static pressure. Deflection shall be measured at the panel midpoint.

D. The casing leakage rate shall not exceed 0.50 cfm per square foot of casing surface area at design static pressure up to a maximum of +5" w.c. in positive pressure sections and -6" w.c. in negative pressure sections (.0025 m³/s per square meter of cabinet area at 1.24 kPa static pressure)

E. Module to module field assembly shall be accomplished with an overlapping, full perimeter internal splice joint that is sealed with bulb type gasketing on both mating modules to minimize on-site labor and meet indoor air quality standards.

F. Access doors shall be flush mounted to cabinetry, with minimum of two six inch long stainless steel piano-type hinges, latch and full size handle assembly. Access doors shall swing outward for unit sections under negative pressure. Access doors on positive pressure sections, shall have a secondary latch to relieve pressure and prevent injury upon access.

G. Construct drain pans from stainless steel with cross break and double sloping pitch to drain connection. Provide drain pans under cooling coil section. Drain connection centerline shall be a minimum of 3'' above the base rail to aid in proper condensate trapping. Drain connections that protrude from the base rail are not acceptable. There must be a full 2'' thickness of insulation under drain pan.

2.1.8.2 FAN ASSEMBLIES

A. Acceptable fan assembly shall be a single width, single inlet, class II, direct-drive type plenum fan dynamically balanced as an assembly, as shown

in schedule. Maximum fan RPM shall be below first critical fan speed. Fan assemblies shall be dynamically balanced by the manufacturer on all three planes. Provide access to motor and fan assembly through hinged access door.

B. Fan and motor shall be mounted internally on a steel base. Factory mount motor on slide base that can be slid out the side of the unit if removal is required. Provide access to motor, drive, and bearings through hinged access door. Fan and motor assembly shall be mounted o

2.1.8.3 COOLING AND HEATING COIL

A. Certification: Acceptable water cooling, water heating, steam, and refrigerant coils shall be certified in accordance with AHRI Standard 410 and bear the AHRI label. Coils exceeding the scope of the manufacturer's certification and/or the range of AHRI's standard rating conditions will be considered provided the manufacturer is a current member of the AHRI Forced Circulation Air-Cooling and Air-Heating Coils certification programs and that the coils have been rated in accordance with AHRI Standard 410. Manufacturer must be ISO 9002 certified.

B. Water cooling coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.

1. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.

2. Fins shall have a minimum thickness of 0.0075 inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.

3. Coil tubes shall be 5/8 inch OD seamless copper, 0.020 inch nominal tube wall thickness, expanded into fins, brazed at joints.

4. Coil connections shall be carbon steel, NPT threaded connection. Connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.

5. Coil casing shall be a formed channel frame of galvanized steel.

C. Water heating coil shall be provided. Provide access to coil(s) for

service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.

1. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.

2. Fins shall have a minimum thickness of 0.0075 inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.

3. Coil tubes shall be 5/8 inch OD seamless copper, 0.020 inch nominal tube wall thickness, expanded into fins, brazed at joints.

4. Coil connections shall be carbon steel, threaded connection. Connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.

5. Coil shall be furnished as an uncased galvanized steel to allow for thermal movement and slide into a pitched track for fluid drainage.

2.1.8.4 Energy Recovery Plate

The ERV core shall transfer both sensible and latent energy between the incoming fresh air stream and the exhaust stale air stream. The ERV core shall be in either a cross-flow or counter cross-flow orientation and have no moving parts. The ERV core shall be certified by AHRI under its Standard 1060 for Energy Recovery Ventilators. Products not currently AHRI certified will not be accepted. The ERV core shall achieve the minimum effectiveness value as indicated in the schedule. The fresh air stream must have complete separation from the stale air stream to prevent cross contamination. The ERV core shall have Exhaust Air Transport Ratio of less than 0.5% as tested to AHRI 1060 (EATR) to prevent cross-over of gases, contaminants or odors. The ERV core's Outdoor Air Correction Factor (OACF) shall not exceed 1.0 as tested to AHRI 1060 (OACF) Standard. The ERV core shall not be degraded or promote the growth of mold and bacteria with a rating of zero in testing according to ISO846 A and C. The ERV core must be able to tolerate freezing temperatures of -30C (-22F) and not have an increase in EATR or decrease in performance after being frozen. The ERV core must be able to tolerate high temperatures of +60C (140F) and not have an increase in EATR or decrease in performance at these elevated temperatures. The ERV core must be freeze tolerant tested to 40 freeze thaw cycles from -20C (-4F) to +20C (68F) while maintaining the energy recovery effectiveness and EATR rating of less than 0.5%. The ERV core must be water washable to remove dust and

contaminants. The ERV core must be flame proof and comply with UL 723 with a flame spread index that shall not be over 25 and a smoke index that shall not be over 50. The ERV cores should have particulate filters positioned before the incoming air streams.

2.2 ELECTRICAL

2.2.1 Electrical Motors, Controllers, Contactors, and Disconnects

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects shall conform to Section 26 20 00, "Interior Distribution System." Provide electrical connections under Section, 26 20 00, "Interior Distribution System." Provide controllers and contactors with maximum of 120-volt control circuits, and auxiliary contacts for use with controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of providing additional electrical service and related work shall be included under this section.

2.2.2 Electrical Work

Provide under Section 26 20 00, "Interior Distribution System." Provide control wiring under Section 23 09 23.13, "BACnet Direct Digital Control Systems."

2.3 METAL DUCT SYSTEMS

Provide shop-fabricated, zinc-coated steel ducts conforming to ASTM A 525 or ASTM A 653/A 653M coating designation G60. Fabricate, construct, brace, reinforce, install, support, and seal ducts and accessories, and test ducts in accordance with SMACNA HVAC Duct Const Stds and SMACNA Leakage Test Mn1. Cover duct transverse joints with single component synthetic rubber type compound suitable for use with passivated coating on zinc-coated steel. Lap joints in direction of flow. Provide ducts straight and smooth on inside with neatly finished airtight joints. Provide air supply and return openings in ducts with air diffusers, registers, or grilles.

2.3.1 Flexible Duct Connectors

Provide airtight flexible duct connectors at duct connections to each air-conditioning unit, air-handling unit, exhaust fan, and ventilating fan. Support connectors at each end with metal angle frame bands, securely bolt in place. Provide not less than 20 ounce glass fabric duct connectors coated on both sides with neoprene.

2.3.2 Turning Vanes

Provide fabricated tees and square elbows with turning vanes in accordance with SMACNA HVAC Duct Const Stds for vanned elbows. Turning vanes shall be single wall with trailing edges.

2.3.3 Dampers

Provide factory manufactured opposed blade adjustable manual dampers where indicated for duct heights of 12 inches and larger. Provide factory manufactured single leaf dampers for duct heights less than 12 inches. Provide damper shafts with 2 inch standoffs to clear 2 inches of duct

insulation with bearings at both ends of the shafts. Provide adjustment quadrant with indicator and locking devices. Provide galvanized steel dampers one gage heavier than duct in which dampers are installed. Provide automatic dampers under Section 23 09 23.13, "BACnet Direct Digital Control Systems."

2.3.4 Diffusers, Registers, and Grilles

Provide factory-fabricated metal units with edges rolled or rounded where exposed to view, and factory primed with white enamel finish. Provide each diffuser and register with factory-fabricated, group-operated, adjustable, opposed-blade, air-volume-control dampers, key or screwdriver operated from the face of unit without the use of a tool. Provide each unit with rubber or plastic installation gaskets. Diffusers in same room shall have same face design.

- a. Diffusers: Provide round, square, or rectangular diffusers as indicated. Ceiling diffusers shall be designed to deliver air in a horizontal direction. Provide baffles or other devices as required for proper air distribution pattern.
- b. Registers: Provide double deflection supply registers arranged to control air direction, throw, and drop. Exhaust and return air registers shall have single set of nondirectional face bars or vanes having the same appearance as supply registers. Provide face bars or vanes spaced not more than 0.75 inch on center and not less than 0.62 inch depth.
- c. Grilles: Provide as specified for registers without air-volume-control dampers.

2.3.5 Outside Air Intake Louvers

Louvers are specified in Section 08 91 00, "Metal Wall Louvers."

2.3.6 Access Doors

Provide for access to volume dampers, fire dampers, plenum chambers, and where indicated. Provide each door with double wall zinc-coated steel construction, gasketed airtight, with continuous hinges and cam latches. Insulate access doors with one-inch thick rigid insulation. Provide 12 inch by 12 inch door, except where larger sizes are indicated, or provide 12 inches by height of duct when duct is less than 12 inches high. Provide keyed-alike 90 degree turn cam locks on each access door in sleeping rooms; furnish three keys.

2.3.7 Fire Dampers

UL 555 and NFPA 90A. Dampers shall be listed in UL Bld Mat Dir. Dampers when open shall not protrude into the ducts.

2.3.8 Duct Hot Water Coils

ARI 410, hot water coils.

2.3.8 Filter Boxes

Provide when filters are not provided integral with the air-conditioning units or air-handling units. Construct filter boxes of zinc-coated steel with track, hinged access doors with latches, seal gaskets between frame, and filters. Arrange filters to filter outside air intake and return air. Filter assemblies shall be removable from filter box and replaceable without use of tools. Replaceable filter rack shall be designed to accept 2 inch thick filters.

- a. Replaceable filters: Provide UL listed throwaway 1 inch thick fiberglass filters, standard dust-holding capacity, 350 fpm maximum face velocity.
- b. High efficiency filters: Provide UL Class 2, mean efficiency of 30 percent when tested in accordance with [ASHRAE 52.1](#). Filter assembly shall include holding frame and fastener assembly, filter cartridge, and mounting frame and retainer assembly. High efficiency filters shall be preceded by replaceable filter.

2.3.9 Flexible Round Ducts

[UL 181](#) and [NFPA 90A](#) with factory-applied insulation, vapor barrier, and end connections. Fire hazard rating of duct assembly shall not exceed 25 for flame spread and 50 for smoke developed. Provide ducts designed for working pressures of 2 inches W.G. positive and 1.5 inches W.G. negative. Flexible round duct length shall not exceed 5 feet. Secure connections by applying adhesive for 2 inches over rigid duct, apply flexible duct 2 inches over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.

- a. Inner duct core: Flexible core shall be interlocking spiral or helically corrugated and constructed of zinc-coated steel, aluminum, or stainless steel; or shall be constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant, flexible vapor barrier film, inner duct core.
- b. Insulation: Inner duct core shall be insulated with mineral fiber blanket type flexible insulation, minimum of one inch thick. Insulation shall be covered on exterior with manufacturer's standard fire retardant vapor barrier jacket for flexible round duct.

2.4 PIPING SYSTEMS

Provide the following [pipe and fittings](#). Provide dielectric fittings, unions or flanges between steel piping and copper tubing for all piping sizes; except that copper alloy valves and strainers may be used without dielectric fittings, unions or flanges. Water piping sizes 4 inches and smaller shall be copper tubing. Water piping sizes larger than 4 inches shall be copper tubing or steel piping. If steel piping is provided, provide a solids-from-water separator.

2.4.1 Soldered Joint Copper Tubing

Provide [ASTM B 88](#), Type L for aboveground piping, Type K for buried piping, with [ASME B16.18](#) or [ASME/ANSI B16.22](#) solder joint fittings, unions, and flanges; provide adapters as required. Provide [ASTM B 42](#) copper pipe nipples with threaded end connections. Provide

ASTM B 32, 95-5 tin-antimony solder, or provide Plumbing Code approved lead-free solder.

2.4.2 Copper Tubing Piping Systems

Provide copper tubing for the following piping systems, except water piping sizes larger than 4 inches shall be copper tubing or steel piping.

- a. Chilled water, and hot water piping.
- b. Cold drain piping from drain pans.

2.4.3 Copper Cold Drain Piping

Provide copper tubing in accordance with paragraph entitled "Copper Tubing" for piping sizes one inch and smaller. Provide ASTM B 306 copper tubing and ASME B16.23 solder joint fittings for piping sizes larger than one inch. In lieu of copper tubing, 1.25 inch Schedule 40 polyvinyl chloride (PVC) plastic pipe, fittings, and solvent cement may be provided.

2.4.6 Buried Preinsulated Water Piping

For buried heating hot water supply and return piping provide expansion loops and expansion bends (Z- and L- type) factory fabricated of casing, insulation, and carrier piping identical to that furnished for straight runs. Properly design expansion loops and bends in accordance with the allowable stress limits indicated in ASME B31.1 for the type of pipe used, and size to accommodate pipe movement. Ship expansion loops and bends to the jobsite in the maximum size sections feasible to minimize the number of field joints. Make field joints in straight runs of the expansion loops and bends, keeping the number to a minimum. For steel pipe, cold springing is not allowed when sizing the expansion loops and bends. Cold spring piping one-half the calculated maximum operational expansion during field assembly is allowed. Stresses shall be less than the maximum allowable stress from the ASME B31.1. Submit pipe-stress and system-expansion calculations for each expansion compensation elbow using a finite element computer generated 3-dimensional analysis, not later than 14 days after notice to proceed. Demonstrate with calculations that pipe stresses from temperature changes are within the allowable requirements in ASME B31.1 and that the anchors and the guides will withstand the resultant forces. Detailed design layout drawings shall include all analysis node points. As a minimum, computer analysis results shall include node stresses, forces, moments and displacements. Calculations shall be stamped by a registered Professional Engineer in the employ of the UHDS manufacturer. Detailed design layout drawings and stress and anchor force calculations shall be provided for all loops and bends. Locations of all anchors, guides and supports shall be shown. The calculations shall be based on design characteristics (pressures and temperatures) specified for both the supply and return lines.

Provide buried preinsulated water piping in conduit complete and ready for operation. Install in accordance with fabricator's published literature. Provide copper tubing for carrier piping; carrier piping sizes larger than 4 inches may be steel piping. Minimum depth of cover shall be 2 feet.

- a. Factory-applied insulation: Provide polyurethane or polyisocyanate insulation, rated for not less than 250 degrees F

service, completely filling the space between carrier pipe and conduit.

- b. Factory-applied conduit: Provide each section of carrier pipe with insulation and conduit complete with waterproof conduit caps at both ends. Mark each section of conduit with fabricator's name, product identification, and publications to which the items conform. Provide same type of insulation and conduit material over field-insulated joints and fittings; provide waterproof shrink sleeves over field-insulated joints to overlap not less than 6 inches of each conduit section.
- c. Bedding: Accurately grade trench bedding with minimum of 6 inches of sand. Backfill sand to minimum of 6 inches above and below conduit. Lay bedding to firmly support conduit along entire length.
- d. Buried utility warning tape: Provide detectable tape for warning of buried piping.

2.4.4 Valves

Valves shall have flanged end connections, except valves smaller than 2.5 inches may have threaded end connections with a union on one side of the valve. Solder end connections may be used for connections between copper alloy valves and copper tubing.

2.4.4.1 Gate Valves

MSS SP-80, Class 125, except sizes 2.5 inches and larger shall conform to MSS SP-70, Class 125.

2.4.4.2 Globe and Angle Valves

MSS SP-80, Class 125, except sizes 2.5 inches and larger shall conform to MSS SP-85, Class 125.

2.4.4.3 Check Valves

MSS SP-80, Class 125, swing check; except sizes 2.5 inches and larger shall conform to MSS SP-71, Class 125.

2.4.4.4 Butterfly Valves

MSS SP-67, except sizes 2.5 inches and larger shall have lugged or wafer body designed for installation between ASME Class 150 flanges. Valves shall have two-position lever handles, except when infinite position lever handles are indicated.

2.4.4.5 Ball Valves

Full port design, copper alloy body, except sizes 2.5 inches and larger shall be cast-iron body. Valves shall have two-position lever handles. Ball valves may be provided in lieu of gate valves.

2.4.4.6 Square Head Cocks

Provide copper alloy or cast-iron body with copper alloy plugs, suitable

for 125 psig water working pressure.

2.4.4.7 Air Venting Valves

Provide copper alloy body valves with automatic or manual air vent as indicated.

2.4.4.8 Combination Pressure and Temperature Relief Valves

ASME/ANSI B16.26, copper alloy body, automatic reseating, test lever, and discharge capacity based on AGA temperature steam rating.

2.4.4.9 Water Pressure Reducing Valves

ASSE 1003, copper alloy body, automatic reseating, with test lever.

2.4.4.10 Water Temperature Regulating Valves

Provide copper alloy body, direct acting, pilot operated, for the intended service.

2.4.8.11 Flow Control Balancing Valves

Copper alloy or cast iron body, copper alloy or stainless internal working parts, and integral pointer that indicates the degree of valve opening. Valves shall be suitable for 125 psig at 190 degrees F hot water. Valve shall function as a service valve when in fully closed position. Valve body shall have factory-installed tappings for differential pressure meter connections for verification of pressure differential across valve orifice. Meter connections shall have positive check valves or shutoff valves. Each valve shall have metal tag showing the gallons per minute flow for each differential pressure reading.

2.4.4.12 Backflow Prevention Assemblies

Provide reduced pressure principle type backflow prevention assemblies which are approved by and has a current "Certificate of Approval" from the FCCCHR-USC. Listing of the particular make, model/design, and size in the current FCCCHR-USC will be acceptable as the required proof.

2.4.4.13 Refrigerant Valves

ASME/ANSI B31.5, and shall be copper alloy. Provide valves in each system for servicing and for isolating system components in compliance with ASHRAE 15.

2.5 PIPING ACCESSORIES

2.5.1 Pipe Hangers and Supports

Provide MSS SP-58 and MSS SP-69, Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18

insert or drilled expansion anchor. Provide Type 40 insulation protection shield for insulated piping.

2.5.2 Strainers

Pressure and temperature range shall be for the intended service. Provide blowoff outlet with pipe nipple, gate valve, and discharge pipe nipple. Provide stainless steel strainer element with perforations of 0.047 inch for water, 0.031 inch for steam mixed with condensate, and 0.016 inch for steam. Provide copper alloy or cast-iron body strainers in steam and condensate systems up to 100 psig. Provide steel body strainers in steam and condensate systems 100 psig and greater.

2.5.3 Traps

Provide traps of the types indicated with stainless steel internals. Pressure and temperature range shall be for the intended service. Traps for steam at 100 psig and greater shall be minimum of ASME Class 150.

2.5.4 Pressure Gages

Provide single style pressure gage with 4.5-inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubber, and syphon. Provide scale range for intended service.

2.5.5 Thermometers

Provide bi-metal dial type thermometers with stainless steel case, stem, and fixed thread connection; 3 inch diameter dial with glass face gasketed within the case; and accuracy within 2 percent of scale range. Provide scale range for intended service.

2.5.6 Pipe Sleeves

Provide where piping passes entirely through walls, ceilings, roofs, and floors. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors. Provide one-inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of sleeves or core-drilled holes with UL listed fill, void, or cavity material.

2.5.6.1 Sleeves in Masonry and Concrete

Provide steel pipe sleeves or schedule 40 PVC plastic pipe sleeves. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth.

2.5.6.2 Sleeves not in Masonry and Concrete

Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves.

2.5.7 Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid where indicated. Connectors shall be suitable for the intended service.

2.5.8 Sight Glass and Refrigerant Drier

AHRI 710. Provide in refrigerant liquid piping.

2.5.9 Expansion and Buffer Tanks

Construct of steel in accordance with ASME BPVC for minimum working pressure of 150 psig. Tank shall have polypropylene or butyl lined diaphragm which keeps the air charge separated from the water.

Expansion Tanks, buffer tanks and other hydronic tanks for chilled water systems exposed to exterior weather and sunlight shall be insulated with 2" closed cell, formaldehyde-free, low-VOC, and fiber-free insulation with a insulation rating of R-8 or greater. Insulation shall be UL listed and have an anti-microbial agent applied at the factory with a built-in vapor retarder. Exterior located tanks shall have a sealed 0.020" or thicker aluminum jacket fully enclosing the insulation.

Chilled Water expansion tanks located inside of mechanical rooms and mechanical outbuildings shall be insulated with 2" closed cell, formaldehyde-free, low-VOC, and fiber-free insulation with a insulation rating of R-8 or greater. Insulation shall be UL listed and have an anti-microbial agent applied at the factory with a built-in vapor retarder.

Heating Hot Water expansion tanks shall be located inside mechanical buildings and shall be provided with a minimum 2" silicone or fiberglass based insulation, factory designed to fit the tank.

2.5.10 Dirt-Air Separators

Provide Coalescent type Dirt-Air separator with internal perforated stainless steel air collector tube to direct released air to automatic air vent, and removing solids of 75 microns and larger with specific gravity of 1.2 and greater. Construct of steel for minimum working pressure of 125 psig. Insulate in accordance with 23 07 00.

2.5.11 Hydraulic Separator

Provide a hydraulic separator for each hydronic system with a primary and secondary loop. The hydraulic separator shall be designed and constructed per ASME BPVC, manufactured of a carbon steel exterior, 304 stainless steel interior baffles, and be minimally rated for a design pressure of 125 psig @ 200 degrees Fahrenheit. Unit shall be factory equipped with a blowdown valve and an air vent. The selected unit shall be factory manufactured with flanged or grooved pipe connections to match the diameter of the design pipe size to which it is connected without the use of pipe reducers. Insulate in accordance with 23 07 00.

2.5.12 Escutcheon Plates

Provide one piece or split hinge metal plates for piping entering floors,

walls, and ceilings in exposed spaces. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.5.13 Flow Meters

Where indicated on the construction drawings, provide a Hershel/classic style venturi flow meter installed in accordance with manufacturer instructions, manufactured of 316 (or higher grade) stainless steel and in a horizontal section of the chilled water/heating hot water pipe with a minimum of five pipe diameters upstream and two pipe diameters downstream of the flow meter flange connections to the main pipe. Install with the sensing lines below the horizontal centerline to prevent gas entrapment in the meter lines. Provide unit with NPT sensing line connections, inlet and outlet connections factory sized to the same pipe size the meter is installed, with a turndown ratio of 10:1, and a maximum pressure loss of 6% of the differential pressure. A factory provided differential pressure cell shall be installed and connected to the control architecture as shown in the controls schematics.

2.6 HEAT TAPE FOR FREEZE PROTECTION OF PIPING

Provide parallel conduction type that is composed of two copper conductors separated by conductive material and all enclosed in an insulating jacket. The heat tape shall be self-regulating that decreases heat output as temperature increases at each point along the length of tape. Provide voltage as indicated. Provide heat tape complete with fittings, adapters, and fittings, adapters, and other devices to connect tape to standard rigid steel conduit junction boxes, switches, or other devices as indicated. Provide tape sealants and jumper connectors up to 5-inches in length for connecting multiple runs. Provide a thermostat that activates the heat tape on drop of outside air temperature at 38 F. Thermostat shall have maximum tolerance of plus or minus 5 degrees F and maximum operating differential of 6 degrees F within temperature operating range. Wattage per foot of pipe at 50 F shall be as follows. This wattage may be achieved by spiraling the tape around the pipe.

Pipe Diameter (Inches)	1/2	3/4	1	1.25	1.5	2	3	4	6	8
Watt/Foot	2	2	2.5	2.5	3	3.5	4	6	7	8

2.6.1 Pressure/Temperature Test Ports (Plugs)

Provide solid bras test plugs where indicated. Test plug shall be capable of receiving a pressure or temperature probe 1/8-inch o.d. Dual seal core shall be rated zero leakage from vacuum to 200 psig and 0 F to 220 F. Each plug shall be extended through pipe insulation and be capped. Provide 2 each, pressure gauge adapters with 1/8-inch o.d. probe, 5-inch stem pocket testing thermometers for 0 F to 220 F.

2.6 ACCESS DOORS FOR VALVES

Provide factory-prefabricated and primed flush face steel access doors including steel door frame for with continuous hinges and

turn-screw-operated latch. Provide door frame installation in plaster and masonry walls. Furnish doors under this section; install doors under appropriate section of this specification.

2.7 CHEMICAL FEED TANK

Construct of steel for minimum working pressure of 125 psig. Provide chemical pipe, fittings, and valves as specified for water piping. Add borate-nitrite corrosion inhibitors to initial fill water for heating and cooling water systems in concentrations of one-half ounce per gallon of system water.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 HVAC System

Installation of HVAC system including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with ASME B31.1, ASME/ANSI B31.5, NFPA 70, and in accordance with the manufacturer's recommendations.

3.1.2 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.2 PIPING

Test, inspect, and approve piping before burying, covering, or concealing. Provide fittings for changes in direction of piping and for connections. Make changes in piping sizes through tapered reducing fittings; bushings will not be permitted. Install valves with stems horizontal or above. Provide flanges or unions at valves, traps, strainers, and connections to equipment; unions are not required in copper tubing piping systems.

- a. Threaded connections: Provide Teflon pipe thread paste on male threads. Do not thread metal pipe into plastic piping.
- b. Pipe hangers and supports: Provide additional pipe hangers and supports at in-line water pumps and flanged valves.
- c. Piping to receive insulation: Provide temporary wood spacers between the pipe hangers and supports, and the pipe in order to properly slope the piping and establish final elevations. Provide temporary wood spacers of same thickness as insulation to be provided under Section 23 07 00, INSULATION OF MECHANICAL SYSTEMS. Support plastic piping every 4 feet. Support metal piping as follows.

MAXIMUM SPACING (FEET)

MAXIMUM SPACING (FEET)

Nominal Pipe Size (inches)	One and under	1.25	1.5	2	2.5	3	3.5	4	5	6
Nominal Pipe Size (inches)	One and under	1.25	1.5	2	2.5	3	3.5	4	5	6
Copper Tubing	6	7	8	8	9	10	11	12	13	14
Steel Pipe	7	8	9	10	11	12	13	14	16	17

- d. Cleaning of piping: Keep interior and ends of new piping and existing piping affected by Contractor's operations, cleaned of water and foreign matter during installation by using plugs or other approved methods. When work is not in progress, securely close open ends of pipe and fittings to prevent entry of water and foreign matter. Inspect piping before placing into position.
- e. Demolition: Remove materials so as not to damage materials which are to remain. Replace existing work damaged by Contractor's operations with new work of same construction.
- f. Tee Joints: Extracted tee joints may be made in copper tube. Make joint with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, provide dimpled depth stops. Notch the branch tube for proper penetration into fitting to assure a free flow joint. Braze extracted joints using a copper phosphorous classification brazing filler metal. Soldered joints shall not be permitted.

3.3 ADJUSTMENTS

Adjust controls and equipment so as to give satisfactory operation. Adjust entire water temperature control system and place in operation so that water quantities circulated are as indicated. Air duct systems shall be adjusted and balanced so that air quantities at outlets are as indicated and so that distribution from supply outlets is free from drafts and has uniform velocity over the face of each outlet.

1. Equipment Start up shall be performed by manufacturer technical start up personnel or service technician.
2. Additional Field Services beyond that required for start-up, shall be provided by manufacturer technical start up personnel or service technician to assist in the functional performance testing by the commissioning authority.
3. Additional Field Services beyond that required for start-up and functional testing shall be provided by manufacturer technical start up personnel or service technician to assist in the Government PVT testing by the Government for both first and second season testing as specified under 23 09 23.13.

4. For Air handling units with factory provided controls which are to be interfaced or monitored by the BAS, provide manufacturer technical start up personnel or service technician for start-up.

3.4 PUMPS

After testing, adjusting, and balancing, trim the impellers on all pumps 10 hp and greater to actual flow conditions plus 10 percent discharge head. Readjust throttling device to correct flow rate.

3.5 INSTRUCTING OPERATING PERSONNEL

Upon completion of work and at time designated by Contracting Officer, provide services of competent technician for period of not less than one 3 8-hour working day for instruction of Government operating personnel in proper operation and maintenance of equipment.

3.6 FIELD QUALITY CONTROL

Upon completion and before final acceptance of work, test each system in service to demonstrate compliance with the contract requirements. Adjust controls and balance systems prior to final acceptance of completed systems. Test controls through every cycle of operation. Test safety controls to demonstrate performance of required function. Correct defects in work provided by Contractor and repeat tests. Furnish steam, fuel, water, electricity, instruments, connecting devices, and personnel for tests. Flush and clean piping and boiler before placing in operation. Clean equipment, piping, strainers, ducts, and filters.

3.6.1 Piping Systems Except for Refrigerant Piping

Before insulating, hydrostatically test each new piping system at not less than 188 psig Maintain pressure for 2 hours with no leakage or reduction in gage pressure. Obtain approval before applying insulation.

3.6.2 Air Ducts

Obtain approval before applying insulation.

3.6.3 Equipment

3.6.3.1 Field Testing

Test each item of equipment in operation for continuous period of not less than 24 hours under every condition of operation in accordance with each equipment manufacturer's recommendation. Verify that the equipment operating parameters are within limits recommended by the manufacturer.

3.6.4 Additional Field Testing

Provide testing, adjusting, and balancing (TAB) of ducts, piping, and equipment under Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.6.5 Testing EMCS Equipment

- a. All EMCS equipment shall be given an operation test.

- b. Items not operating properly shall be repaired or replaced and retested.

-- End of Section --