Division 23 - Heating Ventilating and Air Conditioning

23 00 00 Heating, Ventilating, and Air Conditioning (HVAC)

23 05 00 Common Work Results for HVAC

1. Sleeves and Penetrations
    - Pipe penetrations through exterior walls - use schedule 40 galvanized pipe sleeve with leak plate and premanufactured “linkseal” with stainless steel hardware. Do not use sheet metal sleeves through outside walls. Sleeves shall be pipe conforming to ASTM A 120.
    - Pipe penetrations through interior masonry walls - use schedule 40 steel pipe sleeve.
    - Pipe penetrations through Floors - use schedule 40 steel pipe sleeve. Provide galvanized schedule 40 pipe or cast iron pipe, extended 2 inches above the floor and seal water tight between floor and sleeve.
    - Pipe penetrations through interior (dry-wall) partition walls - use schedule 40 steel pipe sleeve for diameters 6 inch and below; use galvanized steel sheet sleeves for diameters greater than 6 inch.
    - Duct penetrations through non-fire rated interior walls - cover opening between the wall and duct or duct insulation with sheet metal flanges of the same material and thickness as duct. Overlap openings on all four sides by at least 1-1/2 inches.
    - Protect and fire stop all penetrations in accordance with the applicable codes.
    - Coordinate fire stopping requirements with Section 078000.
2. Demolition
    - Remove all utilities, piping, ductwork, wiring, cabling, pneumatic tubing back to the active portion of the distribution system. Portions of distribution systems no longer required for service shall be removed back to the active portion of the distribution system and capped off.
    - All hangers, supports, and controls devices connected to demolished materials shall also be removed.
    - No in-active systems or system components are allowed to be abandoned in place.

23 05 16 Expansion Compensation

1. Welded piping systems:
    - Expansion compensators and expansion joints on concealed piping are not allowed. Provide expansion loops and z-bends on concealed piping.
    - Bellows type expansion joints on HTHW and MTHW piping systems are not allowed. Provide flanged slip type expansion joints on HTHW piping systems. Preferred manufacturer of slip type expansion joints is Advanced Thermal Systems, Inc.
    - Provide expansion loops and z-bends on LTHW piping systems. Bellows type expansion joints are allowed on LTHW piping systems, where approved by Mason.
2. Threaded and soldered piping systems (Piping 2 inches diameter and below):
    - Provide expansion loops, z-bends and swing joints.
    - Bellows type expansion joints are allowed on LTHW piping systems, where approved by Mason.

3. Grooved piping systems (2 1/2 diameter and greater):

    - Expansion and contraction of grooved IPS steel piping systems shall be provided with loops or bends consisting of (8) Victaulic Style 75 or 77 flexible couplings, (4) grooved end 90 degree elbows, and grooved end pipe spools provided in water systems to 230°F in accordance with Victaulic recommendations for expansion compensation.
    - Provide packless, gasketed, slip-type expansion joint with grooved end telescoping body, for installation with Style 07 rigid couplings, providing up to 3" axial end movement with pressure rating up to 350 psi. Victaulic Style 150 Mover® where pipe bends or expansion loops cannot be applied.

23 05 19 Meters and Gages

1. Specify pressure/temperature test stations, combination (PIT) plug on supply and return piping of all water coil connections not otherwise provide with pressure and temperature gages. The basis of design shall be Peterson Equipment Company (Pete's Plug).
2. Water and steam pressure gages shall be liquid filled.
3. Provide water totalizing meter with contact head for make-up water lines on hot water boilers, closed loop hydronic sytems, evaporative cooling systems and steam generating systems.
4. Refer to Section 23 09 00 "Instrumentation and Control for HVAC" for flow meters and BTU meters.
5. Use bimetallic temperature indicators in 5" diameter case. Orient gage so that special flexible joint is not needed.
6. Use materials compatible with service for pressure indicators, temperature indicators and flow meters. Use diaphragm where needed.
7. Use solar powered meters and gages.
8. HTHW – Use 316 Stainless Steel Bimetal Thermowell for all temperature indicators and Pigtail Siphon for all pressure indicators.

23 05 23 General-Duty Valves for HVAC Piping

1. Butterfly valves are not allowed.
2. Valves for High Temperature Hot Water (HTHW) and Medium Temperature Hot Water (MTHW):

    - 2″ and Larger: Shall be OS&Y type of the ASA 300 pound class, cast steel body, 13% Cr. stainless steel trim, flanged at connections to equipment, flanged at other than equipment connections, bored to match inside diameter of pipe.
    - 1-1/2″ and Smaller: Shall be full-port ball valves of ASA 600 pound class, cast steel or forged carbon steel, socket weld pattern, 13% Cr. stainless steel trim, bored to match inside diameter of pipe.
    - Gate Valves: Shall be solid wedge with stainless steel wedge or wedge faces, stainless steel seat rings. Stainless steel bonnet bushings and beveled collar on valve stem for back seating. Provide braided, teflon impregnated backing rings in a large, deep stuffing box suitable for high temperature water service. Insert at bottom of stuffing box, to serve as base for packing. Packing glands shall be non corrosive and shall have bolted gland flange with minimum of 2 eye bolts. Valves with their bypasses, need to be installed for proper operating access.

        1) Gate Valves 1-1/2″ and Smaller: Provide with a minimum of 4 packing rings.
        2) Gate Valves 2″ and Larger: Provide with a minimum of 6 packing rings.

3) Gate valves 6” and Larger: Provide with a minimum of 6 packing rings. Provide forged steel, globe valves bypass, minimum 3/4". Provide with tapered roller or ball bearing yokes and button type grease gun fittings and adapters to allow charging a reservoir with valve lubricant.

4) Gate Valves 8″ and Larger: Provide a minimum of 6 packing rings. Provide forged steel, globe valve bypass, minimum 3/4". Provide with tapered roller or ball bearing yokes, bevel gear operators, clockwise rotation to close, laminated lubricating fittings and approved grease seals.

5) Acceptable manufacturers: Crane, Jenkins, Vogt.

- Globe and Angle Valves: Shall be of the cast plug disc with bevel seat, separately screwed or pressed in disc and seat rings, long disc locknut, port opening full pipe diameter. Provide stainless steel seat ring and disc: stainless steel bonnet bushing and beveled collar for backseating. Provide braided, teflon impregnated packing rings in a larger, deep stuffing box to service as base for packing. Packing glands shall be non-corrosive and shall have bolted gland flange with minimum of 2 eye bolts. Valves with their bypasses shall be installed for proper operating access.

  1) Globe & Angel Valves 1-1/2″ and Smaller: Shall have mini um of 4 packing rings.

  2) Globe & Angle Valves 2″ and Larger: Shall have a minimum of 6 packing rings.

  3) Globe & Angle Valves 6″ and Larger: Shall have minimum of 6 packing rings. Valves shall have forged steel, glove valve bypass; button-type grease gun fittings and adapters to allow charging a reservoir with valve lubricant tapered roll or ball bearing yokes.

  4) Globe & Angle Valves 8″ and Larger: Shall have minimum of 6 packing rings. Valves shall have forged steel, globe valve bypass; button-type grease gun fittings and adapters to allow charging a reservoir with valve lubricant; and tampered roller or ball bearings yokes. Shall be equipped with impactor or hammer-blow hand wheel.

  5) Acceptable manufacturers: Crane, Jenkins, Powell, Vogt.

- Check Valves: Shall be horizontal swing check, 300 lb. cast steel, with 13% Cr. stainless steel disc, disc face and barrel type seat rings. Provide full port opening. Disc and seat shall be removable without removing valve from line. Acceptable manufacturers: Crane, Jenkins, Powell, Vogt.

- Gage and Instrument Valves: Shut-off valves for pressure gages and instrument isolating valves shall be of the “barstock” construction, with stainless steel body and stainless steel plug type disc integral with stem. Ends shall be I.P.S. screwed. Rating shall be 600 psig at 750°F. Valves shall be 1/2" size, Crane Co. or approved equal.

- Blowdown Valves: Blowdown valves for cascades, expansion drums, hot water generators shall be unit-tandem type valves, consisting of none hardseat and one seatless valve in one common steel body to conform to the ASTM Boiler Code. Valves shall be rated at 400 psig and suitable for pressures to 665 psig. Valves shall be welding ends and alloy steel trim.

- Needle Valves: For high temperature water convectors shall be of “barstock” construction with stainless steel body and stainless steel plug type disc integral with stem. Ends shall be I.P.S. screwed. Rating shall be 600 psig at 750°F. Crane Co. or approved equal.

- Drain and Vent Valves: Drain and vent valves shall be ASA 600-pound class 1 forged steel globe or angle valves, as specified above. Drain valves need to be sized and shown on the Drawings. Unless otherwise required, vent valves shall be 1/2" size.

- Control Valves

1) HTHW – 2-way Flanged 300 lb. cast steel, 316 stainless steel trim, Fisher Type ES body, high pressure pneumatic actuator with positioner, if required.

2) HTHW – For equipment requiring a valve over 2-1/2″ please use 2 valves designed at 1/3, 2/3 arrangement to achieve tighter control and improved energy savings.

3) HTHW – Control valve should be on Supply side for better temperature control and should have a bypass valve installed.

4) Use equal percentage contour plug. Preliminary sizing shall be based on 20 psi. pressure differential (verify with Project Manager).

5) Valves shall be capable of closing off against a 100 psi pressure difference.

3. Valves for Low Temperature Hot Water

- Ball Valves (preferred): Use for isolation and shut-off duty, size 2-inch and below, Class 150 (150 psig SWP) screwed connection, two-piece, bronze body, PTFE seat, stainless steel ball, lever operated with insulation extension.
- Gate Valves (not to be used unless specifically approved by Mason): Use for isolation and shut-off.

  1) Size 2-inch and below: Class 150 (150 psig SWP), screwed connection, bronze body, bronze seat, bronze disk, inside screw rising stem operator.

  2) Size 2-1/2 inch and greater: Class 125, flanged connection, cast iron body, bronze seat, cast iron disc, OS&Y operator.

- Globe Valves (not to be used unless specifically approved by Mason): Use for by-pass and throttling duty.

  1) Size 2-inch and below: Class 150 (150 psig SWP), bronze body with union-ring bonnet integral seat, PTFE disc, inside screw rising stem operator.

  2) Size 2-1/2 inch and above: Class 125 (200 psig CWP), cast iron with bolted bonnet, flanged ends, cast iron seat, cast iron disc, OS&Y operator.

4. Valves for Dual Temperature Water

- Ball Valves (preferred): Use for isolation and shut-off duty, size 2-inch and below, Class 150 (150 psig SWP) screwed connection, two-piece, bronze body, PTFE seat, stainless steel ball, lever operated with insulation extension.
- Gate Valves (not to be used unless specifically approved by Mason): Use for isolation and shut-off.

  1) Size 2-inch and below: Class 150 (150 psig SWP), screwed connection, bronze body, bronze seat, bronze disk, inside screw rising stem operator.

  2) Size 2-1/2 inch and greater: Class 125, flanged connection, cast iron body, bronze seat, cast iron disc, OS&Y operator.

- Globe Valves (not to be used unless specifically approved by Mason): Use for by-pass and throttling duty.

  1) Size 2-inch and below: Class 150 (150 psig SWP), bronze body with union-ring bonnet integral seat, PTFE disc, inside screw rising stem operator.

  2) Size 2-1/2 inch and above: Class 125 (200 psig CWP), cast iron with bolted bonnet, flanged ends, cast iron seat, cast iron disc, OS&Y operator.

5. Valves for Chilled Water

- Ball Valves (preferred): Use for isolation and shut-off duty, size 2-inch and below, Class 150 (150 psig SWP) screwed connection, two-piece, bronze body, PTFE seat, stainless steel ball, lever operated with insulation extension.
- Gate Valves (not to be used unless specifically approved by Mason): Use for isolation and shut-off.
    1) Size 2-inch and below: Class 150 (150 psig SWP), screwed connection, bronze body, bronze seat, bronze disk, inside screw rising stem operator.
    2) Size 2-1/2 inch and greater: Class 125, flanged connection, cast iron body, bronze seat, cast iron disc, OS&Y operator.
- Globe Valves (not to be used unless specifically approved by Mason): Use for by-pass and throttling duty.
    1) Size 2-inch and below: Class 150 (150 psig SWP), bronze body with union-ring bonnet integral seat, PTFE disc, inside screw rising stem operator.
    2) Size 2-1/2 inch and above: Class 125 (200 psig CWP), cast iron with bolted bonnet, flanged ends, cast iron seat, cast iron disc, OS&Y operator.

6. Valves for Low Pressure Steam, Low Pressure Steam Condensate Return and Pumped Condensate:
    - Ball Valves (preferred): Use for isolation and shut-off duty, size 2-inch and below, Class 150 (150 psig SWP) screwed connection, two-piece, bronze body, PTFE seat, stainless steel ball, lever operated with insulation extension.
    - Gate Valves (not to be used unless specifically approved by Mason): Use for isolation and shut-off.
        1) Size 2-inch and below: Class 150 (150 psig SWP), screwed connection, bronze body, bronze seat, bronze disk, inside screw rising stem operator.
        2) Size 2-1/2 inch and greater: Class 125, flanged connection, cast iron body, bronze seat, cast iron disc, OS&Y operator.
    - Globe Valves (not to be used unless specifically approved by Mason): Use for by-pass and throttling duty.
        1) Size 2-inch and below: Class 150 (150 psig SWP), bronze body with union-ring bonnet integral seat, PTFE disc, inside screw rising stem operator.
        2) Size 2-1/2 inch and above: Class 125 (200 psig CWP), cast iron with bolted bonnet, flanged ends, cast iron seat, cast iron disc, OS&Y operator.
7. Valves for Condenser Water:
    - Ball Valves (preferred): Use for isolation and shut-off duty, size 2-inch and below, Class 150 (150 psig SWP) screwed connection, two-piece, bronze body, PTFE seat, stainless steel ball, lever operated with insulation extension.
    - Gate Valves (not to be used unless specifically approved by Mason): Use for isolation and shut-off.
        1) Size 2-inch and below: Class 150 (150 psig SWP), screwed connection, bronze body, bronze seat, bronze disk, inside screw rising stem operator.
        2) Size 2-1/2 inch and greater: Class 125, flanged connection, cast iron body, bronze seat, cast iron disc, OS&Y operator.
    - Globe Valves (not to be used unless specifically approved by Mason): Use for by-pass and throttling duty.

1) Size 2-inch and below: Class 150 (150 psig SWP), bronze body with union-ring bonnet integral seat, PTFE disc, inside screw rising stem operator.

2) Size 2-1/2 inch and above: Class 125 (200 psig CWP), cast iron with bolted bonnet, flanged ends, cast iron seat, cast iron disc, OS&Y operator.

8. Balancing Valves:

- 2″ and Smaller: Y-pattern, globe type manual balancing valves with Ametal® brass copper alloy body, EPDM o-ring seals, 4-turn digital readout handwheel for balancing and concealed memory feature with locking, tamper-proof setting, soldered or threaded end connections and provisions for connecting a portable differential pressure meter. Victaulic/Tour & Andersson Series 786 and 787.
- 2-1/2″ and Larger: Y-pattern, globe type manual balancing valves with ductile iron body and Ametal® parts, EPDM o-ring seals, 8, 12, or 16-turn digital readout handwheel for balancing and concealed memory feature with locking, tamper-proof setting, flanged or grooved end connections and provisions for connecting a portable differential pressure meter. Victaulic/Tour & Andersson Series 788 and 789.
- Install a Series 78U union port fitting and Series 78Y strainer/ball valve combination to complete terminal hookup at coil outlet.

23 05 29 Hangars and Supports for HVAC, Piping, and Equipment

1. All piping with insulation shall be supplied with properly fitted sheet metal saddles and high density insulation inserts at all pipe support locations.
2. Victaulic Style 107, 07, and W07 rigid couplings may be used on IPS steel piping systems, which meet the support and hanging requirements of ASME B31.1 and B31.9. An adequate number of Victaulic Style 75, 77, or W77 flexible couplings shall also be used to compensate for thermal expansion/contraction of the pipe.

23 05 53 Identification for HVAC Piping and Equipment

1. Mark location of air handlers, fan coil units, air terminal units, etc., above ceilings with identifying "buttons" to facilitate maintenance through ceiling.
2. Tag roof top exhaust fans and associated fume hood to facilitate maintenance and identification.
3. Utilize standard tag or placard to mark all major equipment. Tag all valves and provide valve chart for each floor.
4. Utilize standard Commonwealth of Virginia color coding for various building service piping and ductwork. Mark each with name of service, direction of flow, and associated unit served where appropriate.
5. All systems handling hazardous materials must have appropriate marking and visual or audible alarms to protect building occupants and maintenance personnel. Mark exhaust fans on roof which handle hazardous fumes with appropriate color code.
6. Mark air handling units with large letters and numbers.
7. Provide strap-on markers for pipe. Pressure-sensitive type markers are not acceptable.
8. Conform with ANSI 13.1

23 07 00 HVAC Insulation

1. All insulation shall conform to the latest Energy Code requirements.

2. Staples are not acceptable for insulation installation.
3. All "raw" ends of insulation shall be sealed.
4. For High Temperature Hot Water, Medium Temperature Hot Water, and Steam/Condensate piping insulation, provide the following:
    - For interior piping: canvas jacket, coated with Fosters 81-42w or equal and painted.
    - For tunnel piping: wrap with an approved non-flammable moisture barrier and cover with an aluminum jacket.
    - Calcium silicate insulation, 4″ minimum thickness for operating temperatures greater than 400°F.
    - Removable insulation jackets shall be provided on all valves and expansion joints.
5. All indoor exposed chilled water and low temperature hot water piping located in the following areas shall be provided with a field installed protective canvas jacket.
    - Existing central heating and cooling plant at the main Fairfax, VA campus.
    - Mechanical rooms which also contain High Temperature Hot Water or Steam piping systems.
6. All indoor exposed chilled water and low temperature hot water piping located in all other areas (except areas identified in paragraph 5 above): 20 mil (minimum) PVC protected jacket shall be provided.
7. For condensation control on interior Chilled Water piping use the minimum thicknesses: Pipe sizes 1-1/2" and smaller use 1-1/2" insulation, pipe sizes greater than 1-1/2" use 2" insulation.
8. Condensate drains shall have 1" of insulation.
9. Internal insulation or lining of ductwork is prohibited unless approved by Mason.
10. Insulation specification shall describe what systems and services are to be insulated. Refer to the insulation schedule below.

INSULATION SCHEDULE					
Insulation Description	**Service**	**Maximum Thermal Conductivity**	**Minimum Density (lb./c.ft.)**	**Pipe Size**	**Thickness**
Closed Cell Foam	Chilled Water	0.23	3	1½″ and smaller 2″ to 5″	1” 1”
Fiberglass Pipe Insulation	Low Temperature Hot Water, Medium Temperature Hot Water, and Dual Temperature Service	0.23	3	2″ and smaller 2½″ and larger	1½″ 2″
Fiberglass Pipe Insulation	Chilled Water	0.23	3	1½″ and smaller 2″ to 5″ 6″and larger	1½” 1½″ 2″
Fiberglass Pipe Insulation	Low Pressure Steam (15 psig and below)	0.23	3	1″ and smaller 1½″ to 2½″ 3″ to 6″ 8″ and larger	1½″ 2″ 3″ 3½″
Fiberglass Pipe Insulation	Medium Pressure Steam (15 to 70 psig)	0.23	3	1″ and smaller 1½″ to 3″ 4″ and larger	2″ 3″ 4″

INSULATION SCHEDULE					
Insulation Description	**Service**	**Maximum Thermal Conductivity**	**Minimum Density (lb./c.ft.)**	**Pipe Size**	**Thickness**
Fiberglass Pipe Insulation	High Pressure Steam (70 psig and greater)	0.23	3	1″ and smaller 1″ to 3″ 4″ and larger	2″ 3″ 4″
Fiberglass Pipe Insulation	Steam Condensate Return and Pumped Condensate	0.23	3	2″ and smaller 2″ and larger	1½″ 2″
Fiberglass Pipe Insulation	Hot Water Air Separators	0.23	3	All sizes	1″
Fiberglass Pipe Insulation	Steam Vent and Relief Valve Piping	0.23	3	All sizes	1″
Fiberglass Pipe Insulation	Coil Condensate Drain and City Water	0.23	3	All sizes	1″
Fiberglass Pipe Insulation	Refrigerant Suction and Hot Gas	0.23	3	All sizes	1″
Fiberglass Pipe Insulation	Indoor Free Cooling and Outdoor Condenser Water Piping	0.23	3	5″ and smaller 6″ and larger	1½″ 2″
Fiberglass Pipe Insulation	Hot Water Valves	0.23	3	2½″ and larger	2″
Fiberglass Pipe Insulation	Valves for Steam and Steam Condensate Return	0.23	3	2½″ and larger	3″
Calcium Silicate Pipe Insulation and Ceramic Cloth	Engine Exhaust	0.42		All sizes	4″
Foamed Plastic Pipe Insulation	Coil Condensate Drain and City Water	0.26	6	All sizes	½″
Flexible Unicellular Pipe Insulation	Refrigerant Suction and Hot Gas	0.26	6	All sizes	½″
Calcium Silicate Equipment Insulation	Boiler Breeching, Induced Draft Fans, Converter Shell, Condensate Receivers, Flash Tanks, Deaerator Heaters, Hot Water Generator Shell, Boiler Feed Water Heaters, Boiler Feed Water Pumps, and Fuel Oil Heaters	0.42		All sizes	4″
Calcium Silicate Equipment Insulation	Boilers	0.42		All sizes	4″
Calcium Silicate Equipment	Condensate Storage Tanks	0.42		All sizes	2½″

INSULATION SCHEDULE					
Insulation Description	**Service**	**Maximum Thermal Conductivity**	**Minimum Density (lb./c.ft.)**	**Pipe Size**	**Thickness**
Insulation					
Flexible Unicellular Equipment Insulation	Chilled Water Pumps, Plate and Frame Heat Exchangers, Air Handling Unit Coil Headers, Centrifugal Refrigeration Machines, and Chilled Water Valves	0.26	6	All sizes	2″
Flexible Unicellular Equipment Insulation	Flexible Duct Connections	0.26	6	All sizes	2″
Rigid Fiberglass Board Insulation	Supply Air, Outdoor Air and Mixed Air Ductwork and Plenums Located in Mechanical Equipment Rooms	0.23	6	All sizes	1½”
Rigid Fiberglass Board Insulation	Supply Air, Return Air, Exhaust Air and Mixed Air Ductwork and Plenums Located Outdoors	0.23	6	All sizes	2″
Rigid Fiberglass Board Insulation	Terminal Air Boxes, Duct Mounted Coils, and Air-to-Air Heat Exchangers	0.23	6	All sizes	Mfgr’s Standard Thickness
Fiberglass Duct Blanket Insulation	Supply Air, Outdoor Air and Mixed Air Ductwork and Plenums	0.31	1.5	All sizes	2″

11. In addition to the thickness of insulation of pipes listed above, the Professional shall consider the use of thicker insulation if required by AHRAE 90.1, latest edition. The insulation shall meet the requirements of International Mechanical Code, latest edition.

12. All supply air, mixed air, and return air ductwork shall be insulated with Ductwrap or rigid fiberglass board (as indicated above). Minimum thickness is 1½” with FSK (Reinforced Foil, aka FRK) laminate facing. It must have a minimum of ¾ density and a minimum an out of package R-value of 5.1.

13. All supply air ductwork in the ceiling used as return air plenum shall be insulated with 1″ thick 1-1/2 lbs./c ft. fiver glass insulation.

14. Duct liners are NOT permitted in the laboratories and the animal use areas.

15. Wherever duct liners are used, the installation shall meet the installation requirements of the manufacturer and SMACNA guidelines.
16. All steam, condensate return, chilled water, hot water, condensate drain, make-up water and ductwork shall be insulated as listed under Insulation Materials.

23 05 93 Testing, Adjusting, and Balancing (TAB)

1. Specify a third party TAB Contractor. The TAB Contractor shall not be subcontracted by the Mechanical Contractor.
2. Agency Qualifications: The independent testing, adjusting, and balancing agency shall be certified by the National Environmental Balancing Bureau (NEBB) or the Associated Air Balance Council (AABC) in the testing and balancing disciplines required for the project, and have at least one Professional Engineer registered in the State of Virginia, certified by NEBB or AABC as a Test and Balance Engineer.
3. In accordance with the submittal specifications and 01810, submit a synopsis of the testing, adjusting, and balancing procedures and proposed agenda.
4. In accordance with the submittal specifications, submit sample forms, if other than those standard forms prepared by the AABC or NEBB are proposed.
5. Submit a detailed testing, adjusting and balancing plan for each system and equipment type that is required to be balanced. Testing, adjusting and balancing work in the field will not be permitted without an approved testing, adjusting and balancing plan for each system and equipment type.
6. All domestic hot water recirculating zones provided with balancing valves shall be tested, adjusted and balanced by the TAB contractor. The TAB contractor shall review the plumbing drawings prior to bidding.
7. Pre-balancing Conference: Prior to beginning the testing, adjusting, and balancing field work, schedule and conduct a conference with Mason, Siemens, the Mechanical Engineer, and representatives of installers of the mechanical systems. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.
8. Draft Reports: In accordance with the submittal specifications, prepare and submit draft reports on the approved forms upon completion of testing, adjusting, and balancing procedures. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports.
9. Final Report: In accordance with the submittal specifications, prepare and submit a final report. Bind approved report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents.
10. Report Contents:
    - General Information and Summary: Inside cover sheet to identify the testing, adjusting, and balancing agency, Contractor, Owner, Architect, Mechanical Engineer, and Project Engineer. Include addresses, and contact names and telephone numbers. Also include a certification sheet containing the seal, name, address, telephone number, and signature of the Certified Test and Balance Engineer. Include a listing of the instrumentation used for the procedures along with the proof of calibration within six months prior to starting the project.
    - The remainder of the report shall contain the appropriate approved forms for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form.

23 06 80 Unitary Air Conditioning Equipment

1. Window air conditioning units are not acceptable unless approved in writing by Mason. If no other options exist, they shall be equipped with a programmable timer which can be shut off when the space is not occupied. The timer can be part of the unit, or at the panel as appropriate.

23 09 00 Instrumentation and Control for HVAC

1. All new buildings shall have a Siemens Building Technologies DDC energy management and control system (EMCS) installed. The new EMCS system will tie into the existing campus EMS system Database. The System Database shall host on the existing Apogee server, and must be able to use Microsoft Internet Explorer or Mozilla Firefox Browsers to remotely view system graphics, monitor, control, and configure the HVAC system and its properties. The energy management and control system shall monitor and control HVAC operations and conditions, alarm abnormal conditions and index control modes and provide AHU optimized start/stop operations, peak demand limiting, demand control ventilation, provide reporting and trend logs. The specific system requirements shall be reviewed with the Mason Building Automation and Energy Management shops during the design phase. All Retail Space will have at a minimum the ability to communicate to the existing campus EMS system as well as the following utility meters:
    - DEM 2000 for tracking electrical use
    - Onicon ultrasonic flow meters for both chilled water and hot water for heating and cooling
    - Onicon ultrasonic flow meter for domestic cold water
    - Onicon gas meter (if applicable) for natural gas consumption
2. In general, the system shall include field level panels receiving information on the status of various sensors in the building and comparing this information with standard instructions relayed from a central processor. The local unit then makes changes required according to programming already present in its memory or overridden by the central processor. All control devices will be electric/electronic with the exception of HTHW or large building CW Valves which will be pneumatic (Refer to Section 230523 for additional HTHW control valve requirements). Control shall generally be DDC, with the exception of general space and equipment room heating and ventilation which shall be electric.
3. The plans and specifications for the EMCS and mechanical system must include a detailed points list showing all monitor and control points and identify all required software and hardware, and must also include a sequence of operations for major equipment and systems. The point list shall also show all alarm conditions. Lab controls, if applicable shall be VAV fume hood type, Siemens lab controls; Phoenix air valves are not acceptable. If chillers are part of the project, consultant shall design the plant using Siemens Demand Flow Program for chiller sizing, plant equipment selection, and chiller system sequences.
4. The EMCS must be capable of alarming to, and allowing interface and programming by any compatible personal computer via Mason's LAN. EMCS shall be expandable and be compatible with the electronic equipment controls. EMCS must have a security password/code for system entry and programming. A network RJ45 jack shall be provided for network communications over Mason's LAN. Aarms must utilize the existing Reno software. Consultant shall specify and identify all EMCS panels for connection to GMU LAN to be connected by the telecom contractor. New laptops or PC workstations are not to be provided in building as part of the project.
5. The EMCS must be capable to perform the following functions: Initiate selected control sequences for AHUs, chillers, boilers pumps, exhaust fans, cooling towers, rooftop mounted units, VFDs, fan coil units, start/stop, occupied/unoccupied modes, optimized equipment start/stop operation, monitor total building electric usage with DEM, chilled water/hot water, domestic water, and dual temp consumption Onicon Ultrasonic 4200 flow meters, demand control ventilation and provide peak

demand limiting routines as determined by Owner. Monitor and alarm selected conditions for temperature, Pressure, Flow, mixed air temperature, supply air temperature, return air temperature, CO2, outside air temperature, static pressure, temperatures of dedicated IT rooms or closets, On/Off, Start/Stop Status; Safety Control Status (Fire, Freeze, and Smoke alarms). Co2 sensors should only be specified where actually required by sequence. Mason does not want inputs for filter status, and valve/damper position unless critical. Mason wants to minimize use of air flow stations and consultant must design adequate straight runs as recommended by manufacturer for accurate reading and TAB set-up.

6. The EMCS control panels shall be located inside the building preferably in the mechanical rooms or one level below the roof if roof mounted equipment is provided. They shall be capable of standalone operation in the event of network communications failure.
7. The EMCS shall include complete graphics that will include all application devices associated with the installed control system including floor-level graphics with links to equipment for each building system. Floor plans will include room numbers, VAV locations and room sensor locations. The graphic start page for each new facility will include links to .pdf files of as-built mechanical plans and as-built control drawings. Samples and templates will be provided by Mason. The Architect must provide background CAD files for creation of floor plans.
8. Provide electric utility metering for each new building and provide setup in Apogee Insight, UCM, and Infocenter. Metering shall be a DEM 2000 installed on building main switchgear. Provide Onicon Ultrasonic 4200 flow meters on all HTHW, CW, HW, Dual Temp, and DHW pipes that serve the building. The flow meters shall be tied into the EMCS system and be setup in Apogee Insight, UCM, and Infocenter. If the building is being retrofitted or upgraded, the consultant shall research and show the existing metering and LANs on the plans and identify for maintained connection and use.
9. Provide CO2 sensors on all air-handling units with economizer control for demand ventilation control, and provide economizer control on AHUs for free cooling. Provide current switches for pump and fan status. VAV terminals shall have room and supply air temperature sensors.
10. Siemens shall provide all VFDs under this section. The VFDs shall be Yaskawa. There will be no substitutes. The VFDs will communicate remotely with the EMCS system via P1 communications and added to the EMCS with the proper unbundled points for control.
11. Integration to other HVAC equipment shall be provided as follows using BACNET MSTP or MODBUS RS485; LON or IP integration is not permitted. Provide integration for CRAC's when there are multiple units and chillers. Integration to boilers, split AC systems, heat pumps, and emergency generators is not required. Specify Siemens controls and EMCS connection for fan coil units, heat recovery units, and roof top air handling units; manufacturer controls are not allowed

23 09 23 Direct Digital Controls

Test Plan

1. Prepare a written test plan indicating in a step-by-step, logical fashion, the procedures by which the automatic control system will be tested, adjusted, and checked.
2. Not less than 6 weeks prior to testing, provide copies of the proposed test plan for approval in accordance with the specifications for submittals. Meet and discuss the test plan, and make agreed changes to the written plan. Resubmit the revised test plan in accordance with the specifications for submittals.
3. The Test Plan shall include, as a minimum, for each system and subsystem of the automatic control work, the following:
    - System name.
    - List of devices with brief description of functional purpose of each.
    - A description of the expected signal values transmitted by the sensor.

- A description of the expected signal values transmitted by the controller to the control device or actuator.
- A description of the expected signal values of the control device over its operating range.
- A description of the instrumentation required to test the system.
- A detailed description of the test.
- A log sheet or sheets on which expected and field read values will be recorded and final field read values indicating that the system is operating in accordance with contract requirements.
- A functional performance test of sequences.
- A functional performance test of sequences.

Testing and Adjusting During and After Installation

1. The testing and adjusting includes the submission of a test plan which shall describe in detail the method by which each component, subsystem, and system will be tested, adjusted, and retested after installation in accordance with the specified sequences of operation and other characteristics of the control system.
2. A report on test results, including set points and operating ranges of all components shall be submitted in accordance with submittal specifications. The set points and operating ranges of all components shall be recorded to be submitted as part of the commissioning tests results.
3. The testing specified in this paragraph shall not replace the testing specified in "Commissioning Tests."
4. The entire test shall be witnessed by the University and the A/E.
5. Upon satisfactory test, a copy of the final test results shall be bound in the Operating and Maintenance Manual.

Commissioning Tests

1. In addition to the "Testing and Adjusting During and After Installation", the contractor shall perform commissioning tests to verify that the entire automatic control systems are designed, installed, and adjusted to perform as required in the contract. This phase is an extension, not a substitute, of the phase "Testing and Adjusting During and After Installation."
2. Demonstrate all calibration and tests performed under "Testing and Adjusting During and After Installation."
3. Point to Point checkout of every control sequence.
4. Verification of Electronic Digital Controllers
    - Verify the operation of the microcomputer operating system of the field panels. Demonstrate proper automatic restart of equipment after power restoration.
    - Verify each required software application routine. They shall include, but not be limited to:
        1) All control sequences specified for each local loop
        2) Time of day scheduling
        3) Chilled/Hot water reset
        4) Outdoor air reset
        5) Occupied/Unoccupied cycle

6) Demand Control Ventilation

7) Start/stop time optimization

8) Event initiated programs

9) Trending

10) Peak demand limiting

- Verify the operation through the use of a laptop connected to the Siemens Field Panel.
- Verify self-diagnostics of the field panel. Each field panel shall be verified by the use of a laptop connected to the Siemens Field Panel.
- Verify the operation of the clock routine in the field panel.
- Demonstrate changing of default values of sensors by the use of a laptop connected to the Siemens Field Panel.
- Demonstrate proper system operation while set points and data are being modified.
- Verify operation of all terminal equipment controllers.
- Verify all graphics for accuracy and that they meet Mason approved standards. Graphics will include all application devices associated with the installed control system including floor-level graphics with links to equipment for each building system. Floor plans will include room numbers, VAV locations and room sensor locations. The graphic start page for each new facility will include links to pdf files of as-built mechanical plans and as-built control drawings.

5. Mechanical system demonstration

    - Demonstration shall include the operation of the entire mechanical system under the control of the contractor and shall include the start-up, operation, and shutdown of the system in accordance with the sequence of operation.
    - The operation of each device shall be performed in accordance with the written instructions contained in the operation and maintenance manual, a copy of which shall be available 10 working days prior to the test. No deviation from the procedures in the operating manual will be permitted.
    - Should the system fail to perform in accordance with the requirements of the operation and maintenance manual, the system shall be repaired, recalibrated, retested as necessary, and a second demonstration performed at no additional expense. The contractor shall reimburse the expenses of the commissioning team for each test after the first.

6. All commissioning tests, verifications, and demonstrations shall be witnessed by Mason Personnel.
7. For any test, verification, or demonstration that fails to meet the specification requirements, the component of the automatic control system causing the control system failure, be it hardware, firmware, or software, shall be repaired, replace, or readjusted. The failed test, verification, or demonstration shall be repeated.
8. Upon satisfactory tests of the automatic control systems, copies of the final test results shall be bound in the Operating and Maintenance Manual.

Final Operational Test and Acceptance

1. The final operational test and acceptance shall constitute an operational test over a 30 day period that the system performs the functions and intent of the contract requirements. During the 30 day test period, Mason's Building Automation and EMS personnel shall operate the system in accordance with the manufacturer's requirements and shall log all deviations, failures, and other deficiencies which constitute contract nonperformance. The requirement for minor adjustments and/or system

modifications shall be submitted in writing stating the scope of said modifications and the need therefore, prior to implementing such changes.

2. During the 30 day test duration, the system shall demonstrate its continuous functional and operational capabilities without breakdown or shutdown defined as "UPTIME." During the testing period, the UPTIME of all field panels, terminal microprocessors, host computer and peripherals, network, etc. shall not be less than 95%. The tests shall be extended on a day-by-day basis until the UPTIME over 30 consecutive days meets the stated level, at which time the system will be accepted by Mason.
3. Consultant to specify training for the EMCS. Training shall be appropriate for building complexity. 8 hours for complex building systems and 4 hours for all others

23 10 00 Facility Fuel Systems

1. All fuel oil handling equipment and systems such as fill stations, transfer pumps, polishing systems, day tanks, etc. shall be checked out and started up by a factory authorized technician. Training and demonstration to Mason's operating staff shall also be provided by a factory authorized representative. Training and demonstration shall not be performed concurrent with the start-up.

23 11 00 Facility Fuel Piping

1. Fuel Oil Piping Schedule
    - Above ground fuel oil supply, fuel oil return, fuel oil vent, 2″ and smaller: Carbon steel, threaded joints and cast iron fittings, standard weight.
    - Above ground fuel oil supply, fuel oil return fuel oil vent, 2-1/2″ and larger: Carbon steel, butt welded joints and fittings, standard weight.
    - Below ground fuel oil supply, fuel oil return, fuel oil vent 2″ and smaller: Double containment piping system; Carrier Pipe same as above grade piping described above with socket welded joints and fittings; Secondary Containment Pipe shall be FRP with bell and spigot adhesive bonded joints, Ameron Dualoy 3000/L or approved equal.
    - Below ground fuel oil supply, fuel oil return, fuel oil vent and fuel oil fill 2-1/2 and larger: Double Containment Piping System; carrier pipe same as above grade piping described above with butt welded joints, Ameron Dualoy 3000/L or approved equal.
    - 100% of all below ground carrier pipe welds shall be UT tested.
    - Galvanized piping is prohibited.

23 21 13 Hydronic Piping

1. All hydronic piping shall be in accordance with this section, unless the piping system is High Temperature or Medium Temperature Hot Water. Refer to 23 21 14 for High Temperature and Medium Temperature Hot Water piping requirements.
2. Pipe sizes 2-inch and smaller, above ground:
    - Type L hard drawn copper, ASTM 88 with wrought copper fittings, ASME B16.22. soldered joints; mechanical joints are not acceptable.
    - Schedule 40 steel, ASTM A53, Grade B, ERW with malleable iron fittings, ASME B16.3. Screwed joints; mechanical joints are not acceptable.
3. Pipe sizes 2-1/2 inch and greater, above ground:
    - Schedule 40, ASTM A53 or A106, Grade B, seamless. Wrought Steel fittings; ASME B16.9, ASME B16.28 or ASTM A420. Welded joints; mechanical joints will be allowed in

mechanical equipment rooms and equipment rooms and equipment connection with prior written approval from Mason.

4. Welding Requirements

    - High Temperature and Medium Temperature Hot Water - ASME B31.1 Power Piping. 100% Radiographic testing. Welder qualifications and welder continuity logs shall be a required submittal.
    - Low Temperature Heating Water within Buildings - ASME 31.9 Building Services Piping. 20% UT testing. Welder qualifications and welder continuity logs shall be a required submittal.
    - Chilled Water Piping Below Grade (Carrier Pipe) or in Tunnel (Campus distribution piping) - ASME B31.1 Power Piping. 100% UT testing. Welder qualifications and welder continuity logs shall be a required submittal.
    - Chilled Water Piping within Buildings - ASME 31.9 Building Services Piping. 20% UT testing. Welder qualifications and welder continuity logs shall be a required submittal.
    - Condenser Water Piping within Buildings - Welder qualifications and welder continuity logs shall be a required submittal.

5. Underground distribution piping shall be a manufactured pre-insulated piping system consisting of carrier pipe, insulation, and outer jacket. Acceptable manufacturers are Perma-Pipe, Thermacor, or Rovanco.

6. Inspection and Testing. Weld inspection to include 100% visual inspection on gap alignment and root pass; and, ultrasonic inspection (UT) of at least 15% of the field welds by each certified welder on the job. Any failure in UT testing to result additional testing of 15% of that welder's work. There is to be 100% hydro testing at 200 psig to be witnessed by and coordinated with Mason Central Heating and Cooling Plant personnel and the Project Inspector.

7. Cleaning:

    - Flushing: Perform initial piping system flush to remove core system debris prior to chemical treatment. Typically, this would involving filling the system with water, leaving no air voids, and then flushing the system out at fire hose volumes. In this process, all vents and drains need to be well rinsed until no visible debris or discoloration is visible. The initial rinse water shall be tested and compared to the raw water source to provide a base line for procedure performance. Flushing to be witnessed by and coordinated with Mason Central Heating and Cooling Plant personnel and the Project Inspector.
    - Chemical Cleaning: Chemical cleaning must remove unwanted debris while installing an initial coating of corrosion inhibitor film. The objective is to reduce internal pipe corrosion by at least 95% during the first year of operation. The chemical treatment must remove oils, grease, mill debris, weld slag and other forms of new piping contaminants. The core ingredients of the chemicals used must be biodegradable. Chemicals used must form an initial film of corrosion inhibitor to yield high levels of internal pipe protection. Chemicals used must include an EPA approved micro biocide that provides a broad spectrum kill of unwanted microorganisms that result in corrosion.
    - Recirculation: Provide taps with isolation valves and cross connections as required to isolate and chemically clean each piping system section. Provide circulation pump(s) as required. Circulate the chemical solution for a minimum of 72 hours. During this process, monitor and maintain system pressure at appropriate levels. After 72 hours, flush the system until debris and products are no longer present. The rinse water shall be tested and be verified to be free of treatment products.
    - Inhibitors: After flushing the chemical cleaning solution, inject an initial charge of inhibitors to maintain the system until it is brought into service. If at any time prior to placing the piping system into service, the system is drained and refilled, then an additional charge of corrosion

inhibitors must be injected into the piping system section. Once all treatment is completed, pipe must remain full of water.

- Report. All chemical cleaning to be witnessed by and coordinated with Mason Central Heating and Cooling Plant personnel and the Project Inspector. Provide a written report of cleaning results.

23 21 14 High Temperature and Medium Temperature Hot Water Piping

1. Materials for High Temperature Water Systems:

- Pipe:

2" and Larger:	1-1/2" and Smaller:
Schedule 80	Schedule 80
ASTM A 53, Grade B	ASTM A 53, Grade B
Black	Black
Seamless	Electric Resistance Welded

- Fittings

2" and Larger:	1-1/2" and Smaller:
Schedule 80	3,000 pound
Seamless	Forged Carbon Steel
Butt-welded type	Socket weld
ASA B 16.9	ASA B 16.11
ASTM A 234 Grade B	ASTM A 105 Grade II

Weld ells shall be long-radius pattern.

- Flanges (all sizes): 300 pound class, forged steel, welding neck type, ASA B 16.5 ASTM A 181 Grade I.
- Gaskets (all sizes): Spiral wound, type 304 stainless steel, non-asbestos filled, 3/16" thick with centering guide, 300 pound class, by Garlock, Flexitallic style CG, or approved equal.
- Strainers (all sizes): Y-type; same size as pipe in which they are installed. Strainers shall have cast steel bodies suitable for 425o F temperature and 600 psig pressure, bottoms drilled, directional arrow on body. Strainers shall be equipped with easily removable cover and basket. Basket shall be stainless steel with 3/32" perforations. Net free area through back of basket shall be 2-1/2 times the area of connecting pipe. Flow shall be into basket and out through perforations.
- Unions (normally not to be used on pipe larger than 1"): 3,000-pound class forged steel, socket-welded type, with steel to steel seat, ASTM A 105 Grade II, as manufactured by Henry Vogt Machine Co. or approved equal.
- Welding Rings (to be used on pipe 4" diameter and larger): Carbon steel with knock off spacer pins, for Schedule 40 and/or Schedule 80 pipe dimensions.
- Bolts and Studs: Alloy steel studs threaded full length and fitted with two hexagon nuts per stud for all flanged joints. Bolting to conform to ASTM A 193 Grade B-7, threads class 7 fit. Nuts shall be semi-finished hexagonal, ASA B 18.2 ASTM A 194 Grade 2H.

2. Cleaning:

- Flushing: Perform initial piping system flush to remove core system debris prior to chemical treatment. Typically, this would involving filling the system with water, leaving no air voids, and then flushing the system out at fire hose volumes. In this process, all vents and drains

need to be well rinsed until no visible debris or discoloration is visible. The initial rinse water shall be tested and compared to the raw water source to provide a base line for procedure performance. Flushing to be witnessed by and coordinated with Mason Central Heating and Cooling Plant personnel and the Project Inspector.

- Chemical Cleaning: Chemical cleaning must remove unwanted debris while installing an initial coating of corrosion inhibitor film. The objective is to reduce internal pipe corrosion by at least 95% during the first year of operation. The chemical treatment must remove oils, grease, mill debris, weld slag and other forms of new piping contaminants. The core ingredients of the chemicals used must be biodegradable. Chemicals used must form an initial film of corrosion inhibitor to yield high levels of internal pipe protection. Chemicals used must include an EPA approved micro biocide that provides a broad spectrum kill of unwanted microorganisms that result in corrosion.
- Recirculation: Provide taps with isolation valves and cross connections as required to isolate and chemically clean each piping system section. Provide circulation pump(s) as required. Circulate the chemical solution for a minimum of 72 hours. During this process, monitor and maintain system pressure at appropriate levels. After 72 hours, flush the system until debris and products are no longer present. The rinse water shall be tested and be verified to be free of treatment products.
- Inhibitors: After flushing the chemical cleaning solution, inject an initial charge of inhibitors to maintain the system until it is brought into service. If at any time prior to placing the piping system into service, the system is drained and refilled, then an additional charge of corrosion inhibitors must be injected into the piping system section. Once all treatment is completed, pipe must remain full of water.
- Report. All chemical cleaning to be witnessed by and coordinated with Mason Central Heating and Cooling Plant personnel and the Project Inspector. Provide a written report of cleaning results.

23 22 00 Steam and Condensate Piping

1. Steam piping, above ground:
    - Sizes 2 inch and Smaller: Schedule 40 steel, ASTM A53, Grade B, ERW. Malleable iron fittings, ASME 16.3 Screwed joints, mechanical joints are not acceptable.
    - Sizes 2-1/2 inch and greater: Schedule 40 steel type E, ASTM A53 or A106, Grade B. Standard weight wrought steel fittings ASME B16.9 or B16.28. Butt welded joints and fittings; mechanical joints are not acceptable.
2. Condensate piping, above ground:
    - Sizes 2-inch and smaller: Schedule 80 type S, ASTM A53, Grade B. Fittings shall be 300 psig malleable iron, ASME B16.3 Screwed joints and fittings; mechanical joints are not acceptable.
    - Sizes 2-1/2 inch and greater: Schedule 80 type E, ASTM A53 or A106, Grade B. Fittings shall be extra heavy duty wrought steel, ASME B16.9 ASME B16.28 or ASTM A420. Butt welded joints and fittings; mechanical joints are not acceptable.
3. Underground steam and condensate piping:
    - Shall be a manufactured pre-insulated piping system consisting of carrier pipe, insulation and outer jacket. The piping system shall be fully dryable, drainable and air testable. Acceptable manufacturers are Perma-Pipe, Thermacor, and Rovanco.
    - Steam piping 2 inch and smaller: Schedule 40 steel, ASTM A53, Grade B, ERW, steel fittings, socket welded joints.

- Steam piping 2 1/2 inch and greater: Same as indoor steam piping 2 1/2 inch and greater.
- Condensate piping 2 inch and smaller: Schedule 80 type S, ASTM A53, Grade B, steel fittings, socket welded joints.
- Condensate piping 2 1/2 inch and greater: Same as indoor condensate piping 2 1/2 inch and greater.

4. Welding:
    - Steam working pressures 15psig and below - ASME 31.9 "Building Services Piping." 100% UT testing. Welder qualifications and welder continuity logs shall be a required submittal.
    - Steam working pressures greater than 15 psig - ASME 31.1 "Power Piping." 100% UT testing. Welder qualifications and welder continuity logs shall be a required submittal.

23 36 00 Air Terminal Units

1. Construction
    - Terminal Casing shall be minimum 22-gauge galvanized steel, internally lined with 1/2″ dual density insulation that complies with UL181 and NFPA 90A. Insulation shall be non-eroding and non water absorbing. Use of fiberglass insulation is allowed only in double wall construction where the insulation is completely protected from the air stream by an inner metal liner.
    - The casing shall have access panels which allow for full service and maintenance to fans, motors, controls.
    - All units that require a motor shall use ECM motors.
    - Fans shall be forward curved steel constructed with permanent lubricated bearings.
    - The primary damper shall be heavy gauge steel with self-lubricating bearings.
2. Noise Criteria
    - Sound ratings for the terminal units shall not exceed NC 35.
    - Sound attenuation shall be provided in consultation with the university.
3. Controls
    - Terminal units shall be provided with factors mounted controls unless approved by the University.
    - The controls manufacturer shall be sole sourced based on the Mason Instrumentation and Controls Standards (see 23 09 00)

23 50 00 Central Heating Equipment

23 52 00 Heating Boilers

1. Modular type condensing boilers rated at 90 % + efficiency are preferred for remote locations.
2. Scotch Marine boilers may be considered for installations larger than 50 horse power. They should be multi-pass and have an efficiency of greater than 90% at the design point. Comply with Factory Mutual requirements. Buy a packaged boiler whenever possible. Consult Mason for use of dual-fuel burners for type of burner to use, turn-down desired and type of control to use.
3. All boilers shall be checked out and started up by a factory authorized technician. Factory start-up services shall include the following as a minimum:

- Pre-functional installation check-out.
- Operation and testing of all operating and safety controls.
- Combustion efficiency testing and reporting (multi-point testing). The engineer shall specify detailed testing requirements.

4. Training and demonstration to Mason's operating staff shall also be provided by a factory authorized representative. Training and demonstration shall not be performed concurrent with the start-up.

23 55 00 Fuel-Fired Heaters

1. Do not use without permission of Mason. If so, use stainless steel heat exchangers that are gas-fired units (not oil fired), using spark ignition only.

23 57 00 Heat Exchangers for HVAC

1. Selection and specifications for liquid-to-liquid, steam-to-liquid, air-to-air, etc. shall be reviewed by the University.
2. HTHW heat exchangers shall be shell and tube type.
    - HTHW shall be in tubes. Tubes shall be 90-10 copper-nickel. Heads shall be steel (forged, steel). Shell pressure rating should be 300PSI.
    - In water-to-water exchangers, the water flow shall be upward.
    - In water-to-steam generators, the controls shall be similar to those used for fired steam generators, excluding low water cutoff.
    - Provide separate over-temperature control on leaving secondary hot water.
    - Provide required level controls, secondary water relief and/or safety valves piped to floor drain on water or steam generators.
    - Provide increase tube pitch on steam generators.
    - HTHW Control valve should be on Supply side for better temperature control.
3. Provide units with a fouling factor of 0.0005 for water or as approved by Mason. For glycol exchangers, consult with Mason. 30% glycol solution should provide adequate freeze protection; consult with Mason if it is felt that a greater percentage is required. Propylene glycol may be required for certain food handling operations.
4. HTHW-to-water heat exchangers shall have the temperature sensing elements operating plus over temp., located in the shell near the outlet nozzle, and immediately adjacent to outlet nozzle.

23 60 00 Central Cooling Equipment

1. Warranty: 5 year parts and labor on all components including the compressor, fan motors, structural components, etc.
2. All equipment shall be checked out and started up by a factory authorized technician. Factory start-up services shall include the following as a minimum:
    - Pre-functional installation check-out.
    - Operation and testing of all operating and safety controls.
    - Verification of refrigerant charge and lubrication levels.

- Verification of proper evacuation and dehydration of all built up systems, custom systems and split systems.

3. Training and demonstration to Mason's operating staff shall also be provided by a factory authorized representative. Training and demonstration shall not be performed concurrent with the start-up.

23 63 00 Refrigerant Condensers

1. Use only on very small projects, with Mason permission. Water-cooled units may be considered for special applications such as back-up refrigeration. Air-cooled units must be justified by life-cycle cost analysis.
2. Limit air cooled condensers to very small systems or for equipment such as constant temperature rooms unless life-cycle cost indicate otherwise.
3. Where air cooled condensers are used, they shall be designed for low ambient temperature operation.
4. Warranty: 5 year parts and labor on all components including the compressor, fan motors, structural components, etc.

23 64 00 Packaged Water Chillers

23 64 16 Centrifugal Chillers – Water Cooled

1. Mason requires as efficient a unit as possible. Units shall be provided with variable frequency drives. Refrigerant type to be approved by Mason. Centrifugal chillers shall not be located outside of the building. A/E shall design all refrigerant relief piping, including all sizes and termination to safe point outside the building.
2. If the unit is pre-purchased, the A/E shall obtain pre-purchase specifications from Mason.
3. Provided condenser shell with marine style water boxes for pipe connection end. Provide hinged or davited water boxes on machines greater than 400 tons.
4. Trane, McQuay or Carrier are approved manufacturers.

23 64 19 Reciprocating Water Chillers

1. Use only on small projects, for remote locations and for special applications such as back-up cooling. Modular type units are preferred. Heat recovery units will require an economic evaluation including life-cycle analysis. Refrigerant type to be approved by Mason.

23 65 00 Packaged Cooling Towers

1. Fan shall be shaft driven.
2. Provide handrail, ladder and cage for access.
3. Provide all needed screens and protective devices. Discharge hoods and sound control measures shall be provided to attain noise levels acceptable to local conditions and ordinances.
4. For multiple cell cooling tower arrangements, provide automatic control valves on each inlet and outlet. Provide equalizer pipe between all cells to maintain equal basin levels under all possible operating conditions.
5. Float type Water level control is preferable. EP, BD and chemical pump should have H-O-A- selection switch.
6. Provide drains near cooling towers to handle overflow. The drains on cooling towers must drain to sanitary sewer as required by code for water treatment reasons.

7. Provide electric basin heaters unless Mason confirms that the cooling tower will be drained down in the winter and does not require basin heat.
8. All cold water basins shall be stainless steel construction.
9. Warranty: 5 year parts and labor on all components including the fan motors, structural components, etc.
10. All equipment shall be checked out and started up by a factory authorized technician. Factory start-up services shall include the following as a minimum:
    - Pre-functional installation check-out.
    - Vibration testing.
    - Operation and testing of all operating and safety controls.
    - Drive and fan blade adjustments.
    - Lubricating system level verification.
11. Training and demonstration to Mason's operating staff shall also be provided by a factory authorized representative. Training and demonstration shall not be performed concurrent with the start-up.

23 70 00 Central HVAC Equipment

23 74 00 Air Handling Units

1. All units shall be modular type unless custom, semi-custom or field erected units are approved by Mason. All air handling units shall be double wall construction.
2. Air handling units over 6,000 CFM capacity shall include the following as a minimum:
    - Double wall access doors, hinged with latches and durable gaskets. Gaskets shall be mechanically secured, they shall not be secured only by adhesives. Access door in positive pressure plenums must swing inward. Access doors in negative pressure plenums must swing outward. All access doors shall be provided with vision panel and the section served shall include a marine light with external switch.
    - All fans shall be non-overloading (backward inclined or airfloil type).
    - Provide all fans with factory mounted inlet airflow measuring devices.
    - Provide field mounted outdoor airflow measuring device and return air flow measuring device (where return fan is not integral to unit).
3. Cooling coil fin density shall not exceed 12 fins per inch.
4. Heating coil fin density shall not exceed 10 fins per inch.
5. Cooling coil section interior liner, supports, framing system and fasteners shall be type 304 or type 316 stainless steel.
6. All individual coils shall be supported by a framing system. Stacked coils shall not be supported by the coil below.
7. Humidifier section interior liner, supports and fasteners shall be type 316 stainless steel.
8. All fans shall be internally isolated.
9. All custom, semi-custom and field erected units:
    - Shall be factory fabricated, assembled and leak. Units shall be broken down in the factory for shipments/rigging. All components requiring field assembly shall be match marked in the factory.

- Shall be leak tested in the field after installation is completed.
- The installation shall be supervised by a factory authorized representative who shall inspect the installation prior to leak testing and start-up.
- The unit shall be started up by a factory authorized representative.
- The engineer shall be responsible for specifying test pressures and allowable leakage rates.
- The factory representative shall be responsible for producing leak test procedures and submitting to Mason for approval. The contractor shall be responsible for leak testing under the supervision of the factory representative. A leak test report shall be submitted to Mason, and shall be certified by the contractor and the factory representative.

10. All outdoor units shall be provided with the following as a minimum:
    - Units with width greater than eight feet shall have slope roof for proper rain water drainage.
    - Units with width exceeding 12 feet shall be provided with rain gutters and downspouts.
    - All exterior access doors shall have drip covers.

23 74 00 Packaged Outdoor HVAC Equipment

Rooftop Heating and Cooling Units

1. These may be used only with Mason approval.
2. When rooftop equipment is suggested for the project, the access to the roof shall be as a minimum a stair tower meeting applicable codes extended full-size to the roof. In addition, an available elevator may be required to extend to the roof.
3. As an alternative, the equipment may be located on an approved ground slab.
4. Coils shall be fully drainable from valve with hose connection.
5. Heating and cooling should be from external sources of hot water (or glycol mixture) or chilled water; do not use gas fired exchangers or air cooled refrigerant (DX) systems without Mason approval.
6. Relief Fan configurations are not acceptable. Return Fans shall be utilized in all applications except where approved in writing by Mason.

23 81 00 Decentralized HVAC Equipment

23 81 13 Packaged Terminal Air Conditioners

1. Use 18 gauge front panels on baseboards.
2. Fan coil units shall have permanent split capacitor motors.

23 81 46 Heat Pumps

1. Mason encourages investigating water-source heat pumps for feasibility. Use only after detailed life cycle cost analysis and approval of Mason.