

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

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### **23 00 00. HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

#### **23 00 03. GENERAL PROVISIONS**

- .1 Where excessive amounts of heat or low to moderately toxic chemicals are present, 10 to 20 room air changes per hour are required to minimize the hazard. The air should not be recirculated, if harmful airborne chemicals are present. In addition, the space should be kept under slight negative pressure, in order to ensure the contaminant does not escape and enter adjacent areas. This design would be appropriate for designated smoking areas.
- .2 Specialized exhaust systems will need to be provided for offset printing and dark room operations.
- .3 **COHESIVE DOCUMENTS OF BUILDINGS, UTILITIES AND SYSTEMS:** The Associate's design documents shall provide one-line diagrams of all utilities, organized in relation to the new construction plus the existing construction. Provide one-line diagrams of each system, organized in relation to the new construction plus the existing construction. The one-line diagrams and system documents must display the interrelationship of all systems with all attributes of the building (number of floors, future or shelled-out spaces, original buildings, added building areas, etc.).
- .4 **ROTATING EQUIPMENT**
  - .4.1 **GENERAL PROVISIONS:** Where possible, specify rotating equipment with antifriction sealed spherical ball or roller bearings, split pillow blocks, and lubrication of bearings in accordance with manufacturer's recommendations before start-up. Bearing life (on equipment 5 hp and larger) per Anti-Friction Bearing Manufacturers Association rating procedures shall be 90 percent expectancy of reaching at least 87,360 hours under design conditions. Caution the contractor to exercise extreme care in cleaning and lubrication of bearings after equipment has been subject to prolonged periods of storage before operation. The contractor shall be made responsible for continued lubrication of equipment until acceptance of his work.
  - .4.2 **NOTIFICATION OF START-UP:** The Associate shall notify the University Architect of the schedule for start-up of all equipment.
  - .4.3 **REPORT REQUIRED:** The Associate shall specify that the Contractor, at the time of acceptance, shall provide the University Architect with a report listing the following:
    - .4.3.1 Dates equipment arrived at job site.
    - .4.3.2 Installation completion date.
    - .4.3.3 Dates of maintenance at start-up and periodic inspections.
    - .4.3.4 Dates of lubrication, specific brand names, manufacturer and type(s) of lubricant.

**23 00 03. GENERAL PROVISIONS (Cont'd)**

.5 EQUIPMENT IDENTIFICATION: Specify that fans, controls, switches, ventilators, pumps, and other items of equipment, which have had the manufacturer's data tags removed or rendered illegible, be equipped with new tags by the installer. Tags shall be brass plates on which operational data plus information regarding areas or other equipment served is stamped. Permanently attach tags to the equipment in locations where they can easily be read.

23 00 05. SUBMITTALS:

.1 FOR DESIGN CONSIDERATION:

.1.1 Economic analysis of proposed recovery systems.

.1.2 Report of soil corrosion analysis for cathodic protection of prefabricated insulated piping. The report of soil corrosion analysis shall be furnished and included by the Associate in the contract documents.

.1.3 Methods for achieving energy conservation: Refer to Part One - The Design Process, paragraph 00034 for general design requirements and to Facility Services-6 (15/16-6) for specific requirements.

.1.4 Motor data for operating equipment.

.2 FOR PROJECT CLOSE OUT:

.2.1 Record Drawings: Refer to Division 01 (01 78 39.2) of these standards.

.2.2 Test Reports: Specify that tests be performed in conformance with the following procedures and that written reports be submitted to the Associate. The Associate shall furnish two copies of each report to the University. Also see Facility Services-4.4 (15/16-4.4).

23 00 07. TESTING

.1 TESTING PROCEDURES

.1.1 Testing Procedures: Specify that all tools, instruments, and equipment required for performing tests be furnished and that required temporary connections be made. Defects that develop under tests shall be repaired promptly and the tests shall be repeated. No caulking of screwed joints, cracks, or holes will be permitted. Leaks shall be repaired by tightening joints or by replacing pipe, fittings, or equipment with new materials. Minor leaks in welded joints may be chipped out and rewelded.

.1.1.1 Hydrostatic and air tests shall be made before piping is concealed or covered. Specify that systems be completely drained after hydrostatic tests are performed and that damages caused by freezing, prior to acceptance of the completed installation, be repaired at no cost to the University.

.1.1.2 Preparation for Testing: Prior to testing, obtain satisfactory operation and uniform temperatures; perform air and water balancing and adjustment of pressure reducing stations and HVAC equipment. Pressure reducing valves, relief valves, air vents, and motor-operated valves shall be checked for proper operation. Pumps shall have operating heads

**23 00 03. GENERAL PROVISIONS (Cont'd)**

adjusted in accordance with the performance curves; test reports shall include amperage readings.

- .1.1.3 Water Chiller and Boiler Check Out: Specify that a factory-trained serviceman employed by the manufacturer perform adjustments, start-up, tests, and provide syllabus-of-training plus instructions to designated University operating personnel. Training by the manufacturer shall be coordinated with the Facilities Operations and Development (FOD) Learning Center.
- .1.1.4 Refrigeration piping shall be isolated from the refrigeration system and tested in accordance with test procedures set by ASME, Section 5, Refrigeration Piping, USASI 31.5. Perform tests at an ambient temperature above 50 degrees F.
- .1.1.5 Testing of service lines shall follow recommended code practices. When lines are tested with water pressure, care must be taken to remove all air to avoid false pressure readings.
- .1.1.6 Refrigerant piping shall be tested independent of existing piping systems and existing or new equipment.
- .1.1.7 Underground and buried lines shall be tested for a period of 24 hours at one and one-half times the normal working pressures. Lines shall not be tested against existing systems. Water lines may be tested in accordance with AWWA, if the test procedure is outlined and approved.
- .1.1.8 Conduit for underground thermal lines shall be tested with air at not less than 15 pounds pressure for a period of twenty-four (24) hours. Piping in the distribution system shall be subjected to a hydrostatic test pressure of 250 psig or twice the working pressure whichever is greater.
- .1.1.9 Pressure and Duration of Tests: Exposed lines shall be tested with the test fluid at pressures indicated for a period of not less than 6 hours and shall show no drop in pressure:

Line	Test Fluid	Pressure Not Less Than
Steam - 200 lbs.	Water	300 lbs.
Steam - 100 lbs.	Water	200 lbs.
Steam - 15 lbs.	Water	125 lbs.
HWHS & HWHR	Water	125 lbs.
Chilled Water	Water	125 lbs.
Condensate	Water	125 lbs.
Condenser Water	Water	125 lbs.
Air	Air	150 lbs.

- .2 **BALANCING:** Specifications shall stipulate that the Balancing Contractor shall be a company certified by the Associate Air Balance Council (AABC), National Environmental Balancing Bureau, Inc. (NEBB), or other nationally recognized authority to perform tests, and shall be certified in the disciplines specific to the project applications and needs, and make recommendations for balancing of air and water systems. The balancing contractor shall be hired by the Associate or Construction Manager.

### 23 00 03. GENERAL PROVISIONS (Cont'd)

- .2.1 Prebalance Meeting: At a date determined by the University Architect, a prebalance meeting will be scheduled with the company, designated University personnel, the Associate Architect, and his engineering consultants to review the system or systems involved. During the meeting, it shall be determined whether the system or systems will be balanced for full cooling, full heating, or modulated as applicable to both design and weather conditions. In preparation for this meeting, the company selected to perform the system balance shall be required to review the project drawings and, within 30 days, submit to the Associate a summary of proposed methods of test procedure for each system. Proposed tests shall include, but not be limited to, the following:
  - .2.1.1 Testing of hot and cold mixing dampers.
  - .2.1.2 Testing and setting of static pressure dampers.
  - .2.1.3 Testing total C.F.M., S.P., R.P.M., O.V., and B.H.P. of all fans and system leakage.
  - .2.1.4 Testing air and water velocities at coils. Describe test conditions and procedures.
  - .2.1.5 Testing ceiling plenum systems for leakage.
  - .2.1.6 Testing air shafts for leakage.
  - .2.1.7 Testing and adjusting of variable air volume systems and the tracking of supply air fans with return air fans at the following normal extremes of system operation:
    - .2.1.7.1 Maximum volumes, i.e., maximum summertime cooling design volumes, with constant volume toilet exhaust in operation.
    - .2.1.7.2 Minimum volumes, i.e., minimum wintertime heating design volumes, with constant volume toilet exhaust in operation.
  - .2.1.8 Prior to any hydronic balancing, the following must first occur. The hydronic systems shall have been circulated and shall be determined to be internally clean and leak-free. The hydronic system contractor shall open all hydronic strainers, remove the strainer from the strainer fitting, throw away the start-up strainer, clean the permanent strainer, re-insert the permanent strainer, and remove all air from the water system. The balancing contractor may then perform the hydronic balance.
  - .2.1.9 For all three-way hydronic control valves, the balancing contractor shall balance for identical system flows at full flow through the coil, plus full flow through the bypass.
- .2.2 Conducting the balance: The company will coordinate the work with equipment manufacturers by obtaining authorization in writing to adjust specific equipment as it involves both air and water balance or to arrange for personnel of equipment suppliers to be available for the necessary adjustment at the time of balance. Copies of all requests and acknowledgements shall be directed to the Associate and the University Architect. Any discrepancies over plus or minus 5 percent, or items not in accord with contract documents, which may affect the total system or systems balance, shall be reported to the HVAC contractor for corrections.

### **23 00 03. GENERAL PROVISIONS (Cont'd)**

Copies of correspondence shall be directed to the Associate and the University Architect. Air and water balance must be repeated following corrections to confirm that corrections were made.

- .2.3 FUME HOOD BALANCING shall be in accordance with procedures outlined in Appendix. Coordinate balancing with Environmental Health and Safety through the University Architect.
- .2.4 REPORTS: One copy of the preliminary air and water balance report is required. Test modes shall be identified in the balance reports. Three copies of the final balance reports indicating specified and actual tested conditions, including verification of equipment performance, as well as explanation for variation from specified conditions shall be submitted to the University Architect. See Facility Services-4.4.

### **23 05 05. HVAC SPECIALTIES**

#### **23 05 20. METERS, GAUGES AND THERMOMETERS**

##### **.1 METERS:**

- .1.1 Temporary services are usually metered. Refer to Division One (01 51 00) for possible metering requirements.
- .1.2 Permanent utility services to each building require permanent metering.
- .1.3 Water meter (follow City of Columbus Regulation #90-1, Effective 2/3/90): An electric impulse water meter measuring in cubic feet shall be provided to record water usage and to proportion water treatment compound and blow-down in accordance with the water make-up quantities. Recommended meters are Badger, Sensus, or Kent.
- .1.4 Sewer auxiliary metering: See 22 05 20.1 (15432.3).
- .1.5 Utility meters shall be provided on all utilities for temporary construction, and for permanent installation to a new building, and for permanent installation to major additions and/or major renovations to a building. Utilities to be metered shall include:
  - .1.5.1 Natural gas
  - .1.5.2 Electricity
  - .1.5.3 Domestic water
  - .1.5.4 Deductive meter for make-up water to cooling towers and for irrigation systems
  - .1.5.5 Chilled water
  - .1.5.6 Steam
  - .1.5.7 Sub-metering may be provided where required or requested.
- .1.6 Utility metering shall incorporate "Custody Transfer" of utility data for totalized consumption and peak demand (peak rate-of-consumption). The collection,

## 23 05 05. HVAC SPECIALTIES (Cont'd)

### 23 05 20. METERS, GAUGES AND THERMOMETERS (Cont'd)

storage and retrieval of the utility data shall be completely independent of any external non-utility system, e.g., completely independent of the building automation system.

- .1.7 Utility metering shall include integral registers, calculators, and totalizers to calculate, store, and display totalized consumption and peak demand (peak rate-of-consumption). All values shall be stored within the meter in non-volatile memory, which can be accessed by the Utility as required to implement utility billing, or resolve billing disputes.
- .1.8 Utility metering shall incorporate isolated outputs that permit external systems, e.g., the building automation system, to monitor selected values for the purpose of improving operational efficiency of the building systems.

#### .2 GAUGES:

- .2.1 Gauges other than draft gauges shall be 4-1/2 inches diameter single spring type with recalibration adjustment in the dial face and with gate valve shut-off. Tailor the range to the application. Gauges shall not be positioned over 6-feet above the floor; install remote sensing gauges as required to conform to this restriction. Gauges shall be applied on all pumps, and air handler coils. Gauges shall include snubbers and/or siphons. Gauges in applications with possible dirty strainers shall include compound-ranges.
- .2.2 Draft gauges in systems of more than 5000 cfm shall be installed across all pre-filter/intermediate filter systems, across after-filters and across low efficiency filters. Below 5000 cfm install magnehelic type gauges.
- .2.3 Pressure gauges, at compressors of over 100 Ton capacity, indicating high side, low side and oil pressure shall be provided, if they are not included as a part of the compressor package.
- .2.4 A steam gauge after regulators (within sight of the regulator but at a suitable distance downstream from the regulator to assure good pressure readings) shall be provided to enable operating personnel to properly adjust the regulator.
- .2.5 Other piped systems: Locate vacuum or pressure gauges as required to properly identify pressure within each system.

#### .3 THERMOMETERS:

- .3.1 Thermometers shall be mercury-free red-reading-in-glass type with 9-inch magnified column, Fahrenheit scale, recalibration feature, adjustable head and brass separable socket. Tailor the range to the application. Thermometers shall not be positioned over 6-feet above the floor; install remote head type of thermometers as required to conform to this restriction.
- .3.2 Piped systems and storage tanks: Locate thermometers as required on all systems or tanks where temperature should be identifiable for operation and maintenance. Suggested applications include hot water converters, domestic water heaters, water tempering stations, air handler heating coils, air handler cooling coils, chiller and condenser water systems, etc.

**23 05 05. HVAC SPECIALTIES (Cont'd)**

23 05 25. VALVES

- .1 PROPRIETARY BRANDS: All valve-types furnished on a project shall be products of one manufacturer only. List 3 (minimum) manufacturers of equal products from which the contractor will make a selection.
- .2 TYPES: Specify the following valve-types for installations indicated:
- .3 VALVES IN STEAM LINES (150 psig and above): Use cast steel, Class 300. Specify the following:
  - .3.1 PERFORMANCE: Rotary valves shall have the performance characteristics as listed below:
    - .3.1.1 Service: steam
    - .3.1.2 Working pressure, maximum: 250 psig
    - .3.1.3 Temperature Range: 650 degrees F.
    - .3.1.4 Bi-directional shut-off dead-end services.
  - .3.2 CONSTRUCTION: Metal seated rotary tight shutoff valve shall be quarter turn, flanged triple offset type of the construction below:
    - .3.2.1 Service: Steam
      - .3.2.1.1 Installation: Above ground or steam vaults.
      - .3.2.1.2 Body type: Flanged Rotary Valve
        - .3.2.1.2.1 Body material: WCB carbon steel.
        - .3.2.1.2.2 Double flanged body construction.
        - .3.2.1.2.3 ASME/ANSI B16.5 class 300 flanges.
      - .3.2.1.3 Seat: Stellite or similar hard surfaced material.
        - .3.2.1.3.1 Resilient, non-flexing laminate metal seal composite of stainless steel and graphite retained such that centering movement is permitted.
        - .3.2.1.3.2 Retainer screws, disk, and plate will be of stainless steel.
      - .3.2.1.4 Shaft shall be of single piece construction.
      - .3.2.1.5 Disk movement relative to shaft rotation shall be triple offset design.
      - .3.2.1.6 Per ANSI B 16.5, 31, 34 construction for body components B31 .1, 31.3 ASME section VII, IX.
      - .3.2.1.7 Valves to meet API 607 Rev.4 standards.

**23 05 05. HVAC SPECIALTIES (Cont'd)**

**23 05 25. VALVES (Cont'd)**

.3.2.1.8 Hardened bearing with bearing seal to be retained in body.

.3.2.1.9 Shaft seal shall be graphite with multiple stud packing gland follower for adjustability utilizing Belleville style washers.

.3.2.1.10 Right angle gear with 2 in. AWWA nut, with loose steel hand wheel or chain wheel attachment, for remote "tee" handle operation, as shown on drawings.

.3.2.1.11 Rotary valves for services requiring insulation shall be equipped with stem housings of suitable length to clear insulation.

.3.3 **INSTALLATION:** Do not use gaskets for resilient seated valves unless instructed by the manufacturer.

.4 **VALVES IN STEAM LINES (15 to 149 psig):** Use cast steel, Class 150, bolted flange yoke bonnet, outside screw, rising stem, butt welding ends 2 inches and larger. Use forged steel, socket welding ends 1-1/2 inches and smaller. Bodies shall be cast carbon steel conforming to ASTM A216, Grade WDB. Bonnet shall be one-piece cast carbon steel conforming to ASTM A216, Grade WCB. Gasket shall be compressed in the body-bonnet. Valves shall be repackable under pressure. Seat rings shall be threaded.

.4.1 **Gate Valves:** Stem and solid wedge shall be stainless steel #P-140 conforming to ASTM A182, Grade F-6. Seat rings shall be stainless steel #P-140 -15, conforming to ASTM A182, Grade F-6, surface hardened. Stuffing boxes shall have high temperature packing. Condensation chamber shall be provided immediately below packing.

.4.2 **Globe Valves:** Disc shall be stainless steel P-140-15 conforming to ASTM A182, Grade F-6, surface hardened. The seat shall be stainless steel P-140 conforming to ASTM A182, Grade F-6. The type "S" seat and disc shall have spindle on underside of the disc guided through a bridge cast integral with the seat. Seat ring shall be threaded.

.4.3 **Check Valves:** Swing disc and seat ring shall be stainless steel P-140 conforming to ASTM A182, Grade F-6.

.5 **VALVES IN STEAM LINES (0 to 15 psig.):** Use bronze or cast iron, 150 lbs. SWP at 500 degrees F, bolted flange yoke bonnet, outside screw rising stem, flange ends 2-1/2 inches and larger; screwed ends 2 inches and smaller. Gate and globe valves shall have Teflon packing. Other construction as specified in paragraph 23 05 25.4.2 (15527.2.2).

.6 **VALVES IN WATER LINES:**

.6.1 **Gate valves:** Make the same as gate valves in 0 to 15 psig steam lines.

.6.2 **Globe valves (2 inches and smaller):** Use all bronze, threaded, union bonnet, rising stem, 200 lbs. SWP, repackable under pressure.

.6.3 **Globe valves (2-1/2 inches and larger):** Make the same as for 0 to 15 psig steam lines.

.6.4 **Check valves:** Make the same as 0 to 15 pounds steam lines.

**23 05 05. HVAC SPECIALTIES (Cont'd)**

23 05 25. VALVES (Cont'd)

- .6.5 Ball Valves: 3 inch and smaller, two to three piece bronze body, screwed ends, chrome plated brass or stainless steel ball, steel stem, reinforced TFE packing and seat ring with appropriate pressure and temperature rating for specific application.
- .7 BALANCING VALVES: Special types of balancing valves may be approved if submitted with detailed information in advance to the University Architect.
  - .7.1 Valves (2 inches and smaller): Use 150 lbs. SWP, all bronze, renewable composition disc, union bonnet, lockshield stem, repackable under pressure, or 175 lbs WOG, threaded brass body, wrench operated ball centric valve suitable for 250 degrees F continuous operating temperature, adjustable stop.
  - .7.2 Valves (2-1/2 inches and larger): make the same as for globe valves in 0 pounds to 15 pounds steam lines; hand-wheel shall be removed and tagged with number of turns that valve is open, or 175 lbs. WOG, flanged iron body, wrench operated ball centric valve suitable for 250 degrees F continuous operating temperature, adjustable stop.
  - .7.3 The University prefers that triple-duty valves should not be applied. We prefer balancing valves shall be separate from check/shutoff valves. In that way, the setting of the balance valve is more likely to be retained without tamper when any shutoff valve is closed.
  - .7.4 For accuracy of balance readings, the design and the installation must include the manufacturer's recommended upstream and downstream unobstructed distances to obtain reliable flow readings.
- .8 VALVES IN CONDENSATE LINES: A union shall be provided downstream of (and within 12 inches of) each valve.
  - .8.1 Lines valves shall be as specified for valves in steam lines, 150 pounds to 200 pounds. Class of service shall be based on class of steam upstream of check valve (inlet side of steam trap).
  - .8.2 Drain valves shall be 3/4 inch gate valves, as specified for valves in water lines, and shall have 3/4 inch hose nipple switch caps.
    - .8.2.1 Nipples shall be of same weight and material as pipe with which they are used, except all close and shoulder nipples shall be extra heavy.
  - .8.3 Spring loaded check valves shall be flanged, silent center guide, 250 pounds, semi-steam body, bronze trim, 1/16 inch raised face.
- .9 VALVES IN HOT WATER HEATING SYSTEMS: Attention is directed to "Ohio Boiler Inspection Laws and Rules," relative to valves at boiler connections and in blowdown lines. Blow down valves shall be provided for all strainers.
  - .9.1 Shut-off valves with gate drain valves shall be provided in branches and risers.
  - .9.2 Lock-shield balancing valves shall be provided at all heating units and in return risers and return mains.
  - .9.3 Manual vents shall be provided on all convectors and radiators.

**23 05 05. HVAC SPECIALTIES (Cont'd)**

23 05 25. VALVES (Cont'd)

.9.4 Ball Valves: 3 inch and smaller, two or three piece bronze body, screwed ends, chrome plated brass or stainless steel ball, steel stem, reinforced TFE packing and seat ring with appropriate pressure and temperature rating for specific application.

.10 VALVE TAGS: Each valve in each piping system shall be tagged with a brass or aluminum tag numbered consecutively for each system and attached to the valve with a brass or aluminum chain. Valve tags shall have stamped abbreviations of the system in addition to the valve number.

**23 07 00. HVAC INSULATION**

.1 GENERAL PROVISIONS FOR FIRE AND SMOKE HAZARD RATINGS: All insulation shall have a system fire and smoke hazard rating as tested by procedure ASTM-E-84, NFPA 255, and U.L. 723 not exceeding: Flame Spread 25 and Smoke Developed 50. The system rating shall be based on insulation, jacket, adhesives, coatings, fittings, and cements. Any treatment of jackets or facings to impede flame and/or smoke shall be permanent. The use of water-soluble treatments is prohibited. ASBESTOS IN ANY FORM OR MIXTURE(S) IS PROHIBITED.

23 07 13. DUCT INSULATION:

.1 THERMAL INSULATION: Thickness of supply air duct and plenum insulation shall be selected to prevent condensation on the surface of insulation when the ambient relative humidity is 90 percent at the maximum difference between the ambient air temperature and the supply air temperature. Minimum thickness of supply-air or return-air duct insulation shall be 1 inch nominal, and 2 inches nominal on outside air duct or plenum. Insulation shall be continuous through all openings, but shall be interrupted at fire dampers. The thermal insulation used to cover the ducts shall meet or exceed ASHRAE Standard 90A-1980 for energy conservation and be asbestos free.

.1.1 Exposed rectangular air conditioning supply and return ducts in non-air conditioned space shall be insulated with rigid or semi rigid fiberglass insulation board having a density not less than 3 pounds/cubic feet and with field or factory applied fire retardant glass cloth jacket with vapor barrier. When factory applied facing is used, all insulation joints will be sealed with pressure sensitive joint sealing tape to match the insulation facing.

.1.2 Concealed air conditioning supply air ducts in ceiling space above an air conditioned room shall be insulated with fiberglass duct wrap insulation of 3/4 pounds/cubic feet density with factory applied vapor barrier and fire retardant jacket. When insulation is necessary on return air ducts, ducts shall be insulated in the same manner.

.1.3 All exposed round air conditioning supply air and return air ducts shall be insulated using "Rigid preformed fiberglass insulation with All Service Jacket at a minimum finish.

.1.4 Outside air intake ducts and air plenums shall be insulated the same as specified for exposed rectangular air conditioning supply air ducts.

.2 ACOUSTIC LINING: INSTALLATION OF INTERIOR DUCT INSULATION IS PROHIBITED. Sound attenuation for each individual project must be reviewed and is subject to approval before design is completed.

**23 07 00. HVAC INSULATION (Cont'd)**

23 07 16. EQUIPMENT INSULATION

- .1 All pieces of equipment with surface temperatures over 130 degrees F or with temperatures causing condensation at ambient relative humidity of 90 percent shall be insulated. Type and thickness of insulation shall be as specified for piping.
- .2 INSULATION NOT REQUIRED: Steam traps, hot water, and condensate return pumps, and hot water expansion tanks shall not be insulated.
- .3 Chilled water pumps are required to be insulated. Insulation may be closed-cell elastomeric, equivalent to Armaflex.
- .4 BOILER BREECHING shall be insulated with manufacturer-provided, pre-fabricated, factory-insulated breeching. Follow specification to determine the specific operating temperature. Apply appropriate finish jacketing range.

23 07 19. PIPING INSULATION:

- .1 REQUIRED INSTALLATION: The following piping shall be insulated:
  - Steam lines
  - Domestic and hot water lines
  - Steam Condensate lines
  - Cooling Coil Condensate Drain Lines
  - Chilled water lines
  - Refrigerant lines, where necessary
  - Cold water lines
  - Fuel oil lines, where necessary or exposed to low temperatures.
- .2 SPECIFICATIONS: Maximum temperature limit of the insulation must be above the maximum operating temperature of piping. Surface temperature of insulation for heated piping in still ambient air at 80 degrees F shall not be above 110 degrees F at the pipe operating temperature below 400 degrees F. The minimum thickness of insulation shall be one inch. Thickness of insulation for cold piping shall be selected to prevent condensation on the surface of insulation and ambient temperature is 50 degrees F above the pipe temperature. Specify that insulation be installed with a continuous unbroken and unpunctured factory applied vapor barrier. Insulation shall meet or exceed the current version of ASHRAE Standard 90.1 -- Energy Standard for Buildings Except Low-Rise Residential Buildings for energy conservation.
  - .2.1 Piping with an operating temperature of 400 degrees F and above shall be insulated with calcium silicate insulation molded in sections with a minimum of .016 Aluminum jacket.
  - .2.2 Piping with an operating temperature under 400 degrees F shall be insulated with molded pipe covering composed of fiberglass wool, resinbonded and factory applied all service jacket. Compression strength at 25 percent deformation shall be 500 pounds per square foot.
  - .2.3 Fittings, flanges, unions, and valves, except valves in hot water lines, shall be insulated. Insulation shall be beveled down to unions with all exposed end sealed with CP.10 or equivalent. Insulation covers shall be either prefabricated or fabricated of pipe insulation. Insulation efficiency shall not be less than that of the adjoining piping. Specify that insulation vapor barrier be installed continuous and unbroken.

**23 07 00. HVAC INSULATION (Cont'd)**

**23 07 19. PIPING INSULATION: (Cont'd)**

- .2.4 Hangers, supports, anchors, secured directly to cold surfaces, must be adequately insulated and vapor sealed to prevent condensation.
- .2.5 Rigid insulation inserts of proper length shall be installed between pipe and insulation protection shield to prevent sagging of pipe covering at hanger points. Compressive strength of insulation inserts shall be not less than 350 psf at 10 percent deformation. Specify that inserts be installed as pipe is erected.
- .2.6 Insulated piping lines running outdoors shall have corrugated or plain 0.016 inches aluminum jacket complete with integral longitudinal laps with 2" overlap and butt joint laps with 3" overlap installed in order to shed water. In addition to the vapor barrier, this jacket is required on cold lines.
- .2.7 In service tunnels, pipe insulation shall be covered with PVC jacket secured in place with aluminum straps on 18 inches centers. Sections exposed to heavy mechanical abuse shall have 0.010 inches stainless steel jacket secured in place with stainless steel straps. The lap shall be at least 2 inches on side shedding water and 3 inches overlap on the end.
- .2.8 Piping with calcium silicate insulation and aluminum jacket shall have fiberglass covering between the calcium silicate and the aluminum jacket.

**23 09 00. INSTRUMENTATION AND CONTROL FOR HVAC:**

- .1 DIRECT DIGITAL CONTROL (DDC) SYSTEM: To achieve precise control of all HVAC systems and to provide the means to integrate standard control functions with energy saving strategies, it is intended that all newly constructed and remodeled buildings on the Columbus campus be controlled using stand alone microprocessor based Direct Digital Control (DDC) computer systems. All hardware, software, and miscellaneous equipment required to insure that the DDC system can be managed from the building and from a remote control center shall be provided as a part of the project. Control centers now in existence are:

Columbus Campus - Academics and Research – FOD  
Columbus Campus - University Hospitals  
Columbus Campus - Student Affairs  
Lima Campus  
Wooster Campus

Each Associate shall submit schemes for connecting new facilities to the control center(s). All DDC systems shall be connected to the appropriate control center(s) using the University's fiber optic network, a hard-wired communication trunk, or a telephone communications trunk, as dictated by the capabilities of the system selected and by the location of the building being controlled.

The control centers in the Columbus Campus (FOD), University Hospitals, Student Affairs, Lima Campus, and Wooster Campus have Central Processing Computers (CPU's) that are compatible with Direct Digital Control. Any expansion in any building within these networks must maintain the integrity of the existing system and allow the new equipment to be controlled by the existing CPU. These locations are to be treated as exceptions and cannot be addressed in the same fashion as an expansion in an area where no CPU exists. The Associate will coordinate this requirement through the University Architect.

**23 09 00. INSTRUMENTATION AND CONTROL FOR HVAC: (Cont'd)**

.1.1 An interconnecting conduit system shall be installed between all DDC panels within a given building. This conduit system shall be extended to the appropriate building exit point to provide the link to the remote communications network. All communications cables required to provide the communications link between the DDC controllers and the external communications network shall be installed as a part of the project. The remote communications link shall be established and remote capabilities shall be verified by the contractor prior to final acceptance of the DDC system.

.1.2 Schemes shall include necessary provisions in the Plumbing, HVAC, Fire Protection and Electrical construction documents for making system connections. Provisions for DDC Systems are described thoroughly in Appendix. Also see Communication Wiring Standards in Appendix and Electrical in Division 16.

.2 CONTROLS AND CONTROL CENTERS: Refer to Facility Services-2.1 (15/16-2.1).

**23 09 05. HVAC BUILDING SYSTEMS CONTROL:**

.1 Before design is begun, consult the University Architect to determine exact requirements for connection to control centers. In addition to requirements for Direct Digital Control Systems described in Facility Services-2 (15/16-2) and Appendix A, the following must be considered in design and installation of equipment.

.2 AUTOMATIC DAMPERS: Automatic dampers which are under proportioning control should be accurately sized in accordance with temperature control manufacturer's recommendations to provide proper mixing and control.

No damper shall have a dimension exceeding four feet or be over 12 square feet in area. Each damper section shall have an individual operator. No linkages shall be installed between dampers to transfer operator power. Manufacturer's catalog information shall be de-rated 50 percent for application to provide positioning of the dampers. Damper operators shall not be of the swing mounting type. They should be mounted outside the air stream where possible, especially in outside air applications. Pneumatic control lines, where they penetrate outside air ducts, shall include dehydrator units. Outside air and return or relief dampers that are automatically controlled shall be of the minimum leakage type.

Quality of dampers shall be specified, including air leakage at 3/4-inch static pressure when the damper is in the closed position. Provide neoprene edges and tips on blades.

.3 AIR COMPRESSORS: Air compressors, when required, shall be provided in the main equipment room for each building. Two compressors shall be provided with the sizes calculated on 50 percent operating time of one compressor to meet the building's compressed air needs. The units' control will include a manual lead/lag control switch. If other compressed air systems are within the building or adjacent to the building, consideration will be given for cross-connecting of the systems.

**23 20 00. HVAC PIPING AND PUMPS**

**23 20 03. PIPING**

.1 GENERAL PROVISIONS:

.1.1 Submittals for Approval by the University: Provide three copies each of the following and obtain approval before preparation of final documents.

## 23 20 00. HVAC PIPING AND PUMPS (Cont'd)

### 23 20 03. PIPING (Cont'd)

- .1.1.1 Calculations of stresses in steam, hot water, and condensate lines.
- .1.1.2 Request for permission to use expansion joints in piping in lieu of bends and/or loops.
- .1.1.3 Request for permission to use special materials for condensate piping in lieu of steel pipe with welded fittings. Provide pressure and temperature characteristics.
- .1.1.4 Operating pressures and temperatures for grooved pipe mechanical coupling systems if permitted to be used.
- .1.1.5 Detailed information on special types of balancing valves.
- .1.2 Valve Tags: Specify that each valve be tagged with a brass or aluminum tag numbered consecutively and attached to the valve with a brass or aluminum chain. Valve tags shall have stamped abbreviations of the system in addition to the valve number.
- .1.3 Valve Chart: A typewritten directory of valve numbers (by system, describing location) shall be furnished, framed, placed under glass, and installed in equipment rooms, where indicated by the Associate. A copy of the valve directory shall be included in each O-&-M manual, and separate copies of the valve directory, bound in hard fiber binders, shall be delivered to the University Architect.

## .2 DESIGN OF PIPING SYSTEMS:

### .2.1 Prohibited Installations:

- .2.1.1 Condensate drip traps above 15 psig shall not be designed to discharge directly into condensate return mains or condensate pump receivers, but shall be designed to discharge into a flash tank (vented into the low pressure side of the system, if possible), and to drip through a low pressure F. & T. trap to a condensate return main or receiver.
- .2.1.2 Bullhead connections in any piping service are prohibited.
- .2.1.3 Cast iron, brass and ASTM A120 pipe shall not be used on lines with pressures higher than 49 psig or temperatures higher than 292 degrees F.
- .2.1.4 Drain, steam, and condensate lines, and any wet lines (including pipes, fittings, valves, or other), shall not be installed or designed for installation over electrical switchgear, motor control centers, transformers, nor in elevator shafts and equipment rooms.
- .2.2 Provisions for Expansion and Contraction: Steam lines shall be engineered with adequate provisions for expansion and the removal of condensate. The campus steam is distributed at 200 psig and 600 DegF.

Generally, bends or loops shall be used to absorb the pipe expansion and contraction.

## 23 20 00. HVAC PIPING AND PUMPS (Cont'd)

### 23 20 03. PIPING (Cont'd)

Particular attention shall be given to proper design of guides and anchors in lines with expansion loops. Expansion joints are not recommended. Approval by the Utilities Division, Facilities Operations and Development is required prior to use of expansion joints.

- .2.3 Pipe anchors to control movement of piping shall be shown on drawing. Anchors shall be welded to the pipe, but anchor connection to the building structure must be bolted. Provide structural support and lateral structural support for all kinetic forces.
- .2.4 Vertical risers for hot water and steam lines passing through more than two floors shall have spring support, preferably at the floor nearest to the center of the riser.
- .2.5 Unions shall be provided on piping at the following locations:
  - .2.5.1 Adjacent to valves on the downstream side.
  - .2.5.2 At the final connections to items of equipment.
  - .2.5.3 On each side of traps.
  - .2.5.4 Where required for construction and assembling purposes.
- .2.6 Supports: Spacing for the horizontal pipe supports and hanger rod sizes must be specified. Refer to paragraph Facility Services-3.19.2 et al.
- .2.7 Hangers: Where piping is subject to expansion and contraction caused by changes in temperature of carried fluid, adjustable roller hangers or adjustable pipe roll stands shall be provided. Hangers for copper piping shall be copper plated or shall have a suitable lining to prevent electrolysis. Hangers for cold insulated pipe and all roller hangers shall be only outside of the insulation with appropriate "U" support plates to prevent crushing of insulation and to avoid condensation.
- .2.8 Pipe Guides shall be detailed and locations shall be shown. Guide shall consist of a guide spider clamped to the pipe for which movement is to be controlled and a guide casing bolted to a suitable support. Casing shall be of two pieces bolted together by 4 bolts for sizes 3 inches and larger and by 2 bolts for sizes 2-1/2 inches and smaller. The inside diameter of casing shall be larger than the outside diameter of the insulated pipe.
- .2.9 Discharge Piping from all refrigeration system pressure relief devices shall extend, in an approved manner, to the building exterior.

### 23 20 05. PIPING MATERIALS:

#### .1 STEAM PIPING (0 to 49 psig, temperature less than 297 degrees F.):

- .1.1 Schedule 40, ASTM A-53, Type E, Grade B black steel pipe shall be used. Schedule 40 butt welding seamless forged steel fittings shall be used with NPS 2-1/2 and larger pipe. Elbows shall be long radius; flanges shall be 150 pounds class forged steel, welding neck, or slip-on, welded inside and outside. For 2 inches or smaller pipe 125 psig class black cast iron screwed fittings may be used.

**23 20 00. HVAC PIPING AND PUMPS (Cont'd)**

23 20 05. PIPING MATERIALS: (Cont'd)

.2 STEAM PIPING (50 to 200 psig, temperature less than 600 degrees F):

.2.1 Schedule 40, ASTM A-53, Type S , Grade B Black steel seamless pipe shall be used. Do not specify and do not permit electric-welded pipe. Schedule 40 butt welding seamless forged steel fittings shall be used with NPS 2-1/2 and larger pipe. Flanges shall be 300 pounds class. For 2 inches or smaller pipe, fittings shall be socket weld forged steel, 2000 lbs. (minimum) class.

.2.2 FITTINGS at the CONNECTION TO THE STEAM UTILITY: Show the details for demolition and new construction for piping and connections to the steam utility in the tunnel. Provide a new socket-welded, forged steel, tee-fitting on the existing steam utility in the tunnel, and extend the branch of the tee into the building. It is prohibited to apply a weldolet onto the existing steam utility.

.3 CONDENSATE PIPING: Schedule 80 black steel pipe, ASTM A-53, Type E, Grade B shall be used with Schedule 80 butt welding fittings of seamless steel or forged steel socket weld fittings 2000 pounds WOG. Special materials might be approved, upon request, if pressure and temperature characteristics are submitted in advance of design.

.3.1 Underground condensate distribution piping requirements:

.3.1.1 Carrier pipe shall be schedule 80, ASTM A53.

.3.1.2 Install per factory specifications.

.3.1.3 Outer jacket shall be PVC of recommended thickness.

.3.1.4 Insulation shall be polyurethane foamed in place. Operating temperature of insulation shall be a minimum of 250 degrees F.

.3.1.5 Steam condensate return piping in underground applications and in tunnel applications shall be Schedule 10 stainless steel, grade 316.

.4 HOT WATER HEATING PIPING: Shall be ASTM A53, Type E except that lines 4-inch diameter and smaller may be hard copper type L with wrought copper fittings.

.4.1 Fittings 2-1/2 inches and larger: Schedule 40, butt welding seamless forged steel. Elbows: long radius; flanges: 150 pounds SWP, forged steel, welding neck, or slip-on, welded inside and outside or wrought copper for use with type L copper piping.

.4.2 Fittings 2 inches and smaller: 125 pounds SWP black threaded cast iron or forged steel welded fittings or wrought copper for use with type L copper piping.

.4.3 Grooved Piping Systems: Grooved piping is prohibited on hot water systems.

.5 CHILLED WATER SUPPLY AND RETURN: Same as specified for Hot Water Heating Piping.

.5.1 Underground chilled water distribution piping requirements:

.5.1.1 Outer jacket shall be filament wound fiberglass of recommended thickness.

**23 20 00. HVAC PIPING AND PUMPS (Cont'd)**

23 20 05. PIPING MATERIALS: (Cont'd)

.5.1.2 Insulation shall be hydrophobic type applied in spray process, void free, to the recommended thickness.

.5.1.3 Carrier pipe shall be schedule 40, ASTM, Grade B, ERW.

.5.1.4 Install per factory specifications.

.5.2 Grooved Piping Systems: For chilled water systems, an engineered system of rolled-grooved piping with couplings and gaskets designed for the application may be used with the approval of the University. Cut-grooved piping shall be specifically prohibited.

.6 CONDENSER WATER SUPPLY AND RETURN: Same as specified for Hot Water Heating Piping.

.6.1 Grooved Piping Systems: For condenser water systems, an engineered system of rolled-grooved piping with couplings and gaskets designed for the application may be used with the approval of the University. Cut-grooved piping shall be specifically prohibited.

.6.2 For condenser water systems, Schedule 80 PVC piping and fittings may be applied. The PVC shall include UV-protectants, and shall be rated for exterior applications.

.7 DRIP PIPING FROM PUMPS: Schedule 40 galvanized steel pipe with 150 pounds galvanized banded malleable iron fittings, minimum size 3/4 inch. Run drip piping to floor drain. Hard copper, type L, minimum size 3/4-in., may be used if protected and clamped in place.

.8 COOLING COIL CONDENSATE DRAIN PIPING FROM AIR HANDLING UNITS: Type "L" hard copper, minimum size 1 inch. Specify that wrought copper fittings with sweat joints of 95-5 solder be used. Trap drain lines and run to suitable drains. Provide cleanouts at traps and in the piping system where pipe changes direction.

.9 REFRIGERANT PIPING: Dry Seal Type "L" or ACR (Air Conditioning & Refrigeration) nitrogen-charged hard copper. Wrought copper fittings with joints brazed with a 6 percent or higher silver alloy with a 1000 degrees F solidus minimum and comparable to J.W. Harris Co., Inc. "Dynaflow". Copper-steel joints shall be brazed with 55 percent silver alloy brazing materials. Fittings for 5 inches or larger lines shall be tinned cast brass.

23 20 07. UNDERGROUND CONDUIT

.1 Underground distribution piping shall be factory prefabricated insulated pipe units.

.2 CATHODIC PROTECTION: The Associate shall include a soil corrosion analysis, by a reputable company with wide experience in this type of work, and shall specify the installation of cathodic protection, as recommended by the conduit manufacturer to produce the required voltage potential.

.2.1 A copy of the analysis shall be submitted to the University Architect.

.2.2 High pressure steam lines may drive out the moisture in the vicinity of steam lines, and may cause cathodic protection to not be required on steam lines. This must be analyzed by the associate and submitted to the University for approval.

**23 20 00. HVAC PIPING AND PUMPS (Cont'd)**

23 20 07. UNDERGROUND CONDUIT (Cont'd)

.2.3 See Section 22 70 30.5 for schedule of cathodic protection.

.3 COORDINATION OF CONTRACT DOCUMENTS:

.3.1 Site Work: Underground conduit shall be pitched for drainage and location shall be coordinated with other underground installations. Installation of the conduit shall be scheduled to follow the last heavy grading or heavy equipment traffic. Minimum earth cover shall not be less than 36 inches or as recommended by the manufacturer, whichever is the greater.

.3.1.1 Underground steam or condensate lines shall not be located within ten feet of buried electric lines in any direction.

.3.1.2 The Associate an Contractor shall submit in writing, for approval by the University, for any earth cover exceeding 12 feet.

.3.2 Concrete: The following requirements may be specified in either Division 3 or Division 23:

.3.2.1 Pipe supports shall be precast of special insulating concrete, steam kiln cured. The outer edge must be corrugated to allow free passage of air and drainage in place.

.3.3 Pipe Sleeves: Refer to Section Facility Services (15/16) for requirements.

.3.4 Anchors shall be installed where shown on the drawings. Anchors shall be steel plates welded to the pipes and steel conduit. Anchor plate shall be embedded in concrete cast over the plate, in accordance with manufacturer's recommendations.

.4 BASIC MATERIALS:

.4.1 Conduit shall be not less than 10-gauge steel designed for proper strength to prevent deformation in service. Interior and exterior surfaces shall be given a hot-dipped galvanized coating. Exterior finish coat shall be a minimum thickness of 20 mils consisting of two alternately applied layers of glass cloth in epoxy resin. Final outside coating shall be capable of maintaining dielectric strength of 5,000 volts. Conduit shall be tested for tightness at 15 lbs. per square inch air pressure before coatings are applied.

.4.1.1 Fittings shall be completely prefabricated.

.4.1.2 Conduit closures complete with pipe insulation shall be furnished by the conduit manufacturer. Closures shall be of 10 gauge steel with a single horizontal side split and shall be finished with prime coat and one finish coat (inside and outside) of epoxy resin.

.4.2 Materials, Other than Steel: Fiberglass or other materials may be used if specific approval is obtained from Facilities Operations and Development. Use of these materials shall be limited to piping systems having a maximum temperature of 212 degrees F and a maximum pressure of 60 psig.

.5 UNDERGROUND CONDUIT: Install under the supervision of a capable factory trained field engineer in the direct employment of the conduit manufacturer.

**23 20 00. HVAC PIPING AND PUMPS (Cont'd)**

**23 20 07. UNDERGROUND CONDUIT (Cont'd)**

.6 SYSTEM TESTING: The conduit manufacturer shall certify in that his field engineer has witnessed the satisfactory tests on pipe and conduit.

.6.1 Hydrostatic Test: All piping in the system shall be subjected to a hydrostatic test pressure of one and one-half times the working pressure per ANSI B 31.1 Power Piping Code.

.6.2 Air Test: System shall be subjected to a 15 pounds per square inch air test; any leakage disclosed shall be made tight before backfilling.

.6.3 Spark Test: The entire system shall be subjected to a final spark test prior to backfilling. Any electrical leaks or other physical damage shall be repaired.

**23 20 09. PIPING SPECIALTIES**

.1 GASKETS: Where flanges must be used, gaskets shall be of materials suitable for use at temperatures and under conditions encountered in the system. Gaskets on steam lines, with pressures of 50 psi gauge or over, shall be wound stainless steel and appropriate composition gaskets.

.2 AIR VENTS:

.2.1 AUTOMATIC AIR VENTS with isolation valves shall be installed at the high points of all hydronic piping, and at all points where horizontal flow goes to vertical down flow. Vents with visual drain shall be specified. The discharge drain shall be extended to a suitable floor drain.

.2.1.1 Automatic air vents shall be applied on hydronic systems employing a diaphragm-type expansion tank (i.e., a tank having air and water surfaces separated by a flexible membrane).

.2.2 AN AIR CHAMBER with manual vent shall be provided at high points on lines above finished ceilings and in areas where a safe and suitable drain point is not readily available. Provide a flexible drain line.

.2.3 Manual air vents shall be used on systems employing a diaphragm-less compression tank, if the air and water surfaces are in direct contact with each other.

.3 STEAM TRAPS: Traps shall be installed at least 24 inches below steam heating devices to assure adequate draining of the coils. Valves, strainers, and unions or flanges shall be provided upstream of traps.

.3.1 INVERTED BUCKET TRAPS: On saturated drips, regardless of steam pressure, use inverted bucket traps (IBT's).

.3.2 BIMETALLIC TRAPS: On superheated drips at 50 psig or greater, use bimetallic traps (BMT's). Suggested for consideration are Armstrong SH-250 or Bestobell DM25.

.3.3 THERMODYNAMIC TRAPS: On superheated drips at 49 psig or less, use thermodynamic traps (TD's).

**23 20 00. HVAC PIPING AND PUMPS (Cont'd)**

23 20 09. PIPING SPECIALTIES (Cont'd)

.3.4 FLOAT AND THERMOSTATIC TRAPS: On any modulating application such as hot water converters, steam heating coils, steam humidifiers, or any other modulating application, use float and thermostatic traps (F&T's).

.4 VACUUM BREAKERS AND AUTOMATIC AIR VENTS shall be provided on all steam heating coils with modulating valves or automatic on-off valves.

23 20 11. PIPING INSTALLATION:

.1. INSTRUCTIONS TO BE INCLUDED IN THE SPECIFICATIONS: The following instructions to the contractor should be included in the applicable paragraphs. These instructions must be edited to suit the work.

.2 DIELECTRIC UNIONS OR COUPLINGS: In water lines where dissimilar metal pipes connect to one another, use a special fitting with neoprene gaskets to counteract electrolysis. All piping and piping accessories shall be suitable for the working pressures and temperatures of the lines in which they are installed. Provide a shut-off valve on the supply side of dielectric unions.

.3 WELDED CONNECTIONS:

.3.1 Stamped Welds: Welders on pressure piping shall be certified and shall carry their certification and stamp with them. Welds on lines with pressures above 125 psig shall be stamped.

.3.2 Items Requiring Welded Connections: Weld steel piping 2-1/2 inches and larger. Weld steel piping installed above finished plaster ceilings and in pipe chases. Weld steam condensate pipe except at 2 inch and smaller threaded connections to equipment and traps.

.3.3 Welded Fittings (see piping specifications 23 20 05 (15506) for specifications of fittings)

.4 BRANCHES: "T" or "Y" forged branch connections or reducing tees are acceptable for branch connections to mains 2 inches diameter or larger. Design all other branch connections with main size tees and eccentric reducers or reducing tees. Branch piping shall not be welded directly to mains. Drip legs in steam lines shall be made with steam line size tees. Eccentric reducers shall be used for pipe size changes with bottom of steam line level, bottom of condensate return lines level, and top of hydronic waterlines level.

.5 VIBRATION ISOLATION shall be provided on chilled and condenser water supply and return piping at all compressors.

23 20 13. PUMPS:

.1 GENERAL PROVISIONS:

.1.1 COUPLING ALIGNMENT: The University requires that the final coupling alignment be documented and the results furnished in writing to the University Architect. Field check all alignments and report the maximum angular and eccentric misalignments to the nearest 0.001 inch.

## **23 20 00. HVAC PIPING AND PUMPS (Cont'd)**

### 23 20 13. PUMPS: (Cont'd)

- .1.1.1 Align coupling flanges for concentricity to assure that the face and curved edges are concentric within the manufacturer's recommendations.
- .1.1.2 Align coupling for angular alignment to tolerances recommended by the manufacturer.
- .1.1.3 Align coupling for parallel alignment. On large equipment, subject to heat conditions, alignment must be done in the hot condition.
- .1.2 SHOP DRAWINGS AND PUMP PERFORMANCE CURVES: Reference should be made to Division 1 for instructions for submittals of shop drawings. Submit performance curves with shop drawings.

### .2 PUMPING SYSTEMS DESIGN:

- .2.1 A PRIMARY-SECONDARY PUMPING SYSTEM is preferred where practicable.
- .2.2 DESIGN PUMPING SYSTEMS so that the engineer-designed net positive suction head available (NPSHA) at the pump intake will be larger than the (manufacturer-required) net positive suction head required (NPSHR) at the highest possible water temperature at the pump intake.
- .2.3 THE PUMP CURVE REPRESENTING FLOW-HEAD RELATIONSHIP shall intersect the system curve at design operating point. Pumps shall be selected to operate at an efficiency of not less than 90 percent of the maximum efficiency. Maximum total pump head at the no flow condition shall be specified.
- .2.4 FRICTION HEAD CALCULATIONS FOR CHILLED WATER SYSTEMS shall be based on the friction loss standards of the Hydraulic Institute in new pipe. For steam condensate (pumped and gravity) and hot water heating systems, base on friction losses in 15 years old pipe. The associate may submit for approval by the University of use other sizing standards, such as ASHRAE, Cameron, Bell & Gossett.
- .2.5 PUMP MOTOR shall be selected and specified as non-overloading over the entire pump curve shown by the manufacturer.
- .2.6 ALL PUMPS shall be installed with line size isolation valves on both sides.
- .2.7 Power Factor Correction: Motors (drives) 50 hp and larger shall be provided with fused, switched, power factor correction capacitors sized to correct to 100 percent or greater. It is preferred that the units be connected between the contactor and overload coils. Units shall meet all fire codes and not be an environmental problem.
- .2.8 Motor and impeller speeds shall be 1750 RPM.

- .3 CONDENSATE RETURNS: Steam powered condensate return systems should be considered in lieu of pump type units. When pumps must be used, specify packaged duplex units, shipped assembled as a complete factory unit with cast iron receiver.

## **23 20 00. HVAC PIPING AND PUMPS (Cont'd)**

### 23 20 13. PUMPS: (Cont'd)

- .3.1 LEAD-LAG ALTERNATOR for pumps shall be automatic with a manual over ride. Electrical float switch shall bring on the second pump if the flow is too great for one pump. Audible alarm shall be activated when either pump fails.
- .3.2 Condensate return pumps shall be limited to no greater than 1800 rpm.

### .4 PUMP TYPES

- .4.1 IN-LINE PUMPS: In-line pumps shall be connected directly to the piping. Motor shall not be separately supported except for large pumps specifically designed for such support. Pumps shall not be mounted with motor shaft vertical unless special thrust bearings are provided. Provide gauge valves at in-line pump suction and discharge. Locations for installation of in-line pumps shall not be obstructed by overhead or beneath equipment or services, such that the pump can be easily maintained and/or removed.
- .4.2 BASE-MOUNTED WATER PUMPS: For primary pumping application, split case centrifugal pumps are preferred over the end suction pumps.
  - .4.2.1 MECHANICAL SEALS are preferred and should be used where adaptable. Complete flushing arrangement shall be provided for mechanical seals and packing.
    - .4.2.1.1 Horizontal split case pump ball bearings shall be double row on outboard. Pump casings shall have vent and drain plugs and pressure gauge tapping.
  - .4.2.2 PUMP AND MOTOR shall be installed on a common steel or cast iron base, isolated from the building structure so that the unit will not transmit vibration to the building. Pump coupling to motor shall be flexible. Coupling shall be equipped with a guard.
  - .4.2.3 PIPING CONNECTIONS to pump shall be flexible and mounted horizontally. Specify that flexible connections be Teflon Flexijoint by Ethylene Corporation or butyl arched spool type expansion joint with tie rods by Uniroyal or approved equal. Provide valved gauges at the pump suction and discharge.
- .4.3 TURBINE PUMPS: Regenerative turbine pumps may be utilized on clean liquid applications. Pump shall have both inboard and outboard bearings. The motor shall be 1750 RPM and shall be sized to prevent overloading at the highest head conditions when the flow of liquid is shut off. Impeller shall be hydraulically self centering. On larger turbine pumps 5 hp and over, a relief valve may be used on the pump to avoid overloading the motor at shut off conditions.

## **23 30 00. HVAC AIR DISTRIBUTION**

### 23 30 05. AIR HANDLING UNITS WITH AND WITHOUT COILS:

- .1 CONSTRUCTION: Central station air handler units shall be of sectionalized construction, consisting of fan section, coil section, and drain pan to catch all condensate. See 22 20 07.2.8 (15453.2.8).

**23 30 00. HVAC AIR DISTRIBUTION (Cont'd)**

**23 30 05. AIR HANDLING UNITS WITH AND WITHOUT COILS: (Cont'd)**

- .1.1 All condensate drain pans shall be aluminum or stainless steel. Galvanized steel, plastic or fiberglass pans are not permitted.
- .2 TWO FAN UNITS: Selection of a two-fan wheel housing assembly in a common section shall be held to a minimum. Selection of two fan units is subject to the approval of the University Architect.
- .3 FAN WHEELS AND HOUSINGS shall be AMCA Class II construction; except, high velocity systems requiring total fan static pressure over 4 inches shall use Class III fans. Medium and high velocity draw-through and built-up systems shall have duct discharge sections designed per accepted good practices to minimize losses and for velocity energy recovery. Minimum length of transition shall be equivalent to one wheel diameter.
- .4 CONDENSATE LINES from drain pan must have deep traps to prevent either draw or blow through conditions.
- .5 INTERIOR SURFACES, as well as the division panel separating the hot and cold deck, shall be insulated with not less than 1 inch thick fiberglass blanket. The drain pan shall be insulated preferably on the exterior; however, interior insulation, if provided, shall be of a type that will resist mechanical damage and deterioration by water. All condensate drain pans shall be aluminum or stainless steel. Galvanized steel, plastic, or fiberglass pans are not permitted.
- .6 FACE AND BY-PASS DAMPERS AND ZONE DAMPERS shall have bronze or nylon bearings with non-slip spline and rib connections between damper blades and mounting rods. Zone dampers shall have neoprene gaskets for blades to seal against entire stop.
- .7 MISCELLANEOUS DETAILS:
  - .7.1 Solid shafts shall be specified. All shafts will be provided with machine centers.
  - .7.2 Wheels shall be of heavy gauge riveted or welded design.
  - .7.3 Wheel hubs shall be machine bored with full line contact on solid shaft.

**23 33 00. AIR DUCT ACCESSORIES**

- .1 FIRE AND SMOKE DAMPERS:
  - .1.1 INSTALLATION: Specify that, after dampers are installed, the contractor shall operate each damper through all positions to assure free operation.
  - .1.2 INSPECTION: Specify that, at final acceptance inspection, approximately 10 percent of all fire and smoke dampers, as randomly selected by the University Architect, must be demonstrated by the contractor to be in proper position and in operational order. Failure of any one of the demonstrated dampers shall require the contractor to check and demonstrate all dampers.
  - .1.3 CERTIFICATION: Specify that the contractor must certify in writing that all fire and smoke dampers were checked by operation at installation and that all are in proper position and functional order.

**23 30 00. HVAC AIR DISTRIBUTION (Cont'd)**

**23 34 00. HVAC FANS**

- .1 GENERAL REQUIREMENTS: Centrifugal fans are preferred for supply and return air requirements. Tubular centrifugal, axial and propeller fans may not be used unless written authorization is obtained from the University Architect.
- .2. SUPPLY AND RETURN AIR FANS:
  - .2.1 HIGH PRESSURE FANS: Fans selected for operations above 6-1/2 inches static pressure are subject to approval by the University Architect.
- .3 EXHAUST FANS:
  - .3.1 EXHAUST FOR HAZARDOUS AIRBORNE CONTAMINANTS: Exhaust fans handling dangerous or obnoxious agents of a contagious disease shall discharge vertically from an outlet and extend at least eight feet above the roof of the building at velocities in excess of 3,000 feet per minute. Extreme care must be exercised to avoid locating exhaust fans and ducts close to: high roof lines, other systems, radioactive systems, operable windows, doors, or fresh air intakes.
    - .3.1.1 Finishes for Exhaust Systems: Consideration should be given to the use of special metal in preference to special paint when designing exhaust fan systems for use with dangerous, corrosive, or obnoxious fumes.

**23 36 05. AIR TEMPERING SYSTEMS:**

- .1 GENERAL DESIGN CONSIDERATIONS:
  - .1.1 Outside air, in lieu of machine cooling, shall be utilized on air conditioning systems serving spaces with cooling loads when outside temperatures of 56 degrees F or below are prevalent and when the cost for additional work and equipment involved can be justified.
  - .1.2 Variable volume air distribution systems should be used to vary the air quantities with the loads rather than falsely loading the system with reheat or mixing at the terminal units. Space-air outlets should be aspirating types to prevent dumping of unmixed air into occupied spaces.
  - .1.3 Interior spaces requiring cooling the year around should be handled independently from perimeter areas requiring heating during winter and cooling during summer. Interior areas should be supplied from a variable volume cooling system utilizing a controlled economizer cycle. The perimeter systems should utilize controlled economizer cycles when cooling is required and minimum ventilation rates when heating is required.
  - .1.4 Heat recovery systems should be considered for use when shutdown of systems cannot be accomplished during hours when building is unoccupied. Each application should be examined independently to determine any special sources for obtaining a recovery of energy.
  - .1.5 Local cooling for limited areas or rooms may be provided by window air conditioners only if stipulated in the Program of Requirements for a project or if permission is granted by the University Architect.

**23 30 00. HVAC AIR DISTRIBUTION (Cont'd)**

23 36 05. AIR TEMPERING SYSTEMS: (Cont'd)

.2 EQUIPMENT:

- .2.1 General: Equipment shall be of adequate size to handle air quantities and static pressure in accordance with design. Air quantities and distribution pattern shall be shown on the pattern drawings. Provisions for controlling air flow to or from outlets shall be included in the specifications, as well as indicated on the drawings. Air velocities in branch runs shall be kept low enough to maintain acceptable noise levels at air grilles.
- .2.2 Fans and Air Handling Units:
  - .2.2.1 Fans: Specify each type of fan separately. All fans shall be statically and dynamically machine balanced and fan motors shall operate within nameplate values.
    - .2.2.1.1 Fan ratings shall be based upon test performance in strict accordance with the AMCA Standard 210-67 Test Code for air moving devices. Specify that each fan bear the seal authorized by AMCA indicating that ratings are certified and that fans not bearing this seal will not be accepted.
    - .2.2.1.2 Centrifugal fans with motors 5 hp or over shall have bearings of the split pillow block, double row roller or ball, grease-lubricated type, with pedestal-type supports. Bearing life per Anti-Friction Bearing Manufacturers Association rating procedures shall be 90 percent expectancy of reaching at least 87,360 hours under design conditions.
    - .2.2.1.3 Space Planning: Fans, motors, and drives shall be located so that safe and easy access for periodic inspections and maintenance is possible.
- .2.3 Drives: The following guidelines must be considered in the selection of, and specifications for, belt drives:
  - .2.3.1 Single belt drives shall not be used on equipment with 1 hp motor and over.
  - .2.3.2 Drives shall always be installed with provisions for center distance adjustment. Motors shall be located on their respective motor bases allowing for 1/6 of the total motor base travel for installation of new belts with remaining 5/6 of the travel available for belt tightening.
  - .2.3.3 Arc of contact on the smaller sheave should not be less than 120 degrees.
  - .2.3.4 Ratios should not exceed 8 to 1.
  - .2.3.5 Belt speed should not exceed 5,000 feet per minute.
  - .2.3.6 A full and free circulation of air should be around the drive at all times.
  - .2.3.7 Drives operating in an explosive atmosphere should be well grounded and equipped with static-conducting belts.

**23 30 00. HVAC AIR DISTRIBUTION (Cont'd)**

**23 36 05. AIR TEMPERING SYSTEMS: (Cont'd)**

- .2.3.8 Variable drive pulleys used with 5 hp and larger motors are prohibited on final drive installations. Specify that original sheaves be changed when required to achieve proper rpm balancing.
- .2.3.9 Power Factor Correction: Motors (drives) 50 hp and larger shall be provided with fused, switched, power factor correction capacitor sized to correct to 100 percent or greater. Units shall be connected between the contractor contacts and overload coils. Units shall meet all fire and environmental codes.
- .2.4 Ducts: Ducts shall not be run above electrical panelboards, switchboards, substations or within electric rooms except for the duct serving the electrical room.
- .2.5 Window air conditioners, when permitted, must have a 0-4 hour 240 volt D.P.S.T. timer for use in offices or a 0-12 hour 240 volt D.P.S.T. timer for use in a computer room or laboratory situation. See University Policy in Appendix.
- .2.6 FRESH AIR SUPPLY:
  - .2.6.1 Intakes: Fresh air intakes shall be located in a vertical plane a minimum of 8 feet above grade and should not be located in close proximity to loading docks, driveways, loading zones, or any other contaminant source. Sufficient distance or a direction change of fresh air shall be provided between the outside air intake louver and the filters to eliminate snow and rain being carried to the air filters. Intake ducts ahead of filters must incorporate adequate and accessible drains. Duct must also be totally rust resistant.
  - .2.6.2 Masonry Structures: If masonry plenums or air shafts are used to handle air flow, they shall be coated with special materials or lined with sheet metal to make them air tight.
- .2.7 Return Air: Include return air fans in ventilation systems. Provide controls to coordinate return air fans with supply fans and to use return air or outside air as needed for highest energy efficiency.
  - .2.7.1 Plenums: The use of return air plenums in lieu of ducted return air systems is prohibited.

**23 40 00. HVAC AIR CLEANING DEVICES**

- .1 REQUIREMENT FOR FILTERS: All air supplied by a forced air type unit or system shall be filtered. Pre-filter in a single filter installation or a pre-filter intermediate filter combination shall be upstream from the coils. After-filter, where required, shall be on the discharge side of the fan and downstream from all coils.
- .2 SPACE REQUIREMENTS: Adequate clearances must be allowed for cleaning or changing filters.
- .3 EFFICIENCIES: Filter efficiency shall be specified and shall be in accordance with the following guide for unit efficiency.

**23 30 00. HVAC AIR DISTRIBUTION (Cont'd)**

**23 40 00. HVAC AIR CLEANING DEVICES (Cont'd)**

Pre- Filter % Efficiency	Intermediate- Filter % Efficiency	After- Filter % Efficiency
17-25	None	60
17-25	60	80-95
17-25	60-90	95-99

.4 DRAFT GAUGES: See 23 05 20.2 (15540.2).

.5 AIR FILTRATION FOR HOSPITALS: Air filtration shall comply with the General Standards of Construction and Equipment for Hospital and Medical Facilities. (The Hill-Burton Program)

.6 PRE-FILTERS in a single filter installation shall be of the following types; filter size and thickness shall be specified.

.6.1 Throw-away type.

.6.2 Disposable media pad between permanent frames.

.6.3 Disposable media pad and frames.

.6.4 Disposable filtering media for roll-type filters. Roll-type filters shall not exceed 10 ft. in width for horizontal or vertical operation and shall be provided with dust covers and motor and drive covers. The filter media shall be provided with adequate support to keep it from being pulled out of place.

.7 INTERMEDIATE AND AFTER-FILTERS shall be of the following types:

.7.1 Dry-type throw away cartridges. Cartridge casings shall be fabricated from zinc-coated steel, with fully gasketed holding frames with compression fastening devices set in a zinc-coated sheet steel frame.

.7.2 Deep pockets of high performance filter media.

.7.3 Bag-type filter, fixed to a zinc-coated steel holding frame and equipped with wire supports to hold bags erect.

.8 ELECTRO-STATIC FILTERS may be incorporated in a project only with approval of the University Architect.

**23 50 00. CENTRAL HEATING EQUIPMENT**

.1 GENERAL PROVISIONS: Refer to paragraph 01 78 23 (01730). in Division 01; specifications shall include provisions for:

.1.1 TRAINING OF UNIVERSITY OPERATORS by specially qualified personnel furnished by the boiler manufacturer.

.1.2 OPERATING AND MAINTENANCE INSTRUCTIONS: Four sets of operating and maintenance instructions and wiring diagrams shall be submitted to the University Architect.

**23 50 00. CENTRAL HEATING EQUIPMENT (Cont'd)**

.1.3 CAPACITY AND EFFICIENCY TESTS of each boiler, including the proper testing of other equipment in the boiler plant installation.

.1.4 TESTS: The specifications shall be written to require the contractor to prepare and perform all tests, to place the boiler in operation, and to demonstrate to designated University personnel that the safety valves and all other safety and control devices function properly.

.2 COORDINATION WITH BUILDING DESIGN:

.2.1 TWO SEPARATE MEANS OF EGRESS shall be provided, consistent with requirements of current Ohio Building Code, in boiler plants housing large boilers.

.2.2 LOCATION AND ARRANGEMENTS of the combustion air and explosion relief openings shall be such that any piping or equipment in the boiler room will not be subject to freezing.

.2.4 ACCESS for cleaning, replacement of tubes or sections, and maintenance is mandatory. Show manufacturer-specified clearances on plan views and elevation views for tube-pull areas, flanges, unions, etc., as needed to remove equipment heads as required for service.

.3 FUEL HANDLING EQUIPMENT:

.3.1 GENERAL: Fuel handling equipment and fuel burning equipment on boilers shall comply with FIA recommendations.

23 52 00. HEATING BOILERS:

.1 PREFERRED BOILER PLANTS: Where their use is practical, hot water boilers are preferred over steam boilers.

.2 SEPARATE PLANTS: Many buildings will be heated with separate boiler plants. It is the intent of the University that these plants be fully automatic and equipped with the latest and best safety devices.

.3 SIZES: Plants shall be designed with boiler sizes, so selected as to not require an attendant licensed operator.

.4 ELECTRIC BOILERS: The associate must submit for review and approval by the University before applying any electric boiler. Electric boilers shall use the highest voltage available. Electrode boilers are favored over resistance-element type boilers. Adequate provisions shall be made for boiler capacity control.

.5 STEAM BOILERS: Steam boilers shall have blow down tanks located below the boiler water level in compliance with the State of Ohio rules for the construction and installation of steam boiler blow off systems.

.6 VIBRATION CONTROL: Boilers located on floors above grade shall be installed on precompressed fiberglass vibration pads.

23 52 10. BOILER ACCESSORIES:

.1 THE WATER COLUMN on steam boilers shall comply with the Ohio Boiler Code. Float controls are desired.

**23 50 00. CENTRAL HEATING EQUIPMENT (Cont'd)**

**23 52 10. BOILER ACCESSORIES: (Cont'd)**

- .2 CONTROLS: On multiple boiler plants, the controls shall be of the modulating selector type so that individual boilers can be made to lead or lag. These controls shall be located in view of the boilers themselves so that personnel can see the boilers as controls are being adjusted.
- .2.1 Float chambers of level control devices shall have gate valve drains with pipes extended to discharge over a floor drain.
  - .2.2 Pressure Type Relay: Steam boiler plants having more than one boiler shall have a pressure type relay and non-return valve on each boiler to prevent steam pressure in lag boilers from dropping below header pressure. (The purpose of this control is to prevent header steam from condensing in the boiler and raising the water level above the high level point in the header).
  - .2.3 Aquastat Relay: On steam and hot water boilers, an aquastat relay shall be installed on each boiler to prevent the burner from reaching high fire rating before the water temperature in the boiler rises to within a few degrees of the normal operating temperature.
  - .2.4 Safety Valves: On both hot water and steam boilers, relief valves shall be installed and so vented that they may be blown down without danger to personnel. Design will require adequately sized vent lines with appropriate drains to prevent steam and hot water from blowing back into the boiler room or other areas where they can endanger personnel.
  - .2.5 Vacuum Breakers: Each steam boiler shall have a vacuum breaker provided on a pipe connected to the top of the water column or float control for vacuum release.
  - .2.6 Cut-offs: Boilers shall have a low water cut-off on the burner.
- .3 GAUGE GLASSES shall be automatic ball shut-off type.

**23 53 00. HEATING BOILER FEEDWATER EQUIPMENT:**

- .1 WATER SOFTENER: Each boiler room shall be provided with a water softener for boiler feedwater makeup.
- .2 THERMAL SHOCK PREVENTION: Each steam boiler plant shall have a factory assembled de-aerating feedwater heater with automatic controls. The heater shall be located at an elevation to provide net positive suction head for the boiler feedwater pumps. Hot water boilers shall have system piping and cold water makeup arranged to prevent cold water from entering a hot boiler.
- .3 CHEMICAL TREATMENT: Boilers shall be provided with individual means for feeding chemicals into the boilers. Steam boilers having an output of 3,000,000 Btu or more and having at least 75 percent feedwater makeup requirement shall be provided with an automatic surface blow off arrangement. The device shall maintain a constant conductivity concentration by means of a boiler water probe and controller. Boilers having a high makeup requirement shall be provided with special chemical feedpumps for continuously feeding chemicals into the boiler.
- .4 BACK FLOW PREVENTERS: Domestic "makeup" waterlines to boilers shall be provided with backflow preventers.

**23 50 00. CENTRAL HEATING EQUIPMENT (Cont'd)**

**23 60 00. CENTRAL COOLING EQUIPMENT**

23 60 05. COILS AND PIPING SYSTEMS:

- .1 COILS: All coils shall be ARI certified. Direct expansion coils may be used on small systems and shall be piped and installed in accordance with factory recommendations, if the installation can be considered normal or average by the manufacturer. Additional design precautions shall be taken, or a field refinement procedure shall be included in the specifications, on those installations not covered by the manufacturer's guide.
  - .1.1 Coils shall have copper tubes with aluminum fins, permanently bonded. Water cooling coils shall be designed for full counter-flow of water and air with water inlet at the bottom of the supply header and outlet at the top of the return header.
  - .1.2 Water Coils and Steam Coils: Constant full-flow water coils are preferred.
    - .1.2.1 For VAV (variable air volume) HVAC systems, include a pre-heat coil of sufficient size to pre-heat the code-required minimum ventilation air up to 55 DegF leaving air temperature. This will help to prevent nuisance low-temperature shutdowns, and will help to avoid negative pressurization of the building, during the heating season.
    - .1.2.2 For any pre-heat, provide a coil with integral face-&-bypass air control dampers, coil recirculation pump for constant heating flow to the coil, and two-way (normally open) heating control valve. The heating control valve shall be specified to remain in continuous control under 'all' normal operational sequences of the fan system, even when the fan system is normally 'OFF'. The heating coil shall be specified to fail to wide-open 'only' upon alarm of the low-temperature detection thermostat.
    - .1.2.3 Steam coils, if used, shall be positive drain type with vacuum breakers, air vents, and double parallel condensate drip traps to reduce the possibility of freeze-up. The steam coils shall be installed with suitable pitch such that condensate shall naturally drain from the coil.
  - .1.3 Design Details:
    - .1.3.1 Condensate Removal: Whenever cooling coils are stacked one above the other in a plenum, drip troughs shall be installed on the downstream side of the top coil(s) to eliminate drip into the air stream of the bottom coil. Pay special attention to pitch of cooling coil housing, exterior piping, and traps to ensure adequate removal of condensate from the plenum.
    - .1.3.2 Access: Provide access areas on both sides of coils for maintenance purposes.
    - .1.3.3 Freeze-up Protection: Specify that the volume of heating medium being supplied to a coil facing outside air shall not be modulated. Provide manual freeze-up protection, applied to the downstream side of the coil.
- .2 PIPING: Piping for hot and chilled water systems shall include isolation valves, drain valves, air vent facilities, and pipe unions at each coil, as well as a lockshield balancing valve or balancing cock for those systems having more than one coil being served. Air vents (automatic, or manual, as appropriate) with a line extended to an adjacent floor drain shall be specified for installation wherever air is likely to be trapped. A strainer with isolation valves on the suction side of a pump and a pressure relief valve are required on

**23 60 00. CENTRAL COOLING EQUIPMENT (Cont'd)**

**23 60 05. COILS AND PIPING SYSTEMS: (Cont'd)**

all systems. Back-flow preventers shall be provided to prevent contamination of potable water systems.

- .2.1 Refer to Appendix for Technical Provisions for Corrosion-Scale Inhibitors, Microbiocides and Water Analysis Services for Cooling Towers.
- .2.2 Refrigerant Piping: Accessory equipment in a refrigerant circuit shall include:
  - .2.2.1 A dryer of adequate size.
  - .2.2.2 Sight glass-moisture indicator, installed in the liquid line at a convenient and accessible location.
  - .2.2.3 Liquid solenoid valve located near the expansion valve on systems using coil pump-down.
  - .2.2.4 Service hand valves shall be considered a convenience on small refrigerant systems and a necessity on extensive or large systems. They shall be located for component isolation purposes during normal maintenance.
  - .2.2.5 Liquid charging port and service valve installed in the liquid line for large systems.

**23 61 05. COMPRESSORS**

- .1 COMPRESSORS OF 60 TO 100 TON CAPACITY: Semi-hermetic reciprocating or scroll type, equipped with full running protection as described for larger compressors, suction and discharge oil pressure gauges, crankcase heater(s) oil reservoir sight glass, replaceable refrigerant filter-dryers and 5-year warranties. Incorporated features shall include the following:
  - .1.1 Hydraulic capacity control by cylinder unloading for adjustments to load fluctuations.
  - .1.2 Positive unloaded start.
  - .1.3 An adequate discharge muffler.
  - .1.4 Internal vibration isolation to provide minimum vibration transmission.
  - .1.5 Closed transition starting switchgear, determined by the electrical specifications for the particular sizes of motors.
  - .1.6 Air cooled units shall be furnished with a receiver on the condenser and provisions for pumping the full refrigerant charge into the receiver.
  - .1.7 Power factor correction as described for large compressors.
- .2 COMPRESSORS UNDER 60 BUT OVER 15 TON CAPACITIES shall be semi-hermetic reciprocating or scroll type or scroll type. Incorporated features shall be as specified in paragraph 23 61 05.1 (15652.2) plus inherent thermal overload protection for motors.

**23 60 00. CENTRAL COOLING EQUIPMENT (Cont'd)**

23 61 05. COMPRESSORS (Cont'd)

.3 COMPRESSORS BELOW 15 TONS OF CAPACITY SHALL be full hermetic, semi-hermetic or scroll cylinder unloading and unloaded start features are not required, but should be considered. Units shall have inherent thermal overload protection for motors.

.4 COMPRESSOR PRESSURE RELIEF DISCHARGE PIPING -See 23 20 03 (15505).

23 63 05. CONDENSERS:

.1 All condensing units under 100 tons shall come factory pre-charged with NON-CFC refrigerants and compressor manufacturers recommended lubricating oil. The unit shall be clearly marked as to the refrigerant and oil that it contains.

.2 SPECIFIC DESIGN REQUIREMENTS:

.2.1 CONDENSER CONSTRUCTION: Blow-through evaporative condensers are preferred to draw-through units. Where required for all season operations, air cooled systems shall be designed for condenser location within equipment rooms with discharge air to the outside. Where this is not possible, the condensers must be exterior mounted, the system shall be provided with adequate winter protection to prevent short cycling of the system. Winter protection shall be in accordance with the manufacturer's recommendations and so warranted by the manufacturer.

.2.1.1 Air cooled condensers shall be selected in accordance with ASHRAE Standard 20-70 or ARI Standard 460-70 using 115 degrees F condensing temperature and 95 degrees dry bulb entering air temperature.

.2.1.2 Water-cooled condensers utilizing city water are prohibited.

.2.1.3 Modulating dampers used for controlling air quantities through towers or condensers shall have non-ferrous blades, linkages, and bearings. The operator motors and linkages shall be located outside the tower for convenient maintenance and operation.

.3 ARRANGEMENT OF EQUIPMENT:

.3.1 Condensers shall be located so that tubes can be rodded without hindrance from walls, piping, or equipment.

.3.2 Evaporative condensers shall be located near their compressors to reduce refrigerant piping to a minimum.

.4 CONDENSER PIPING: Piping of condensers shall have proper and adequate fittings and supports to facilitate removal of water box ends for maintenance. One set of flange fittings shall be located adjacent to the water box and a second set of flange fittings located away from the water box at such a distance that would permit the removal of the header and to provide maintenance space. This same provision for removal of headers in piping shall be made in the chilled water circuits at the chiller unit. Provisions shall be made for continuous blow down at the highest points in the condenser water system. Dry sumps shall be utilized with interior storage when winter operation is required.

.4.1 Water treatment control of pH and solids shall be provided. Backflow prevention or an air gap shall be provided to prevent contamination of all potable water

**23 60 00. CENTRAL COOLING EQUIPMENT (Cont'd)**

23 63 05. CONDENSERS: (Cont'd)

systems. Refer to Appendix for Condenser, Water Treatment System Sample Specification.

- .4.2 Condenser water lines and city water make-up lines exposed to the weather shall have drain facilities properly located to allow drain down of the system to prevent freeze-up during the winter.
- .4.3 Check valves shall be installed on condenser water pump discharge lines where a reverse flow could occur in event of pump shut down.
- .4.4 A basket type strainer shall be installed ahead of the condenser water pump on all systems. Strainer shall be valved so that minimum amount of water will be lost when strainer is removed for cleaning. The pressure gauges on any condenser water strainer or condenser water pump shall be compound-range gauges, such that if the strainer becomes plugged, the gauge will read below zero (0) without damage to the gauge.
- .4.5 Refrigerant Piping to and from an air-cooled condenser shall be installed in accordance with the manufacturer's recommendations (re: pipe size, traps fittings, and receiver size).
  - .4.5.1 Installation of Refrigerant Piping: Specify that lines be fitted, installed, and pressurized with dry nitrogen before being brazed. Use 6 percent or higher silver alloy with a 1000 degrees F solidus minimum. Specify that lines be blown with dry nitrogen to eliminate brazing debris before starting evacuation and charging procedures.
  - .4.5.2 Elbows and fittings for refrigerant lines shall be long-radius to minimize capacity loss.

23 64 05. CHILLERS:

.1 CHILLERS OF OVER 100 TON CAPACITY: Units will be centrifugal or screw type which utilize NON-CFC refrigerants with safety classification A-1 (as defined per ASHRAE Standard 34-2001 -- Designation and Safety Classification of Refrigerants) such as R134a. The primary considerations are high efficiency at part load, high efficiency at full load, low acoustic noise, ease of service, high reliability of operation, low operating costs, low service costs, fast response from local service representatives, and ease of data transfer using BACnet communications to the building automation system from chiller controller. Also specify:

- .1.1 Motors: Dual winding, star-delta design, with matching two-step, closed transition, time-delay starting switchgear is preferred. An auxiliary timer in the starting circuit is required. Specify that timer be set to limit starts to a minimum of 60-minutes apart, or greater as recommended by the manufacturer.
  - .1.1.1 Alternate Starting Arrangements: An auto-transformer with reduced voltage start or solid state starter are acceptable alternates.
  - .1.1.2 Thermal Protection: All motors shall have heat sensors in the windings for thermal protection.
  - .1.1.3 Provide alternate add pricing for variable frequency control of chiller drive motor.

**23 60 00. CENTRAL COOLING EQUIPMENT (Cont'd)**

23 64 05. CHILLERS: (Cont'd)

- .1.2 Power Factor Correction: The equipment manufacturer shall provide fused, switched, power factor correction capacitors to correct to 100 percent or greater. It is preferred that the units be connected after the contractor, before the overloads. Units shall meet all fire and environmental codes.
- .1.3 Full-running Protection: Specify that compressors be equipped with high and low pressure safety cut out, external overload protection, and low oil pressure safety cutout. Safeties shall be manual reset type initiating an electrical lockout of the starting circuit when tripped, with an indication of which safety device has tripped.
- .1.4 Gauges: See 23 05 20.2 (15540.2).
- .1.5 Forced feed lubrication with filter, cooler and visual inspection port in the oil reservoir shall be provided.
- .1.6 Capacity Control: A capacity control will be located in the machine control cabinet with an adjustable range of 20 to 100 percent. This will be a pneumatic-electric or a microprocessor based device suitable for remote reset.
- .1.7 Heaters: Compressors shall be equipped with crankcase heaters wired on a separate electrical circuit. Units using low-pressure refrigerants shall be furnished with purge units to eliminate the non-condensable gases. Units shall be furnished with a pump-out unit and receiver large enough to hold the full refrigerant charge.
- .1.8 Air-cooled units shall be furnished with a receiver on the condenser and provisions for pumping the full refrigerant charge into the receiver.
- .1.9 Bidding Requirements: See Division Facility Services-6 (15/16-6) for Base Bid requirements for CHILLERS over 100 ton capacity.
- .1.10 Evaporator and condenser connections shall be specified to include marine boxes which will permit ease of service to tubes.
- .1.11 Oil filtration system shall be specified to include isolation valves, to isolate the filter from the machine and avoiding removing the refrigerant charge when servicing the oil filter.
- .1.12 Refrigerant circuit shall be specified to include refrigerant isolation valves, and sufficient volume in both evaporator and condenser to allow all of the refrigerant to be moved into one section of the circuit while servicing the other section, to avoid removing the refrigerant from the machine.

23 65 00. COOLING TOWERS:

- .1 GENERAL DESIGN REQUIREMENTS: Cooling towers shall be of the induced draft design with propeller type fan. Fan drive shall be right angle gear type with electric motor mounted outside the air stream.
  - .1.1 Free-standing towers shall be provided with appropriate factory made service platforms, ladders and a safety railing to provide adequate access for servicing the equipment inside and on top of the tower.
  - .1.2 Cooling towers shall be sized based on 78 degree F wet bulb outside air temperature, 95 degree F entering and 85 degree F leaving water temperature.

**23 60 00. CENTRAL COOLING EQUIPMENT (Cont'd)**

23 65 00. COOLING TOWERS: (Cont'd)

Cooling tower capacity requirements shall be checked by the associate throughout the full operating range of the chiller and outside air ambient conditions to ensure adequate tower capacity.

- .1.3 Fan motors shall be inverter-rated, to permit warranted-use of the motors when controlled by variable frequency drives.
- .1.4 The use of variable frequency drives for tower fans is strongly encouraged in order to provide the lowest suitable condenser water supply temperature to the chillers, such that the chillers can operate more efficiently at the lowest lift.
- .1.5 The use of tower bypass control valves is encouraged in order to allow friendly start-up to chillers and avoid nuisance shutdowns of chillers with too-cold tower water. It is encouraged to apply a single two-way tower-bypass control valve, and avoid three-way valves.
- .1.6 For towers with indoor sumps, provide a 1"-size drain-equalizer at the indoor sump, interconnected between tower supply and tower return lines, such that both lines will automatically drain to the sump. The 1" drain-equalizer shall have zero (0) valves and shall be continually open to both lines.

**23 80 10. LIQUID HEAT TRANSFER:**

- .1. HOT WATER HEATING PIPING AND INSULATION: Refer to Sections 23 07 19 (15505), 23 20 05 (15515), and 23 20 09 (15543).
- .2. STEAM HEATING PIPING AND INSULATION: Refer to Sections 23 07 19 (15505), 23 20 05 (15515), and 23 20 09 (15543).
- .3. HEAT EXCHANGER PIPING AND INSULATION: Refer to Sections 23 07 19 (15505), 23 20 05 (15515), and 23 20 09 (15543).

23 80 15. TERMINAL UNITS:

- .1 DESUPERHEATER STATION: Desuperheat all reduced pressure steam. For example, if a program calls for 60 psi steam distribution, desuperheat both 60 and 15 psi media to each appropriate temperature. Each pressure reduction shall be accompanied by a corresponding reduction in superheat. Submit details for construction and installation during preliminary design for review and approval.

23 80 17. DESIGN AND INSTALLATION OF STEAM PRESSURE REDUCING STATIONS:

- .1 SOUND ATTENUATION: Provide either sound attenuating valve trim or a downstream in line silencer or both to maintain noise levels below 85 dB. Attenuator outer body and inner wall shall be of steel construction with pressure and temperature rating as required by the safety relief valve set point and stream conditions. Acoustical insulation shall be fiberglass for service below 450 degrees F and fiberglass with steel casing for service above 450 degrees F.

- .2 BUILDING HEATING SYSTEMS: Refer to Appendix U for design guidelines for building heating hot water converter systems in main campus buildings.

**23 80 10. LIQUID HEAT TRANSFER: (Cont'd)**

**23 80 17. DESIGN AND INSTALLATION OF STEAM PRESSURE REDUCING STATIONS:  
(Cont'd)**

.3 MAIN BUILDING STATIONS: Steam stations processing campus high pressure steam at 200 psig at 600 degrees F to produce building utilities such as heating hot water, domestic hot water and reduced pressure process steam shall be located immediately adjacent to an exterior wall. The Control Valves shall be selected to satisfy winter and summer steam usage, which in most cases has a turndown of 50:1.

Routing campus high pressure lines through interior building spaces is prohibited except in the case where the steam line is completely enclosed in a utility tunnel physically segregated from interior building space. The space shall be adequately ventilated/cooled to achieve an overall temperature not to exceed 95 degrees Fahrenheit at a distance of 4 feet from the station. Label all piping that is anticipated to carry superheated steam with the appropriate abbreviation listed in section Facility Services-.3.17.1.11 and an additional 'S'. For example medium pressure superheated steam: MPSS. High pressure stations, requiring close reduced pressure control and reliable operation, shall be designed to include:

.3.1 Valves shall be cast carbon steel body, Class 300 rating, hardened stainless steel trim, normally closed single port, cage guided, bonnet extension, with graphite packing and Belleville style washers.

.3.1.1 Diaphragm shall be molded EPDM with a nylon fabric insert, iron diaphragm, plate, silicone manganese-steel actuator spring, stainless steel travel indicator scale.

.3.1.2 Pressure Controller: Specify that each valve be furnished with a proportional and reset action pressure controller with overload protection on the bourdon tube. Bourdon tube shall be of #316 stainless steel. Unit shall have supply pressure gauge and output pressure gauge. See 23 05 20.2 (15540.2).

.3.1.2.1 A 1/4 inch filter regulator shall be installed in the air line ahead of each controller.

.3.1.2.2 The sensing line connecting the pressure controller to the steam pipe shall be #316 stainless steel pipe, minimum 3/8" NPT size, or larger as specified by the controller manufacturer.

.4 HIGH VOLUME STATIONS: Medium pressure (less than 150 pounds saturated steam) stations, requiring close reduced-pressure control, shall be designed to include:

.4.1 Valves shall be Class 150 cast iron body hardened stainless steel trim, normally closed single port, cage guided, with Teflon packing.

.4.1.1 Diaphragm, pressure controller, and filter regulator shall be the same as required for main building station.

.5 SMALL VOLUME STATIONS: When extremely light loads will exist for a season, design a small regulator station to suit requirements. Stations less than 150 pounds, and not requiring close reduced-pressure control, shall be designed to include:

.5.1 Pilot operated reducing valve with bronze bellows seal on the valve stem, stainless steel valve plug, removable stainless steel seat.

**23 80 10. LIQUID HEAT TRANSFER: (Cont'd)**

**23 80 17. DESIGN AND INSTALLATION OF STEAM PRESSURE REDUCING STATIONS:  
(Cont'd)**

.5.2 Valves shall have 250 pounds SWP screwed cast iron bodies, single port with top and bottom guided stainless steel valve plug, replaceable screwed-in stainless steel seat, Inconel main spring, double stainless steel diaphragm.

.6 **INSTALLATION DETAILS: Specify that:**

.6.1 Valves with pneumatic controls be provided clean, dry air at 75 psi.

.6.2 Steam gauge: See 23 05 20.2 (15540.2).

.6.3 Safety valve and safety valve vent be provided. Safety valves should discharge to the outside. The pressure drop in the safety valve discharge piping shall be minimal so that it does not impede the safety valve operation. Where steam passes through regulators to a lower class of piping, safety valves shall be installed with enough capacity to prevent over-stressing the piping in event of regulator failure.

.6.4 A drip-pocket, full pipe size, and a trap be provided just ahead of each regulator to remove the moisture from the steam before it enters the regulator.

.6.5 Two regulators be provided on primary regulator stations, both sized for full flow capacity with one being a stand-by regulator. Regulators should be installed with valves and unions so that any regulator can be removed without disturbing the others. Strainers with blowdown valves shall be installed ahead of regulators. Provide a full-flow globe valve by-pass on primary stations.

.6.6 Regulator stations shall be of such design that regulators can be easily removed without straining the pipe.

.6.7 Gauges on steam lines are encouraged to be compound-range gauges, such that gauges will not be damaged if steam systems draw a vacuum when shut-down.

.6.8 Provide removable/reusable insulation jackets on all devices, to reduce heat gain to the space, and allow for convenient service.

.7 **ZERO ENERGY POTENTIAL: Double block and bleed techniques, as recommended by OSHA, shall be used to achieve ZEP (Zero Energy Potential) on all systems of 50 psig or higher.**

**23 82 10. COILS, RADIATORS, AND FAN COIL UNITS:**

**.1 USAGE:**

.1.1 **Forced Air Type Units:** An adequate supply of heat shall be provided at building entrances and in air locks. Cabinet unit heater with thermostat control shall be used. Units shall be equipped with filters to minimize dirt collection on coils.

.1.2 **Convectors** shall be used where architectural features cause an increase in heating requirements. When used, convectors shall have ratings based upon test procedures as set up by the Hydronics Institute, Institute of Boiler and Radiator Manufacturers (I=B=R).

**23 80 10. LIQUID HEAT TRANSFER: (Cont'd)**

**23 82 10. COILS, RADIATORS, AND FAN COIL UNITS: (Cont'd)**

- .1.3 Through-wall type heating/cooling units shall not be provided with any liquid service to avoid winter freeze-up problems.
- .1.4 Energy Conservation: Fan coil units and radiation will be required in specific areas to facilitate shutdown of major fan units after hours to save energy. Where necessary, the controls on these units shall be coordinated with the controls on the air handling units.

**.2 DETAILS:**

- .2.1 Convectors shall be wall hung type with sloping top and knob dampers. Elements shall be tested at 150 psi.
  - .2.1.1 Fins shall be non-ferrous, spaced not closer than 72 fins per foot.
  - .2.1.2 Tubes shall be copper.
  - .2.1.3 Cabinet shall be sheet metal, no less than sixteen gauge on fronts and tops, and eighteen gauge on backs.

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END OF DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)