



**Office of Capital Planning
and Project Management**

DIVISION 23

HEATING, VENTILATING AND AIR CONDITIONING

This Article on Codes, Regulation and Standards shall apply
to all Divisions of the Building Standards

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23 01 00 OPERATION AND MAINTENANCE OF HVAC SYSTEMS

- All construction punch list items shall have been resolved prior to system start-up.
- All manufacturers' representatives required by specification to witness equipment start-up are present.
- Domestic water systems have been certified as conforming to the Federal Safe Drinking Water Act.
- Refer to related [Integrated Automation 25 00 00](#) Sections.

23 01 20 OPERATION OF HVAC PIPING AND PUMPS

- Pressure gauges shall be installed in all pumps suction and discharge piping to aid in maintenance and trouble-shooting.
- Refer to the following list of schematics for information of installation standards. If different installation is to be done university approval will be needed.
 1. [High temperature hot water to hot water converter](#)
 2. [Steam to hot water converter](#)
 3. [Hot water heating coil](#)
 4. [Hot water heating coil with recirculating pump](#)
 5. [Steam heating coil](#)
 6. [Chilled water cooling coil](#)
 7. [Chilled water cooling coil with recirculating pump](#)
 8. [VAV box with reheat coil](#)

23 05 00 COMMON WORK RESULTS FOR HVAC MOTORS

- The equipment manufacturer of the driven equipment shall establish the size of the motors.
- Horizontal mounting is preferred. Vertical mounting is acceptable where space is limited. Refer to this Division (Division 23) for any additional requirements.

23 05 16 EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

- Piping expansion and contraction shall be accommodated via the use of expansion loops only. Mechanical expansion shall not be allowed

23 05 19 METERS AND GAUGES FOR HVAC PIPING

- Meet ASHRAE 62.1-2004 requirements.
- All thermometers shall be the digital and solar type.
- Digital solar thermometers shall be installed upstream and downstream of all air and liquid temperature systems and subsystems for the purpose of maintenance and troubleshooting.
- Gauges shall be installed before and after all equipment to aid in troubleshooting and maintenance.
- Operating pressure scale to be centered at the top of the gauge.
- Pressure sensitive gauge tubing to be looped to prevent visual flutter of the indicator.
- Do not use P&T plugs to replace P&T gauges.
- All fans and air handling units shall have solar temperature gauges for the discharge, return air and outside air.

23 05 23 GENERAL DUTY VALVES FOR HVAC PIPING

- All automatic flow valves shall come with ports for verification.
- All control valves and dampers shall be electronic modulating.
- **They shall be "proportional" and shall provide feedback to the BAS.**
- Gate valves 2" and smaller: 150 lb. bronze, rising stem, screwed ends, ASTM B 61 (B62 for domestic water) bronze body and union bonnet, solid wedge disc, and painted malleable iron wheel. Design shall allow repacking under pressure. For use in steam condensate, chilled water, hot water, and fire protection.
- Gate valves 2-1/2" and larger: Iron body, bronze trim, flanged ends, OS&Y, ASTM A 126 Class B ferro steel body and bonnet, solid cast iron disc with bronze trim, replaceable bonnet bushing, 2 piece ball-type gland. Design shall allow repacking under pressure. Wheel shall be malleable iron. For use in steam condensate, chilled water, hot water, and fire protection.
- Globe valves 2" and smaller: 150 lb. bronze, screwed end with ASTM B 62 bronze body, union bonnet, composition disc, and painted malleable iron wheel. For use in steam condensate, chilled water, hot water, and fire protection.
- Globe valves 2-1/2" and larger Flanged end with ASTM A 126 Class B ferro steel body and yoke bonnet, bronze disc, stem, stem hole bushing and bronze renewable body seat rings, and malleable iron wheel. For use in steam condensate, chilled water, hot water, and fire protection.
- Check valves 2" and smaller . Y pattern, bronze, body, 200 lb, SWP, screwed ends and cap. For steam, chilled water, hot water, domestic water and fire protection systems.
- Check valves 2-1/2" and larger for domestic water: Spring loaded, center guided. Check valves shall be wafer type for 6" and smaller type, and flanged type for 8" and

larger. Check valves shall have semi-steel body and bronze trim, and shall be designed for pressure service required but not less than 125 psi. For steam, chilled water, hot water, domestic water and fire protection systems.

- Check valves for sump pumps and ejectors: Iron body, bronze trim, bolted cap, renewable and re-grindable bronze seat ring, composition disc, with lever and weight or lever and spring, flanged ends.
- Refer to [23 05 53 Identification for HVAC Piping and Equipment](#) Section for valve tag identification.
- High Performance Butterfly Valves: carbon steel body with stainless steel disc, stainless steel stem with top and bottom alignment bearings, ANSI 1 Class 125/150 flanges. Teflon seats and seals for use in chilled water systems.
- Plug Valves: ASTM A 126, Class B, cast iron body, bolted bonnet, teflon-coated plug, 200 psi WOG rating, threaded ends. For use in compressed air systems.
- Pressure Relief Valves: Pressure relief valves shall be self-closing type, conforming to ASME Boiler code, and shall be provided with non-corrosive interior operating parts with valve seats and high temperature silicone. Valves shall have test levers. Valves shall be sized in accordance with ASME requirements. Refer to contract Drawings for capacities of systems and required set points.
- Compressed air relief valve shall be the self-operated, tamper-resistant type designed to keep instrumentation on line in case of supply overpressure. The relief valve shall be installed in an in-line, flow-through arrangement with no remote vent piping. Valve shall have aluminum body, steel spring, stainless steel trim, nitrile diaphragm, and threaded ends, and be suitable for 250 psig and 150°F.
- Water Pressure Reducing Valve: Water pressure reducing valves shall have bronze, renewable stainless steel seats, stainless steel strainers and high temperature diaphragms. For potential use in chilled water and low temperature water systems.
- Fire Hose Valve:
 1. Fire hose valves shall be similar to the following catalog number which is based on Potter-Roemer.
 - a. Valve shall be No. 4065, 2-1/2" rough brass, 300 lb. Valve with brass cap and chain, with threads complying with the Chicago Fire Department requirement.

23 05 29 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

- Galvanized or painted threaded rods and hangers shall be used to prevent rusting. The rod supporting the hangers, bolts and screws shall be no longer than ½" below the lower nut. Perforated strap hangers for pipe shall not be used.

23 05 53 MECHANICAL IDENTIFICATION HVAC PIPING AND EQUIPMENT

- All pipes in the piping systems shall be identified, both where exposed in a room and where concealed from view in a chase or above a hung ceiling.
- Provide color coded banding for proper identification of pipe contents and directional flow arrow(s) decals at the following locations:
 1. Behind every access door or panel.
 2. At each valve.
 3. At each riser and/or "T" joint.
 4. At each point of entry or exit where pipe passes through walls, floors or ceilings.
 5. At intervals not exceeding 50'-0" apart on long runs.
- Engraved laminated plastic nameplates under each instrument in the control panel shall designate its function.
- Ducts and fans shall be stenciled with 1" high black letters and/or numerals. On multi-zone air handling units, ducts shall be marked near respective fans to indicate room served, capacity, and location of zone control. Fans shall be marked to indicate unit number, rooms served, actual cfm, rpm and amperage of motors under final operating conditions.
- Mechanical System Color Identification: Adhesive markers with directional flow arrow(s).
 1. Red: Fire protection apparatus; control cabinets, water pipes, fire pumps, and jockey pumps.
 2. Orange: Boiler produced hot water and steam piping, pressure relief piping.
 3. Yellow: Natural gas piping, gas boosters and emergency generators.
 4. Light Green: Chiller skins and compression tanks.
 5. Dark Green: Domestic water pipes.
 6. Blue Green: Chilled water piping
 7. Light Blue: Pumps and motors.
 8. Dark Blue: Domestic water storage, sewage ejectors and refrigerant compressors.
 9. Light Gray: Condenser Water Pumps and air handlers.
 10. Dark Gray: Safety rails, pipe hangers and vibration isolators.
 11. Purple : Air compressors and compressed dryers and piping.
 12. Black: Oil piping, fuel oil tank, water holding tanks, drain and waste lines.
 13. White: Heat exchangers and chemical treatment piping.
- Placement - provide identification markers:
 1. On all pipes at 50 foot intervals.
 2. On all branches and valves.
 3. On both sides of walls where pipes pass through wall.

- 4. Where pipes pass through floor.
- 5. At changes of flow direction.
- Type and Size of Letters:
 Contrast shall be provided between color field and legend for readability. On overhead piping, apply markers on the lower quarter of the pipe where a view from the floor is unobstructed. Use of standard style, in sizes ½" (13mm) and larger, is recommended. Refer to Table of Sizes (below) for specific size recommendations. For identification of materials in pipes of less than ¾ in. (19mm) in diameter, and for valve and fitting identification, the use of a permanently legible tag is recommended. Apply an arrow marker at each identification marker, with arrow pointed away from legend in the direction of flow. If flow may be both ways, apply double-headed arrows.

Outside Diameter of Pipe		Size of Letters	
<u>INCHES</u>	<u>MM</u>	<u>INCHES</u>	<u>MM</u>
¾ to 1¼	19 to 38	½	13
1½ to 2	38 to 51	¾	19
2½ to 6	64 to 150	1¼	32
8 to 10	200 to 250	2½	64
Over 10	Over 250	3½	89

- Valve Tags and Numbering
- All valves shall be tagged with 1¼ in. diameter, 0.040 in. thick brass or laminated plastic tags with numbers and letters. A complete directory of valves, pump motors, controls, devices, and other equipment, giving use, location, size, and manufacturer's number of each shall be prepared with permanent ink, framed under glass, and hung in the mechanical equipment room where directed by the University.

**23 05 93 TESTING, ADJUSTING AND BALANCING FOR
HVAC**

- Test existing conditions prior to retrofitting. Submit results in report form to the University.
- Permanently mark the settings on valves, dampers and other adjustable devices, allowing settings to be restored. Set memory stops and lock.
- Effect adjustment of water distribution systems by means of circuit setters and balancing valves. Do not use service or shut-off valves for balancing.
- Adjust hydronic systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measuring temperature differential in conjunction with air balancing.

23 07 13 DUCT INSULATION

- All ductwork insulation shall be in accordance with the "National Commercial and Industrial Standards" as published by the Midwest Insulation Contractors Association, with the following additional requirements.
- All ductwork insulation shall be external to the ductwork.
- Internally lined ductwork is not allowed.
- Minimum insulation thickness is 1½ inches of fiberglass. Minimum density shall be 3 lbs/ft³.
- Supply ductwork, including flexible ducts, that conveys mechanically cooled air, shall have a vapor barrier.

23 07 16 HVAC EQUIPMENT INSULATION

- All equipment insulation shall be in accordance with the "National Commercial and Industrial Standards" as published by the Midwest Insulation Contractors Association, with the following additional requirements.
- Any equipment that contains a fluid (liquid or gas) which is normally at a temperature of 10° F above or below the normal temperature of the room containing the equipment shall be insulated.
- Vapor barriers shall be installed on any equipment subject to condensation.

23 07 19 HVAC PIPE INSULATION

- All pipe insulation shall be in accordance with the "National Commercial and Industrial Standards" as published by the Midwest Insulation Contractors Association, with the following additional requirements.
- In general, all domestic piping (except Fire Protection piping, medical gas, and pneumatic air) shall be insulated. All piping subject to sweating shall have vapor barriers.
- Piping to be insulated includes:
 1. Domestic water: cold, hot and return.
 2. Chilled water, supply and return.
 3. Condensate return.
 4. Roof Drains (horizontal sections only)
 5. Steam
 6. High Temperature Hot Water, supply and return refrigerant.
- Any insulated piping passing through walls shall have no reduction in insulation through the wall or pipe sleeve.
- Clevis supports and rods on insulated piping shall be insulated.

- Roller supports on chilled water piping shall isolate the roller from the pipe to prevent condensation formation on the roller assembly.

23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC

- Refer to related [Integrated Automation 25 00 00](#) Sections.
- Temperature Control Air Compressors:
 1. Control air compressor shall be used for no other purpose than for temperature control air supply.
 2. Compressors shall be sized to maintain adequate control air while running not more than 50% of the time. Compressors shall be duplex type to assure standby protection. Provide an automatic alternator that distributes wear between the two compressors on a 70% to 30% ratio (adjustable) i.e., lead 70%:lag 30%.
 3. A refrigerated or desiccant air dryer shall be installed on all control air systems to insure dry air.
 4. Install an oil separator and an air filter in the supply line ahead of the dryer and an air filter after the dryer of a type that can be easily serviced.
 5. Air receivers must be constructed in accordance with the ASME code and bear the ASME stamp.
- Air compressors (10hp and under) shall be air cooled. Caution shall be exercised in locating compressors, with respect to heat producing equipment and room ambient temperature.
- Provide an air pressure gauge on each receiver air tank.
- Three Valve Bypasses
 1. Provide three valve bypasses using gate or ball valves around the following devices to allow maintenance of these devices without interruption of compressed air service:
 - a. All air filters, oil separators, etc.
 - b. Refrigerated or desiccant drier.
- Provide a 3 valve bypass around the PRV with a second "standby" PRV in the bypass leg.
- Electrical Supply to Compressor Motors.
 0. Provide a separate set of electric feeders to each compressor motor with a separate circuit breaker for each motor in the supply panelboard or motor control center. This arrangement allows one compressor to remain in service while the other one is being serviced. Single electrical feeds to dual compressor systems are expressly prohibited.
- Compressor bodies and cylinders shall be of cast iron construction only and shall be by the following preferred manufacturers:
 0. Quincy
 1. De Vilbiss

23 09 33 ELECTRIC AND ELECTRONIC CONTROL SYSTEMS FOR HVAC

- Provide a Sequence of Operations for new building systems as approved by the User.
- Provide Central HVAC Systems Display as applicable:
 1. System graphic
 2. System on/off indication
 3. System day/night mode
 4. Supply fan on/off indication
 5. Return fan on/off indication
 6. Heating coil pump on/off indication
 7. Outside air temperature indication
 8. Mixed air temperature indication
 9. Fan discharge air temperature indication
 10. Fan discharge temperature control point adjustment
 11. Supply static pressure indication
 12. Supply static pressure control point adjustment
 13. Humidity sensor
 14. Enthalpy sensor
 15. System on/off auto switch position.
 16. System day/night/auto switch position.
 17. Supply fan on/off switch position.
 18. Return fan on/off/auto switch position.
 19. Heating coil pump on/off switch position.
 20. Time of day scheduling.
 21. Start/stop time optimization.
 22. Peak demand limiting.
 23. Duty cycling (temperature and/or time based).
 24. Enthalpy optimization.
 25. Supply air reset.
 26. Chilled water reset.
 27. Hot water reset based on outdoor air temperature.
 28. Event initiated programs.
 29. Trending.

23 09 43 PNEUMATIC CONTROL SYSTEMS FOR HVAC

- Refer to related [Integrated Automation 25 00 00](#) Sections.
- All pneumatic controllers, actuators and other related equipment (except sensors) shall be mounted outside of the ductwork airstream (on the "outside" of the ductwork) and

located in mechanical rooms or other accessible spaces such that these components are readily accessible for maintenance, replacement or repair without requiring personnel to enter the ductwork airstream, open duct access doors or shutdown the air handling system.

23 0953 PNEUMATIC AND ELECTRIC CONTROL SYSTEMS FOR HVAC

- Refer to related [Integrated Automation 25 00 00](#) Sections.
- Use copper tubing only, except for terminations.

23 09 93 SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

- For each mechanical system, provide the sequential operating procedure for both start-up and shut-down, a wiring diagram and operating description. Data provided should be adequate to determine sequence of operation and how various components are wired into system. Wiring diagrams shall include a legend, which identifies the symbols used in the diagram.
- Conservation of energy, minimizing life cycle and operating cost are items of prime importance to the University. (min. to be provided by UIC) Accordingly, the design of systems, the selection of electric motors and drive equipment for each mechanical system should be based on high reliability, low maintenance, high efficiency and overall low life cycle cost.
- Electrical repair parts for mechanical systems should be readily available.
- Motor control centers are preferred.

23 11 00 FACILITY FUEL PIPING

- All pipes going through walls or floors shall go through sleeves, and the openings in the sleeves shall be fire caulked.

23 20 00 HVAC PIPING AND PUMPS

- All pipes going through walls or floors shall go through sleeves, and the openings in the sleeves shall be fire caulked.
- All pumps have to have pressure gauges on the inlet and outlet, and if a strainer is part of the pump another pressure gauge shall be installed downstream of the strainer.
- Where dissimilar metals are used, use 'Clearwater' or 'Perfect Nipples' in place of dielectric.

- All pumps shall be installed with line size isolation valves on both sides.
- Pumps shall have line size strainers at intake with blow downs. Flow setters should not be substituted for isolation valves.
- For primary pumping application, split case centrifugal pumps are preferred over the end suction pumps.
 1. Mechanical seals are preferred and should be used where adaptable. Complete flushing arrangement shall be provided for mechanical seals and packaging.
 - a. Horizontal split case pump ball bearings shall be double row on outboard. Pump casings shall have vent and drain plugs and pressure gauge tapings.
 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.
 3. Inlet and outlet pressure gauges shall be provided to read differential pressure.
- In-line pumps shall be connected directly to the piping. Motor on large pumps shall be separately supported. Pumps shall not be mounted with motor shaft vertical unless required by space limitations. Provide gauge valves at in-line pump suction and discharge.
 1. Provide line size inlet strainer with blow down.
 2. Provide unions or flanges to connect pump to inlet and outlet lines.
 3. Use shaft sleeves for pumps with packing.
- Pumps shall be field aligned and/or balanced to operate at a maximum allowable vibration level of 0.15 inches per second velocity or less in any plane measured at the pump bearings.

23 21 00 HYDRONIC PIPING AND PUMPS

- Flushing and cleaning should be under the supervision and direction of the same chemical company the Facilities Management Department uses.
- After the acceptance of installations of chilled water or hot water piping the Contractor shall fill the piping with water that matches the chemical composition of the water in the system with respect to hardness and nitrite composition.
- Except for 100% outside air AHUs, all Air Handling Units shall have air blenders.
- Separate heating systems for each of the AHUs; the perimeter heating and the booster reheat coil system should be provided.

23 21 13 HYDRONIC PIPING

- All drain valves, strainers, dirt legs, traps, vents, etc., shall be hard piped to a floor drain.

23 21 13.23 PROCESS PIPING

- Comfort cooling and process cooling systems are not to be mixed.

23 21 20 PIPING SPECIALITIES

- All vents shall be dedicated vents installed at all high points and shall be goose neck, pointing straight down (drain down not up). All vent piping shall be min. of 1/4" hard pipe with a 1/4" shut-off valve.
- Vents that come with all combination valves will not be considered dedicated vents and as such they will not be accepted.
- Vents in mechanical rooms shall be hard piped to a floor drain.
- All drains shall be dedicated drains and shall be at the lowest point in any system.
- Drains in mechanical rooms shall be hard piped to floor.
- Floor drains shall be provided in all mechanical rooms and shall be within 15 feet of any air handling units.
- 4" floor drain is to be minimum size.
- All pipe branches shall have an isolation valve at the point of branching.

23 21 23 HYDRONIC PUMPS

- ITT/Bell and Gossett pumps are preferred.

23 22 00 STEAM AND CONDENSATE PIPING AND PUMPS

- All pipes going through walls or floors shall go through sleeves, and the openings in the sleeves shall be fire caulked.
- Hot water heating is the preferred heating method.
- It is desired insofar as possible to divide the steam distribution piping and returns within the building into separate systems to facilitate metering, and to keep as much piping as possible out of service during the summer.
- Condensate for all building steam services may be returned through a single meter, receive and pump arrangement, provided that proper flash tanks are used for higher pressure condensate (25 psi and over). Condensate must be discharged using condensate pumps at the building into a pressure return main against a head of not less than 50 psig. Where departmental billing or other cost sharing is required, provide appropriate separate metering and piping.
- Direct radiation systems shall be of the two pipe hot water type, up or down feed. Normal design shall be based on inside temperature of 70 deg. F, and outside

temperature of -10 deg. F. Hot water systems may be used if separate controls are used for temperature reset schedules.

- Meters shall match existing University inventory.
- Locate in the mechanical equipment room off of the steam tunnel, accessible for reading and servicing.
- All steam traps to have testing ports.

23 23 00 REFRIGERANT PIPING

- All pipes going through walls or floors shall go through sleeves, and the openings in the sleeves shall be fire caulked.
- All refrigerant systems shall have moisture/liquid indicators, suction line filter driers and high/low pressure shut-offs.
- Contractor to provide piping layout diagram approved by the equipment manufacturer.
- No unique University Standard for refrigerant and oil.

23 24 00 INTERNAL-COMBUSTION ENGINE PIPING

- All pipes going through walls or floors shall go through sleeves, and the openings in the sleeves shall be fire caulked.

23 25 00 HVAC WATER TREATMENT

- Flushing and cleaning should be under the supervision and direction of the same chemical company the Facilities Management Department uses.
- After the acceptance of installations of chilled water or hot water piping the Contractor shall fill the piping with water that matches the chemical composition of the water in the system with respect to hardness and nitrite composition.
- All new chilled, hot water and steam piping installed shall be sufficiently clean such that water samples submitted to the Facilities Management shall meet the following test limits before acceptance of piping by the University.

Chloroform Extractables	5 PPM or less
Particulate Matter	25 PPM or less on 1.2 micron media
Corrosion Inhibitors	500-1000 PPM as Nitrite
O:1	Zero
Grease	Zero
Alkalinity	±30 PPM

- Any on-site pipe cleaning shall be performed in the presence of the University Commissioning Representative.

23 31 00 HVAC DUCTS AND CASINGS

- Less than 6" duct dimensions will not be allowed.
- All ducts going through walls or floors shall go through frames/curbs, and duct insulation shall be continued through the walls or floors. All duct opening through fire walls or floors shall be fire caulked.
- Ductwork and ductwork supports shall be designed per SMACNA (latest issues) or the more stringent of the following criteria.
- Ventilating ducts normally shall be of galvanized iron. Where corrosive acids or fumes are handled, 316L stainless steel minimum 18 gauge shall be used. Duct from dishwashers and other steam producing equipment shall be 316L stainless steel with soldered joints.
- Flexible fiberglass ducts shall not be allowed to go through any walls or floors.
- Connections between inlet and discharge openings of fans and ducts shall be made with a section of 1/16 in. thick neoprene coated fiberglass fabric. Flexible connections should not be less than 4 in. long and with at least a 1 in. slack. Connections shall have angle frames at each end for rectangular ducts, and metal tension bands for round ducts.
- Ductwork carrying mixed air should be of sufficient length prior to entering heating coils to prevent stratification. Factory fabricated air blenders may be used where space is limited but proper duct design is the preferred method of stratification control.
- 90 degree take-offs are not permitted. Use bell mouth for round ducts.

23 31 13 METAL DUCTS

- All air-conditioning supply air duct shall be insulated.
- Use, design and construction per SMACNA.
- No 90 degree take-offs are allowed. Use bell mouth for round duct.

23 31 16 NONMETAL DUCTS

- Use, design and construction per SMACNA.

23 31 16.13 FIBROUS GLASS DUCTS

- Use, design and construction per SMACNA.

23 33 00 DUCTWORK ACCESSORIES

- Dampers:
 1. Multi blade dampers shall be of opposed blade pattern.
 2. Damper Blades: Galvanized steel or 6063-T5 aluminum.
 3. Bearings: Stainless steel or base bearings.
 4. Bearing pins (axles): Stainless steel.
 5. Jackshafting: Where multiple damper sections are used (more than one damper section) jackshaft shall be used for simultaneous activation of dampers sections. A jackshaft shall be defined as a common steel shaft with outboard bearings arranged to distribute torque evenly to one section of the damper assembly.
 6. Linkages: Non concealed and accessible for maintenance.
 7. Provide access doors at both sides of dampers for maintenance.
 8. Provide access door large enough to maintain dampers.
 9. Flex duct shall not be used when pressure is in excess of 2 inches w.c.
 - a. Flex duct, when used, shall not be more than 5 feet in length.
 - b. Flex duct shall be used for terminal diffuser / grille connections.
- Louvers:
 1. Refer to related [Integrated Automation 25 00 00](#) Sections.
 2. All air intake openings shall be provided with storm proof louvers, "Z" construction, bird screen, and dampers.
 3. Intake openings shall be sized for an actual maximum face velocity of 400 FPM is preferred. Intake chambers should be equipped with watertight drip pans with draining directed to open sight drains.

23 33 13.13 VOLUME CONTROL DAMPERS/VALVES

- Control valves (and actuators) shall be sized for 100% shut-off against system's maximum differential pressure.
- Design criteria for sizing modulating water valves shall be based on 2 port equal percentage valves. Select heating control valves for minimum of 25% of equipment sub-circuit pressure drop, but not more than maximum available pump head allowing minimum 2 psi drop for balancing valve. Select cooling control valves for minimum of 10% of equipment sub-circuit pressure drop, but not more than maximum available pump head allowing minimum 2 psi drop for balancing valve.
- Steam Valves:
 1. Modulating steam valves shall be straight-through globe type valves with linear characteristics for 90% of closing stroke and equal-percentage for final 10%.
 2. For steam inlet pressure less than 15 psig, the pressure drop is assumed equal to 75 to 80% of gauge inlet steam pressure.

3. For steam inlet pressure of 15 psig or greater, pressure drop is assumed equal to 53% of absolute inlet pressure.
- Dampers shall be sized, and pressure drops obtained, from ASHRAE.
 - Modulating control dampers shall be opposed blade or parallel blade type and w position (open/close) dampers shall be parallel blade type.
 - Smoke dampers shall be leakage rated at no higher than Leakage Class I (4 cfm/ft² at 1" WG and 8 cfm/ft² at 4" WG) under UL 555S at temperature category 250 degrees F.
 - Damper actuators shall be electronic modulating and still have 120 VAC E-P switches to interface with Fire Protection System.

22 33 13.16 FIRE DAMPERS

- There are no unique University Standards for this section.
- Refer to related [Integrated Automation 25 00 00](#) Sections.

23 36 00 AIR TERMINAL UNITS

- The preferred variable air volume supply return/exhaust terminals for connection to single duct central air systems shall be ceiling mounted with direct acting controls on new systems and pneumatic controls on replacement systems.
- Belimo actuators are preferred.

23 37 00 AIR OUTLETS AND INLETS

- All vents shall be dedicated vents installed at all high points and shall be goose neck, pointing straight down (drain down not up). All vent piping shall be min of 1/4" hard pipe with a 1/4" shut-off valve.
- Vents that come with all combination valves will not be considered dedicated vent and as such they will not be accepted.
- Vents in mechanical rooms shall be hard piped to a floor drain.

23 37 13 DIFFUSERS, REGISTERS, AND GRILLES

- All diffusers, registers, and grilles shall be sized in accordance with the manufacturer's recommendations as to the face velocity, and throw. Noise levels for occupied spaces shall be based upon the recommended NC design criteria in ASHRAE.
- All diffusers and registers shall be without volume control dampers. Volume control shall be via dampers provided in the ductwork at take offs from main or branch ducts.

- University preference on suspended ceilings is 2 x 2 for supply/return diffusers and grilles.

23 38 00 VENTILATION HOODS

- Ventilating system shall be designed per ASHRAE (latest issues) or the more stringent of the following criteria:
- Specific uses, such as radioactive materials or pathogenic organisms may need filtering and/or disinfection equipment. Check with University Safety Office.
- Discharge outlets shall be a minimum of 25 ft. away from intake or stake vents.
- Volume dampers shall be used to enable proper balancing of exhaust and supply systems. They shall be installed in all branch take-offs from main ducts and in each zone duct near unit in the case of multi-zone units. The use of splitter dampers or air scoops is prohibited. Consult SMACNA standards for proper design.
- Minimize ozone depleting emissions from HVAC equipment, refer to LEED v.3, Energy and Atmosphere, Credit 4, Option 2.

<http://www.usgbc.org/ShowFile.aspx?DocumentID=5546>

23 38 16 FUME HOODS

- Locate hoods away from air turbulence, egress traffic, openable windows, doors, air supply grilles and heavy traffic aisles.
- Fume hoods shall be designed per ANSI/AIHA (latest issues) or the more stringent of the following criteria:
 1. Airflow velocity over the face shall be uniform within + or - 10% and are measured during normal room conditions, with a conventional exhaust system and measured at opening top, bottom, sides and center.
- Cementitious board-lined laboratory hood: The superstructure interior shall be fabricated of asbestos-free, acid-resistant, fiber-reinforced cement board at least 1/4 in. thick and manufactured for use in this application. Interior fasteners, brackets, and hinges shall be type 304 stainless steel.
- Hood performance monitoring devices or testing procedures shall be provided by the manufacturer.
- The performance monitor report or output shall be accessible to the user of the hood.
- Hood design, placement, and operation shall ensure a uniform flow of air into the hood.
- Manufacturers and suppliers of pre-built hoods shall make available the following information regarding the manufactured hood to the Designer, User and the University's Environmental Health and Safety Office:

- Shall certify in writing that the fume hood is designed in accordance with the latest edition of the ANSI/AIHA Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems.
 - a. The Coefficient of Entry (C_e) and/or Loss Factor for the hood under desired operating conditions.
 - b. The actual volume flow rate required for optimum performance under the conditions of operation.
 - c. The hood static pressure required to generate the appropriate flow.
 - d. Performance test descriptions and test results that prove hood performance.
 - e. Other appropriate physical parameters (e.g., damper positions, slot widths) to achieve optimum performance.

23 41 00 PARTICULATE AIR FILTRATION

- All new installations shall be equipped with standard 24 inch by 24 inch steel frames in which are installed filters such that the face velocity does not exceed 400 feet per minute. Use stationary clips for two-stage filters.
- Special applications such as wet laboratories, clean rooms, animal care facilities, museums, materials handling and storage, and fan systems with static pressures over 3" shall require consultation with the Physical Plant and the Using Department.
- Air handling systems over 10,000 cfm shall be equipped with a two-stage filter system. The final filter shall have an atmospheric dust efficiency of at least 80% or higher if required by ASHRAE. The pre-filter shall be of the expanded area type, 2" deep with a high performance reinforced cotton and synthetic fabric media. The pre-filter shall be enclosed in a rigid, heavy-duty high wet strength frame with diagonal support members on the entering and exiting sides of the filter. The inside periphery of the enclosing frame shall be bonded to the filter to eliminate bypass.
- All return and exhaust grilles in animal rooms shall be equipped with 2" washable area filters located in the room before the return or exhaust duct.
- Filters shall be located upstream of all coils in the air handling system.
- **MERV 8** shall be the minimum for any air handling unit.
- Differential Pressure Gauges shall be installed across each filter bank in all air handling systems. The preferred gauge shall be a Dwyer series 2000 Magnahelic differential pressure gauge with appropriate fittings or approved equal. Fans located in areas which are not readily accessible or which serve critical applications shall be equipped with a Dwyer series 3000 Photohelic gauge with adjustable high and low alarms or approved equal. All gauges shall operate from 30-80% full scale initial to final pressure. Inclined manometer gauges are not acceptable.

23 53 33.16 GAS FIRED HEATING UNITS

- There are no unique University Standards for this section.

23 57 00 HEAT EXCHANGERS FOR HVAC

- High temperature hot water and high pressure steam to have tube and shell type heat exchangers with removable U-tube bundles.

23 61 00 REFRIGERANT COMPRESSORS

- The contractor shall furnish 5 yr. Warranty. 1st year, parts and labor. 2nd thru 5th year, parts only.
- The following auxiliary equipment is required on each reciprocating system:
 1. Flexible connections at piping/compressor interface, sight glass, dehydrator, strainer ahead of each solenoid and expansion valve, suction strainer, oil separator, heat interchanger, back pressure valve, suction and discharge pressure gauges, blocking valves at compressor and at receiver (if remote from compressor), low and high pressure safety cutouts, relief valves with outlets piped to outdoors in safe location, capacity unloader, and automatic control system. Suction pressure control for compressor operation is preferred.
 2. Compressor controlled by a liquid solenoid valve to allow unit to pump down before compressor stops. Use non-recycling relay.

23 62 00 PACKAGED COMPRESSOR AND CONDENSING UNITS

- Condensers or condensing unit systems intended for winter operation to be provided with refrigerant side low ambient controls suitable for operation at -20°F ambient temperature. Volume dampers on condenser air are not acceptable.
- Condensers with aluminum tubing are not acceptable. Use copper. Units at ground level shall be placed on concrete pads or supports and be provided with vandal resistant coil guards.
- Roof mounted units shall be placed on a minimum 18" high frame or curb to permit roof maintenance below the unit. Enclose roof curbs on all four sides when narrower than 24".
- Do not locate units under roof overhangs or gutters where damage from falling ice is possible.
- Insulation should be placed on the low suction side of all isolation valves.

23 64 00 PACKAGED WATER CHILLERS

- Meter separately the condensate from each steam absorption refrigeration unit.
- Where more than one steam absorption unit is employed, the chilled water supply shall be connected to a common header to allow the advantage of diversity factors. Primary-Secondary piping loops are preferred.
- Condensate return from steam absorption units shall be continuously monitored with a conductivity meter to detect any contamination due to absorbent leakage. The Conductivity meter shall actuate a valve to waste all contaminated condensate. An alarm shall also be connected with an alarm signal provided to the central control system.
- Absorption refrigeration equipment to be capable of being started automatically as dictated by an outside air sensor. Provide required interconnecting wiring between the absorption machine control panel, circulating water pumps and cooling tower fans. Provide for cooling condensate from the absorption machine. Preferred method is by using cooling tower water through a heat exchanger.
- Provide for central campus automatic steam valve control.
- Steam traps to be orifice or float and thermostatic type.
- Single stage units shall have lithium bromide side inhibited from corrosion using lithium chromate. Lithium nitrate is not allowed.
- Control condenser inlet temperature between 80 to 90°F.

23 65 00 COOLING TOWERS

- Packaged Cooling Towers:
 1. Certify cooling tower's thermal performance according to CTI 201.
 2. Electrical Components, Devices, and Accessories shall be listed and labeled as defined in NFPA 70, Article 100.
 3. The University prefers the following manufacturers:
 - a. Induced-draft, cross-flow cooling towers:
 - i. Baltimore Aircoil Co.
 - ii. Marley Cooling Tower Co.
 - b. Forced-draft, cross-flow cooling towers:
 - i. Baltimore Aircoil Co.
 - c. Induced-draft, counterflow cooling towers:
 - i. Amcot Cooling Tower Co.
 - ii. Ceramic Cooling Tower Co.; an affiliated company of Baltimore Aircoil Company.
 - iii. Evapco, Inc.
 - iv. Protec Cooling Towers, Inc.
 - v. Thermal Care/Mayer.

- d. Forced-draft, counterflow cooling towers:
 - i. Baltimore Aircoil Co.
 - ii. Evapco, Inc.
- Cooling Towers
 1. Multiple tower units shall have common tower basins with provisions for isolation.
 2. Crossflow design is preferred.
 3. Do not locate towers in pits, inside buildings or surround with close-fitting screens that impede tower performance.
 4. Tower systems designed for winter operation shall have heated sumps.
 5. New towers shall be of packaged construction. Wood fill and construction are not acceptable.
 6. Galvanized steel cooling towers shall have an electrostatically bonded polymer coating. Bare or painted galvanized construction shall not be used.
 7. Do not mix process refrigeration with building coolant.
 8. Use variable frequency drive to control fan speed.
 9. Provide cooling towers with automatic chemical feed systems.
 10. Pitch pans minimum of 1/2" per foot to drain sump. Provide drain at bottom of sump.
 11. Provide maintenance lighting for all hot water decks.

23 73 00 AIR HANDLING UNITS

- Chilled water drip pans are to be drainable. Evaporation pans are not allowed.
- If permanently installed air handlers are used during construction, filtration media with a minimum efficiency reporting value (MERV) of 8 must be used at each return air grille, as determined by ASHRAE Standard 52.2-1999 (with errata but without addenda 1).
- Replace all filtration media prior to occupancy with filters of a minimum efficiency reporting value MERV 13.
- Filtration should be capable of processing supply air delivered from return and outside sources.

23 74 00 PACKAGED OUTDOOR HVAC EQUIPMENT

- The Universities preference is to not install a supplemental rooftop air conditioning system unless it is required for year round cooling and the primary system is not capable of providing adequate cooling.
- Water coil capacities, pressure drops and selection procedures shall be certified to be in compliance with A.R.I. Standard 410.
- Compressors to have a five (5) year warranty.

23 82 16 AIR COILS

- Evaporator coils assembly to be mounted in a stainless steel drain pan. Cooling coil frame to be stainless steel.
- Steam coils shall be selected with tube lengths not to exceed 6 ft. of finned copper tube with aluminum fins and shall be vertical tube with internal face and by-pass (wing) type. Special care shall be taken in sizing all steam coils where modulating control is used so as to obtain even distribution of steam under light heating loads and to prevent stratification of air temperatures. Modulating control should only be considered for coils with above freezing inlet temperatures. All modulating coils shall be provided with vacuum breaker and trap discharge legs with sufficient vertical drop to clear the coil of condensate liquid under all operating conditions.
- Steam Coils:
 1. Pipe trap 18" lower than lowest section of steam coil.
 2. Provide vacuum breaker for steam coil.
 3. Face velocity not to exceed 600 FMP.
 4. Provide each header with ½ inch vent & ¾ inch drain.
 5. Tubing requirement 5/8 OD. copper tubes with minimum 0.035" wall thickness & max 12 fpi.
 6. Casing minimum 16 gauge stainless steel. Steam coils used in systems requiring 50 to 100% outdoor air and or exposed to inlet air temperatures below 35-deg., use vertical face & by-pass arrangement only.
 7. Maintain constant steam flow through coil at outdoor air temperatures below 40 deg F.

23 82 19 FAN COIL UNITS

- Chilled water coil frames and drain pans shall be stainless steel.

23 83 00 RADIANT HEATING UNITS

- Baseboard radiation heating element to be 3/4" minimum ID copper tube with aluminum fins. Baseboard Enclosure to be 7" minimum height with removable front panel.
- Cabinet unit radiation heating element to be copper (3/4" minimum) or steel (1-1/4" minimum) tubing with aluminum or steel fins. Provide enclosure with sloped top and access door. Access door to be a minimum 6" x 7", or sized to accommodate items requiring access.
- Chilled water coils shall be serpentine type with continuous circuits. Coils shall be completely drainable and vented. Coil shall be constructed of round seamless copper

tubes with parallel pattern against air flow. Secondary surface shall be plate type copper or aluminum fins continuous across entire coil mechanically bonded to tubes. Casing shall be stainless steel, 16 gauge. Drain pans shall be 16 gauge stainless steel. Provisions shall be made to totally drain and air dry chilled or hot water coils. All drains and vents shall be hard piped directly to a floor drain. Control valves shall be provided at each coil.

2 3 8 4 1 3 H U M I D I F I E R S

- Where required, provide humidifiers of the direct steam injection type provided with steam from a local source. Injection should happen downstream of the last coil in a straight horizontal run of ductwork. Evaporative pan type or water spray humidifiers are not acceptable.

**This section of the Building Standards establishes minimum requirements only.
It should not be used as a complete specification**