

23 0000 | HVAC

This section includes guidelines and requirements for the design and construction of HVAC systems, equipment, materials, and other items covered in Division 23. Unless specifically noted, all standards apply to both the healthcare campus and the education campus.

The standards are a resource for the designer of record. The requirements are to be reviewed by the design team and incorporated into the contract documents. The standards themselves will not be included in the contract documents. It is the responsibility of the design team to incorporate them throughout the drawings and specifications.

The standard is not intended to encompass all components required in a complete HVAC design, but to indicate the university's preferences where they exist. Exceptions to these standards may be considered on a case-by-case basis for extraordinary projects or where value engineering is required. All deviations must be approved by the Capital Projects Project Manager.

Designers are encouraged to present the university with new or different systems, equipment, or materials when they may provide a better or more valuable product.

Sections

[Section 23 0000 | General HVAC Requirements](#)

[Section 23 0513 | Common Motor Requirements for HVAC Equipment](#)

[Section 23 0516 | Expansion Fittings and Loops for HVAC Piping](#)

[Section 23 0523 | General-Duty Valves for HVAC Piping](#)

[Section 23 0553 | Identification for HVAC Piping and Equipment](#)

[Section 23 0593 | Testing, Adjusting, and Balancing for HVAC](#)

[Section 23 0719 | HVAC Piping Insulation](#)

[Section 23 0900 | Instrumentation and Control for HVAC](#)

[Section 23 2113 | Hydronic Piping](#)

[Section 23 2213 | Steam and Condensate Heating Piping](#)

[Section 23 2123 | Base-mounted, Centrifugal Hydronic Pumps](#)

[Section 23 2216 | Steam and Condensate Heating Piping Specialties](#)

[Section 23 2323 | Refrigerants](#)

[Section 23 2500 | HVAC Water Treatment](#)

[Section 23 3300 | Air Duct Accessories](#)

[Section 23 3600 | Air Terminal Units](#)

[Section 23 3713 | Grilles, Registers, and Diffusers](#)

[Section 23 3816 | Fume Hoods](#)

[Section 23 4100 | Particulate Air Filtration](#)

[Section 23 5200 | Heating Boilers](#)

[Section 23 7300 | Indoor Central-Station Air Handling Units](#)

[Section 23 8219 | Fan Coil Units](#)

[Section 23 8413 | Humidifiers](#)

Section 23 0000 | General HVAC Requirements

1. GENERAL DESIGN CONSIDERATIONS

- A. The preferred HVAC system on both campuses is a variable speed air handling unit with VAV terminal units and hot water reheat coils.
- B. Generally, the cooling coils will be supplied by the campus chilled water system.
- C. Hot water for AHU heating coils and VAV reheat coils should be generated by the campus steam system via shell and tube heat exchangers. Electric reheat coils are not allowed.
- D. Each occupied space (office, classroom, lab, etc.) shall have its own thermostat and associated terminal unit. This would typically be a VAV and reheat coil, but the requirement applies for other terminal units such as fan coil units or heat pumps as well. Transient spaces such as corridors, restrooms, supply rooms, etc. may share a thermostat.

2. NOISE REQUIREMENTS

- A. Systems shall be designed to the following noise criteria requirements

TYPE OF SPACE	MAXIMUM ACCEPTABLE NOISE CRITERIA (NC) CURVE
1	
GENERAL	
CLASSROOMS/LIBRARIES	35
RESIDENCE-MULTIPLE OCCUPANT	35
BANQUET HALL/BALLROOMS	35
MUSEUM/DISPLAY AREA	35
LABORATORIES	40
RESTAURANT	40
RECREATION HALLS	40
LOBBIES/HALLS/CORRIDORS	40
CAFETERIA	45
RETAIL SPACE	45
KITCHEN/LAUNDRY/GARAGE	45
RESTROOMS/LOCKER ROOMS	45
MEDICAL FACILITY	
PATIENT ROOMS	25
OPERATING ROOMS/WARDS	35
WAITING ROOMS	40
OFFICES	
BOARD ROOMS	25
CONFERENCE ROOMS	30
PRIVATE OFFICE/RECEPTION ROOMS	35
OPEN OFFICE/STUDIO	40
TABULATION/COMPUTATION	45
AUDITORIUMS	
CONCERT HALLS/SOUND STUDIO	15
LEGITIMATE THEATER	25
MOVIE THEATER/LECTURE HALL	32
SPORTS CENTER	
COLISEUM	35
GYMNASIUM	40
SWIMMING POOL	50

Section 23 0513 | Common Motor Requirements for HVAC Equipment

1. GENERAL REQUIREMENTS

- A. Motors served by a VFD shall have shaft grounding rings.

Section 23 0516 | Expansion Fittings and Loops for HVAC Piping

1. PHYSICAL REQUIREMENTS

- A. All expansion joints shall be metal expansion joints consisting of a single hydraulically formed metal bellows with flange end fittings. Flanges shall be 150 lb. carbon steel and bellows shall be 304 or 316 stainless steel. All wetted surfaces shall be stainless steel.
- B. Joints shall be designed to meet the design pressures and temperature for the system and shall be capable of accommodating piping system and equipment movements as needed. Pressure rating minimums shall be:
 - 1. 150°F Maximum Working Pressure: 225 psi
 - 2. 212°F Maximum Working Pressure: 190 psi
 - 3. 480°F Maximum Working Pressure: 110 psi
- C. Tie rods shall be included to prevent overextension of the expansion joints from pressure thrust loads. The number and size of the control rods shall be sufficient for the maximum system test pressure.
- D. Rubber expansion joints are not acceptable in any of these applications.

Section 23 0523 | General-Duty Valves for HVAC Piping

1. GENERAL REQUIREMENTS

- A. Isolation valves are to be installed on water systems on all mains, all floor take-offs of mains, and take-offs of branch lines where multiple devices are fed by that take-off.
- B. Valves in mechanical rooms located greater than eight feet above the floor shall be gear-operated with chain operators.
- C. Valve stems shall have extensions sized appropriately for insulation thickness.

2. VALVE TYPES

- A. Ball valves shall be bronze, full-port, with two-piece stainless-steel trim and threaded joints.
- B. Butterfly valves shall be ductile iron with flanged connections. The seat shall be EPDM with aluminum bronze disc and stainless-steel stem.
- C. High-performance rotary valves shall be suitable for 500°F, bi-directional zero leakage, triple offset design suitable for dead-end service, double flanged cast steel body, Type 316 stainless steel disc, laminated Type 316 stainless steel and graphite seat, external valve-stem packing adjustment. Entire valve, including body and seat shall be suitable for 150 or 300 psig steam at 500°F. High-performance rotary valves shall be made by Adams.

3. VALVE SCHEDULE

System	Size	ANSI Class and Type
Chilled Water	2 1/2" and smaller	150 lb. threaded bronze ball valve*
Chilled Water	3" and larger	250 lb. flanged or grooved butterfly valve*
Heating Hot Water	2 1/2" and smaller	150 lb. threaded bronze ball valve
Heating Hot Water	3" and larger	150 lb. flanged or grooved butterfly valve
High Pressure Steam & HPR (>75 PSIG)	2" and smaller	300 lb. bronze threaded gate valve** 300 lb. bronze threaded ball valve** at traps
High Pressure Steam & HPR (>75 PSIG)	2 1/2" – 3"	300 lb. cast steel flanged gate valve**
High Pressure Steam & HPR (>75 PSIG)	4" and larger	300 lb. cast steel, flanged high-performance, triple offset rotary valve**
Medium/Low Pressure Steam & MPR/LPR (≥75 PSIG)	2" and smaller	150 lb. bronze threaded gate valve 150 lb. bronze threaded ball valves at traps
Medium/Low Pressure Steam & MPR/LPR (≥75 PSIG)	2 1/2" and larger	150 lb. cast steel, flanged gate valve or 150 lb. cast steel, flanged, high-performance, triple offset rotary valve

*Rated for 250 PSIG WOG. Valves with ANSI 125/150 bolt pattern may be used if flanges and valves meet the 250 PSIG WOG design pressure.

**Designed for 500°F steam at 300 psig

4. VALVE CLASSIFICATIONS

A. Valves shall be classified by ANSI according to the following classification schedule:

Valves 2 1/2" and Smaller				
Service	Gate	Globe	Ball	Check
Chilled Water	---	150*	150*	150*
Heating Hot Water	---	150	150	150
Low/Medium Pressure Steam/Condensate	150	150	---	150
High Pressure Steam/Condensate	300**	300**	---	300**

*Rated for 250 psig WOG working pressure

**Designed for 500 deg F steam at 300 psig

Valves over 2 1/2"				
Service	Gate	Globe	Butterfly	Check
Chilled Water	---	250*	250*	250*
Heating Hot Water	---	150	150	150
Low/Medium Pressure Steam/Condensate	150	150	---	150
High Pressure Steam/Condensate	300**	300**	---	300**

*Valves with ANSI 125/150 bolt pattern may be used if flanges and valves meet the 250 psig WOG design pressure.

**Designed for 500 deg F steam at 300 psig (cast steel)

5. STEAM CLASSIFICATIONS

A. The Valve Schedule and Valve Classification tables above should follow the following steam classifications:

1. High Pressure Steam and Condensate: 76 psig – 300 psig
2. Medium Pressure Steam and Condensate: 21 psig – 75 psig
3. Low Pressure Steam and Condensate: 0 – 20 psig

Section 23 0553 | Identification for HVAC Piping and Equipment

1. PIPE LABELS

- A. All piping is to be labeled – every 15 feet above ceiling, every 10 feet in an open mechanical room, and at least once in every room.
- B. Labels are to be preprinted, color-coded, with lettering indicating service and showing flow direction.
 - 1. Pretensioned Pipe Labels: Pre-coiled, semirigid plastic formed to cover the full circumference of pipe and to attach to pipe without fasteners or adhesives.
 - 2. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent adhesive backing
- C. Lettering size: Minimum 1-1/2 inches high.
- D. Label colors shall be per the University of Kentucky Standard Color-Coding schedule at the end of this section.

2. DUCT LABELS

- A. All piping is to be labeled – every 15 feet above ceiling, every 10 feet in an open mechanical room, and at least once in every room.
- B. Stencils: Prepared with letter sizes a minimum of 1-1/2" for ducts.
- C. Duct label contents: Include identification of duct service using same designations or abbreviations as used on drawings, duct size, and arrow indicating flow direction.
- D. Stencil Paint: Exterior, gloss, acrylic enamel black.

3. EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
 - 2. Letter Color: Black.
 - 3. Background Color: White.
 - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 7. Fasteners: Stainless-steel rivets or self-tapping screws.
- B. Label Content: Include equipment's Drawing designation (i.e. AHU-3).
- C. Air Handling Unit labels shall indicate which area they serve.

4. CEILING LABELS

- A. Attach Seton-ply discs to the ceiling grid under equipment or valves.

B. Label discs according to the following schedule:

Equipment	Color	Engraving
Valve	Yellow	V.
Fire Damper	Black	F.D.
Fire/Smoke Damper	Black	F.S.D.
Terminal Unit	Red	T.U.
Variable Volume Unit	Red	V.A.V.
Heating Coil	Blue	H.C.
Cabinet Unit Heater	Red	U.H.

5. VALVE TAGS

A. Stamped or engraved 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link or S-hook. Wire shall not be used as a method for connecting the tags to the valve. The tags shall be installed after insulation has been installed.

B. Valve Schedule: Provide for each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shut-off and similar special uses.

1. Valve tag schedule shall be included in the operation and maintenance data.

6. PAINTING

A. All piping in mechanical rooms shall be painted once insulation is complete. Paint colors shall be per the University of Kentucky Standard Color Coding for Mechanical Piping Chart at the end of this section.

7. UNIVERSITY OF KENTUCKY STANDARD COLOR CODING FOR MECHANICAL PIPING

Type of Service	Markings	Color*	No.*
High pressure steam and return (over 76 psig)	H.P.S. & H.P.R	Safety Red	SW4081
Medium pressure steam and return (21 psig to 75 psig)	M.P.S. & M.P.R.	International Orange	SW4082
Low pressure steam and return (0 psig to 20 psig)	L.P.S. & L.P.R.	Safety Orange	SW4083
Heating Hot Water supply & return	H.W.S. & H.W.R.	Junction yellow	SW4033
Chilled water supply & return	C.W.S. & C.W.R	Safety blue	SW4086
Condenser water supply & return	C.D.W.S. & C.D.W.R.	Slate gray	SW4026
Safety valve vents	S.V.V.	Galvano	SW4027
Chromate or cooling tower additives	C.T.A.	Galvano	SW4027
Boiler treatment	B.T.	Galvano	SW4027
Condensate pump discharge	P.D.R.	Galvano	SW4027
Glycol solutions	GLYCOL	Rotor Turquoise	SW4066
Geothermal Water supply & return	G.W.S & G.W.R.	Kinetic Teal	SW4078

*Color and number are from Sherwin Williams System 4000 color selection guide dated 2020

Section 23 0593 | Testing, Adjusting, and Balancing for HVAC

1. GENERAL TAB REQUIREMENTS

- A. The testing and air balancing (tab) contractor is to be a member of and certified by the associated air balance council (AABC) or the National Environmental Balancing Bureau (NEBB). The TAB testing equipment and procedures are to follow the guidelines of the appropriate organization.
- B. The TAB report is to be signed and stamped by a registered professional engineer.
- C. The TAB contractor will conduct an inspection of the mechanical installation at 30% and 70% completion. A report on the installation will be given to the prime contractor listing items to be corrected and addressed prior to the TAB contractor beginning TAB work.
- D. Specify a range of acceptance for the testing and balancing of the HVAC system.
- E. Notify the university of any duct and AHU pressure tests so they may be given an opportunity to witness. Results shall be included in the final TAB report and O&M manuals.
- F. Include a fan curve for each fan serving a 2000 CFM or larger system, in the TAB report.
- G. Testing and balancing shall be performed only after all equipment and controls have been installed and all systems are 100 percent functional.
- H. Testing shall be performed at both maximum and minimum conditions.

Section 23 0719 | HVAC Piping Insulation

1. FIBERGLASS INSULATION APPLICATION AND THICKNESS

Pipe System	Temp. Range	1"	1-1/4" – 2"	2-1/2" – 4"	5" – 6"	8" – 10"	12" and Up
High Press. Steam	320 – 500	2½"	2½"	3"	3½"	3½"	4"
Medium Press. Steam	260 – 320	2"	2½"	2½"	3"	3"	3½"
Low Press. Steam	201 – 260	1½"	1½"	2"	2"	2½"	3"
Steam Condensate	180 – 250	1½"	1½"	2"	2"	2½"	2½"
Heating Hot Water	120 – 200	1"	1"	1½"	2"	2"	2"
Chilled Water	40 – 60	1"	1½"	1½"	2"	2"	2"
Condensate Drain	50 - 60	½"	½"	½"	1"	1"	1"

- A. Equivalent thickness of closed cell foam insulation may be used on pipes 1" diameter or less. Provide Armacell closed cell polyethylene or approved equal. Product must meet all current specification compliance i.e. ASTM, UL NFPA and UL. Where possible, insulation tubes are to be slipped over the carrier pipe (not slit). With split tubes, all joints and seams are to be wrapped with Black LapSeal for protection against condensation, mold, and energy loss. Any outdoor use must be UV protected with WB Finish or other protective jacketing to prevent damage from UV or physical damage and comply with the energy protection sections of the IECC and ASHRAE. Use in steam vaults is prohibited.

- B. Exposed piping in any room and all piping in mechanical rooms shall have an 8-ounce canvas jacket applied over the fiberglass factory ASJ/SSL jacketing to further protect the insulation from abuse.
- C. This jacketing must be properly applied with lagging adhesive, such that the outer surface is smooth and free of wrinkles.
- D. The canvas jacketing in all mechanical areas is to be prepared for painting and then painted according to the University of Kentucky standard piping color coding.
- E. For all systems except steam, an alternate to the canvas wrap shall be plenum-rated PVC jacket equal to LoSmoke PVC jacket with flame/smoke rating of 25/50, ASTM-E84 test method. Minimum thickness 0.04 inches. Steam systems shall utilize plenum rated CPVC jacket with minimum thickness of 0.04 inches. Jackets shall be applied over top of specified pipe insulation. Approved equal manufacturers are Zeston and Speedline. If PVC jacket option is used it must be color-coded to match UK color-coding schedule.
- F. Insulation shall be installed in such a way to allow use of all piping accessories – strainers, test ports, etc. Provide removable jackets where needed.

2. CALCIUM SILICATE INSULATION APPLICATION AND THICKNESS

Pipe System	Temp. Range	1"	1-1/4" – 2"	2-1/2" – 4"	5" – 6"	8" – 10"	12" and Up
High Press. Steam	320 – 500	3	3½"	4"	4"	4"	4"
Medium Press. Steam	260 – 320	2½"	3"	3½"	3½"	4"	4"

- A. Calcium Silicate is preferred over fiberglass on steam in mechanical rooms and in heating plants where piping is more subject to abuse. Insulation in mechanical areas must be protected with an 8 oz. canvas jacket applied with lagging adhesive.

Section 23 0900 | Instrumentation and Control for HVAC

1. GENERAL DESIGN REQUIREMENTS

- A. All new HVAC systems shall have a full DDC controls system which reports back to the campus head-end Tridium system.
- B. Refer to the separate 23 0900 standard specification.
- C. Provide wet-floor sensors around all equipment located on all floors other than the lowest floor of the building.

2. DESIGNER REQUIREMENTS

- A. Each mechanical design shall include Instrumentation and Control (IC) drawings which include the following:
 - 1. System architecture drawings – indicating architecture of tier 1 control devices, tier 2 control devices, data connections, MSTP connections, etc.
 - 2. Matrix of responsibility (Required for non-capital projects. Not required on capital projects) – indicating responsibility between the university entities and contractors for all elements of the control system: Controller acquisition, programming, and installation, control device

acquisition, wiring, and installation, controller power, data drop wiring, IP assignments, graphic creation, commissioning, etc.

3. Floor plans – indicating locations of all controllers and equipment
4. Sequence of operations
5. Points lists
6. Control flow diagrams

Section 23 2113 | Hydronic Piping

1. PIPING SCHEDULE

Service	Sizes	Pipe	Fittings
Chilled and Heating Hot Water	1 ½" and Less	Type L Hard Copper	Wrought copper. Lead free solder.
Chilled and Heating Hot Water	2" – 4"	Type L Hard Copper	Wrought copper. Lead free solder or grooved rigid couplings and fittings.
Chilled and Heating Hot Water	6" and Larger	Sch. 40 Steel	Standard weight steel, welded or grooved rigid couplings and fittings.
Condensate Drains	All sizes	DWV Copper	Wrought copper. Lead free solder

*Brazing is also acceptable wherever solder is listed

2. All chilled water piping systems to be designed for 250 psig working pressure, including pumps, valves, strainers and fittings.
3. Grooved Fitting Requirements
 - A. All fittings on a project must be of a single manufacturer.
 - B. Manufacturer shall train and certify all installers on installation of grooved fittings.
 - C. Manufacturer shall make periodic site visits to ensure quality of installation.
 - D. Roll grooving is preferred to cut grooving.
 - E. Grooved fittings are not permitted inside chases and risers. Piping shall be soldered or welded in chases and risers.
 - F. Acceptable Manufacturers – Medical Campus
 1. Victaulic
 - G. Acceptable Manufacturers – Education Campus
 1. Victaulic
 2. Gruvlok
4. Use dielectric coupling when dissimilar metals are joined and dielectric isolation at any point where dissimilar metals are in contact. (Bronze is not considered a dielectric)
5. No pressure piping is to be placed below slab or in an unconditioned space unless protection is provided.
6. All hydronic piping should be concealed behind walls or ceilings except in mechanical spaces or otherwise approved.

Section 23 2213 | Steam and Condensate Heating Piping

1. GENERAL REQUIREMENTS

- A. All piping, fittings, valves, strainers, check valves, control valves, pressure reducing valves, etc., on the high-pressure steam, boiler feedwater, and high pressure steam condensate return to be designed for 300 psig steam pressure, (300 Class) at 500 deg F.
- B. Low Pressure Steam Condensate to have 300 lb. fittings, not for pressure concerns, but for longer life against corrosion. 150 lb. rated valves and flanges are acceptable on steam condensate.

2. PIPING SCHEDULE

Service	Sizes	Pipe	Fittings
High Pressure Steam (above grade)	2" and Less	Sch 40 Black Steel ASTM A106, Grade B	300 lb. malleable iron, screwed
High Pressure Steam (above grade)	2-1/2" - 8"	Sch. 40 Black Steel ASTM A106, Grade B	Standard weight steel, welded
High Pressure Steam (above grade)	10" and larger	Black Steel ASTM A106, Grade B 1/2" wall thickness	Extra strong steel, welded
High Pressure Steam Condensate	2" and smaller	Sch. 80 Black Steel	300 lb. malleable iron, screwed
High Pressure Steam Condensate	2 1/2" and larger	Sch. 80 Black Steel	Extra strong steel, welded
Low and Medium Pressure Steam (above grade)	2" and smaller	Sch. 40 Black Steel	150 lb. malleable iron, screwed
Low and Medium Pressure Steam (above grade)	2-1/2" and larger	Sch. 40 Black Steel	Standard weight steel, welded
Low and Medium Pressure steam condensate (above grade)	2" and smaller	Sch. 80 Black Steel	300 lb. malleable iron screwed
Low and Medium Pressure steam condensate (above grade)	2-1/2" and larger	Sch. 80 Black Steel	Extra strong steel, welded
Safety Valve Vents	2" and smaller	Sch. 40 Black Steel	125 lb. Cast iron, screwed
Safety Valve Vents	2-1/2" and larger	Sch. 40 Black Steel	Standard weight steel, welded

3. STEAM CLASSIFICATIONS

- A. The Piping Schedule above should follow the following steam classifications:
 1. High Pressure Steam and Condensate: 76 psig – 300 psig
 2. Medium Pressure Steam and Condensate: 21 psig – 75 psig
 3. Low Pressure Steam and Condensate: 0 – 20 psig

Section 23 2123 | Base-Mounted, Centrifugal Hydronic Pumps

1. GENERAL DESIGN REQUIREMENTS

- A. Building chilled water pumps and heating hot water pumps shall be base-mounted end-suction pumps.
- B. Heating hot water pumps shall be designed with N+1 capacity for all buildings.
- C. At least one of the building's heating hot water pumps shall be on emergency power.
- D. Chilled water pumps shall be designed with N+1 capacity for healthcare and laboratory buildings. Redundancy should be discussed during the design of other buildings.
- E. Provide trumpet-style pressure gauges across the pump and suction diffuser.

Section 23 2216 | Steam and Condensate Heating Piping Specialties

1. STEAM PRESSURE REDUCING VALVES

- A. Provide a high/low flow circuit to reduce high-pressure steam in a facility with an extreme seasonal or daily load variance. This circuit should consist of two parallel pressure reducing valve's. Size one pressure reducing valve for the nominal low flow and the other for nominal high flow requirement. (i.e. low 0 - 25%, high 20 - 75%) The high flow pressure reducing valve should be set at a lesser pressure than the low flow pressure reducing valve. This type of control may cause a larger than normal control point offset. If the equipment in the facility requires a smaller control point offset, use PRV with positive feedback.
- B. This piping arrangement will prevent valve maintenance problems due to a full-sized pressure reducing valve operating at very low loads and hunting problems experienced when using series PRV circuits.
- C. The main valve body shall be constructed of ductile iron for steam service and be single-seated, globe-style, packless design, with hardened stainless steel internal trim for a maximum operating pressure of 300 psig. The main valve shall be diaphragm-actuated and self-operated with threaded or ANSI 300 # flanged connections. Diaphragm shall be high tinsel, phosphor bronze. The main valve shall be factory tested to Class IV shut-off per ANSI/FCI 70-3. Pilot shall be spring-loaded and full enclosed to protect it from atmospheric conditions. Pilot shall mount to the main valve for control accuracy of downstream pressure equal to +/- 1 psi and allow for variation in set pressure while in service. The interconnected tubing between pilot and main valve shall be internal to the footprint of the main valve and shall be shipped fully assembled. The side-mounted and field-reversible pilot adapter shall have a full port integrated strainer with 60 mesh screen and integral blowdown valve. There shall be no springs in the steam space. The valve shall be repairable in-line and require a pilot for operation.
- D. Acceptable Manufacturers
 1. Medical Campus
 - a. Spence (basis of design)
 - b. Watson McDaniels
 2. Education Campus
 - a. Spence (basis of design)

- b. Watson McDaniels
- c. Armstrong

Section 23 2323 | Refrigerants

1. See separate standard 23 2323 Refrigerant Management

Section 23 2500 | HVAC Water Treatment

1. Medical Campus Closed Loop Chemical Requirements
 - A. The following levels of chemicals are to be maintained in the respective systems:
 1. Heating hot water (tight system) – 200 to 300 ppm of Molybdate / 150 to 250 ppm of Nitrite / 5 to 20 ppm of Azole / pH 8.5 to 10.
 2. Heating hot water (regular water losses) – 1000 to 1500 ppm of Nitrite / 5 to 20 ppm Azole / pH 8.5 to 10.
 3. Glycol systems – 50% inhibited ethylene or propylene glycol
 - B. The contractor doing the project work is to use the same vendor, product brands and chemical mixtures as the Medical Center to maintain consistency of material in the systems.
 - C. See Standard 232500 Medical Campus HVAC Water Treatment for procedures inside existing buildings on the medical campus.
2. Glycol Systems
 1. All glycol systems shall be designed for 50% propylene glycol concentration (pumps, coils, etc.).
 2. Every glycol system must have a make-up system for the addition of the glycol/water mixture to the overall system. The make-up system needs to have a mixing tank for mixing the glycol and water to maintain the 50/50 mixture in the system. The mixing tank is to have a fill pump for pumping the mixture into the overall system. The make – up water connection to the system is not to directly connect to the overall system in such a manner that non-mixed water could be introduced into the system.
3. Water System Cleaning
 - A. This standard applies to all water, steam, and condensate systems.
 - B. Provide flushing and drain connections for complete flushing and drainage of the entire system.
 - C. Remove strainers, open all valves, and continuously flush the system with clean domestic water until all foreign matter is removed.
 - D. Fill and vent the system, adding cleaning solution as directed by the chemical treatment representative. Circulate this solution as directed by the chemical treatment representative. Drain and flush the system with clean domestic water until all cleaning chemicals have been flushed out.

- E. No chemical treatment solution may be flushed to the sanitary system which has a pH of greater than 11.5. If the solution is greater than 11.5, it shall be collected and disposed of properly at the contractor's expense.
- F. Replace the strainers and fill the system with clean water, circulate for one hour and test for alkalinity. If the system pH is below 7, add trisodium phosphate until the pH reads 7-8.
- G. Fill chilled water and steam systems using water or steam from the permanent system.
- H. For closed loop heating hot water systems – add permanent chemicals at the direction of the chemical treatment representative.

Section 23 3300 | Air Duct Accessories

1. ACCESS DOORS

- A. Provide duct access doors upstream and downstream of all duct-mounted coils (specifically for VAV reheat coils).
- B. Provide duct access doors at fire and combination fire/smoke dampers. Doors to be no smaller than 12" x 12" (except where duct is smaller than 14" wide).
- C. Duct access doors above ceilings shall be full cam lock style – no hinges. Ducts located in mechanical room with appropriate clearances may be hinged.

2. FLEXIBLE DUCT

- A. All supply flexible duct shall be insulated with a 1 1/2 " blanket of glass wool with an out moisture barrier. The insulation assembly shall have a flame spread of not more than 25 and a smoke development rate of not over 50.
- B. A single length of flexible duct shall not exceed 5'0". Splicing of multiple pieces of flexible duct is not permitted.
- C. The minimum bend radius shall be 1 ½ times the duct diameter. The radius shall be measured to the inside edge of the flexible duct.
- D. Total offset in any run of flexible duct shall not exceed 90 degrees for aluminum flexible duct or 180 degrees for PVC flexible duct.
- E. Install flex duct without kinks or sharp bends.
- F. Flexible duct shall be secured to the rigid duct and grille/diffuser with nylon adjustable, self-locking strap and a minimum of three sheet metal screws. The flexible duct shall be sealed airtight at each connection with aluminum tape. Fiber or cloth duct tape is not permitted to seal rigid or flexible duct.
- G. Support PVC flexible duct at connection to diffuser/grille with "Flexright" flexible duct elbow support or similar radius support.
- H. Flexible ductwork shall not be used in high or medium pressure ductwork.
- I. Allowable materials:
 - 1. Medical Campus – Aluminum or PVC.
 - 2. Education Campus – Aluminum.

Section 23 3600 | Air Terminal Units

1. VARIABLE AIR VOLUME UNITS
 - A. VAV's shall be double wall construction. They shall have a low leakage damper with a cell foam gasket. Bearings shall be self-lubricating.
 - B. Special consideration should be given during design, coordination, and construction to provide adequate access to the VAV controller, reheat piping accessories, and duct access doors.
2. REHEAT COILS
 - A. Each VAV shall have an associated hot water reheat coil. The VAV box and reheat coil shall be separate components. There shall be an access door upstream and downstream of each reheat coil for coil cleaning. Access door to be minimum 8" x 8" and larger where larger duct allows.
 - B. Reheat coils shall be selected at an entering water temperature of 135 deg F and an entering air temperature of 55 deg F.
 - C. Coils shall have 0.0095" aluminum fins and 0.035" copper tubes.
 - D. All VAV boxes and Reheat Coil Assemblies control valves must have adequate access space for maintenance, including removal of coils, damper arms, reheat valves, etc. Space must be maintained to top of acoustical ceiling grid. A "coil pull" space of coil length plus 6" is required.
 - E. Reheat coils shall be hard piped, not connected with flexible hoses.

Section 23 3713 | Diffusers, Registers, and Grilles

1. GENERAL REQUIREMENTS
 - A. Generally, diffusers, registers, and grilles shall be of aluminum construction.
 - B. Where terminal units require to be filtered (such as a fan coil unit), the filter shall be at the return grille and not at the unit.
 1. Grille shall be hinged with concealed hinges.
 2. Shall accept a 20" x 20" x 1" filter.

Section 23 3816 | Fume Hoods

1. See separate standard 233816 – Fume Hood Standard
2. See separate drawings 233816 – Fume Hood Details

Section 23 4100 | Particulate Air Filtration

1. Medical Campus Filter Requirements
 - A. Prefilters
 1. Prefilters shall consist of a pleated media, media support grid, and enclosing frame. The filters shall be labeled by Underwriters Laboratories as Class 2.

2. The media shall be a non-woven cotton fabric and shall have a minimum efficiency (ASHRAE test standard 52 - 76) of 25% with a minimum arrestance of 90%.
3. The media support shall be a welded wire grid with an effective open area of not less than 90%. The grid shall be bonded to the filter media to eliminate media oscillation and pull away.
4. The enclosing frame shall be constructed of rigid, heavy duty, high wet strength beverage board. The frame shall be bonded to the filter pack. Standard sizes shall be 12" x 24" x 2" and 24" x 24" x 2".
5. Filters shall be Cam-Farr 30/30 or equal by American Air Filter, Eco-Air or Airguard.

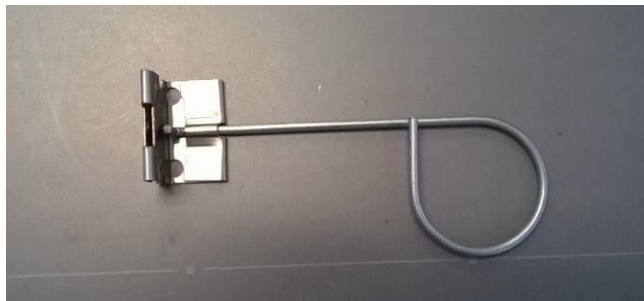
B. Final Filters

1. The final filter shall be a high performance, deep pleated, totally rigid type and shall consist of a glass fiber media, media support frame, contour stabilizers and enclosing frame. The filters shall be labeled by Underwriters Laboratories as Class 2.
2. The media shall be a high density micro fine glass fiber laminated to a non-woven synthetic backing to form a lofted filter blanket. The media shall have a minimum efficiency (ASHRAE test standard 52 - 76) of 90% with a minimum arrestance of 90%.
3. The media support shall be a welded wire grid with an effective open area of not less than 96%. The grid shall be bonded to the filter media to eliminate media oscillation and pull away. The grid shall support the media both vertically and horizontally. Contour stabilizers shall be permanently installed on both the air entering and exiting sides of the filter media pack to insure the pleat configuration is maintained throughout the life of the filter.
4. The enclosing frame shall be constructed of galvanized steel. It shall be constructed and assembled to provide a rigid and durable enclosure for the filter pack. The frame shall be bonded to the filter pack. Standard sizes shall be 12" x 24" x 12" and 24" x 24" x 12".
5. Filters shall be Cam-Farr Riga-Flo or equal by American Air Filter, Eco-Air or Airguard. Provide Dwyer Instruments Inc Series 2000 Magnahelic gauges across each filter bank.

C. All air handlers serving the medical campus shall achieve a minimum of MERV 13 filtration.

D. Pre-filter and Final Filter Clips

1. For pre-filters and final filters, the Camfil C78 series clip pictured below or approved equal (equivalencies need to be approved during the submittal process and should not be installed until approved.) is required. This clip comes in various lengths; follow manufacturer recommendations to match clip length with filter size.



E. HEPA Filter Clips

1. For HEPA filters, the filter rack needs to be a Camfil Magna-Frame II as pictured below or approved equal (equivalencies need to be approved during the submittal process and should not be installed until approved.). The frame needs to be supplied with the J-bolt type clip (also pictured below) for holding the HEPA filters in place.



- F. The preference is for filters to be loaded in the airstream and not slide out the side of the unit.

Section 23 5200 | Heating Boilers

1. GENERAL REQUIREMENTS

- A. Certificates for posting are issued from the State of Kentucky - Department of Housing, Buildings, and Construction (Bureau of Boiler and Pressure Vessel Inspection), Frankfort, Kentucky. When "Boiler and Pressure Vessel Inspection" certificates are received following boiler inspection.
- B. Original copies of Certificate of Boiler and Pressure Vessel Inspection are then placed in a frame (under glass) near the boiler site(s).
- C. Copies of the certificate are given to the FMMC for filing in FMMC General Files under Boiler Certificates.

Section 23 7300 | Indoor Central-Station Air Handling Units

1. GENERAL REQUIREMENTS

- A. The preferred fan system is a fan array.
 1. Fan motors should be 15 HP or less.
 2. Provide a trolley and rail system for ease of motor replacement.
- B. Units that are 100% outdoor air shall have freeze-proof cooling coils, similar to those made by Cooney.
- C. Condensate pans are to be stainless steel or aluminum.
- D. Provide Magnehelic gauges across all filter banks, in addition to any differential pressure sensors.
- E. Provide an analog thermometer in the discharge supply air duct directly off the unit.
- F. Provide high and low pressure safeties.

1. At a minimum, provide manual reset high and low pressure safety switches
 2. Additionally, provide a redundant safety, either in the form of a pressure relief damper or a pressure sensor that limits the fan speed as it approaches the safety switch set point.
- G. For custom or built-up air handlers, the manufacturer's representative shall make site visits during the installation to oversee/provide quality control.
- H. At a minimum, provide an on-site pressure test after all electrical, piping, and controls connections are complete. UK and the engineer shall be invited to witness.
- I. Original manufacturer tag information is to be maintained on components of air handling units, i.e. fans, coils, etc.
- J. Steam coils shall have headers on the side and not the bottom. All copper construction; no dissimilar metals.

Section 23 8219 | Fan Coil Units

1. GENERAL REQUIREMENTS

- A. Note: VAV boxes with hot water reheat coils are the preferred terminal units. Occasionally a project will require the use of fan coil units and these requirements will apply.
- B. Provide a duct access door at the discharge of the unit for coil cleaning.
- C. Provide proper clearances at control box and for fan motor removal/replacement – typically underneath the unit.
- D. Provide condensate trap of adequate depth to seal against fan pressure.
- E. Filters shall be at the return grilles, not at the unit.

Section 23 8413 | Humidifiers

1. GENERAL REQUIREMENTS

- A. All water serving humidification systems shall be treated using a reverse osmosis water treatment system.
- B. Review the RO water treatment system requirements in the 22 0000 Plumbing Standards.
- C. For adiabatic humidification applications, the RO system shall be selected and provided by the manufacturer of the humidifier.