23 Heating Ventilating and Air Conditioning

NOTE: Significant revisions or additions to the previous standards are highlighted in italics.

GENERAL
Designers shall verify that all applicable portions of these standards are incorporated into the project’s design, drawings, specifications and final construction. Request for variances from these standards shall be submitted in writing to the DCM Project Manager, using the KU Standards Variance Request Form found in Appendix A1.1, for review and written approval or rejection as indicated on the form.

RELATED DOCUMENTS & REQUIREMENTS
Refer to the following for requirements that also apply to work of this section.

- **Division 1 - General Requirements**: Refer to sections regarding construction testing, field quality control requirements, acoustical design criteria and general design guidelines that apply to this section.
  - Unless directed otherwise, the Owner shall separately contract for quality control testing during construction.

- **Standards of Practice**: The University has adopted specific mechanical system construction practices that are referenced by the applicable AIA – Masterspec section and/or University Standards of Practice (SOP). The Designer shall use these supplemental guidelines and standards of practice in development of project construction documents.

- **Appendix A23.4 – Design Standards for Energy Efficiency**

- **Division 26 - Electrical**: Review all sections of Division 26 for related work and systems that must be coordinated with provisions of Division 23.

**DUCT INSULATION – 230713**

**Duct Insulation Designs**: 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. The Designer is responsible for determining the lowest potential supply air temperature whether the ducting is associated with a new or existing air system.

- Fresh air intake ducts shall be insulated with fiberglass board insulation or duct wrap two inches thick, mechanically fastened, and shall have finish suitable to the location and surrounding conditions. Fastenings shall not penetrate to the inside of ducts. Insulation pins shall be fastened to ductwork by welding.

- Insulated ducts in exposed areas shall be insulated with fiberglass board or duct wrap one inch thick with glass cloth or canvas jacket with vapor barrier. In concealed areas ducts shall be insulated with 2 inch thick fiberglass blanket, 3/4 pound density.

- Insulation shall be suitably framed at all access panels.

- Duct liner is generally prohibited, but may be used for sound absorption in critical areas only after consultation with University Project Manager.

- Installation shall meet latest edition of SMACNA.
HYDRONIC PIPING – 232113

Heating Water Piping Systems: The Designer shall include the following considerations in preparation of designs that include heating water piping systems.

- Standard weight black steel pipe, ASTM A53 or A120 continuous weld and Type L copper up to two inches.
- Piping systems up to and including two inches in size shall be screwed construction with standard weight cast iron fittings or brazed copper.
- Larger systems shall be welded, 150# class weld neck, or slip-on flanges. Copper, type L, is also allowable.

Chilled and Condenser Water Piping Systems: The Designer shall include the following considerations in preparation of designs that include chilled and condenser water piping systems.

- Chilled and condenser water piping systems shall be standard weight black steel pipe, ASTM A53 or A120 continuous weld. May also be HD copper, HD, type L, with brazed fittings.
- Condenser water piping may be schedule 40 PVC with solvent weld joints, where allowed by Plumbing Code.
- Victaulic couplings are preferred for chilled water piping.
- Pipe insulation may be closed cell elastomeric or fiberglass w/ASJ. Thickness per the most current version of ASHRAE 90.1.

Specialties: The Designer shall include the following considerations in preparation of designs that include hydronic piping systems specialties:

- Provide details showing valves, unions, and controls on all converter and expansion tank systems. Properly size relief valves for the system designed.
- Provide piping connection detail showing valves, unions, control valves, flow metering devices and gauges for all types of coils.
- Expansion tank and makeup: Specify expansion tanks with butyl rubber bladders, Taco Series CA or University approved equal.
- Make up water line: with code approved backflow preventer to protect the domestic water supply.
- Heating coils shall be provided with air vent.
- Service Valves: Provide supply and return mains and risers with isolation valves for service and valved and capped drains at low points to facilitate complete drainage of the hydronic system.
- Vent all high points of the system with air vents that will not permit air to enter the system under vacuum conditions.
- In order to minimize water hammering, make up water lines to steam generators shall have slow close solenoid valves.
- Provide air/dirt separator in chilled water and condenser water systems. Spirotherm brand is preferred, and is available on state contract.

WATER TREATMENT – 231513
All HVAC closed-loop and recirculating water systems shall have a chemical corrosion protection system. When anti-freeze protection is required, specify a mixture of ethylene glycol (Dowtherm SR-1) and water. The Designer shall specify the necessary equipment for treatment and the initial cleaning and treatment of the system. Do not specify supply of chemicals for the first year. The University will take over treatment of the system at substantial completion.

- Consult University for current vendor(s) and specify same for equipment and initial treatment.

STEAM AND CONDENSATE PIPING – 232208

Steam Supply and Return Piping Systems: The Designer shall include the following considerations in preparation of designs that include steam and condensate piping systems.

- Steam distribution piping shall be black steel pipe; ASTM A120 welded through four inches; A53 welded for larger pipe.
- Condensate return piping shall be extra heavy steel pipe, ASTM A53 or A120, continuous welded.
- Steam and condensate piping shall be of welded construction, except at valves, traps, and similar devices. Exception: Low pressure (0-15 psig) steam and low pressure condensate return piping two inches and under may be screwed using extra heavy weight malleable or cast iron fittings.
- Piping larger than two inches in size shall be fabricated using butt or socket weld fittings. Flanges may be welded neck or slip-on type 150# class (through 75 psig) or 300# class (above 75 psig).
- Drip piping shall be welded except for connection to screwed strainers and traps. Screwed unions shall be 300# AAR, or black steel.
- Drip and trap assemblies for steam mains and headers shall be fabricated using two inch extra heavy steel nipples with screwed caps for mains over two inches line size, and line size for lines under two inches, with full size gate valve (N.O.) between the main and the take-off to the trap.
- Steam and return piping, valves fittings and accessories shall be accessible for maintenance.
- Traps shall not be bypassed. Traps shall be designed to have a test valve discharging to atmosphere located between the trap and the discharge shut off valve.
- Branch steam mains shall be valved at the main.
- Flanges or unions shall be provided, and valving arranged so removable equipment may be easily dismantled for maintenance without disruption of service.
- Flash Tank: High pressure condensate shall be discharged to a flash tank before draining to a low pressure condensate return line.
  - The flash tank shall be vented to the outside.
  - The Designer shall include a detail of the flash tank installation including piping arrangement.
  - The design of the flash tank installation and its sizing shall comply with all the requirements in the ASME Boiler and Pressure Vessel Code. Utilize the flash steam to the greatest extent that is economically possible.

MECHANICAL EQUIPMENT SOUND CONTROL – DESIGN GUIDELINES
General: The University has experienced numerous problems with excessively loud or annoying sounds and noise levels generated by mechanical equipment, such as chillers and cooling towers, which disrupt the activities of persons within university buildings or living in residential areas adjoining the University.

- Designers shall specify equipment and design the project so that generated sound levels do not exceed those established as acceptable for each project.
- Refer to Division 1 – General Requirements section re: Acoustical Design Services.

Noise Levels: The University will establish acceptable noise generation and sound level criteria for each project, as appropriate for its intended use and location. Unless established otherwise, the standard sound levels that may be generated by mechanical equipment and other equipment installed as part of any KU project shall not exceed the following levels, when measured on the receiving property.

- 7am to 11pm: 55 dBA maximum
- 11pm to 7am: 50 dBA maximum
- For any source of sound which emits a pure tone or impulsive sound, the maximum sound level limits indicated above shall be reduced by 5 dBA.
- Designers shall also comply with applicable acoustical criteria established by the City of Lawrence or other local municipalities, as applicable to projects that may impact them.

Point of Measurement: For exterior equipment, those sound levels shall be measured either along the property line adjacent to privately-owned property, or at the face of adjacent University buildings. For interior equipment, it shall be measured within the adjacent occupied rooms.

- Future Building Sites: Sound shall also be controlled and measured along the assumed perimeter of future buildings. Future building sites shall include those indicated on the Campus Master Plan and those identified by University personnel during the preliminary design phases.

Equipment: The Designer shall specify acceptable noise levels to be met by the manufacturer of each type of equipment. Confirm with Owner’s Representative the need for factory testing for verification of performance.

Documentation: The Designer shall provide calculations and other documentation as necessary to verify to the University’s satisfaction that proposed design meets these criteria. The Designer shall document the following minimum considerations:

- Manufacturer’s data that identifies unattenuated sound pressure levels for prospective equipment at known directions and distances from the equipment.
- Designers are to verify that this data represents sound levels resulting from both compressor and condenser fan operation, and that this data is based upon a compressor type that matches the compressor type in the proposed specifications.
- Designers are to verify if the proposed machine has different sound pressure characteristics for the sides and opposite ends of the unit.
- Calculations to convert the manufacturer’s data from the sound levels at the distance from the machine indicated in their data, to the estimate sound pressure level at the adjacent buildings or property lines surrounding the project.
Sound Attenuation Options: If calculations and documentation indicate that proposed equipment will apparently exceed the allowable noise levels, Designers shall do one or more of the following, provided they are documented as providing effective sound control within the acceptable levels.

- Modify the specified equipment type, such as a different type of chiller
- Limit the manufacturers to those who can meet the acceptable criteria
- Specify sound control accessories to be provided with the equipment
- Provide architectural barriers or screen walls

ABSORPTION CHILLERS – 236413
Prohibited Use: Absorption Chillers shall NOT be specified.

CENTRIFUGAL WATER CHILLERS – 236416
Approved Refrigerants: The University is phasing out its use of CFC-based refrigerants.

- Designers shall specify machines built for operation with HCFC-123, HFC-134A refrigerants, or HCFC-410A.

Noise Levels: The Designer shall specify acceptable noise levels to be met by the manufacturer of the equipment. Confirm with Owner's Representative the need for factory testing for verification of performance.

Special Warranties: The Designer shall specify minimum five-year factory warranties for all water chiller compressors, which shall include all parts, labor, and diagnostic labor. Warranties shall also include annual inspection for the first five years.

Selection Criteria: The Designer shall use the following as general guidance in selection of chilled water system components.

- For systems smaller than 100 tons, the recommended system is a screw or scroll compressor chiller with an air-cooled condensing unit. For replacement chillers where an existing cooling tower is suitable for re-use, the new chiller may be designed as water-cooled.
- For cooling loads over 100 tons but less than 250 tons, water cooled screw compressor chiller or centrifugal compressor chillers shall be used.
- Over 250 tons, the Designer shall specify the use of water cooled centrifugal chillers.
- Heat rejection equipment shall be rated at 115 degrees ambient.
- Chilled water systems shall be selected with a minimum 12 degree delta T.
- Air-cooled chillers may use a remote evaporator for freeze-protection. Alternately, provide an ethylene glycol/water mixture and/or circulating pumps for freeze protection. Heat tracing is not recommended.
- Consideration of heat recovery bundle for chillers where there is sufficient heating load. Perform life-cycle cost analysis (LCCA) to determine if beneficial to Owner.
- Consideration of magnetic bearing centrifugal chiller. Perform LCCA to determine if beneficial to Owner.
Year-Round Cooling: Special year-round cooling and dehumidifying systems shall be stand-alone air conditioning units capable of operating at outside temperature of as low as minus-20 degrees F and shall be separated from the general comfort cooling system in the building. These special systems shall be equipped with an economizer cycle.

- Examples of these special cooling systems are research spaces, telecommunication rooms, computer rooms, dry rooms, and instrumentation rooms.
- When required by application, condensing equipment shall be capable of starting and operating at -10 degree F ambient temperature.

Refrigerant Emissions Safety Systems: Equipment rooms with refrigeration equipment shall comply with ASHRAE Standard 15, with exception of self-contained breathing apparatus which will be provided by Owner.

- Chillers shall be equipped with high-efficiency refrigerant recovery/purge systems.

Remote Monitoring: The Designer shall specify that newly installed water chillers be capable of communicating with the University’s Building Automated Controls System (BACS) network with integration.

- Refer to Appendix A23.2, Standard of Practice - Building Automation Control System for additional discussion of the University’s campus-wide BACS network.

RECIPROCATING WATER CHILLERS – 236419
Prohibited Use: Air-cooled reciprocating chillers shall NOT be specified.

PACKAGED COOLING TOWERS – 236513

Cooling Tower Specifications: If it is determined that a cooling tower is necessary for the air conditioning system and other heat rejection systems, careful consideration shall be given to its location in relationship to: noise and appearance, prevention of fresh air intake contamination, disease spread, and similar aesthetic or environmental issues, as well as function. It is intended that landscape arrangements and appearance will be included in the discussions of other site considerations.

- All non-media surfaces of cooling towers and evaporative condensers shall be stainless steel. All cooling tower support beams (steel) shall be hot-dip galvanized to ASTM specifications.
- Cooling tower fans shall be gear-driven and supplied with synthetic oil for five year maintenance-free operation. If capacity control is required, use variable frequency drives on fan motors. Tower controls shall include flow bypass and fan speed reduction based upon measured return water temperature.
- Cooling towers shall not be located at lower elevation than chiller.
- Provide vibration shutoff switch.
- SPX/Marley is a preferred vendor, but final selection should be based on life-cycle cost in consultation with Owner.

ROTARY-SCREW CHILLERS – 236426
Selection Criteria: The Designer shall use the following as general guidance in selection of
chilled water system components.

- For systems smaller than 100 tons, the recommended system is a screw or scroll compressor chiller with an air-cooled condensing unit. Condensing unit shall be rated at 105 degrees F. ambient.

- For replacement chillers where an existing cooling tower is suitable for reuse, the new chiller may be designed as water-cooled. For cooling loads over 100 tons but less than 250 tons, water cooled screw compressor chiller or centrifugal compressor chiller shall be used. Heat rejection equipment shall be rated at 105 degrees ambient.

**AIR TERMINALS – 233600**

- Preferred source of reheat is hot water. Provide access panel upstream for cleaning.
- Steam reheat coils where required, shall be steam distribution type with sufficient pitch to completely clear the coil in the event of trap failure. No copper tubes.

**AIR-TO-AIR ENERGY RECOVERY UNITS – 237280**

*Exhaust Air Energy Recovery:* Energy recovery hardware shall be provided in HVAC systems in accordance with ASHRAE 90.1.

- Run-around coils shall be used in all instances except high latent loads, where desiccant wheels may be used. *Dessicant wheels may not be used in laboratory exhaust systems.*
- Heat recovery systems shall be controlled to prevent overheating. If other opportunities exist for heat recovery the Designer shall provide an energy cost analysis for the proposed system.

**FANS – 233400**

*Fan Identification:* All fan units shall be permanently marked to clearly identify the area served.

- Provide ventilation for battery chargers in housekeeping closets.

**CENTRAL-STATION AIR-HANDLING UNITS – 237300**

*Key Air Handling Unit Specifications:* Air handling units over 2000 cfm and all 100 percent outside air ventilating units shall have the following features:

- Double wall galvanized construction with perforated inner wall.
- Two inch wall thickness--typical
- Four inch wall thickness in sections where the air temperature is less than 0 degrees F
- Less than one percent leakage per section at operating conditions.
- All coils supported on stainless steel racks to allow individual removal of coils
- Stainless steel drain pan below each coil.
- The coil drain pans drainage system shall be designed to handle the maximum static pressure of the system. The water shall flow out of the pan at the specified maximum static pressure, without overflowing the pan.

- Air handling units shall have door access to filters, heating and cooling coils, dampers, humidifiers, and fan. The Designer shall include in the plans the manufacturer recommended clearances for maintenance and repair work. The contract documents shall show the service space around all equipment. Panels shall be gasketed and air tight.
Fans shall not require shaft removal for bearing replacement.

Vane axial fans above five inch static pressure shall have thrust restraints.

Air handling units over 15000-cfm units shall be provided with interior service and inspection lighting at each access door.

Provide air handlers with a 35-percent efficient pre-filter and an 80-percent efficient final filter. Provide cartridge style filters. Efficiencies shall be based on ASHRE standard 52.

The Designer shall specify a set of filters upstream from heat recovery coils.

To maintain coil cleanliness, conserve energy and extend filter life, the selection of the filter area shall be based on a maximum face velocity in constant volume units of 350 FPM. In variable volume units the maximum design velocity at the filters shall be 500 fpm.

Steam preheat coils are required for entering air temperature below 35 degrees F. Preheat coils shall be integral face and bypass coils, 150# W.S.P. construction; Wing, Flo-con, or University approved equal.

All heating coils shall be provided with an approved vacuum breaker and air vent.

Chilled water coils shall be completely drainable through individual headers; Trane Type D or University approved equal. Specify EWT and LWT to the cooling coil to provide minimum 12 degree F. delta T. Chilled water coils shall be a maximum of eight rows and shall be selected for maximum 500 FPM face velocity.

Hot water coils shall be completely drainable through individual headers. Specify EWT to the heating coil of 180 degrees F.

Provide piping connection detail showing valves, unions, control valves, flow metering devices and gauges.

Utilize current practices and best methods to prevent air stratification in coils.

All new air handling units shall be directly connected to the campus BACS network. Refer to Appendix A23.2, SOP – Building Automation Control Systems for interface requirements.

Rooftop Air Conditioners: When other viable options are not available, rooftop equipment may be considered.

The Designer shall locate the unit to minimize the adverse effects to the building aesthetics.

The Designer shall select unit and location to minimize noise impact on occupied spaces.

FIBROUS-GLASS DUCTS – 233116.13

Prohibited Use: Fibrous-glass duct material shall NOT be specified.

METAL DUCTS – 233113

Duct Drainage: Outside air intake chambers shall be furnished with water tight drain pans two inches minimum depth. An indirect drain line shall be designed to carry rain or melting snow to a nearby floor drain.

At duct humidifiers, solder ductwork water tight five feet upstream and 25 feet downstream of the ductwork. Pitch ductwork to a drain located at the humidifier. No duct or terminal box liner in section with humidifier.

All ducts exposed to weather shall be watertight.
Duct System Classifications and Testing: The Designer shall determine static pressure ranges for each duct section in a system. Any sections expected to operate above 3.0-inches H₂O of static pressure shall be identified as such on construction documents. The Designer shall specify and witness duct leakage tests on supply and exhaust systems expected to operate above 3.0-inches H₂O of static pressure. The frequency and extent of testing to be determined by design engineer, and University.

Building Penetrations for Air Intake and Exhaust: The Designer shall coordinate size and type of louvers, roof intake and relief hoods. Each intake shall be sized based on manufacturers criteria for no rain and snow penetration or carry-over into the air handling system.

Ductwork Construction Criteria:
- No pipe or any other type of obstruction shall pass through a duct.
- Contract documents shall indicate duct transitions. Duct transitions at fan discharges shall have a maximum slope of one in seven. Supply duct connections shall be made with a 30 degree to 45 degree take-offs in the direction of air flow. Tee connections shall be used only where necessary.
- Flexible duct length shall not exceed six feet. Limit total sag to less than 1/2 inch per foot. Minimize bends in flexible duct, limit total bends on one branch to 90 degrees.
- Firestopping sealants shall be installed in accordance with the requirements of Section 07270. Refer also to Division One of the KU Design Standards.
- The Designer shall coordinate the sealing of floor and wall penetrations.
- All ventilation ducts and related piping shall be independently supported from the building structure. All horizontal ducts 48 inches or wider shall be rigidly and securely supported with trapeze hangers formed of rods and angle iron under duct, according to SMACNA standards.
- All vertical ductwork shall be supported by structural members at each floor.
- Preferred insulation system is duct wrap or duct board.
- Laboratory and any other corrosive exhaust systems shall utilize PVC-coated (4 mil interior and exterior) galvanized steel or stainless steel, type 304 or 316 with finish meeting ASTM A240, with welded joints.

Criteria for Placement of Building Air Intakes: It is the responsibility of the Designer to locate the outside air intake away from sources of exhaust fumes such as loading docks, parking areas, heavily trafficked areas, cooling towers, incinerator stacks, fume hood stacks, and other stacks exhausting toxic or radioactive materials, nuisance odors, plumbing vents, emergency generator exhausts, and engine driven fire pumps exhausts.
- It is the responsibility of the Designer to locate building exhausts away from air intakes on adjacent existing buildings.

HVAC INSTRUMENTATION AND CONTROLS – 230900
Responsibilities for Design: The Designer should be aware that the University has a contractual agreement with Johnson Controls, Inc. and Control Service Company (Automated Logic) to provide all systems and equipment for installations of building
automated controls systems campus-wide.

- The project Designer is responsible for development of an HVAC controls system design that meets the specific needs of the site and/or building location of the project.
- The controls system provider has responsibility for provision and startup of a system that conforms to the Designer’s requirements.

**Minimum Requirements for Design Documents:** The Designer is expected to provide the following documents as part of any HVAC design that includes DDC controls:

- Control Diagrams
- Description Of Operation and Sequence of Controls
- DDC Points Schedules

**SEQUENCE OF OPERATION – 230993**

The Designer shall supplement specifications with necessary mechanical equipment control diagrams to clearly define sequences of operation required and responsibilities of mechanical and electrical subcontractors.

**Energy Considerations:** The Designer shall use the following guidelines in completing projects with opportunities for energy conservation:

- **Run Equipment Only When Needed:** Schedule HVAC unit operation for occupied periods. Run heating at night only to maintain internal temperature between 60 and 65 degrees F to prevent freezing.
  - Start morning warm-up as late as possible to achieve design internal temperature by occupancy time (optimal start control) taking into account residual temperature in space, outdoor temperature, and equipment capacity.
  - Do not use outdoor air for ventilation until the building is occupied, and then use psychometrically proper outdoor air quantities.
  - When on minimum outdoor air, do not use more than that recommended by applicable standards and codes.

- **Provide Only the Heating or Cooling Actually Needed.** In general, the supply temperature of hot and cold air (or water) should be reset according to actual load. This is especially important on systems or zones that allow simultaneous heating and cooling.

- **Supply Heating and Cooling from the Most Efficient Source:** Use free or low cost energy sources first, then use higher cost sources if necessary.

- All energy consuming systems shall have controls on them to optimize energy consumption.
- Electric heat or reheat is prohibited.
- Space setpoints shall be 76°F (summer), and 69°F (winter).

**Fume Hood Control:** Laboratory airflow control components shall be specified to be supplied by Phoenix Controls, and integrated into the Universities BACS system by Johnson Controls or other University temperature control systems provider.

- The laboratory airflow control system shall be required to be furnished with interface panels, software and programming necessary to communicate with the BACS system.
campus backbone for remote monitoring. The interface would be required to accomplish the following:

- Receive all critical alarms.
- Monitor current conditions of all points
- Change set points.
- Trend critical data.
- Modifying point data (alarm limits, etc.)
- Override output points in emergency situations.
- The laboratory airflow control system shall be required to be a completely engineered, cataloged and factory coordinated by a single manufacturer; with the system installed by and set up by an authorized factory representative.

Utilities Metering and Controls Interfaces: The Designer shall review Appendix A23.2, for a discussion of the University’s use of BACS for remote monitoring and metering.

TESTING, ADJUSTING, AND BALANCING SECTION - 230800

General Requirements: The Designer should be aware that the University may elect to retain the services of an independent commissioning agent for projects that involve the installation of utilities systems.

- As early in the design phase of a project as is possible, the Designer shall determine, through discussion with the University, if the project team will include a commissioning agent.
- The Designer shall specify detailed testing, balancing, and adjusting procedures by an independent agency only if independent commissioning is not planned for the project.
- Refer to the Appendix A23.2, Standard of Practice - Commissioning for a discussion of the project commissioning means, methods, and objectives.

Systems Testing – Non-Commissioned Projects

- Piping Systems Tests: Detailed requirements for pipe system cleaning, flushing, disinfecting, and pressure and vacuum leakage testing should be included in the applicable specification sections.
- Ductwork Systems Testing: Detailed requirements for duct system leakage testing shall be included in the applicable specifications sections for those duct systems whose pressure class warrants testing.
- The temperature control contractor will be responsible to provide needed assistance to the balancing contractor during the balancing of the HVAC systems.
- The balancing contractor shall be subcontracted through the general contractor, not the mechanical contractor.
- The balancing contractor shall be pre-qualified through KU Purchasing Services.
- Specify 10 percent tolerances on air and water systems.
- Laboratory projects shall include air balance table, room air changes per hour, design temperatures and humidity percentages, and air flows on contract documents.