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CHAPTER 8---MECHANICAL SYSTEMS

Section 8.1 General Mechanical Guidelines

8.1.1 The designer is notified that the campus water distribution system operates at 90-100 psi. This may create the need for pressure reducing stations or other special considerations for specific applications. Designer is to verify pressure in lines prior to beginning design.

8.1.2 All motors shall be high efficiency.

8.1.3 All piping systems shall be labeled with the type of service and the direction of flow. Insulated piping shall be labeled as “non-asbestos.”

8.1.4 Mechanical joint piping systems (Victaulic, etc.) shall be used only for fire protection systems. This type of joint system can NOT be used on KSU chilled and/or hot water systems.

Section 8.2 Building Plumbing Systems

8.2.1 General guidelines

8.2.1.1 Access doors

8.2.1.1.1 Access doors shall be supplied for all concealed valves or other equipment that may require operation or adjustment.

8.2.1.1.2 The access doors shall have a minimum size of 24" x 24". In some instances, this size may not be possible. The doors should be sized to allow access to the valves or other equipment.

8.2.1.1.3 Both the mechanical and architectural drawings shall note the need for access doors, the number of doors needed, and the general locations. Exact locations are not desired. The design should require that access doors be located to allow access to the valves or other equipment. A problem often arises because the access doors were not noted on the ceiling drawings or in the ceiling specification. Exact locations are not wanted because an exact location that may work during design may not work after construction is started.

8.2.1.1.4 Access doors shall have keyed locks.

8.2.1.2 Thermometers and gauges

8.2.1.2.1 All thermometers and gauges shall have dial faces between 2" and 5" in diameter. All thermometers installed more than 8' from floor level shall have a minimum dial face of 6" and shall be installed to allow reading from floor level. (See also 8.6.5.5.4)

8.2.1.2.2 All thermometers shall be of the dry well type. All thermometers shall be installed with thermal conductive material in the dry wells. Installation without the thermal conductive material yields inaccurate readings.
8.2.1.2.3 All thermometers and gauges shall be selected with the expected operating conditions near the middle of the range of the device.

8.2.1.2.4 Thermometers and pressure gauges shall be accurate to 1% of full scale.

8.2.1.2.5 All gauges shall be installed with gauge cocks.

8.2.1.2.6 All CW and HW systems should have thermometers as well as pressure gauges installed on both supply and return lines and/or on both sides of pumps. No Pete's plugs are allowed.

8.2.1.3 Metering

8.2.1.3.1 All meters will be coordinated with KSU Utility Systems. The designer should coordinate the sizing of the meters with that office. The contractor shall be responsible for the purchase and installation of the meter.

8.2.1.3.2 All fluid meters shall be installed with a three valve bypass design. The bypass valve shall be full flow and capable of being locked. The valves shall be OS&Y rising stem gate valves. The meters shall be installed in a straight run with no obstructions 10 diameters upstream and 5 diameters downstream. All meter installations shall have 40" of clear space above the location of the meter. This is to allow the meter to be serviced without a water outage. The lock is to prevent operation of the bypass mode without the knowledge of KSU Utility Systems.

8.2.1.3.3 All meters shall be connected to telemetering panels supplied by contractor, per current KSU utility systems specifications. The contractor is responsible for mounting the panels, supplying the necessary 110v power, and connecting the meters to the panels. The meters shall be connected to the panels with 16 gauge, 3 conductor, shielded, stranded control wire. Terminations and startup will be completed by KSU Utility Systems.

8.2.1.4 A water-sampling tap shall be installed on all water mains upon entering the building. The tap shall consist of a 1" tap with a ball valve installed at the 12 o’clock position. Two 90° elbows shall be installed to direct the water flow toward the floor, similar to a faucet. Locate tap so that discharge outlet is a minimum of 12” above the floor. Do not locate tap in any pit that is below the main floor level.

8.2.1.5 All piping systems, except natural gas, shall be tested at a minimum of one and one-half times the expected working pressure, or a minimum of 100 psig and a maximum of the design pressure of the pipe and fittings. Test all systems for a minimum of four hours. For natural gas, test at twice the working pressure or a minimum of 3 psig. When the test pressure exceeds 125 psig, the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50% of the specified minimum yield strength of the pipe.

8.2.1.6 All piping systems shall be installed with section valves at all branch connections.

8.2.1.7 All equipment, fixtures, or other appliances attached to any piping system shall have a shut off valve located at the connection to the piping system.

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8.2.1.8 All piping shall be labeled at intervals no greater than 20 feet on straight runs including risers and drops, adjacent to each valve fitting, and at each side of penetrations of structure or enclosure. All labeling shall comply with ANSI A13.1.

8.2.1.9 All valves shall be tagged with an engraved brass tag that describes the type of service and area controlled by the valve.

8.2.2 Domestic water systems

8.2.2.1 Materials

8.2.2.1.1 No PVC piping shall be used for domestic water systems.

8.2.2.1.2 All pipe and fittings, 3" and smaller, shall be copper, Type L, hard or soft drawn for solder joint connections, ASTM B88. All solder shall be lead-free. For pipe sizes larger than 3", galvanized pipe and fittings may be used.

8.2.2.1.3 Unions 2-1/2" and larger shall have flange joints.

8.2.2.1.4 Valves

8.2.2.1.4.1 Gate valves, 4" to 12", shall be flanged, cast iron, 125 lbs., solid wedge, bolted bonnet, OS&Y, Nibco F617-0 or equal. Gate valves smaller than 4" shall not be used.

8.2.2.1.4.2 Check valves 2" and smaller shall be soldered, bronze, 125 lbs., horizontal swing, Nibco S-413 or equal. Check valves 2-1/2" to 8" shall be flanged, cast iron, 125 lbs., bolted bonnet, horizontal swing, Nibco F-918 or equal.

8.2.2.1.4.3 Ball valves, 3" and smaller, shall be soldered, bronze 125 lbs., full port, Nibco S-580 or equal.

8.2.2.1.4.4 Butterfly valves, 6" and larger, shall be gear operated.

8.2.2.1.4.5 Globe valves shall be 2" and smaller. Globe valves 2" and smaller shall be threaded Nibco or equal.

8.2.2.1.4.6 Strainers, 2" and smaller, shall be threaded, bronze, 250 lbs., 20 mesh stainless steel screen, Watts Model 777 or equal. Strainers 2-1/2" to 12" shall be flanged, cast iron, 125 lbs., .045" perforated stainless steel screen, Hoffman Model 450 or equal. All closed loop systems should have strainers.

8.2.2.1.4.7 Low point drain valves shall be equipped with a hose adaptor fitting.

8.2.2.2 Hot water systems

8.2.2.2.1 Instantaneous, tankless water heating systems are preferred whenever feasible. All installations should be evaluated for the possibility of using this type of system.
8.2.2.2 All domestic hot water systems shall have recirculating pumps except in those systems that have the heating in close proximity to the use. Close proximity is considered to require less than 50’ of piping between the heat source and the farthest outlet on the system. Where practical the recirculating pumps should be controlled by the building energy management system.

8.2.2.3 Recirculating pumps in hot water systems shall be constructed of non-ferrous material.

8.2.2.4 The desired temperature for hot water is a maximum of 120°F at the point of usage for normal faucet applications. Other types of usage may require other temperatures (dishwashers, cage washers, etc.) and should be evaluated individually. Where temperatures higher than 120°F are required at certain outlets for a particular intended use, separate heaters or booster heaters shall be installed for those outlets. A DDC control temp setpoint of __ °F is required.

8.2.2.5 Expansion tanks

8.2.2.5.1 All water systems that have backflow preventers shall be designed and installed with provisions for thermal expansion.

8.2.2.5.2 Each system shall be evaluated for the most efficient and cost effective method of providing for expansion.

8.2.2.5.3 Allowing the pressure relief valve to dump excess water due to expansion is not acceptable.

8.2.2.5.4 All expansion tanks shall be installed with provisions for draining and venting, and shall have a sight glass. Bladder tanks will require similar provisions as possible for the bladder type.

8.2.2.3 Water softeners

8.2.2.3.1 Water softening is required on all hot water systems. Other water shall not be softened except for specific applications that require softened water.

8.2.2.3.2 Specifications for water softening equipment should be based on Water Rite.

8.2.2.3.3 All water softening equipment shall be installed with a test port immediately downstream from the softening equipment.

8.2.2.3.4 Water softening systems should be designed to supply water at less than 1 grain of hardness. The water supply on the KSU campus typically has 13.5 grains of hardness.

8.2.2.4 Electric water coolers

8.2.2.4.1 All electric water coolers shall be of the refrigerated type.

8.2.2.4.2 ADA guidelines shall be used in the selection and installation of all electric water coolers.
8.2.2.4.3 Locations of electric water coolers shall be noted on the electrical plans as well as plumbing and architectural plans. This is to prevent the problem of having a drinking fountain with no electricity, causing a problem with a change order.

8.2.2.5 Hose bibbs and wall hydrants

8.2.2.5.1 A hose connection shall be installed in each mechanical room. Maintenance workers often need a water source in mechanical rooms.

8.2.2.5.2 Hose connections shall be located on the exterior of each building. A minimum of one hose connection shall be installed on each side of the building. The preferred spacing for hose connections is one every 100'. (These are needed by Grounds.) Where feasible, hose connections should be installed within 15' of the main entrance to the building. Vacuum breakers/backflow preventers are required at all connections.

8.2.2.5.3 All exterior hose connections shall be of the recessed socket type. This type will prevent use with a pair of pliers, which damages the faucet.

8.2.2.5.4 All wall hydrants shall have individual shutoff valves for repair work.

8.2.2.6 Backflow preventers

8.2.2.6.1 All domestic water systems shall have backflow prevention devices at the point of building entry. No metering devices, taps, or other fittings shall be located upstream of the backflow preventer. However, if a common supply serves both the domestic water system and the fire protection system, it is preferred that the two systems be split immediately upon entering the building. Install the backflow preventer for each system at this point. For a description of the backflow preventer for the fire protection system see items 8.4.1.8 and 8.4.1.9, Fire Protection Systems.

8.2.2.6.2 All backflow preventers shall be reduced pressure principle devices.

8.2.2.6.3 All backflow preventers shall be located and configured to allow ready accessibility for maintenance and testing. Minimum clearance is 24” in all directions.

8.2.2.6.4 No backflow preventers shall be located more than 4' above floor level.

8.2.2.6.5 Pit installations of backflow preventers will not be allowed.

8.2.2.6.6 Drainage from backflow preventers must be possible by gravity only, either to a floor drain or to the surface of the ground. Drains should be sized for the size of backflow. The average 2” floor drain will take about 55 G.P.M.

8.2.2.6.7 All backflow prevention devices must be approved by the Kansas Department of Health and Environment. Watts type RPZ’s is the preferred device to match existing University testing equipment.
8.2.2.7 Insulation

8.2.2.7.1 All domestic water systems shall be insulated with fiberglass insulation.

8.2.2.7.2 Insulation on piping in plenum areas shall be plenum rated.

8.2.2.7.3 All insulation shall comply with ASHRAE 90.1.

8.2.3 Sanitary waste and vent

8.2.3.1 Materials

8.2.3.1.1 Pipe and fittings may be cast iron, DWV copper, or DWV Schedule 40 PVC. The copper and PVC may be used above grade only. The cast iron may be either hubbed or no-hub. All piping systems shall be designed for the intended use.

8.2.3.2 All sanitary waste systems shall be designed for a maximum of 140°F material. No material shall be dumped in any sanitary waste system that has a temperature of more than 140°F. In some cases this will require cooling units on waste discharge. A particular problem is autoclaves. This steam is often dumped into the sanitary waste system, causing many problems. If equipment such as a dishwasher is installed that may discharge at slightly higher temperatures, PVC piping may not be used until that discharge has cooled to 140°F or less.

8.2.3.3 Every piece of equipment that requires indirect waste (backflow preventers, ice machines, autoclaves, etc.) shall be served by a drain at that piece of equipment. More than one piece of equipment can be served by a drain provided the pieces of equipment are close to each other and the sizing of the drain provides adequate drainage for the equipment. The preferred method for supplying this drain is by use of a floor drain, but other types of drains are acceptable, depending on the individual situation. In no case shall the drainage be accomplished by installing piping across the floor to a central floor drain. Drain lines that are installed at floor level to a central floor drain cause trip hazards, clutter the mechanical rooms, and often overload the capacity of the floor drain.

8.2.3.4 Floor drains

8.2.3.4.1 All floor drains shall have a minimum pipe size of 2", a minimum strainer size of 6", and have a removable strainer.

8.2.3.4.2 Upon completion of the installation of the floor drain and the floor around it, each area shall be tested to ensure that water on the floor in the area served by the drain is able to reach the drain by the force of gravity alone. We often have floor drains that are too high or that have a ridge around them, making them useless.

8.2.3.4.3 All mechanical rooms shall have a minimum of one floor drain. More floor drains shall be installed as required to maintain a ratio of one floor drain for every 500 square feet of floor area. These floor drains are in addition to those drains required for equipment.

8.2.3.5 All drain piping for accessible sinks that could be touched by the public shall be insulated. This shall comply with the requirements of ADA. A unit found satisfactory by the University is made by Tru-Bro.
8.2.4 Storm sewer systems

8.2.4.1 Pipe and fittings may be cast iron or DWV Schedule 40 PVC.

8.2.4.2 All surface water shall be directed to a storm sewer system. In no case shall storm water be placed in a sanitary sewer system.

8.2.4.3 Surface discharge of storm water shall not be allowed.

8.2.4.4 All interior piping of storm water shall be insulated.

8.2.5 Special systems

8.2.5.1 Emergency showers and eyewashes

8.2.5.1.1 Floor drains shall not be installed in close proximity to emergency showers and eyewashes. The use of an emergency shower or eyewash implies that a caustic chemical or radioactive material is involved. It is considered better for cleanup purposes to not contaminate the building drainage piping.

8.2.5.1.2 All piping to emergency showers and eyewashes shall comply with ANSI Z358.1.

8.2.5.1.3 In all new construction, any situation requiring either an emergency shower or eyewash should have both installed. It is preferred that they be co-located.

8.2.5.1.4 All emergency showers shall have a local alarm to notify persons in the area that the shower is in use.

8.2.5.1.5 Designs for installations of emergency showers or eyewashes should consider the feasibility of providing an alarm connection to the building security system.

8.2.5.2 Acid waste

8.2.5.2.1 Pipe and fittings may be Duriron or glass. All materials must be rated and approved for acid waste use. Use of plastic pipe is strongly discouraged for use in any and all academic and research facilities.

8.2.5.3 Distilled and de-ionized water

8.2.5.3.1 Pipe and fittings shall be Schedule 80 PVC or other plastic piping systems designed specifically for this type of service.

8.2.5.4 Natural gas

8.2.5.4.1 Pipe and fittings shall be carbon steel, A53 Gr. B or A106 Gr. B, Schedule 40.

8.2.5.4.2 Valves 1" and smaller shall be ball valves, rated for the type of service.
8.2.5.4.3 All valves that are exposed to the outdoor elements shall be of steel body construction. No brass shall be used outdoors.

8.2.5.5 Compressed air and vacuum

8.2.5.5.1 Pipe and fittings shall be Type L or K copper.

8.2.6 Fixtures

8.2.6.1 All fixtures and related equipment shall be of commercial grade or better.

8.2.6.2 Custodian closets

8.2.6.2.1 Each custodian closet shall be supplied with a floor sink. The preferred size is 24" x 36" and the minimum size is 24" x 24". The sink shall be supplied with a stainless steel edge cap.

8.2.6.2.2 Splash plates shall be installed on the wall around the floor sink.

8.2.6.2.3 The faucet shall be equipped with a hose connection. Vacuum breakers/backflow preventers are required at all connections. Both hot and cold water shutoffs are required for faucets.

8.2.6.2.4 All custodial closets should be located by the restrooms for easy hookup of water supply and drains. These rooms must be large enough to store supplies and all custodial equipment needed for the type of cleaning that needs to be done.

8.2.6.3 Rest rooms

8.2.6.3.1 ADAAG guidelines shall be used in the design of rest rooms.

8.2.6.3.2 All fixtures (sinks, urinals, water closets, etc.) shall be white in color.

8.2.6.3.3 All fixture hardware (faucets, flush valves, etc.) shall be chrome color.

8.2.6.3.4 For typical campus applications, no pop-up drain stoppers shall be installed in sinks. In residence halls or other special applications, pop-up drain stoppers may be desirable. In those applications without pop-up drain stoppers, the faucets should be specified without provisions for stoppers, but shall include strainers. Stoppers are an additional item that may break and need maintenance, and they are not needed in most campus applications. A faucet designed for a stopper and installed without one leaves a hole in the faucet body.

8.2.6.3.5 All water flow control devices shall be of the water conserving type.

8.2.6.3.6 In new construction, all fixtures shall be wall-hung. In existing construction, wall-hung fixtures are preferred if feasible.

8.2.6.3.7 All water closets shall have check hinges.

8.2.6.3.8 On applications that have automatic faucets, the infrared proximity sensor type is preferred. Spring return valves on faucets are not acceptable.
8.2.6.3.9 All showers shall have anti-scald mixing valves.

8.2.6.3.10 All plumbing fixtures need individual shutoffs for repair work.

**Section 8.3 Underground Piping Systems**

8.3.1 General requirements

8.3.1.1 In locations where piping passes beneath roadways or driveways, the engineer shall evaluate the expected load and specify appropriate materials to carry the load.

8.3.1.2 All underground piping systems, except copper, shall have a #12 AWG wire attached to the pipe for a tracing wire. The wire shall be labeled and terminated in an accessible location.

8.3.1.3 All underground piping systems shall have a warning tape, with appropriate wording, buried 24" above the pipe.

8.3.1.4 All underground piping systems that are installed using boring methodology shall have a warning system installed above the pipe. Review details of warning system intended for use before completing specification with University Facilities Planning staff.

8.3.1.5 Using a standard proctor at optimum moisture content (2%), all backfill shall be mechanically compacted to a minimum of 88% and a maximum of 92% of maximum density under landscaped areas and a minimum of 95% of maximum density under other areas.

8.3.2 Sanitary sewer

8.3.2.1 Cast iron systems

8.3.2.1.1 Pipe and fittings, all sizes, shall be cast iron, service weight, bell and plain end spigot, ASTM A 74. No-hub type piping can be considered for use after consultation with University Facilities Planning staff.

8.3.2.1.2 Joints, all sizes, shall be rubber gasket, push-on type, ANSI ASTM C 564.

8.3.2.2 PVC Systems

8.3.2.2.1 All piping shall be a minimum of Schedule 40.

8.3.2.2.2 All fittings shall be DWV.

8.3.2.2.3 PVC systems shall be protected by bedding material 6" above and on each side and 3" below the pipe. The bedding material may be sand, rolled stone, or other appropriate material that has no rocks larger than 3/4".

8.3.2.2.4 PVC shall not be used beneath buildings.

8.3.2.3 Clean outs
8.3.2.3.1 All clean outs shall be located in non-traffic areas.

8.3.2.3.2 Clean outs shall be installed in a concrete surround that is a minimum of 12" x 12" and 4" thick.

8.3.2.3.3 All clean out plugs shall be cast bronze with a hex head.

8.3.2.4 Testing

8.3.2.4.1 All sanitary sewer systems shall be tested with 10' of head pressure for not less than four hours.

8.3.3 Storm sewer systems

8.3.3.1 PVC piping may be used on storm sewer systems. For pipe sizes 8" and less, Schedule 40 shall be the minimum pipe used. For pipe sizes greater than 8", SDR 35 piping may be used. All fittings shall be DWV.

8.3.3.2 Cast iron pipe may be used. The same standards apply as for sanitary sewer above.

8.3.3.3 Concrete pipe and corrugated metal pipe may be used.

8.3.3.4 Clean outs

8.3.3.4.1 All clean outs shall be located in non-traffic areas.

8.3.3.4.2 Clean outs shall be installed in a concrete surround that is a minimum of 12" x 12" and 4" thick.

8.3.3.4.3 All clean out plugs shall be cast bronze with a hex head.

8.3.4 Water distribution systems

8.3.4.1 All piping systems shall comply with AWWA standards.

8.3.4.2 All water piping shall have a minimum of 32" of cover.

8.3.4.3 All water meters shall be located inside buildings. See item 8.2.1.3 for more information about water meters.

8.3.4.4 Valves shall be installed with cast iron valve boxes, set in concrete surround that is a minimum of 12" x 12" x 4" thick. The cover to the valve box shall be marked “Water.”

8.3.4.5 The preferred material for water distribution systems is PVC.

8.3.4.6 PVC systems

8.3.4.6.1 All PVC piping shall be C900 installed according to AWWA M23.

8.3.4.6.2 All fittings shall be ductile iron encased in polypropylene.

8.3.4.6.3 All fittings shall be installed with UL listed and approved retainers. Thrust blocks are required.
8.3.4.6.4 Valves shall be ductile iron, with resilient seats and bronze gates, which conform to AWWA C509. No split (2 piece) gates shall be allowed.

8.3.4.7 Copper systems

8.3.4.7.1 Copper shall only be used on pipe sizes 3" and smaller, and shall be used for building service only.

8.3.4.7.2 All copper pipe shall be Type K, ASTM B88, installed per AWWA C800.

8.3.4.7.3 Fittings shall be ANSI B16.22 wrought copper.

8.3.4.7.4 Valves, 2" and larger, shall be ductile iron, flanged, with key head and dielectric isolation. All bolts shall be stainless steel. Valves, 2" and smaller, shall be a key operated stop.

8.3.4.8 All water systems shall be hydrostatically tested at 1.2 times the expected working pressure, or 100 psig, whichever is greater, for a minimum of 4 hours.

8.3.4.9 The water piping systems shall be cleaned according to AWWA M23.

Section 8.4 Fire Protection Systems

8.4.1 Sprinkler systems

8.4.1.1 All test valves shall be located in mechanical rooms in central locations. A minimum number of locations shall be used for test valves. In new construction it is preferred that all test valves be at one location.

8.4.1.2 A pressure gauge shall be installed on the main supply of each sprinkler system, upstream from the main test valve. This is to monitor the pressure drop during operation of the main test valve.

8.4.1.3 Drainage shall be provided for all test locations that are sufficient to carry the full flow of water that can be expected during testing of the systems. This is particularly important at the location for testing the main drain of a system. Directing test water to the exterior of the building is not acceptable.

8.4.1.4 All valves shall be located with sufficient room for maintenance or replacement.

8.4.1.5 All sprinkler systems shall have a fire alarm panel installed that is capable of monitoring and reporting flow in all zones and tampering with all valves of the system. The panel shall be equipped for sounding a local alarm and shall be capable of interface with the campus security system. If the campus security system is in place in the building, the fire alarm panel shall be connected to that system. Contractor shall be responsible for marking the location of all fire alarm panels on as-built plans before submitting as-built's to the owner's representative.

8.4.1.6 Materials

8.4.1.6.1 All materials shall comply with NFPA.
8.4.1.6.2 If mechanical joint systems are used, the fittings shall be equal to Victaulic 005 Firelock Rigid. No cut grooves shall be allowed.

8.4.1.6.3 All underground piping shall be C900 with ductile iron fittings. The fittings shall be coated and wrapped with polyethylene per AWWA C105.

8.4.1.7 Testing

8.4.1.7.1 All sprinkler systems shall be tested at no less than 200 psig for no less than four hours.

8.4.1.8 All sprinkler systems shall have a RPZ type backflow preventer installed at the point of building entry. Sprinkler systems should not have double-check type back flow preventers.

8.4.1.9 Where a sprinkler system is to be installed in a non-heated area, it is preferred that a dry pipe system be installed rather than a chemical system. (If using a chemical system the AN RPZ backflow preventer must be used.)

Section 8.5 Refrigerant Cooling Systems

8.5.1 General design guidelines

8.5.1.1 All refrigerant systems shall comply with ASHRAE 90 and KSU Facilities Planning and utility systems Energy Conservation Policies (Appendix 2).

8.5.1.2 Design of cooling systems should avoid operating refrigerant systems when the outside air is less than 55°F.

8.5.1.3 All mechanical room installations shall comply with ASHRAE 15.

8.5.1.4 Wastewater cooled units are not acceptable.

8.5.1.5 All condensing units shall be designed to 105°F outside air temperature.

8.5.1.6 Consideration shall be given to accessibility for service when locating all equipment.

8.5.2 Material

8.5.2.1 All piping and fittings shall be copper except in an evaporative condenser, where steel piping is acceptable. Long radius fittings are preferred for HVAC systems where space allows and are required for refrigerant systems.

8.5.2.2 All valves shall be full port. Provide isolation valves on each side of driers. The designer shall evaluate the need for check valves on the discharge of compressors, especially when the condenser is higher than the compressor. The discharge from all relief valves shall be piped to the exterior of the building. Documentation of the amount of refrigerant a system contains is required in the as-builds.

8.5.2.3 All solder shall be 15% silver solder except on connections to expansion valves, sight glasses, and driers where “Stabrite” solder is acceptable.
8.5.2.4 Insulate suction and hot gas bypass in all locations and discharge lines if exposed in occupied areas. For units above 5 tons, use 1" fiberglass insulation. For smaller units, use 2" closed cell foam insulation, minimum. All insulation shall comply with ASHRAE 90.1. All insulation on exterior piping shall be protected by an aluminum jacket.

8.5.2.5 Label all lines at all access points and every 20' of exposed piping with the type of refrigerant contained in the lines.

8.5.3 Equipment

8.5.3.1 All equipment shall be mounted on isolation pads.

8.5.3.2 Compressors

8.5.3.2.1 All compressors shall be supplied with a 5-year warranty.

8.5.3.2.2 Multiple units are preferred over larger single units.

8.5.3.2.3 All compressors shall be single speed.

8.5.3.2.4 All 3-phase units shall have adjustable voltage monitors for each phase, with manual reset.

8.5.3.2.5 Provide recycle timers and crankcase heaters with all compressors.

8.5.3.2.6 Provide driers on all liquid lines with isolation valves on each side of the drier.

8.5.3.3 All solenoid valves shall have a manual lift stem.

8.5.3.4 Provide driers on all liquid lines with isolation valves on each side of the drier.

8.5.3.5 Condensing units, if designed to operate at less than 55°F, shall be provided with hot gas bypass and with condenser fan cycle control operated from the head pressure. Outside air dampers are proffered for free cooling.

8.5.3.6 All coils shall have copper tubes and aluminum plate fins.

Section 8.6 Water Cooling Systems

8.6.1 General Requirements

8.6.1.1 All new chilled water systems shall be Primary/Secondary systems with 2-way control valves. The designer may consider variable speed pumps for secondary systems.

8.6.1.2 During the design of all cooling systems, the designer shall evaluate the current and proposed chilled water loops.

8.6.1.3 Piping at HVAC units shall not obstruct filter access panels.

8.6.2 Chilled Water Loops

8.6.2.1 All chilled water loops shall be two-pipe systems.
8.6.2.2 Material for chilled water loops shall be PVC C900, class 150 piping only, with ductile iron fittings. Insulation will be provided if economically justified. Insulation shall be provided where chilled water lines pass close to steam lines.

8.6.2.3 All fittings shall be installed with UL listed and approved retainers. Thrust blocks shall be provided.

8.6.2.4 All underground piping shall have a minimum earth cover of 36" to the top of the pipe.

8.6.2.5 All underground piping systems shall have a #12 AWG copper wire attached to the pipe for a tracing wire. The wire shall be labeled and terminated in an accessible location.

8.6.2.6 All underground piping systems shall have a warning tape, with appropriate wording, buried 24" above the pipe.

8.6.2.7 Isolation valves shall be installed for each building service. The isolation valve shall be a gate valve, installed with a valve box, located as close as practical to the main line. Gear-operated butterfly valves may be considered on a case by case basis.

8.6.2.8 All loop systems shall be provided with a means of air relief at all high points. The preferred method for air relief is a manually operated ball valve located underground in a meter box or similar enclosure.

8.6.2.9 All building service piping shall have a strainer and side-arm filter installed at the point of entry into the building.

8.6.3 Interior Chilled Water Systems

8.6.3.1 Piping

8.6.3.1.1 PVC shall not be used for chilled water systems above ground.

8.6.3.1.2 Welded steel systems shall use black steel piping and fittings, ASTM A120, Schedule 40. The minimum pipe size shall be 3/4".

8.6.3.1.3 Copper systems shall use a minimum of Type L copper. The solder shall be lead-free.

8.6.3.2 Valves

8.6.3.2.1 Control valves, for pipe sizes 3" and smaller, shall be globe valves. For pipe sizes larger than 3", the control valves shall be butterfly valves.

8.6.3.2.2 Isolation valves, for pipe sizes 2" and smaller, shall be ball valves. For pipe sizes larger than 2", the isolation valves shall be butterfly valves.

8.6.3.2.3 Balancing valves 2-1/2" and smaller shall be plug valves. For pipe sizes larger than 2-1/2", butterfly valves shall be used.
8.6.3.2.4 Butterfly valves shall be resilient seated with bronze or stainless steel discs and shall be bubble-tight. All butterfly valves shall be lug-type and gear operated.

8.6.3.3 Insulation

8.6.3.3.1 All insulation shall comply with ASHRAE 90.

8.6.3.3.2 All insulation shall be fiberglass, flexible unicellular foam, or cellular glass.

8.6.3.3.3 All exterior, exposed piping shall have an aluminum jacket installed to protect the insulation. The jacket shall be weather-resistant, waterproof, smooth surfaced aluminum with a minimum thickness of 0.016".

8.6.3.3.4 All interior piping that is exposed in occupied areas and is within 6' of the finished floor shall have a PVC jacket installed. This jacket shall be painted to match the surrounding background.

8.6.3.3.5 All interior piping that is exposed in mechanical rooms, and is within 6' of the finished floor, shall have an aluminum jacket installed.

8.6.3.3.6 All penetrations through fire walls, or floor or roof decks shall have fire-stopping material installed at the penetrations.

8.6.3.4 Hanger design, application, and installation shall comply with MSS SP-58 and SP-69.

8.6.3.5 All chilled water systems that are not part of campus loop shall have a fill and make-up connection installed. A backflow preventer shall be installed at each connection. It is preferred that the connection be sized to allow the filling of the system in approximately 4 hours. However, the size should be evaluated in relation to the cost of the backflow preventer.

8.6.3.6 All chilled water systems shall have an air separator installed.

8.6.4 Condenser Water Systems

8.6.4.1 The designer shall evaluate the cost/benefit of using PVC, FRP or stainless steel piping instead of steel piping. It is preferred that steel piping not be used. If PVC is used, it shall be Schedule 80. If stainless steel is used, it shall be Schedule 10.

8.6.5 Equipment

8.6.5.1 The selection of all equipment shall comply with the KSU Energy Conservation Policy #030 located in Appendix 2.

8.6.5.2 All motors shall be high efficiency and meet the KSU Energy Conservation Policy #060 located in Appendix 2.

8.6.5.3 All equipment shall be mounted on isolation pads.

8.6.5.4 Cooling Towers
8.6.5.4.1 The minimum standard of quality is a fiberglass structure with stainless steel fittings and PVC fill. The designer shall evaluate the cost/benefit of using a wood or stainless steel tower for each installation.

8.6.5.4.2 Consideration shall be given to the aesthetic qualities of any towers located in the view of the public. A screen or other method of removing the tower from view may be appropriate in some situations.

8.6.5.4.3 If year-round operation is desired, a dry-basin type tower is preferred over sump heaters. An indoor sump is preferred to outdoor types.

8.6.5.4.4 Gravity flow distribution systems are preferred.

8.6.5.4.5 All hot water basins shall have easily removable covers.

8.6.5.4.6 A five-year warranty shall be provided with each cooling tower.

8.6.5.4.7 All cooling towers must have CTI certified performance.

8.6.5.4.8 All fans shall be gear/shaft driven with the motor located outside the air stream. No belt-driven fans shall be allowed. The designer shall evaluate the use of 2-speed or variable speed fans. All variable frequency drives shall be installed with a bypass switch.

8.6.5.4.9 All cooling towers shall have extended lubrication lines.

8.6.5.4.10 All cooling towers shall have vortex breakers installed on cold water sumps.

8.6.5.4.11 The designer shall evaluate the cost/benefit of aluminum or fiberglass support systems over coated steel.

8.6.5.4.12 Roof-mounted cooling towers that are elevated above the surrounding grade shall have deck installed around the perimeter of the tower.

8.6.5.5 Chillers

8.6.5.5.1 The type of chiller to install shall be determined by Facilities Planning and Facilities Management, for chillers larger than 100 tons.

8.6.5.5.2 The designer shall consider efficiency losses over time when sizing the cooling tower for a chiller.

8.6.5.5.3 Chiller controls shall be digital type controls. For systems larger than 100 tons, controls shall be integrated with the building EMS. A hand-off-auto switch shall be provided to allow local control or EMS control. All control panels shall be provided with interface capabilities for connection to the EMS for demand control and chilled water reset.

8.6.5.5.4 Provide thermometers and pressure gauges for the entering and leaving condenser and chilled water and the bypass lines. The thermometers shall be 6" dial type. Mercury thermometers are not allowed in this application. (See also 8.2.1.2.1).
8.6.5.5  Provide hour meters on electric chillers.

8.6.5.6  Provide flow meter/switch combinations on chilled water, condenser water, and steam lines.

8.6.5.7  Consideration shall be given to sound attenuation when designing the location and installation of a chiller.

8.6.5.8  Condensate coolers shall be used on absorption chillers.

8.6.5.9  All pipe connections to chillers shall be flanged.

8.6.5.10  All cold sections and lines shall be insulated.

8.6.5.11  All chillers shall be installed on housekeeping pads that are a minimum of 4" in height.

8.6.5.6  Pumps

8.6.5.6.1  All pumps shall have mechanical seals. Pumps that are 7 \( \square \) horsepower and greater shall have mechanical split seals. A standard of quality for mechanical split seals is Bell & Gossett.

8.6.5.7  Expansion Tanks

8.6.5.7.1  All expansion tanks shall be located on the suction side of pumps and shall be diaphragm type.

8.6.5.8  All condensing water systems shall have stainless steel strainers installed.

8.6.5.9  Controls

8.6.5.9.1  All equipment shall have a hand/off/auto switch installed to allow manual override of the normal controls.

8.6.5.9.2  Chiller controls shall be digital and shall include the capability to interface with the Energy Management Control System for chilled water reset, demand limiting, and remote start/stop.

8.6.5.10  Water Treatment

8.6.5.10.1  The designer shall coordinate the design of the water treatment system with KSU Facilities utility systems.

Section 8.7  Steam and Hot Water HVAC Systems

8.7.1 Distribution (Steam)

8.7.1.1  Direct buried systems are not allowed. All distribution piping shall be installed in a steam chase.

8.7.1.2  Pipe and fittings

8.7.1.2.1  All piping shall be black steel. Supply piping 2" and smaller shall be Schedule 80. Supply piping larger than 2" shall be Schedule 40.
8.7.1.2.2  Fittings 2" and smaller shall be threaded only for appendages. Fittings for general piping shall be welded. Fittings 3" and larger shall be welded, with flanged connections to valves and equipment. All fittings shall be forged steel. Piping at HVAC units shall not obstruct filter access panels.

8.7.1.3  Valves 2" and smaller shall be threaded OS&Y gate valves, 800 lbs. class. Valves 3" and larger shall be flanged, cast steel, OS&Y, properly rated for operating pressure, at 550° F.

8.7.1.4  Strainers shall be forged bodied of 300 lbs. class.

8.7.1.5  Traps shall be cast iron bodied of 250 lbs. class. A cooling/storage chamber shall be installed with each trap. The KSU Facilities utility systems will supply a design for the chamber.

8.7.1.6  Pipe guides for 4" and smaller shall be axial, full circumference, “spider” type. For larger sizes, "T"-style slides shall be used.

8.7.1.7  All anchors shall be fully welded to the pipe and shall be located in manholes or other accessible spaces whenever possible.

8.7.1.8  All anchors, guides, and other metal accessories shall be constructed of painted metal, and shall not be mounted on the floor of manholes or chases. All support systems shall be wall mounted.

8.7.1.9  All drip legs shall be a minimum of 12" above the floor.

8.7.1.10  All items that require maintenance shall be located to allow ease of access.

8.7.1.11  The designer shall evaluate the cost/benefit of using expansion joints or expansion loops on a life cycle basis. If a leak occurs plug pac type joints can be repaired while in operation, eliminating down time. If you don’t pac them, they don’t work.

8.7.1.12  All condensate mains shall have float-type automatic air vents, 250 lbs. class, located at the high points of the system. All air vents shall be easily accessible.

8.7.1.13  Insulation

8.7.1.13.1  All steam and condensate lines shall be insulated to meet KSU Energy Conservation Policy #020 located in Appendix 2, and ASHRAE 90.1

8.7.1.13.2  Owens-Corning Fiberglass shall be used as a standard of quality.

8.7.1.13.3  Jackets of .020" smooth surfaced aluminum shall be installed in accessible areas. Insulation in non-accessible areas shall not have a jacket installed.

8.7.1.14  Steam Chases

8.7.1.14.1  Steam chases shall be constructed of “U” channel, reinforced concrete. Weatherproofing shall be provided between sections of the chase.

8.7.1.14.2  The floor of the chase shall have a continuous drain trough that is a minimum of 2" deep and 6" wide. The chase shall be graded to provide drainage of this trough to the manholes. Nothing shall be allowed to
obstruct this drain trough.

8.7.1.14.3 The lid for steam chases shall be pre-cast, reinforced concrete, that is notched over the 2" channel walls to prevent movement. Lifting eyes or lugs shall be provided. Weatherproofing shall be installed at the joints between the lid and the chase walls and between the adjoining lids. A weatherproofing system over the top of the chase shall be installed.

8.7.1.14.4 Soil compaction beneath steam chases shall be a minimum of 95% of maximum density at optimum moisture content (+ 2%), standard proctor. Excavation to undisturbed soil is not considered sufficient. Compaction to the sides and above a chase is dependent on the area. If the chase is passing beneath a paved area, the above conditions shall apply. If the chase is passing beneath a landscaped area, the soil shall be compacted to 88-92% of maximum density.

8.7.1.14.5 All supports shall be wall mounted. Nothing shall be supported from the floor of the chase.

8.7.1.14.6 When a steam chase crosses another utility line, a minimum clearance of 6" shall be maintained and a minimum of 2" of insulation shall be installed between the chase and the other utility.

8.7.1.14.7 When a steam chase is routed through landscaped areas, the top of the chase shall be a minimum of 3' beneath the surface. The designer shall evaluate the need for insulation to protect plantings.

8.7.1.15 Manholes

8.7.1.15.1 All manholes shall be constructed of reinforced concrete.

8.7.1.15.2 All penetrations shall be sealed.

8.7.1.15.3 All manholes shall have a sump with a minimum size of 2' x 2' x 2'. Gravity drainage of the sump is preferred. French or siphon drains are not allowed.

8.7.1.15.4 A pump shall be installed where gravity drainage of the sump is not possible. The pump will be supplied by the plumbing shop and installed by the contractor. A dedicated electrical circuit shall be provided for the pump. Discharge piping shall be copper and shall include a check valve, union, and a shut-off valve. Pumps shall be rated for high temperature liquids.

8.7.1.15.5 Where electricity is supplied to a manhole, a separate circuit with a waterproof GFI duplex receptacle shall be installed for maintenance. All electrical wiring shall be installed in rigid conduit.

8.7.1.15.6 One piece ladders shall be used. Individual rungs mounted or cast to the wall are not acceptable. All ladders shall be welded carbon steel that is hot dipped galvanized. Rungs shall be non-slip, 3/4" diameter on 12" centers.

8.7.1.15.7 Manhole lids shall be sized for any equipment in the manhole, but shall be no smaller than 32" in diameter. The lid shall not be fastened. All manhole covers and frames shall be cast iron. A standard of quality is the Neenah R-6080 with solid cover. All covers shall be imprinted with the
8.7.1.15.8 A vent hole with a solid lid shall be provided in each manhole. The minimum size is 12" in diameter. All vent covers and frames shall be cast iron. A standard of quality is the Neenah R-6007 with type F underside hooks for locking.

8.7.2 Medium and Low Pressure Steam (Above Grade)

8.7.2.1 Medium pressure steam is defined as being 15-90 psig. Low pressure steam is below 15 psig.

8.7.2.2 All drawings shall show drip legs and the specifications shall require drip legs for all risers.

8.7.2.3 Pressure Reducing Valves (PRV)

8.7.2.3.1 Leslie is the preferred brand of valve and shall be used as a standard of quality. Other acceptable brands are Spence, Masoneilan, Dunham/Bush and Spirax/Sarco.

8.7.2.3.2 All PRV's shall be installed with isolation valves, a bypass loop with a globe valve in the bypass, and pressure gauges on both sides of the PRV. All PRV's shall be located and configured to allow ready accessibility for maintenance. Whenever possible, provide a minimum clearance of 24" in all directions. No PRV shall be located more than 8' above floor level. The designer shall evaluate the feasibility of using wall-mounted PRV's.

8.7.2.4 Pipe and Fittings

8.7.2.4.1 All piping shall be black steel. For supply, the piping shall be Schedule 40. For condensate, the piping shall be Schedule 80. No malleable iron is allowed on steam or condensate lines. FRP is acceptable for remote condensate.

8.7.2.4.2 Fittings 2" and smaller shall be threaded cast iron or iron. Fittings 2" and larger shall be welded, with flanged connections to valves and equipment.

8.7.2.4.3 Piping at HVAC units shall not obstruct filter access panels.

8.7.2.5 Valves 2" and smaller shall be 150 lbs. Rising stem gate valves with a union on one side. Valves 2" and larger shall be OS&Y gate valves. Globe valves shall be used only for throttling purposes. Globe valves shall be a minimum of 150 lbs., and shall be rated for steam. Value trim shall match steam temperature. Do not assume saturation temperature.

8.7.2.6 All traps shall be protected by a strainer upstream. Isolation valves shall be installed on each side of each trap. No integral check valves shall be used. Armstrong traps should be used as a standard of quality.

8.7.2.7 Strainers shall by Y-pattern, rated for steam, with stainless steel baskets. All strainers shall be installed with a blow down valve.
8.7.2.8 Safety relief valves shall have piping that is equal to or larger than the tappings of the valve. The discharge shall be piped to a safe point. It is preferred that the discharge be piped to the exterior of the building. Provide flanged or union connections for replacement.

8.7.2.9 All pipe shall be insulated to meet ASHRAE 90.1 and the KSU Energy Conservation Policy #020 located in Appendix 2. Closed cell foam insulation shall not be used.

8.7.2.10 All piping that is exposed in occupied areas, and is within 8’ of the finished floor, shall have a jacket installed. PVC shall not be used for this jacket.

8.7.2.11 Heat exchangers shall be ASME approved and shall be installed with relief valves, rated for the service, on both the steam and hot water systems. Locate heat exchangers to allow removal of the bundle. Drawings shall clearly show the reserved pulling space to allow removal of the bundle. Install gauges and thermometers to indicate the following: Pressure of the entering steam, pressure and temperature of the entering water, and pressure and temperature of the leaving water. Install diaphragm expansion tanks on the water side of all heat exchangers. All heat exchangers require individual shutoffs for repair work.

8.7.2.12 All coils shall be tube-in-tube, non-freezing type with a minimum 1" O.D. tubing. The designer shall consider the use of integral face and bypass coils, especially in situations using steam to pre-heat outside air. Provide two steam traps with bypass for all pre-heat coils.

8.7.2.13 Steam humidifiers shall be equipped with normally closed controls to automatically shut off the steam supply during the cooling season.

8.7.2.14 Air vents/vacuum breakers shall be installed on steam equipment as required.

8.7.3 Hot Water

8.7.3.1 Pipe and fittings may be either black steel or copper. Steel should be as described at 8.7.2.4. Copper shall be Type L and shall be 3" or smaller.

8.7.3.2 All hot water piping shall be insulated to meet ASHRAE 90.1 and KSU Energy Policy #020 located in Appendix 2.

8.7.3.3 All piping that is exposed in occupied areas, and is within 8’ of the finished floor, shall have a jacket installed.

8.7.3.3.1 Piping at HVAC units shall not obstruct filter access panels.

8.7.3.4 Pumps

8.7.3.4.1 All pumps shall be installed in easily accessible locations and shall have isolation valves installed on each side of the pump.

8.7.3.4.2 Bell & Gossett shall be used as the standard of quality.

8.7.3.4.3 All pumps shall have mechanical seals.

8.7.3.4.4 Horizontal in-line pumps shall have a maximum of 1 horsepower. Vertical in-line pumps shall have a maximum of 5 horsepower, be
mounted within 4' of the floor, and shall be protected by a strainer. It is preferred that all in-line pumps be close-coupled.

8.7.3.4.5  Base-mounted, centrifugal pumps shall be installed with a pressure gauge manifold and a suction diffuser/strainer. The use of triple duty valves is preferred. Pipe vibration isolators shall be stainless steel. The designer shall evaluate the need for vibration isolation on the pump.

8.7.3.5  Air Venting

8.7.3.5.1  Automatic air vents are not preferred. If used, they must be readily accessible.

8.7.3.5.2  Hose bibbs shall be installed for manual air vents at all high points of the hot water systems.

8.7.3.5.3  Air separators are required on all systems. Centrifugal-type air separators are preferred.

8.7.3.6  Coils

8.7.3.6.1  All coils shall have a minimum of .025" tube wall thickness and 5/8" O.D. minimum diameter.

8.7.3.6.2  It is preferred that hot water only coils have a maximum of 8 fins/inch.

8.7.3.6.3  All coils shall have copper coils, aluminum fins, and non-ferrous headers.

Section 8.8  Air Handling Systems

8.8.1  General requirements

8.8.1.1  Design of air handling systems shall comply with ASHRAE 90.1 and KSU Energy Conservation Policies located in Appendix 2. Equipment shall be limited to the fewest number of components practical. Variable Air Volume (VAV) systems are preferred.

8.8.1.2  Economizer cycles are preferred. If an economizer cycle is used, and the size of the equipment dictates, a return air fan is suggested to prevent over pressurization of the conditioned space. Freezestats must be installed with all economizer cycles.

8.8.1.3  All systems that use 100% outside air should be evaluated for the use of heat recovery systems and/or outside air for free cooling whenever possible.

8.8.1.4  All designers shall consider noise and ease of maintenance when locating equipment.

8.8.1.5  A drawing shall be mounted near the air handling unit showing the as-built locations of all fire dampers, balancing dampers, VAV boxes, coils, and other equipment in the ductwork served by that unit. The drawing shall be protected by glass or other suitable material.
8.8.1.6 The location of outside air intakes shall be carefully considered to prevent intake of exhaust from other systems equipment or delivery vehicles.

8.8.1.7 Piping at HVAC units shall not obstruct filter access panels.

8.8.1.8 It is preferred that no HVAC units are to be located in classrooms or where you have to place scaffolding or use extension ladder to get to the equipment.

8.8.2 Comfort Systems

8.8.2.1 Air Handling Units

8.8.2.1.1 For new construction (and existing buildings where possible), locate all air handling units inside the building or in a penthouse. Rooftop and above ceiling locations are not preferred. Variable air volume (VAV) boxes should be located in corridors or other common areas whenever possible.

8.8.2.1.2 All units shall provide thorough mixing of outside and return air. Blowthrough units are preferred over draw-through units. The designer shall evaluate the need for engineered mixing boxes, blenders, or other methods to prevent stratification of the air.

8.8.2.1.3 Hinged access doors shall be provided on all units to provide access to filters, coils, fans, dampers, etc. Door handles shall be used on these doors. Bolted panels are not acceptable except on very small units.

8.8.2.1.4 All drain pans shall be insulated and bottom drained. Provisions for cleaning shall include either a removable pan or ease of access for cleaning in place. Traps for drain systems shall be sized for the system served. Ensure adequate room for the size of trap required. Adjust the height of the housekeeping pad as required. However, 6" is the preferred minimum height for housekeeping pads.

8.8.2.1.5 All units shall have a manometer-type filter pressure differential indicator installed with a manifold and valves to isolate the lines to each side of the filter. Units sized under 10 tons do not need to have this indicator.

8.8.2.1.6 Thermometers shall be installed to show the temperatures of the mixed, discharge, outside, and return air. Thermometers shall be bi-metal type with a minimum dial face of 6". Units sized under 10 tons do not need to have this indicator.

8.8.2.1.7 All oil and grease lines shall be extended to the exterior of the case.

8.8.2.2 Filters shall comply with ASHRAE Systems and Equipment Handbook, Chapter 25, Table 2.

8.8.2.3 Dampers

8.8.2.3.1 All dampers that will be used in a fully closed position shall be low-leakage type. A standard of quality is Ruskin CD60.
Maximum leakage for all duct systems is 5%. To be verified by independent testing and balancing after contractor has provided a rough balanced system.

All branch duct takeoffs shall use the 45 degree design and shall have a balancing damper installed in each branch as close to the main duct as practical. No splitter dampers or air extractors shall be used.

Insulation shall comply with ASHRAE 90.1. Only external insulation shall be used. In mechanical rooms or other places where ductwork is exposed, rigid fiberglass insulation shall be used. The rigid fiberglass insulation shall be a minimum of 2” thick and shall be glued and pinned.

Flexible ductwork shall have a maximum length of 6’ and shall be properly supported. Flexible ductwork shall only be used for connecting the branch duct to the diffuser. In no case shall flexible ductwork be used upstream of VAV boxes.

Outside air-cooling will be used whenever possible.

Diffusers

Diffusers with integral dampers shall not be used. System balance dampers shall be installed upstream of diffusers.

Perforated diffusers are acceptable for use.

System balance dampers shall be installed upstream of diffusers.

In a suspended ceiling installation, it is preferred that diffusers use a 24” x 24” mounting plate. A small diffuser mounted in a large ceiling tile is not preferred.

Diffusers for VAV systems shall be specified with consideration given to air dumping at low velocities.

Duct is to be in line with diffuser of ductline (no off sets).

All turning vanes shall be airfoil type. Single or double vane is acceptable based upon application.

Variable air volume controllers should be specified with high quality and long-term usage in mind.

Fume Hoods and Laboratory Systems

General Requirements

All fume hood systems shall be designed based on hazard designations from KSU Public Safety.

For all fume hood installations or alterations, the balance of make-up air to exhaust air for the affected zone or building shall be evaluated. Fume hoods that will cause or aggravate an imbalance between the make-up air and exhaust air shall not be installed unless the
imbalance is corrected. The preliminary design for a project may proceed on the basis of existing drawings and/or balance data. The final design must be based on actual test data.

8.8.3.1.3 All systems, whether new or replacement, shall be designed using variable air volume (VAV) hoods, VAV supply fans and constant volume exhaust fans. If the complete exhaust-supply system cannot be installed at the time of fume hood installation, this may require a constant velocity-type fume hood be installed. If so, select the fume hood for future modification to a VAV-type fume hood. Minor modifications to existing fume hoods that do not increase makeup air problems or cause other imbalances are exempt from this requirement.

8.8.3.1.4 A life-cycle economic analysis shall be performed for every fume hood installation. Factors for the analysis shall include, but not be limited to, initial cost of installation, projected energy costs, and projected maintenance costs. Analysis shall give the present worth of the system based on 15 years operation with annual costs listed.

8.8.3.1.5 All fume hood systems shall be designed according to ANSI Z9.5 with the following exception: The design face velocity shall be consistent with 8.8.3.1.1.

8.8.3.1.6 All measurements performed to ensure compliance with the listed face velocities shall be performed with a velocity grid sensor. (KSU Public Safety owns one.)

8.8.3.1.7 Where feasible it is preferred that systems be grouped to use fewer pieces of equipment.

8.8.3.1.8 Fume hoods and supply air diffusers shall not be located so that a supply diffuser is in front of a fume hood.

8.8.3.1.9 Perchloric and radioactive systems shall be completely separate from other exhaust systems.

8.8.3.1.10 Provide manifold exhaust systems where possible. When manifold systems are used, use redundant, high plume Strobic fans.

8.8.3.2 Fume hoods

8.8.3.2.1 The standard of quality for fume hoods is Labconco. A state contract for fume hoods exists and is available for use on projects.

8.8.3.2.2 All fume hoods shall be equipped with a face velocity monitor and markings on the front of the hood indicating the maximum sash opening height and sash height for maximum air flow. A standard for quality is Phoenix Controls.

8.8.3.2.3 All fume hoods must be certified by KSU Public Safety before use.

8.8.3.2.4 All fume hoods shall have half-sash locks with alarms. The alarms may have a useroverride but, if the override is used, shall sound again after four minutes.
8.8.3.2.5 All fume hoods shall have flow indicators with low flow alarm.

8.8.3.2.6 Vertical sashes are preferred. The use of horizontal sashes is discouraged.

8.8.3.3 Ductwork

8.8.3.3.1 All fume hood and laboratory exhaust system ductwork shall be constructed with 304 stainless steel and shall be of riveted and sealed construction unless other materials are required by the uses of a particular system.

8.8.3.4 Controls

8.8.3.4.1 Control the fume hood exhaust, room exhaust, and room supply air flows with a variable air volume (VAV) scheme to maintain a constant fume hood face velocity of 100 FPM and to provide climate comfort control for the room occupants.

8.8.3.4.2 Control equipment shall be Phoenix or approved equal. Air flow control devices shall be Venturi type valves.

8.8.3.4.3 Any control system used shall have a response time of 1 second or less.

8.8.3.4.4 Use the sash position type of control design, not air pressure differential.

8.8.3.4.5 Use a proximity sensor to reduce the face velocity to 70-80 FPM when no one is in the immediate vicinity of the front of the fume hood.

8.8.4 Animal Quarters

8.8.4.1 Design parameters for animal quarters shall include 100% outside air, 100% exhaust, heat recovery on the exhaust air, and a 50% safety factor on the total heat load.

8.8.4.2 Verify the required space temperatures with the ultimate user of the space.

8.8.4.3 Where available, use steam for all preheat coils. Use a freeze-proof design on all coils.

8.8.5 Auditoriums

8.8.5.1 Design of air handling systems for auditoriums should consider the use of CO2 monitors and occupancy monitors to control the amount of outside air required.

8.8.5.2 Generally, it is preferred that auditorium systems be separate from other building systems.

8.8.5.3 Special consideration shall be given to noise problems in auditorium applications. Submit acoustic calculations for the mechanical equipment. Particular attention shall be given to low frequency vibrations.
Section 8.9  Control Systems

8.9.1 General requirements

8.9.1.1 All control systems shall comply with Energy Conservation Policy #040 located in Appendix 2.

8.9.1.2 All large systems, as defined by Energy Conservation Policy #040, shall be controlled by the university’s energy management control system (EMS). Small systems may be controlled by stand alone pneumatic or electronic systems. If electronic controls are used on small systems they must be 100% compatible with the university’s EMS.

8.9.1.3 Special consideration shall be given to noise problems in classroom or auditorium applications. Submit acoustic calculations for the mechanical equipment. Particular attention shall be given to low frequency vibrations.

8.9.1.4 The use of pneumatic actuators with electronic sensors and controls is preferred. If electric actuators are used, they shall be heavy-duty.

8.9.1.5 All safeties, including freeze-stats, smoke detectors, high static detectors, outside air Eps, etc. shall be hard wired in series with the motor controllers.

8.9.1.6 As much as practical, place controllers in a central, easily accessible location inside a protective cabinet. The designer shall evaluate the need for a cabinet for individual controllers.

8.9.1.7 For areas that have variable occupancy loads such as auditoriums, gymnasiums, classrooms, etc., consideration should be given to control of the outside air volume through the use of CO2 monitors.

8.9.1.8 Designer needs to make sure that the Contractor will be responsible for hardwiring to base line in the steam tunnel or back to Dykstra. All control will be connected to the DDC controls system at Dykstra Hall.

8.9.2 Equipment

8.9.2.1 Actuators

8.9.2.1.1 Pneumatic actuators are preferred.

8.9.2.1.2 The use of positioners is preferred.

8.9.2.1.3 For damper applications, use a minimum of one actuator for each 25 square feet of damper area.

8.9.2.1.4 For valve applications, size valves and actuators for full close and full open with a maximum of 18 pounds of air pressure.

8.9.2.1.5 Actuators for outside air dampers and pre-heat coils shall have a spring return.

8.9.2.2 Air compressors for control air shall be supplied with air filters, air dryers, and oil separators.
8.9.2.3 Install gauges on all input and output control signal lines at the controller.

8.9.2.4 Sensors

8.9.2.4.1 All electronic temperature sensors shall be 1,000 ohm platinum, resistance temperature detectors (RTD's) with 2 wire connections. Install using thermo-conductive material in thermo wells.

8.9.2.4.2 If the application requires a humidity sensor, a high quality unit should be specified. Hy-cal can be used as a standard of quality.

8.9.2.4.3 Differential pressure switches, if used for fan status on VAV applications, shall not be Barber-Coleman PC301. All units used shall be repeatable, reliable, and adjustable.

8.9.2.4.4 Air flow stations shall be used to measure outside air on all systems. These stations shall be averaging grid type with 90% accuracy that comply with ASHRAE standards for duct traversing.

8.9.2.4.5 Freeze-stats shall be sized and configured to provide accurate averaging for the coil and shall have a manual reset.

8.9.3 All tubing shall be hard drawn copper except within 2' of a device, where poly tubing may be used. All tubing shall be supported directly from the building structure with supports at a maximum of 6' on center.

8.9.4 Sequence of Operation

8.9.4.1 The following sequences of operation are to show our preferred controls for a typical system. Where the designer determines that these are not appropriate for a specific design, these may be changed. However, every effort shall be made to comply with the intent of these arrangements.

8.9.4.2 100% outdoor air systems

8.9.4.2.1 Typical equipment list, in order from outside air intake to exhaust.

- Outside air sensor
- Outside air damper, NC, 2 position.
- Filter rack
- Air flow monitor
- Heat recovery coil
- Heat recovery discharge air temperature sensor
- Steam pre-heat coil w/NO 2 position valve and NO modulating valve
- Supply fan
- Pre-heat coil discharge temperature sensor
- Freeze-stat, manual reset
- Chilled water coil, NC modulating valve, antifreeze pump
- Cooling coil discharge temperature sensor
- Heating coil, NO modulating valve
- Humidifier, steam NC modulating valve, NC 2 position valve
- Heating coil discharge temperature sensor
- Smoke detector

(Compare with mixed air system)
- Hood connection points

8.9.4.2.1.2 Occupant zone
- Occupant override
- Humidity sensor
- Temperature sensor

8.9.4.2.1.3 Exhaust air duct
- Smoke detector
- Air flow monitor
- Heat recovery coil
- Exhaust fan

8.9.4.2.2 Typical point list

8.9.4.2.2.1 Analog inputs
- Outside air temperature
- Heat recovery discharge temperature
- Pre-heat discharge temperature
- Cooling coil discharge temperature
- Heating coil discharge temperature
- Zone temperature
- Zone humidity
- Supply fan air flow
- Exhaust fan air flow
- 3 heat recovery loop temperatures

8.9.4.2.2.2 Binary inputs
- Supply fan status
- Exhaust fan status
- Heat recovery pump status
- Occupant override

8.9.4.2.2.3 Analog outputs
- Supply fan speed
- Exhaust fan speed
- Pre-heat modulating valve
- Chilled water valve (Coil or building as required)
- Hot water valve
- Humidifier valve
- Heat recovery loop valve

8.9.4.2.2.4 Binary outputs
- Supply fan start/stop command
- Exhaust fan start/stop command
- Heat recovery pump start/stop command
- Pre-heat 2 position valve
- Humidifier 2 position valve
- Anti-freeze pump
- Outside air damper

8.9.4.2.2.5 Direct connected safeties
- Freeze-stat
- Supply fan smoke detector
- Exhaust fan smoke detector

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**8.9.4.2.3  Safety and shutdown features**

8.9.4.2.3.1 All safety shut downs shall be hardwired into the system.

8.9.4.2.3.2 In the event of a smoke alarm signal from either smoke detector (exhaust air duct or supply air duct), the supply and exhaust air fans shall shut down and the outside air dampers shall close.

8.9.4.2.3.3 A manual reset freeze-stat on the upstream face of the cooling coil will stop the supply and exhaust air fans, close the outside air dampers and open the modulating preheat valve.

8.9.4.2.3.4 An outside air damper limit switch will stop the supply and exhaust fans when the dampers are not open. Add a spring return on the damper to close the damper in case of power outages.

8.9.4.2.3.5 The 2 position humidifier valve will be closed upon shut down of supply air fan by using an analog DDC.

8.9.4.2.3.6 For VAV systems, a manual reset high limit static pressure sensor shall be located in the discharge ductwork near the fan discharge. It shall shut down the supply air fan whenever the static pressure is greater than the set point.

**8.9.4.2.4  Occupied/Unoccupied Cycle**

8.9.4.2.4.1 Occupied/unoccupied cycle for the AHU will be determined by the controller scheduling program.

8.9.4.2.4.2 During occupied cycle the fans run continuously. During the unoccupied cycle the fans are off, the outside damper is closed and the preheat coil remains in control. (Close outside air damper on 100% outside air system? - Okay for offices but not labs. - Review system design with Facilities Planning Staff.)

8.9.4.2.4.3 During the unoccupied cycle, a zone temperature sensor will enable the AHU system if the zone setback set point is reached.

8.9.4.2.4.4 All systems will have an occupant override button located in the occupied zone.

**8.9.4.2.5  Preheat Control**

8.9.4.2.5.1 With the outside air below 55°F, the preheat valve modulates to maintain preheat discharge air temperature set point.

8.9.4.2.5.2 With the outside air below 35°F, the 2 position preheat valve opens. The valve is sized for 10°F rise at full air flow.
8.9.4.2.5.3 With the outside air above 55°F, the preheat valves will be closed.

8.9.4.2.6 Static Pressure Control for VAV Systems

8.9.4.2.6.1 The controller shall maintain the static pressure set point in the supply air ductwork by varying the speed of the fans.

8.9.4.2.6.2 Ramp functions will be accomplished in the variable frequency drive controls, not in the EMS controller software.

8.9.4.2.6.3 Building pressure will be maintained by matching the supply air and exhaust air flows, as measured by flow monitoring stations.

8.9.4.2.7 Chilled Water Coil Control

8.9.4.2.7.1 In the cooling mode (OA>55°F), the controller shall maintain the cooling coil discharge air temperature set point by modulating the two-way cooling coil valve.

8.9.4.2.7.2 In the dehumidification mode (OA>55°F & Zone RH >60%), the controller shall maintain the dehumidification set point by modulating the two-way cooling coil valve.

8.9.4.2.7.3 In the heating mode (OA<55°F), the controller shall shut the cooling coil valve. The temperature setting may be lower for some conditions.

8.9.4.2.7.4 When OA<35°F, the antifreeze pump will be energized.

8.9.4.2.8 Heating Coil Control

8.9.4.2.8.1 In the dehumidification mode (OA>55°F & Zone RH >60%), the controller shall maintain the discharge air temperature set point.

8.9.4.2.8.2 In the heating mode (OA<55°F), the controller shall maintain the heating coil discharge air temperature set point by modulating the heating coil valve.

8.9.4.2.9 Humidifier Control

8.9.4.2.9.1 In the cooling mode (OA>55°F), the controller shall shut the modulating humidifier valve and the 2 position valve. The 2 position valve will be used to stop the flow of steam to the steam jacket and humidifier.

8.9.4.2.9.2 In the heating mode (OA<55°F), the controller shall maintain the humidification set point by modulating the humidifier valve. The 2 position valve will open. (Set to 45° or 50°? Provide deadband.)

8.9.4.2.10 Heat Recovery Control

8.9.4.2.10.1 Energize the heat recovery system when the outdoor air temperature is below 50°F or above 80°F.

8.9.4.3 Mixed Air Systems
8.9.4.3.1 Typical equipment list, in order from outside air intake to exhaust.

8.9.4.3.1.1 Supply air duct
- Outside air sensor
- Outside air damper
- Return Air inlet w/damper in cross connection
- Filter rack
- Air flow monitor
- Supply fan
- Mixed air temperature sensor
- Heating coil, NO modulating valve
- Heating coil discharge temperature sensor
- Freeze-stat, manual reset
- Chilled water coil, NC modulating valve, antifreeze pump
- Cooling coil discharge temperature sensor
- Smoke detector

8.9.4.3.1.2 Occupant zone
- Occupant override
- Temperature sensor

8.9.4.3.1.3 Return air duct
- Return air temperature sensor
- Smoke detector
- Return air fan
- Cross connection to supply air duct
- Exhaust air damper

8.9.4.3.2 Typical Point List

8.9.4.3.2.1 Analog inputs
- Outside air temperature
- Mixed air temperature
- Cooling coil discharge temperature
- Heating coil discharge temperature
- Zone temperature
- Outside air flow
- Return air temperature
- Supply air static

8.9.4.3.2.2 Binary inputs
- Supply fan status
- Return fan status
- Occupant override

8.9.4.3.2.3 Analog outputs
- Supply fan speed
- Return fan speed
- Chilled water valve
- Hot water valve
- Outside air damper
- Return air damper
- Exhaust air damper

8.9.4.3.2.4 Binary outputs
- Supply fan start/stop command
- Return fan start/stop command
- Anti-freeze pump

8.9.4.3.2.5 Direct connected safety
- Freeze-stat
- Supply fan smoke detector
- Return fan smoke detector
- Outside air damper
- High fan static
- Supply fan
- Return fan
- Hot water valve

8.9.4.3.3 Safety and shutdown features

8.9.4.3.3.1 All safety shutdowns shall be hardwired into the system.

8.9.4.3.3.2 In the event of a smoke alarm signal from either smoke detector (return air duct or supply air duct), the supply, return and exhaust air fans shall shut down and the outside air dampers shall close.

8.9.4.3.3.3 A manual reset freeze-stat on the upstream face of the hot water heating coil will stop the supply, return and exhaust air fans, close the outside air dampers and open the modulating heating valve.

8.9.4.3.3.4 For VAV systems, a manual reset high limit static pressure sensor shall be located in the discharge ductwork near the fan discharge and shut down the supply air fan whenever the static pressure is greater than the set point.

8.9.4.3.4 Occupied/Unoccupied Cycle

8.9.4.3.4.1 Occupied/unoccupied cycle for the AHU unit will be determined by the controller-scheduling program.

8.9.4.3.4.2 During occupied cycle, the fans run continuously. During the unoccupied cycle, the fans are off, the outside air damper is closed and the heating coil remains in control.

8.9.4.3.4.3 During the unoccupied cycle, a zone temperature sensor will enable the AHU system if the zone setback set point is reached.

8.9.4.3.4.4 All systems will have an occupant override button located in the occupied zone.

8.9.4.3.5 Heating coil control

8.9.4.5.5.1 In the heating mode (OA<55°F), the controller shall maintain the heating coil discharge air temperature set point by modulating the heating coil valve.

8.9.4.5.5.2 In the cooling mode (OA>55°F), the controller shall shut the heating coil valve.

8.9.4.5.5.3 For single zone systems, zone temperature will be used to control the
discharge temperature.

8.9.4.3.5.4 For systems supplying more than one zone, the discharge air temperature will be reset based on outdoor air temperature.

8.9.4.3.6 Chilled Water Coil Control

8.9.4.3.6.1 In the cooling mode (OA>55°F), the controller shall maintain the cooling coil discharge air temperature set point by modulating the cooling coil valve.

8.9.4.3.6.2 In the heating mode (OA<55°F), the controller shall shut the cooling coil valve.

8.9.4.3.6.3 When OA<35°F, the antifreeze pump will be energized.

8.9.4.3.6.4 For single zone systems, zone temperature will be used to control the discharge temperature.

8.9.4.3.6.5 For systems supplying more than one zone, the discharge air temperature will be reset based on outdoor air temperature.

8.9.4.3.7 Outside Air Control

8.9.4.3.7.1 When OA<65°F, modulate outside air, return and exhaust air dampers to maintain discharge air temperature set point.

8.9.4.3.7.2 When OA>65°F, maintain minimum outside air position.

8.9.4.3.7.3 Air flow monitor will be used to control minimum outdoor air position.

8.9.4.3.7.4 When no chilled water is available and when the outside air is 5°F less than the return air, open the outside air and exhaust air dampers to cool and ventilate the occupied zones.

8.9.4.3.7.5 When a CO2 monitor is used, maintain the return air set point through a point interface device loop by modulating outside air, return air, and exhaust air dampers. Make sure to anticipate if outside air is too cold in the design of the control system.

8.9.4.3.8 Static Pressure Control for VAV Systems

8.9.4.3.8.1 The controller shall maintain the static pressure set point in the supply air ductwork by varying the speed of the fans.

8.9.4.3.8.2 Ramp functions will be accomplished in the variable frequency drive controls, not in the EMS controller software.