THE UNIVERSITY OF TENNESSEE KNOXVILLE

FACILITIES SERVICES

Mechanical Design Criteria

February 2024

Table of Contents

1. GENERAL MECHANICAL CRITERIA

Equipment should be selected for long range operation and reliability targeting a 25-30-year service life. Practical, off-the-shelf technology is preferred. To the greatest extent possible, select electric motors for all mechanical equipment from off-the-shelf motor sizes for ease in replacement from typical motor suppliers.

Energy-saving and cost-reduction strategies and technologies should be evaluated via both initial and life-cycle cost analyses.

All equipment shall be located to allow for required service areas around equipment. This includes space for removing and replacing coils, tube bundles, etc. Equipment shall be located such that service personnel can stand on floors or permanent platforms to the greatest extent possible.

Deviations from these criteria shall be discussed on a case-by-case basis with UTK Facilities Services (UTFS).

2. UTILITIES

2.1. SOURCE OF HEATING AND COOLING

Space heating shall be provided from the campus steam distribution system to heating water loops, where available. For larger domestic water heating demands, steam may be used, with electric water heating being preferred for smaller loads. Existing cooling plant capacity shall be used to the greatest extent practical. The designer shall consult UTFS to determine if future cooling plant capacity may be required to service surrounding buildings.

Variable refrigerant flow systems are only acceptable with prior agreement from UTFS.

2.2. OUTAGES

All outages shall be coordinated in advance with UTFS. A written outage plan including start time, expected duration, and description of work shall be provided to UTFS a minimum of 14 calendar days ahead of the outage. If the work requires specialty or custom parts, such as high voltage termination kits, pieces of major equipment, etc., the availability of those items must be confirmed prior to scheduling the outage. All parts must be on site prior to the outage beginning.

2.3. INTERFACE WITH OFF-CAMPUS UTILITY COMPANIES

All interactions with off-campus utility companies must be coordinated through UTFS. This applies equally to interactions during the design and construction phase of all projects.

2.4. METERING

All utilities shall be metered at the entry point to buildings. Consult UTFS on any requirements for additional submetering for specific uses. All meters shall be revenue-quality devices. Consult UTFS on the specific make and model of meters to be used, as there may be utility company requirements present. Irrigation water shall be metered separately from domestic water. Boiler, chiller, and cooling tower make-up and blow down water shall be metered separately.

3. DESIGN CONDITIONS

Unless otherwise stated in specific building/space criteria, the following design conditions shall be used. These conditions also apply to the selection of all equipment.

Indoor Design Conditions	Outdoor Design Conditions
Cooling: 72 FDB	Summer: 95 FDB; 80 FWB
Heating: 72 FDB	Winter: 0 FDB
Dehumidification: 50% RH	

The indoor relative humidity should not exceed 50% RH. This may result in dehumidification as the primary driver for distribution or equipment design or selection.

Systems shall be capable of maintaining the indoor design conditions across all load conditions in all spaces. This is particularly important for spaces with highly variable occupancies or equipment loading.

Indoor design conditions for animal facilities require special consideration. Air changes in these spaces should generally be a minimum of 15 air changes per hour in all operating modes. Room conditions shall be maintained throughout the entire airflow range, minimum to maximum flows. Heat loads must meet the specific animal temperature requirements.

4. PRESSURIZATION REQUIREMENTS

Buildings shall be positively pressurized relative to the outdoors. Laboratory spaces shall be negatively pressurized relative to adjacent public spaces such as hallways.

5. AIR DISTRIBUTION

5.1. DESIGN

Air distribution must be as uniform as possible with temperature variation in the space not exceeding 2 F. This applies across all load conditions, with particular attention being required for spaces with highly variable occupancies or equipment loads.

Ducted return air systems are preferred. Plenum return systems shall not be permitted. Mechanical rooms shall not be used as return or outside air plenums.

In ductwork layout, duct crossings, duct paralleling, duct backtracking, and other similar complicating features should be minimized when possible.

Noise levels should not exceed NC 35 for all occupied spaces other than classrooms and teacher spaces, where noise levels should not exceed NC 30. Sound and vibration control may be required for both equipment and duct systems.

Provide all blade dampers as opposed blade. This includes for airflow control applications and for open-close operation. All dampers shall be capable of closing "bubble-tight".

5.2. REGISTERS, GRILLES, AND DIFFUSERS

Locate air outlets to provide a proper throw, drop, and spread at or above 20 fpm minimum and 75 fpm maximum room velocity. In general, the range of supply air outlet velocities should be 500-750 fpm, and return and exhaust inlet face velocities should be 300-500 fpm.

Supply air should be introduced through round neck, louvered-face ceiling diffusers. Dampers, where provided with diffusers, should be radial type.

Ceiling return and exhaust air registers and grilles must be grid core type. Return air registers should be located near the exterior wall of the space served. Ducts serving return or exhaust air ceiling registers should be sized to accommodate the full face of the register. Do not provide round or flex duct to serve return or exhaust air ceiling registers.

5.3. DUCTWORK

Fibrous duct shall not be used except as insulation on metal duct.

Joints in low pressure supply air ducts located in unconditioned spaces, other than Ductmate® systems, must be sealed using Hardcast® pressure-less tape with RTA-50 adhesive, or a similar product.

Rectangular branch take-offs should be of 45-degree tap-in type. Splitter dampers, extractors, and scoops are unnecessary. Bellmouth fittings should be used for round duct take-offs.

Duct elbows are to be the full radius type, r/D = 1.5. Radius ells with square throats shall not be used. Where mitered 90-degree elbows are necessary, they should include factory-made turning vanes.

Provide manual volume dampers with minimum 20-gauge thickness blades in ducts where required for proper adjustment and balancing of airflows.

Medium and high pressure ducts must be factory-fabricated double-wall round or flat oval with factory insulation and perforated liner. Take-offs must be the conical type. Factory elbows must be full radius type, r/D = 1.5. Divided flow fittings must be provided where required. Joints should be sealed with Hardcast® pressure-less tape with RTA-50 adhesive, or a similar product. Specify ducts to be leak tested in accordance with SMACNA's "Air Duct Leakage Test Manual".

Flexible duct with 1" thick insulation should be provided to connect supply air diffusers to main or branch ducts. Include applicable duct pressure in the specifications. Duct length should be limited to 4 feet. Ducts must be installed without kinks or sags and supported with 3/4 in. wide metal bands. The minimum inside radius of any bend should be one-half the diameter of the duct.

Access doors or panels must be provided in ducts for access and inspection of filters, heating coils, sound attenuators, control dampers, fire and smoke dampers, humidifiers, air flow stations, and other similar system components. In addition, doors should be within reach of obstructions such as turning vanes and dampers and at approximately every 20 feet in long ducts for cleaning and maintenance if no other means of access is available. Doors should be as large as practical and be able to be opened or removed without the use of tools.

The location of inaccessible doors and other mechanical equipment, including valves, dampers, coils, VAV boxes, fan coil units, and other similar system components should be coordinated with architectural design. A minimum 24" x 24" access door should be included in inaccessible ceilings and walls as necessary for access to this equipment. Access doors shall be located within reach of the equipment to be serviced.

Branch ducts serving VAV boxes should be maintained at 2-1/2 duct diameters straight duct at the entrance to the box, and final connection aligned properly so as not to restrict air flow to the box.

Shot pins are not acceptable fastening devices for supporting ductwork and sheet metal specialties.

5.4. AIR SIDE ECONOMIZERS

Damper actuators shall be mounted outside of the air stream.

Outside air intakes shall be protected by screens of corrosion-resistant material not larger than 1/2 in. mesh.

Return and outside air ductwork and dampers shall be arranged to achieve complete mixing of the two airstreams prior to entry into the air handling unit. Where complete mixing cannot be achieved, stationary blenders or baffles shall be provided.

Inline return air fans, where required, shall be the mixed flow type, belt driven, with lubrication fittings outside the fan housing. Provide fans with integral hinged access door for inspection and cleaning. Fans should be selected for an outlet velocity of not greater than 3000 fpm. Vane axial fans are not acceptable.

5.5. VAV BOXES

Variable air volume boxes are to be the pressure-independent type provided with pressure taps and air flow curves for making air flow and pressure measurements. Air leakage through fully closed boxes must not exceed 2% of design air volume at 8 in. static inlet pressure. Total pressure drop should not exceed 0.5 in. wc. Boxes should be normally closed, have access doors, and a minimum 1 in. thick foil faced glass fiber liner or double wall construction.

Boxes with hot water coils should be provided for most applications requiring heating. The use of fan-powered boxes should be minimized. Fan-powered boxes may be considered for spaces with high heating requirements or where high minimum air flow rates are required.

Heating water coils should have minimum 0.02 in. thick tubes with 0.006 in. aluminum fins. Fin spacing should not exceed 12 fins per inch. Coil casings are to be insulated with fiberglass duct wrap where condensation may occur. PT plugs and drain valves should not be provided on piping serving VAV boxes with hot water coils.

Boxes installed above inaccessible ceilings should have adequate access regardless of finished appearance. The engineer is responsible for coordinating this with the architect.

Boxes, including hot water valves, are to be furnished with DDC controls. Controllers should be fully programmable. Air flow should be monitored and minimum and maximum set points adjusted from the DDC system. In addition, monitor box leaving air temperature.

5.6. MECHANICAL VENTILATION AND EXHAUST

Corrosion-resistant registers should be installed directly over sources of odor and moisture in sanitary facilities (toilets, locker rooms, janitor's closets, etc.). Other spaces requiring ventilation should not be connected to sanitary exhaust systems.

In mechanical and electrical rooms containing heat-generating equipment (steam PRV stations, boilers, heat exchangers, chillers, switchgear, etc.), air should be introduced on the cool side of the room and exhausted on the hot side. Exhaust fans must be thermostatically controlled to maintain room conditions as required for proper equipment operation.

Exhaust air shall be ducted directly to the fan. Ceiling registers shall be connected independently by branches to the main ductwork to facilitate balancing and attenuate noise.

Exhaust fans shall be the centrifugal type, preferably directly driven, and selected for a wheel tip speed not to exceed 3500 rpm. Fans shall be isolation mounted and have corrosion-resistant gravity type backdraft dampers with blade edge and end seals. An accessible non-fused disconnect switch shall be installed in or adjacent to each fan base. Where available, the fan housing shall be hinged at one edge for access to motor and drive.

Fans shall be AMCA certified with motor starters with a "soft start", or variable speed drives for motors larger than 5 hp.

Wherever possible, fans must be installed on building roofs or in mechanical rooms. Avoid installation above ceilings or other concealed or inaccessible locations.

Roof curbs should be of the sound attenuating type with a minimum height of 12 in and must be approved in advance by UTFS.

Exhaust fans should be controlled by the DDC system or by interlocking with the respective air handling unit.

Where fan systems feature bypass air intakes, design of the bypass shall minimize the possibility of either entrained or direct rain water entering the intake and, subsequently, entering the duct system or building.

5.7. FIRE AND SMOKE DAMPERS

Fire dampers shall be U.L. labeled dynamic rated, curtain type dampers. Dampers shall be type “B” for low pressure and type “C” 100% free area for high pressure duct.

Smoke dampers shall be classified in accordance with U.L. Standard 555S.

5.8. AIR FILTRATION

All systems shall have final filtration of MERV 14 or better. MERV 8 pre-filters shall be provided to prolong service life of final filters.

Filter boxes or housings must be provided with a hinged access door on each side. All joints between filter segments and the enclosing ductwork shall be gasketed or sealed to provide a positive seal against air leakage. In large filter banks, provide 3 in. stiffening straps between filter frames vertically every second frame. A Magnehelic® gauge shall be installed across each filter bank.

Filters must be new and clean in all equipment at the time of final inspection. A complete, new spare set of filters for all equipment must be provided in addition to the ones inspected. Filters that were in use during the construction period will only be accepted with prior authorization by UTFS.

6. INSULATION

6.1. GENERAL

Insulation linings, coverings, vapor barriers, etc. and the adhesives used for applying them shall have a flame spread classification of not more than 25 and a smoke-developed rating of not more than 50 as tested in accordance with ASTM Standard E84. Insulation materials must be installed in accordance with manufacturer’s recommendations.

Insulation thickness shall be as required to prevent condensation on the exterior surface.

A vapor barrier should be provided on the exterior side of the insulation, which can serve as a finishing cover for the insulation.

6.2. DUCTWORK

All supply, return, and outside air ductwork and plenums in unconditioned spaces must be insulated, preferably on the exterior. Consult with UTFS where liner may be required for sound control, keeping in mind the NC criteria in section 6.1. Cold air duct components subject to condensation, including plenums, transitions, VAV box HW coils, fan casings, air flow stations, fire dampers, apparatus connections, and the top surfaces of ceiling diffusers must be insulated.

Ductwork other than internally lined or factory insulated is to be wrapped with minimum 2 in. thick glass fiber insulation with vapor barrier.

Specify ductwork manual volume damper handles, airflow station pressure ports, access door handles, duct mounted instrumentation, etc. to be left exposed or accessible above the insulation vapor barrier. Damper handles in externally wrapped ductwork are to be provided with stand-off brackets and locking quadrants to ensure the handle can be adjusted without disturbing the insulation vapor barrier.

Outside air ducts and plenums should be insulated on the exterior with glass fiberboard insulation and made weatherproof by sealing.

Supply and return air ducts should be wrapped with glass fiber insulation. With the exception of exhaust to heat recovery devices or other high temperature exhausts, do not insulate exhaust ducts.

6.3. PIPING AND EQUIPMENT

All domestic hot and cold water piping, space heating and chilled water piping, rainwater leaders, refrigerant suction lines, steam and steam condensate piping, piping traced with heating elements, and A/C unit drain piping must be insulated.

All valves except pressure reducing valves, strainers, fittings, flanges, hydronic specialties, tanks, etc., including heat exchangers, condensate receiver tanks and associated piping, emergency generator mufflers and exhaust piping, and air release tanks shall be insulated. Chilled water pumps shall be insulated. Compression tanks and condenser water piping inside the building or in mechanical rooms should not be insulated. On condensate receiver tanks and piping, no connections or gauges shall be covered by insulation.

Glass fiber sectional pipe insulation is to be used for most pipe insulation applications. Glass fiber factory premolded fittings matching basic insulation equivalent to HAMFAB should be provided at all pipe fittings (tees and ells) and finished with glass fabric and vapor barrier mastic. Glass fiber blanket inserts with PVC covers are not acceptable for pipe fitting insulation. Fittings 8" and larger may be field mitered. Valves, strainers, flanges, etc. shall be covered with mitered insulation segments of the same type and thickness as adjoining pipe insulation.

Chilled water pump casings and large valves and strainers in steam PRV stations are to be insulated with custom made, field measured removable and reusable covers.

Piping below grade shall be factory, pre-insulated type, or be insulated with Foamglas® with Pittwrap® jacket. Piping exposed to weather and in manholes should be insulated with Foamglas®. Premolded fittings shall be provided at tees and ells. Piping with Foamglas® with Pittwrap® jacket to be bedded in sand and topped with approximately 2 feet of sand above the pipe.

Insulation of piping and fittings shall allow for thermal expansion and/or contraction, especially where bends or loops are present.

Prefabricated and pre-insulated steam piping shall consist of a steam service pipe, insulation, an air gap, and a jacket pipe which permits venting and draining of air gap area. Also include a temperature sensing line which can identify possible steam leaks in the system and their approximate location. This temperature sensing line should be run into a building, not terminated in a manhole. Steam piping insulated with Foamglas® with Pittwrap® should be pitched to drain condensate back to the steam vault drip leg.

Refrigerant suction piping and A/C unit drains should be insulated with flexible, elastomeric pipe insulation. Where exposed to weather, finish with vapor barrier jacket.

Air separators, and chiller evaporators, including flanges, are to be insulated with flexible, sheet-type elastomeric insulation.

Heat exchangers, hot water air separators, condensate receiver tanks, etc. shall be insulated with board-type heavy density glass fiber insulation and finished with canvas jacket. On condensate receiver tanks and piping, no connections or gauges shall be covered by insulation.

Insulated piping, valves, and fittings within 7 ft. of floors or work surfaces shall be finished with 0.016" smooth aluminum jacket, secured with sheet metal screws and 1/4 in. aluminum bands. Corrugated or textured jacket is not acceptable. Fittings, etc. must be covered with factory-formed aluminum elbow covers.

Insulated piping above grade exposed to weather and in manholes and tunnels shall also be finished with aluminum jacketing.

Any heat tracing elements shall be installed prior to the installation of insulation and be thermostatically controlled with a status light visible outside of the insulation.

Protect insulation at each hanger and support point with a 14 gauge galvanized shield which extends up to the centerline of the pipe and is centered inside the pipe hanger. Minimum shield length should be 12". Where glass fiber insulation is used on piping 3" and larger, provide a section of Foamglas® insulation between pipe and metal shield to prevent crushing of insulation.

7. HYDRONIC SYSTEMS

7.1. DESIGN

Size hydronic piping for a general range of pipe friction loss of 1-4 ft/100 ft. A value of 2.5 ft/100 ft. represents the mean to which most systems are designed. Flow velocities should not exceed 8 fps (4 fps for 2 in. and smaller pipe) nor be less than 2 fps.

Hydronic systems shall include a buffer tank if the system does not meet the minimum volume requirement for the equipment.

Piping runouts greater than 10 ft. in length should be a minimum size of 3/4 in.

Nominal pipe size shall be used to select and designate piping in the contract documents.

Chilled water systems should be designed for leaving water temperatures of 42-43 F; hot water systems for 180-190 F.

Chilled water coil temperature differential should be no less than 16 F for central station and built-up equipment, and no less than 12 F for terminal equipment. Hot water coil temperature differential should generally be 30 F.

The systems should be variable flow with two-way control valves provided instead of three-way. Variable frequency drives are to be provided at the pumps. Chillers shall be capable of turn down when flow turns down. A three-way valve is permissible at the end of a loop to maintain flow through the loop. All controls are to be BACNET capable.

For multiple chiller systems with variable primary flow, system shall be designed with the ability to maintain system flows when all chillers are not in operation.

Where the building is served by the campus distribution system, provide a strap-on flow meter with minimum 1% accuracy to meter the building flow. If a tertiary pump is needed, a control valve should be provided in the distribution system return line to control building return water temperature to the distribution system.

Process cooling systems shall include provisions for using the building's domestic water supply as a redundant cooling source. The system shall automatically swap to this redundant source in the event of loss of flow or the loop temperature exceeding an emergency setpoint.

Heating coils that may be subject to entering air temperatures below freezing shall be equipped with run-around pumps in the coil piping to maintain full water flow velocity through the heating coils.

7.2. PIPING

Piping 2 in. and smaller shall be Type L, hard drawn seamless copper tubing with wrought copper, solder joint type fittings, ANSI B16.22. Elbows are to be long radius pattern. Solder shall be 95-5 type. "Tee pullers" shall not be used in place of tees on copper piping. ProPress® fittings are acceptable if manufacturer's installation instructions are followed and with prior approval from UTFS.

Piping 2-1/2 in. and larger shall be seamless black steel, Schedule 40, ASTM A-53, Gr. B, or A106 with welded or flanged fittings, ANSI B16.9. Elbows are to be long radius pattern. Field-fabricated fittings are not acceptable. Forged steel, gasketed flanges, ANSI B16.5, of the welded neck type are to be used at flanged connections. Slip-on type may be used on straight pipe. Flanges must be compatible with valve and equipment connections. Where a branch connection from a main or header is one half the main diameter or smaller, saddle-type, forged steel welding fittings may be used.

Aquatherm® and other similar piping products may be considered for specific applications after prior approval of UTFS.

Welding shall conform to ANSI Code for Pressure Piping, Section B31.1. All welds shall be of the single "V" butt joint type with optimum fusion and 100% weld penetration of wall thickness. Piping should be welded by the shielded arc type electrode-electric arc process. Butt joints should be made with split backing rings. In most cases, direct welded connections shall not be made to valves, strainers, equipment, etc. The contractor should be required to obtain certification of all pipe welders on the project, in accordance with Section IX of the ASME code.

Valves must be installed in each branch circuit of all chilled and heating water.

A drain shall be provided that is located at the lowest point of the main riser.

Union or flanged connections should be provided at valves, equipment, etc. Provide dielectric unions at the junction of steel pipe and equipment with copper piping systems. Preferably, provide steel to brass to copper connections. Where size changes on horizontal lines, use reducing fittings having eccentricity down, bottom level. All piping take-offs should be made from the top of mains or headers. "Bullhead" tee connections on return piping shall not be used.

Specify adequate support for horizontal piping at intervals of not more than 7 feet for piping and tubing 1-1/2 in. and smaller and not more than 10 feet for piping 2 in. and larger. In addition, supports should be provided within 18" of all changes of direction, at all vertical pipes, and within 18" of valves 4 in. and larger or at other points of concentrated weight. Roller type guided supports should be provided where piping is subject to expansion. All pipe supports and hangers shall be those specifically designed for the piping materials being supported.

Provide adequate shields between pipe insulation and supports.

Shot pins are not acceptable fastening devices for supporting piping and hydronic specialties.

Specify identification for all piping to be snap-on or strap-on labels with flow directions, equal to that manufactured by Seton or Brady. Band color for chilled water and condenser water piping shall be green. Color for hot water piping shall be yellow. Adhesive labels or painted markings are not acceptable forms of piping identification.

Specify piping to be thoroughly flushed before it is put into operation.

7.3. VALVES

Ball valves of full port, two-(or three) piece body construction with soldered end connections and extended stems shall be used on hydronic piping 2 in. and smaller. Valves should have stainless steel balls and stem and be rated for 600 psig WOG, similar to Apollo 77-200.

Butterfly valves with lug-type body, bronze disc, EPT seat, and extended neck shall be provided on piping 2-1/2 in. and larger. Valves should be rated for "bubble-tight" service at 200 psig WP. Butterfly valves should also be used in condenser water piping.

Valves 6 in. and smaller should be provided with lever handles with infinite throttling and memory stops. Valves 8 in. and larger should have worm gear operator with hand wheel and indicator. Where gear operator is 10 feet above floor or work surface, provide chain wheel, chain, and guides.

Provide sufficient number of valves for proper isolation of the piping systems. In addition to equipment connections, valves must be provided at all major pipe branches, risers, at the service entry for each floor of a multi-story building, and at the entry to every laboratory, kitchen, equipment room, or other spaces with large quantities of piping connections.

7.4. AIR CONTROL AND DRAINS

Hydronic systems must be provided with air/dirt separation devices to minimize the amount of entrained air and sediment in the piping circuits. Manual air vents are to be provided at high points, wherever there is a change in elevation of the piping and at intervals of long runs of piping. Ball valves of 1/4 in. minimum size should be used for air vents.

Full-bladder type tanks are preferred for air confinement in the piping system.

Drain valves must be provided at low points in the piping system and where needed in mechanical rooms. Valves should be 3/4 in. ball type with capped, hose-end connections. Provide a drain valve, accessible from the mechanical room floor, on air separators and strainers and pipe to a floor drain.

The minimum pitch of hydronic lines shall be 1 in. in 40 ft. Piping shall pitch down to drain points and up to vent points.

7.5. SPECIALTIES

Strainers with 20 mesh screens should be provided at the suction of each pump and at other equipment recommended by the manufacturer, including control valves. Strainers larger than 1 in. shall be provided with a ball type blow-down valve and piped to a floor drain. Suction diffusers should be used in place of strainers on end suction pumps. The screens in pump strainers should be removed once it has been ascertained construction dirt has been eliminated.

Triple-duty valves are not preferred. Proper control valve Cv selection paired with pump VFD control should remove the requirement for them. If provided, valves should be straight pattern, in-the-line type.

Balancing valves are not needed on the discharge of variable speed pumps.

Flow balancing valves, or circuit setters, shall be provided at each air handling unit coil, coil bypass line, terminal unit coil and at other locations in the piping where required for balancing and monitoring, including major branch lines. Provide with a metering kit. Size of valves should be specified or shown on the drawings. For variable flow systems, provide automatic flow balancing valves instead of circuit setters.

Hydronic system filters of either the full flow or bypass type should be considered where piping is to be connected to existing systems. Discuss with UTFS.

7.6. INSTRUMENTATION

Thermometers with wells shall be provided at the inlet and outlet of each chiller evaporator, condenser, and heat exchanger. Thermometers should also be provided on chilled water and hot water supply lines serving each mechanical room. Thermometers must be readable from the mechanical room floor or platform.

Thermometers shall be of the adjustable angle type with minimum 9 in. scales. Range shall be specified on the drawings. Thermometer wells shall be 3/4 in. N.P.T. with 2-1/2 in. extension neck for insulated piping. All wells must be thoroughly packed with a heat conducting compound.

A single pressure gauge shall be provided for each pump, piped from the suction and discharge flanges with isolation valves. Pump gauges are to be compound type. All gauges are to be 4-1/2 in. size and have an accuracy of 0.5% over scale range. All gauges are to be provided with impulse dampeners and needle or 1/4" ball valves.

Pressure-temperature fittings (P-T plugs) shall be provided at the inlet and outlet of each AHU heating and cooling coil, chiller evaporator and condenser, heat exchanger, and 2 in. and larger control valve. Provide one P-T test kit. P-Ts should not be provided on small terminal unit coils, including VAV box HW coils, fan coil units, etc.

Flow meters shall be a clamp-on design with no liquid contact. The meters must utilize the transit-time flow measurement technique employing the use of two transducers appropriate for the pipe diameters with which it is used.

All transducers supplied must have an accuracy of better than 1% of the flow reading. All calibration and transducer data must reside in a non-volatile memory chip located in the transducer junction box or flow meter.

Flow meters must compensate for temperature change as the system ramps up and down when flow conditions start and stop. Meters must work without any low-flow cutoff or dead spots.

The flow meter electronics shall be housed in a NEMA 2, 3R or better enclosure and must have the ability to indicate flow rate, flow velocity, mass flow, total flow, signal strength, signal quality, liquid sonic velocity, Reynolds regime (laminar/turbulent/transition). The meter shall be capable of outputting multiple 4-20ma, Voltage 0-1v or 0-10v, RS-232, binary output pulse or alarm for relay total and meter status. The meters shall have the ability to status alarm for fault conditions. The meters shall have the ability to set the 4-20ma to a settable status condition (i.e. 2ma for an alarm condition).

Provide flow and BTU meters to monitor flow and energy to each building and generally within each building. At a minimum, cooling water, heating water, and process water systems should be monitored for both fluid flow and energy use throughout each building. This monitoring shall be connected to the DDC system for the building. Consult with UTFS regarding the need for additional flow and energy monitoring for specific spaces in buildings. All controls must be BACNET compatible.

7.7.PUMPS

Pumps for hydronic systems should be flexibly coupled, bronze-fitted, centrifugal type with cast iron or steel bases with drain pans. Provide with internally-flushed mechanical seals rated for 200 F. End inlet with diffusers are the preferred pump. Split case pumps dual inlet pumps are preferred for applications with higher flow rates.

Motor speed should not exceed 1750 rpm. Consider 1150 rpm pumps for high flow, low head applications.

Acceptable pump manufacturers: Bell & Gossett, Armstrong, Taco, and Grundfos.

Provide variable speed drives for motors larger than 5hp. For motors larger than 20hp, the variable speed drive shall function as a motor soft starter. All drives shall be BACNET compatable.

Pumps above 20 hp shall be floor mounted.

Condenser water pumps shall have stainless steel shafts.

Select pumps at best efficiency point. Overloading should not occur at any point on the pump curve. Flat-curve pumps are preferred over steep-curve pumps for HVAC applications. Select so that neither the largest nor the smallest impeller is provided. Resist the temptation to specify unnecessary head.

Locate pumps on ground or basement level mechanical rooms. In-line pumps shall be mounted at heights allowing service access (typically not more than 3 feet above standing surface) from the floor or equipment platforms without use of ladders or lifts. Carefully review the space available for installation and insure that the installation footprint as well as the access space required to service the pump properly is available.

Base mounted pumps must have the base filled with a non-shrinking grout. Pump couplings must be properly aligned.

Specify each pump to be provided with one spare set of bearings and mechanical seals.

8. STEAM SYSTEMS

8.1. DESIGN

Steam systems should be the two-pipe type.

High pressure (approximately 125 psig) steam is the medium available from the campus distribution system for serving a building. Low pressure (0-15 psig) steam should be used for space and domestic water heating applications; medium pressure (16-60 psig) for process applications. Do not use high pressure steam for heating.

8.2. PIPING

Steam and condensate piping shall be seamless black steel, ASTM A-106 Grade B. Steam piping 2 in. and smaller shall be schedule 80. Steam piping 2-1/2 in. and larger shall be schedule 40. Fittings shall be 2000 lb. or 3000 lb. forged steel. Cast iron fittings are not acceptable for steam or condensate piping. Piping 2 in. and smaller may have screwed or welded joints. Piping 2-1/2 in. and larger may have welded or flanged joints. Elbows shall be long radius type, unless otherwise noted.

Flanges shall be weld neck or slip-on, raised face, with non-asbestos gasket. Gasket shall be either stainless steel spiral wound strip with graphite filler or compressed inorganic fiber with nitrile binder rated for saturated steam at system design pressure and temperature. Flange bolting shall be with carbon steel bolts or studs.

Condensate piping shall be the same as steam, except Schedule 80.

Pipe fittings, welding, supports, identification, and cleaning shall comply with the requirements described in Section 6. Flange gaskets must be spiral wound, metallic type. Where size changes occur on horizontal lines, use reducing fittings with eccentricity up, bottom level.

Provide adequate compensation for expansion and contraction. Anchors, guides, expansion loops and joints, etc. where required must be shown on the drawings.

All supports and restraining devices shall be selected as part of the system stress analysis. These devices shall be suitable to sustain the static and dynamic loads of the system as defined in the applicable codes.

When rollers are used, the piping saddles shall match or exceed the insulation thickness. When slides are use, a Teflon slide surface shall be integral to the slide design. All pipe supports shall be secured in position. Anchor and guide supports shall be cast into base slabs whenever possible. When supports provide only vertical support, they may be secured via stainless anchor bolts rather than being cast in place.

No anchoring systems which use insulation as a means of pipe restraint or support are permitted. Anchors shall be welded to the piping with full welds along the contact lines. Piping shall be pitched slightly from anchors towards steam vaults on each side of anchor points. All wear shall occur between saddles and roller or between guides and their contact points, with no wear at the piping.

Anchors for use on underground piping shall be shown on the engineered drawings.

Pipe hangers shall be those specifically designed for steam and condensate use.

Expansion joints shall be the tube type "Yarway" with single end or double ends, flanged or butt welded. Expansion joint design shall include packing glands with screw down plungers to force additional packing into the stuffing box. The additional packing is added, when needed, evenly around the expansion joints via the packing cylinders. The manufacturer's instructions for installation and maintenance must be followed without exception. Bellows design expansion joints are not to be used on steam and condensate piping.

Steam and condensate piping shall pitch down to drains and up to vent points. The minimum pitch of steam lines shall be 1 in. in 40 feet. The minimum pitch of condensate lines shall be 1 in. in 20 feet.

Specify identification for all piping to be snap-on or strap-on labels with flow directions, equal to that manufactured by Seton or Brady. Band color for all steam and condensate piping shall be yellow. Include pressure on steam pipes. Adhesive labels or painted markings are not acceptable forms of piping identification.

Piping shall be flushed with water to remove loose debris prior to testing.

All steam and condensate piping shall be tested at a hydrostatic pressure of 225 psig for at least 4 hours without pressure drop. If any leaks are found and corrected, the test shall be repeated. UTFS must witness this test being performed.

After testing, piping shall be cleaned by means of steam blow only prior to connection to the campus distribution system. Piping shall be steam blown 3 times, with a cool down between each blow, to thermal cycle the piping and release welding slag and bonded debris. The exhaust end of the lines being blown shall be muffled or quenched to maintain 85 dBA or less at a distance of 50 feet from the steam discharge point. Precautions should be taken to prevent materials blown from the end of the piping from settling on cars, buildings, or persons in the area.

All inline instruments or devices shall be removed and replaced with spool pieces as necessary prior to flushing, steam blowing, and testing. Any temporary piping shall be designed in accordance with ASME B31.1. Replace all instruments and devices after successful test.

8.3. VALVES

Gate valves shall be provided on steam and condensate lines to isolate risers and branches from mains, and to isolate each piece of equipment, control valve, fixture, etc. Gate valves 6 in. and larger installed more than 10 feet above the floor shall be provided with chain wheel, chain, and guides.

Gate valves 2 in. and smaller shall be 800 lb. socket weld, OS&Y, solid wedge disc. Forged steel body, ASTM A105 with maximum 0.31 percent carbon suitable for operating at campus steam temperature of 365F.

Globe valves 2 in. and smaller shall be 800 lb. socket weld, OS&Y, loose disc. Forged steel body, ASTM A105 with maximum 0.31 percent carbon. Stellited disc and seats. Seats integral. Welded bonnet and bolted gland. Valve dimensions per ANSI B16.10.

Check valves 2 in. and smaller shall be 600 lb. socket-weld. Horizontal lift, cast steel body, ASTM A216 Grade WCB with 0.30 percent maximum; or forged steel body, ASTM A105 with 0.31 percent carbon. Stellited disc. Seats integral. Bolted cap with contained Flexitallic (or equal) gasket. Dimensions of socket weld ends to comply with ANSI B16.11.

Gate valves 2-1/2 in. and larger shall be Class 300, outside screw and yoke, flexible wedge disc. Cast steel body and bonnet per ASTM A216 WCB. Bonnet gasket to be stainless steel spiral wound. Hard- faced seat rings. Disc to be CA-15 or 13 % CR overlay. Stem to be 410 SS. Graphite packing. Back seat 410SS. Bonnet studs A193 Gr. B7, nuts A194 Gr. 2H. Face to face dimensions per ASME B16.10. Weld ends per ASME B16.25. Flanged ends per ASME B16.5. Steel grease fitting. (Valve similar to Crane fig 33 and 33 ½ for flanged and butt weld ends)

Globe valves 2-1/2 in. and larger shall be Class 300, outside screw and yoke, bolted bonnet. Cast steel body and bonnet per ASTM A216 WCB. Bonnet gasket to be stainless steel spiral wound graphite. Hard-faced seat rings. Disc to be 13 % CR overlay. Gland 410 SS, Stem to be 410 SS. Graphite packing. Back seat 410SS. Bonnet stubs 193 Gr. B7, nuts A194 Gr. 2H. Face to face dimensions per ASME B16.10. Weld ends per ASME B16.25. Flanged ends per ASME B16.5. (Valve similar to Crane fig 151 and 151 1/2)

Check valves 2-1/2 in. and larger shall be Class 300, Bolted Cap. Cast steel body and cap per ASTM A216 Grade WCB. Cap gasket to be stainless steel spiral wound graphite. Hard faced seat rings. Disc 13 % CR Overlay, Hinge WCB, Hinge pins 410 SS, Cap screw A307 Grade B. Cap studs A193 Gr. B, Nuts A194 Gr. 2H.

Gate valves 8 in. and larger in high pressure piping shall have integral bypass and valve.

Provide steam distribution valves with weld-end connections.

8.4. SPECIALTIES

Strainers of 250 lb. SWP, (300 lb. if more than 100 psig steam) Y-pattern shall be provided upstream of all control valves, pressure reducing valves, steam traps, etc. Provide globe blowdown valves piped to the floor on strainers larger than 2 in.

Steam traps should be inverted bucket type with 1 in. connections. Steam traps must be positioned below the steam line for optimum drainage of condensate. The orifice sizes used in the traps shall be sized to suit system design conditions.

Traps shall be installed with isolation valves, unions, check valves, and a strainer with blow down valve.

Float and thermostatic traps may be used on any equipment where steam pressure may vary from maximum supply pressure to vacuum.

Size traps to handle two times the maximum equipment rating. Bypass lines are not required around steam traps.

All condensate from buildings and from trap discharge shall be routed to a vented flash tank and then a condensate receiver. Condensate is pumped from the receiver to the condensate return line. Elevated tanks are preferred if condensate can be gravity-drained. Provide with tank thermometer and inlet strainer.

Condensate from a trap injecting directly into a pumped condensate return line is not permitted.

The condensate pump/receiver sets shall be duplex type provided with a float operated mechanical alternating switch, sight glass, and check and gates valves on each pump discharge line.

The condensate pump shall be rated for continuous operation of pumping 212 F fluid. Back pressure in the condensate line must be taken into consideration when sizing the pump set.

Condensate pump motors shall be “off the shelf” electric motors for easy replacement from a typical motor supplier.

Provide pressure gauges on the discharge of each condensate pump, upstream and downstream of each pressure reducing valve, and on steam supply to heat exchangers. Gauges shall be 4-1/2 in. size and have a minimum accuracy of 0.5% over scale range. Provide each gauge with an iron coil siphon and needle valve.

Provide a clamp-on condensate flow meter to monitor steam flow for each building.

8.5. PRV STATION

High pressure steam from the campus distribution system shall be reduced to medium and low pressure for process and space and domestic water heating applications through a pressure-reducing valve station.

Reducing stations shall be single or two-valve, single stage type, complete with pressure reducing valves, pressure controller, air loading valves, relief valves, isolation valves, pressure gauges, and, where required, transfer valves.

Reducing and regulating valves shall be normally closed, air loading, diaphragm-operated type, 250 lb. SWP with cast iron body and stainless steel trim having “Stellited” renewable seat ring for entering pressures less than 100 psig. For pressures greater than 100 psig, provide 300 lb. cast steel regulating valve. Valves shall be selected so that a noise level of 90 dba will not be exceeded. Reducing and regulating valves 2 in. size and larger shall have flanged connections.

Locate PRV stations near exterior walls for access to ventilation air. Piping, flanges, etc. should be at least 12 inches from wall.

8.6. CONVERTORS

In most instances, where steam is available, a heat exchanger shall be installed to provide hot water for the building heating medium.

Heat exchangers shall be steam-to-water type of shell and U-tube construction, ASME labeled for 125 psig working pressure. A manufacturer's data report for unfired pressure vessels is to be submitted to the University certifying that construction conforms to the latest ASME code for pressure vessels. The form must be signed by a qualified inspector who holds a National Board Commission.

Steam supply pressure to the exchanger control valve should be 10-15 psig and capacity based on a fouling factor of 0.001. Steam pressure downstream of the control valve should be about 80% of that upstream of the valve. A single (where capacity permits) F&T trap selected for a capacity of double the condensing rate should be provided.

Locate heat exchangers near exterior walls for access to ventilation air.

Heat exchangers/converters shall be located to allow space for removal of tube bundle for inspection and repair/replacement.

8.7. STEAM VAULTS AND TUNNELS

Steam vaults shall be sized to provide adequate and safe movement within the finished vault. This includes work clearances for operating and replacing valves, traps, or other components. A typical vault size is approximately 10 ft x 10 ft x 8 ft high internally with 12-inch-thick walls, with larger vaults being used as necessary to maintain working clearances.

Steam vaults to be constructed with two openings for egress, component removal and installation, and ventilation of the vault. Openings shall be sized to allow for the removal/installation of components. Openings are optimally located diagonally across the vault, rather than along a single side.

If required for valve operation or service, an access opening is allowed on the top of the vault in addition to the egress openings. Such access openings should have a water seal in place to keep water out when closed. Covers for the vault openings to be lightweight, lockable, and be able to withstand vehicle loads. Covers to be designed for steam vault applications and have stainless steel tags that bear the identification number of the vault.

Access openings to have galvanized steel ladders up to 6" below cover in lieu of cast in place steps. The steam vaults to be waterproofed by applying a sprayed on or rolled on membrane to provide overall water proofing. Special attention to be given to joints and penetrations where extra coats are needed to insure a water tight seal. Piping penetrations in the steam vaults shall use an approved "link seal" product to provide a water tight seal. The structural design of the vault walls, roof, floor, and re-enforcement of the vault to be designed by a licensed structural engineer.

Steam tunnels to have a minimum of 8 feet of head clearance, and 3 feet of clear aisle space for walking and carrying materials. They are to be cast in place and have egress openings approximately 300 feet in any direction. The walkthrough tunnels shall have natural ventilation with thermostat controlled fans to assist where needed. Fans are also to be provided with a hand/off/auto switch. Water proofing of the walk through tunnels to be similar to that used for water proofing of the steam vaults.

9. HEAT TRANSFER EQUIPMENT

9.1.AIR HANDLING UNITS

Provide field-assembled or factory-fabricated, central station air handling units for mechanical systems. All unit sections should be of double-wall construction with 2 in., 3.0 lb. density fiberglass or foam insulation. For most applications, provide a perforated interior liner for the fan section. Provide units with positive draining, double wall stainless steel drain pans. Where coils are stacked, provide intermediate pans. Lay out units to permit servicing and repair of fans and filters and replacement of coils.

There should be access to each side of each coil. Where access cannot be attained through fan or filter sections, full sized access sections with hinged doors, preferably not less than 18" wide should be made available. Where space permits, hinged access doors should be installed on both sides of fan casings, access sections, filter sections, and mixing box sections. Screws or bolts are not acceptable for access to coils, etc.

Install units and field-assembled plenums on a minimum 4 in. high concrete housekeeping pad. Rails may be acceptable in some applications. If not provided with the unit fan, install on spring vibration isolators.

Specify opposed blade dampers for mixing boxes with air leakage not greater than one percent of the rated flow. In addition to the return air damper, provide one minimum and one maximum (for economizer operation) O.A. damper in the O.A. damper section.

Belt drives are to be sized for a minimum of 150% motor hp. Specify a minimum of two belts for the drives.

Fan bearings shall be grease lubricated, self-aligning ball, or roller type mounted externally and designed for 200,000-hour life. Bearing lubrication lines must be extended to an easily accessible location. Provide one spare set of bearings and belts for each fan.

Provide variable speed drives for motors greater than 5 hp.

Include in the AHU schedule on the drawings total, external, and component (coils, filters, dampers, etc.) static pressure. Indicate whether or not the static pressure for the filters is included in or independent of external static. Total static pressure should be the sum of external and component static pressures.

Filter static pressure indicated should be the change-out pressure. A guideline for this is 3/4 of the distance between the published initial and final or terminal pressure drops. Another is no more than twice the initial pressure drop.

A thermometer of the proper range and size must be provided in the discharge duct of each air handling unit.

Air handling unit submittals shall include fan curves for maximum and minimum operating conditions.

9.2. UNITARY SYSTEMS

Unitary systems and their components shall conform as closely as possible to the criteria defined elsewhere in this document.

Unitary systems shall be provided with hot gas reheat for humidity control.

Unitary systems shall be equipped for standalone economizer operation.

Systems shall be mounted on a roof stand instead of a roof curb. The roof stand shall be 18" to 30" above the finished roof surface.

Unitary systems shall be directly connected to the building DDC system.

9.3. COILS

Cooling and heating coils shall have minimum 0.007 in. aluminum plate fin secondary surface and 0.024 in. seamless copper tubing primary surface with not more than 11 fins per inch. Avoid spiral-type fin configurations.

The physical height of cooling coil sections should be limited to 45 in.

Select AHU chilled water coils for a minimum 16 F temperature rise and hot water coils for a 30 F temperature drop.

Cooling coils should be piped so that chilled water is supplied on the air leaving side and is returned on the air entering side. Arrange unions or flanges so that coils can be removed without removing any additional piping upstream of the unions.

In general, CW coil face velocities should not exceed 500 fpm.

Indicate coil pull space on mechanical room floor plans.

9.4. CHILLERS

Centrifugal water chillers shall be provided on projects requiring more than 200 tons. Compressors may be single or multi-stage, open or hermetic. Machines shall be specified to deliver water at a temperature of 42 F (with the exception of ice storage applications) with an evaporator temperature not below 32 F.

Chillers should have microprocessor-based controls compatible with the campus energy management system. Capacity control should be electronic and capable of modulation from 100% to 10% of rated capacity. Chiller controls shall have the capability of connection to the building DDC system for remote control.

Evaporator and condenser tubes shall be 0.028 in. thick copper, smooth or enhanced.

Provide centrifugal chiller water boxes with davits or hinged doors to optimize service and cleaning of tubes.

Where required, provide low pressure chillers with a high-efficiency purge system, consisting of air cooled condensing unit, purge condensing tank, and pump-out compressor. The purge exhaust shall not exceed 0.05 lb. refrigerant per lb. of purged air. Purge system to be provided by chiller manufacturer.

Low GWP refrigerants may be used in equipment.

Safety and operating controls shall include the following: current limiting overload device; evaporator and condenser pressure/temperature gauges; oil pressure gauge; temperature cutouts for low chilled water and refrigerant temperatures and high motor, compressor discharge, oil, and bearing temperatures; pressure cutouts for low oil and refrigerant pressures and high condenser pressure; oil pump switch; guide vane time delay switch; evaporator and condenser water flow switches; and pilot lights for safety circuit items.

The chiller system should include power factor correction capacitor to maintain minimum PF of 0.95 at loads between 40-100%, as well as motor soft starters or variable speed drives for motors greater than 20 hp. Noise suppression lagging on machines should be installed where noise level exceeds 85 dBA.

Chillers should be placed at ground level or basement mechanical rooms with sufficient clearance to perform maintenance, repair, and replacement of components, including evaporator and condenser tube bundles.

Factory start-up report must be provided before final acceptance.

Low ambient control shall be provided.

9.5. COOLING TOWERS

Cooling towers shall be induced draft, cross-flow, stainless steel construction with PVC fill and stainless steel or PVC louvers, complying with current CTI design standards. Counter-flow towers are to be avoided. Fans are to be gear driven or direct drive, with a low turn down ratio for variable speed operation. Use of any belt drives requires specific advance approval from UTFS. Cooling tower submittals shall include CTI performance curves.

All steel panels and structural members, including the structural frame, hot and cold water basins, distribution covers, fan deck, and fan cylinder shall be constructed of Series 300 stainless steel and assembled with Series 300 stainless steel nut and bolt fasteners. All factory seams in the cold water basin shall be welded to ensure watertight assembly and welded seams shall be warranted against leaks for five (5) years. Stainless steel basins with bolted seams are not acceptable. The entire cooling tower, including fan motor, drive system, bearings, and structure, shall be backed by a comprehensive 5-year warranty.

Any fiberglass or plastic components are not acceptable.

Base design on entering and leaving water temperatures of 95 F and 85 F, respectively, with 80 FWB ambient temperature. Drift loss shall be less than 0.001%.

The location of the cooling tower on the project site should be coordinated with UTFS. The elevation of the tower basin and condenser water pump must be thoroughly reviewed to assure pump operation free of cavitation. Ladders serving cooling tower platforms and fan decks must extend to grade or roof deck and comply with OSHA standards. Two ladders must be provided where needed for access to both sides of the fan deck. Handrails and service platforms should be installed as required by OSHA standards.

Provide sufficient heat in the basin and at the exposed piping to avoid draining during cold weather.

Provide a variable speed fan for condenser water temperature control. Maintain set point by varying the speed of the fan and positioning 3-way diverting valves, 1 valve in the supply and 1 valve in the bypass line that operate in series. (Bypassing the tower basin is preferable). Tower bypass lines shall be full supply pipe size and located near the tower and not in the mechanical room. Interlock tower fans and condenser water pumps so that fans will only operate when pumps are operating.

Vibration limits shall be according to CTI Cooling Tower Manual. Vibration limits shall be achieved through the warranty period without any maintenance or remedial work other than normally scheduled maintenance and operation. Any vibration limit switches shall be field-adjusted to comply with CTI.

All taps and ports necessary for CTI testing shall be provided.

CTI testing for performance and capacity should be performed for field-erected towers. UTFS reserves the right to test all towers for capacity, performance, and drift during the warranty period. Corrections of any deficiencies noted during such testing shall be made the responsibility of the installing contractor.

Cooling towers shall not produce prominent tonal sounds that are audible in any of the surrounding buildings or areas.

10. TESTING AND BALANCING

The HVAC system design must incorporate means for balancing the air and water systems. Such means include dampers, temperature and pressure test connections, flow meters, and balancing valves.

An agency or subcontractor independent of the contractor is required to balance the air and water systems. This subcontractor should be AABC or NEBB certified.

Air side testing and respective adjustment should include the following:

1. Equipment and motor data.
2. Traverse air flow measurement of all main supply air, return air, outside air, relief air, and exhaust air ducts, especially those at AH units and ducted exhaust and return air fans.
3. Static pressure at entering and leaving points of each AH unit, exhaust, relief, or return fan, coil, filter bank, etc.
4. Entering and leaving air temperatures at AH unit coils.
5. Fan rpm and motor volts and amps. Fan curves for AH units and return and exhaust fans must be included in the report.
6. Air flow rate and pressure differential for each VAV box.
7. Air flow rate at each register and diffuser.

Water side testing and respective balancing should include the following:

1. Equipment and motor data.
2. Differential pressure and water flow rate at each AH unit, heat exchanger, chiller evaporator, and condenser, and at each flow meter, including flow meters serving terminal equipment (VAV boxes, etc.).
3. Entering and leaving water temperatures at AH unit coils.
4. Shut off head, full flow head, final head, and final flow rate at each pump. Pump curves must be included in the report, as well as motor voltage and amperage.
5. Entering and leaving pressure at each AH unit coil, chiller evaporator and condenser, and heat exchanger.
6. Include testing and balancing of domestic HW recirculating system.

The balancing report must include a drawing or sketch identifying each terminal unit and register and diffuser with respect to the spaces served. Each AH unit should also be identified, with test points indicated.

11. CONTROLS

Direct digital temperature controls (DDC) with electronic operators must be included for all mechanical systems. The acceptable controls vendors are Trane, HSC – Automated Logic, and Hoffman Building Technologies – DISTECH. If specific equipment or systems have their own controllers (for example, chiller plant controllers), these must be fully compatible with the DDC systems and BACNET.

For buildings with existing DDC systems being expanded or partially renovated, specific discussion with UTFS is required to coordinate appropriate controls scope prior to the completion of design.

All controls systems shall be fully open protocol with no points hidden. All controls systems installed shall be coordinated with UTFS to connect fully with the UTFS front end system. This also applies to any specific equipment or systems with their own controllers separate from the DDC system.

A new PC or laptop for DDC system monitoring is required to be provided with each new building controls installation. A new PC or laptop is not required when renovating or repairing an existing system. Any software used for the DDC system shall be made available to UTFS without additional cost and must be capable of connecting to all control systems of the same vendor on campus.

11.1. GRAPHICS

Software graphics with pictorial representations of equipment and devices being controlled and actually displayed on the PC monitor must be provided. Ability to change or add graphics by UTFS is critical and must be allowed.

11.2. CONTROL WIRING

In general, 24v control wiring should be furnished and installed by the control subcontractor. The electrical subcontractor should be responsible for furnishing and installing all 120v and above wiring and associated conduit, required starter coils, etc., as well as starters and control panels not within a packaged unit. This must be coordinated with the electrical engineer.

11.3. AIR COMPRESSORS

Where required due to modifications of existing pneumatic controls systems, duplex control air compressors shall be high pressure, low dew point design with single ASME receiver of 30-gallon minimum capacity. Compressor unit shall be sized to operate on one-third on, two-thirds off time cycle. Provide automatic drains, vents, relief valves, manual valves, gauges, pressure regulators, filters, belt guard, control accessories, etc.

An alternator shall be provided to automatically start the second compressor if the first fails to maintain receiver pressure. It shall also alternate the order of starting the compressors to balance run time.

The compressor unit shall be mounted on a 4 in. concrete housekeeping pad with vibration isolators.

A properly sized refrigerated air dryer to be installed before discharge to building.

11.4. PNEUMATIC TUBING

Where used in existing pneumatic controls systems, seamless copper tubing shall be provided for all pneumatic lines. Tubing shall be Type M with either solder or compression connections. Polyethylene tubing may be used only inside equipment enclosures and at thermostat and operator connections with a 12 in. maximum length.

11.5. GAUGES

When manual gauges of any type are provided on air or water systems, gauges shall be provided with a valve cock installed below them to allow changing the gauge without shutting down the monitored service.

11.6. THERMOSTATS

Room thermostats shall be the electronic type compatible with the direct digital control system and equipped with communication ports. Thermostats must be provided with setpoint adjustment capability with a temperature scale indication in Fahrenheit gradations. Accuracy shall be ±1 F. The location of wall thermostats should not interfere with light switches.

Controls for all thermostats and temperature sensors shall be configured to allow for settings to heat a space to one temperature and cool to a different temperature. Typical settings would be heating to 68.5F and cooling to 73.5F, with a dead band between those setpoints.

All thermostats, including night low limits, etc., shall be indicated on the HVAC floor plans. Provide with appropriate guards where subject to damage.

11.7. HUMIDITY SENSORS

Humidity sensors shall be provided in each control zone. Wall and duct mounted humidity sensors shall have ±2% RH accuracy. Combination sensors, where required, shall have thin-film platinum type temperature sensors.

The location of wall humidity sensors should not interfere with light switches. All humidity sensors shall be indicated on the HVAC floor plans.

All humidity sensors shall be connected to the building DDC system.

11.8. AIR AND WATER DP SENSORS/TRANSMITTERS

DP sensor/transmitters should be a 3-valve manifold assembly that will allow field test measurements to be taken without interrupting the BAS reading.

11.9. CONTROL VALVES

Valves 8 in. and smaller shall be equal percentage type ball valves. Provide electronic actuators with spring return.

Provide bypass valves for critical systems and all heating in air handlers.

11.10. CONTROL DAMPERS

Provide opposed blade dampers with air leakage not greater than one percent of the rated flow.

11.11. TEMPERATURE CONTROL DRAWINGS AND SEQUENCES

A schematic drawing showing applicable sequence of operation for each HVAC system, including AHU's, chillers, cooling tower/condensers, boilers, heat exchangers, exhaust fans, etc. should be provided Schematics and sequences must be shown on the HVAC drawings, not in the Project Manual. Sequences must be clear and concise, written as simply as possible.

Sequences for AHU's should start with turning the unit on in the occupied mode, then describing the cooling control (with economizer if applicable), the heating control (if not sequenced with the cooling), air flow control if VAV, including RA fan control, if applicable, the operation in the unoccupied mode, the safeties, and ending with a brief description of desired points, etc. to be monitored. The following Temperature Control Sequence for Operation of AHU's marked with an asterisk (*) shall be applied when applicable:

I. Start the Air Handler
   a) BAS
   b) Occupied Mode HOA Sw.
   c) Min OA damper*
   d) Smoke dampers*
   e) 100% OA damper*
   f) RA fan (economizer)*
II. Control the Temperature
   a) Cooling Coil
   b) Economizer*
   c) Heating Coil
   d) Air Flow*
   e) Dehumidification
III. Control the Preheat*
   a) F&B dampers*
IV. Control the Air Flow (VAV AHU)*
   a) RA fan (economizer)*
V. Safeties
   a) Freezestat
   b) Smoke Detectors
VI. Unoccupied Mode
   a) Temperature Setback
   b) De-energize*
VII. Monitor
   a) SA temperature
   b) SA Fan Status
   c) OA temperature and Humidity (global)
   d) Filter DP
   e) RA temperature and Humidity (economizer)*
   f) Preheat Temperature*
   g) Duct SP (VAV AHU)
   h) SA CFM*
   i) RA CFM (economizer)*
   j) Minimum OA CFM*
   k) Space Temperature and Humidity (dehumidification control)*
   l) RA Fan Status (economizer)*

Specify hydronic DP transmitters to be initially set up at 15 psig, then adjusted by TAB agency.

Show location of DP and SP sensor/transmitters on plans. Do not specify SP sensors to be located "2/3 length of SA duct".

12. PLUMBING

12.1. DOMESTIC COLD WATER SYSTEMS

Domestic cold water service will be provided from a connection to the existing site main using pressure booster pumps if required. Domestic cold water will serve toilet rooms, mop receptors, general purpose sinks, wall hydrants, and other specific equipment as required. A minimum pressure of 25 psig should be maintained to operate water closet flush valves.

Pressure reducing valves shall be provided just downstream of the meter. Provide a full-size bypass loop around the PRV and meter.

Just downstream of the meter bypass loop, the incoming domestic water service shall be provided with two reduced pressure backflow preventers of equal size piped in parallel to protect the site system from contamination. Each backflow preventer shall be sized to accommodate full flow conditions with installation such that flow can be equalized to each one. Each backflow preventer assembly shall be provided with Y strainer and air gap. Test cocks shall face up. Isolation valves shall be provided before the strainer and after the backflow assembly to allow for either backflow preventer to be removed. The strainer shall have a drain plug connected to the blow-off port for flushing.

System capacity shall be based on fixture unit values with appropriate code factors and actual equipment demands.

12.2. DOMESTIC HOT WATER SYSTEMS

Domestic hot water systems shall be provided with complete supply and return piping to maintain hot water at each appropriate fixture at all times. Hot water shall be distributed in the domestic hot water system at 120 F with service to lavatories, showers, general purpose sinks, service sinks, and other specific equipment as required. For requirements for higher temperature water, local booster water heaters should be provided with the equipment.

Hot water should be produced by steam-fired instantaneous hot water generators, similar to PVI COBREX units. System capacity shall be based on fixture unit values with appropriate code factors and actual equipment demands.

Provide circuit setters on branch recirculating lines at each floor.

12.3. SERVICE PIPING

Aboveground domestic hot and cold water piping shall be Type L hard drawn copper with wrought copper fittings or PEX-a piping and fittings. Water lines installed underground shall be Type K copper with wrought copper fittings or HDPE with appropriate fittings. Underground piping thickness shall be appropriate for the expected loads from roadways or vehicles. Soldered joints shall be made with lead-free 95-5 solder. Press-type joints may not be considered. Underground HDPE piping may be considered after review by UTFS.

Mechanically formed tee connections are not acceptable for piping tees.

Outside water mains shall be A.W.W.A. bell and spigot cement lined ductile iron (250 lb. class), provided with a coat of black asphaltum, or HDPE with appropriate fittings.

Underground valves shall be in accordance with those A.W.W.A. listed for domestic water mains. Underground piping shall be of the thicknesses adequate for the loading from roads or vehicles.

All mechanical underground valves to be “Right Handed” with shut off clock-wise and opening counter-clockwise. Valves to be installed for ease of operation using a “T Handle” operator. Valves should be exercised periodically during construction to insure ease of operation.

Service water piping shall be clean and free of gravel and debris once the installation is complete. Service water piping shall be tested and disinfected in accordance with applicable code requirements. Testing shall be completed by an approved, third-party testing lab.

Water hammer arresters shall be located in domestic water piping as necessary to eliminate noise and prevent possible damage to the piping system from excessive vibration.

An isolation valve for each water service main, branch main, riser, branch serving a floor in a multi-story building, branch line serving a group of fixtures, and each equipment connection shall be provided. Valves shall be two (or three) piece, full port ball type with SS balls and stem for pipes 2 in and smaller and lug butterfly valves for pipes 2-1/2 in and larger.

Pipe hangers shall be those specifically designed for the piping and insulation materials being used. Hangers shall be spaced so as to prevent pipes from sagging between them. Hangers are required at every change of direction in the piping.

Piping identification shall comply with Section 8 in these design criteria. Specify identification for all piping to be snap-on or strap-on labels with flow directions, equal to that manufactured by Seton or Brady. Band color for domestic cold water shall be green and yellow for domestic hot water and hot return respectively. Fire protection shall be in red color, while natural gas should be yellow. Adhesive labels or painted markings are not acceptable forms of piping identification.

12.4. SANITARY AND STORM DRAINAGE SYSTEMS

A separate sanitary drainage, waste, and vent system shall be provided for all water closets, lavatories, service sinks, etc. Sanitary drainage shall be connected by gravity directly into the site sewer system. Capacity shall be based on fixture unit values with appropriate code factors and actual equipment demands.

A stormwater drainage system shall be provided for all roof, clear waste, and area drains and connected into the site storm system. Particular attention should be paid to the University of Tennessee Illicit Discharge Policy when considering drain connections to the storm system.

Cleanouts should be provided for access to horizontal and vertical drain lines to facilitate inspection and provide a means of removing obstructions. Cleanouts shall be not more than

100 feet apart measured from the upstream entrance to the cleanouts. Cleanouts are required for any change of direction greater than 45 degrees.

For building sewers 8 in and larger, manholes shall be provided and located not more than 200 feet from the junction of the building drain and building sewer, at each change in direction and at intervals of not more than 400 feet apart.

Sanitary and storm drainage system materials shall follow applicable codes and standards. Pipe fittings shall be appropriate for the materials used.

Cast iron piping shall be used for underground locations where pipe coverage is less than 4 feet in areas with traffic loading, locations where pipe coverage is greater than 15 feet before or after installation, and where crossing above or below water mains, other drain lines, and steam lines.

Piping should be pitched to drain at a minimum slope of 1/4 in. per foot for piping 3 in. and smaller, and 1/8 in. per foot for piping 4 in. and larger.

Discharge from sump pumps shall be separately routed to exterior structures located such that any pressurized waste backflow shall not re-enter a building.

12.5. GREASE INTERCEPTORS

Grease interceptors shall be sized and installed in accordance with the Knoxville Utilities Board Grease Control guidelines.

12.6. INSULATION

Hot, cold, and chilled water and roof drain piping must be insulated to prevent energy loss and condensation. Insulation of cold and chilled water piping shall include an exterior vapor barrier. Insulation shall comply with Section 6.

12.7. FIXTURES AND SPECIALTIES

Plumbing fixture material should be of non-absorptive, acid resistant type. Provide a schedule on the drawings to indicate each type of fixture specified, including supply and waste sizes, trim, accessories, manufacturer and model number, etc. Schedules in the project manual are not acceptable.

A 1/4 turn ball valve shall be provided at each fixture. Each fixture, floor drain, or other equipment connected to the drainage system shall have separate traps installed as close to the fixture as possible with a cleanout for each trap. Wall mounted fixtures shall be supported with floor mounted fixture carrier.

Water closets shall be wall hung for all new construction. Floor mounted can be considered in renovation applications with existing floor mounted water closets only with prior approval of UTFS.

Water-efficient fixtures are required. Sensor activated flush valves and lavatory faucets should be provided. Faucet temperature adjustment should be included where needed.

Urinals should be 1/8 gal, low-flush type with battery operated flush valves. Water closets must be provided with batter operated 1.1 gal/flush or less valves.

Lavatory faucets for most applications must be selected for a maximum water usage of 0.5 gpm (60 psi).

Fire hydrants shall be a 3-way design with two hose connections and one pumper connections. The main valve opening shall be 4-1/2 inch unless otherwise required for a specific use. Hydrants shall be rated at 250 psig working pressure and 500 psig static test pressure. Left turn shall open hydrants.

12.8. FIXTURE PREFERENCES

The following is a list of the UTFS preferred manufacturer and, in some cases, the preferred model number for various plumbing fixtures. These preferences are not strict requirements, but shall be considered when selecting the basis of design and creating the design specifications.

Backflow Preventers: Wilkins
Fire Hydrants: Mueller Super Centurion 250 3-way
Domestic Water Pumps: Grundfos
Floor and Roof Drains: Zurn
Wall Hydrants: Zurn
Sump Pumps: Zoeller
Sanitary Sewerage Pumps: Zoeller
Instantaneous (Tankless) Water Heaters: PVI COBREX Double Wall
Water Closets and Flush Valves: Zurn with 1.1 gpf
Urinals: Zurn with 0.125 gpf
Mop and Service Sinks: Zurn
Kitchen Sinks and Faucets: Symmons, Elkay, and Zurn
Sinks: Elkay
Lavatories and Faucets: Zurn
Safety Showers and Eye Washes: Bradley
Thermostatic Mixing Valves: Symmons for point of use, Bradley for emergency fixtures
Water Coolers: Elkay with Bottle Fillers
Shower Valves and Showers: Symmons
Shower Bases: Comfort Designs with 10 year warranty

13. FIRE PROTECTION

The building shall be fully sprinklered with automatic wet pipe sprinkler systems being the primary type of fire suppression. Dry pipe sprinkler systems must be utilized in spaces subject to freezing. The wet sprinkler systems on each floor should take their water supply from a fire protection standpipe system, creating a sprinkler/standpipe system.

The water supply shall be provided by connections to the site water system before the point of domestic water metering. A fire department connection shall be provided at the building.

The sprinkler system design shall comply with applicable editions of and NFPA Standard 13. The installing contractor is required to provide a sprinkler system layout sized by hydraulic calculations. Design documents, however, must comply with the State Board's minimum criteria for fire protection sprinkler design.

A Class I wet standpipe system shall be provided to supply fire department hose valves and the sprinkler systems on each floor. Design shall comply with applicable editions of NFPA Standard 14.

All fire pump couplings shall be metallic. Elastomeric pump couplings are not allowed.

Flexible sprinkler head fittings similar to Aquaflex may be provided if acceptable the Tennessee Fire Marshal.

14. LABORATORY SYSTEMS

14.1. LABORATORY AIR PRESSURIZATION CONTROL

For laboratories with fume hoods or defined air pressurization requirements, provide a system to control air pressurization. This system shall control the supply air, hood exhausts, general exhaust, and any other exhaust air flows. This system shall not include temperature control devices but shall receive inputs for temperature controls from the building DDC system.

14.2. LABORATORY WATER SYSTEMS

Laboratory area sinks, cup sinks, and required equipment drainage will be collected into a separate acid waste system in the building and discharged into a neutralization basin before being discharged into the site sanitary waste system. Acid waste piping shall be fire-retardant polypropylene with heat-fusion joints.

Laboratory grade purified water shall be provided where required for general laboratory uses such as laboratory testing, rinse water, and wash water. Purified water shall be distributed in a continuous loop system. Any dead legs to fixtures shall be minimized. Piping and fittings shall be beta-polypropylene with socket welded joints. Valves and supplies must also be of materials that will not contaminate the purified water before the point of being used.

The water purification system shall be provided by a third party vendor contracted by UTFS. Space in a ventilated mechanical room shall be provided with necessary power and supply and return piping connections for the equipment skid. The specific sizing of this equipment will be based on the design demand calculations and the required purity, so careful coordination during the design process will be required.

The use of domestic water for process cooling is prohibited except for emergency backup.

14.3. LABORATORY COMPRESSED AIR

Where building programs indicate a need for laboratory compressed air, duplex multi-stage oil-free scroll air compressors shall be provided. Compressor discharge pressure shall be based on programmatic requirements, but not below 115 psi. Compressor unit shall be sized to operate on one-third on, two-thirds off time cycle. Provide automatic drains, vents, relief valves, manual valves, gauges, pressure regulators, filters, belt guard, control accessories, etc.

Provide a refrigerated air dryer at the wet tank to maintain a system dewpoint of -40F.

Desiccant dryers should be installed between the compressed air loop and the building supply line.

The compressed air system shall be equipped with an ASME-rated wet tank at the outlet of the air compressor.

An alternator shall be provided to automatically start the second compressor if the first fails to maintain receiver pressure. It shall also alternate the order of starting the compressors to balance run time. Multi-stage scroll machines shall have a self-contained control system with the ability to lock out a single stage in case of a failure.

The compressor unit shall be mounted on a 4 in. concrete housekeeping pad with vibration isolators.

14.4. LABORATORY VACUUM SYSTEMS

Where building programs indicate a need for laboratory vacuum systems, duplex multi-stage oil-free scroll vacuum pumps shall be provided. Vacuum pressure shall be based on programmatic requirements. Multi-stage scroll machines shall have a self-contained control system with the ability to lock out a single stage in case of a failure.

Provide an ASME-rated buffer tank between building outlet and the vacuum pump.

The vacuum pump shall be mounted on a 4 in. concrete housekeeping pad with vibration isolators.

15. CONTRACT DOCUMENTS

The contract documents must be easy to interpret without a great deal of study and instantly convey a clear picture of the design philosophy of the systems. Isometric drawings or sketches are not acceptable.

All floor plans should show room numbers and names, and column lines.

Plan drawings should graphically illustrate a scale and a north arrow with the preferable method representing both true north and building north.

Mechanical plans must show all ductwork and duct fittings to scale. With the exception of flexible runouts, ductwork should not be single-line. Standard drafting conventions should be used for turns, joints, changes in size, drops or rises, crossings above and below one another, etc. Section views showing where ductwork appears to conflict with other ducts, piping, structure, electrical, etc., especially in corridors should be included.

The mechanical plans must show size and air quantity for each diffuser (neck and face size), register, and manual balancing damper on the plan. An air distribution schedule must be provided. Indicating size and air quantity range on the schedule does not remove the requirement to show this information on the plans.

For VAV boxes, mechanical plans or schedules should show minimum air quantity desired, taking into consideration box capability, space outside air requirements, and minimum air motion in the space served. Sound data should be included.

All piping and show flow directions on all hydronic piping should be identified. Piping should be shown on the same plans as the ductwork if feasible.

All mechanical rooms shall be drawn at 1/4" scale. Show clearances for coil replacement on all floor plans. Provide 1/4" longitudinal section view of all AHUs including piping, walls, ceilings or top structure, etc. A section, not an elevation, is required. Show duct thermometers in section views.

The mechanical drawings or schedules should indicate the filter thickness or depth of each filter type in all equipment. The design or change-out static pressure must also be indicated for each type filter. Do not simply show the initial and final pressure but indicate the range of the differential pressure gauge across the filters on the project plans.

Simplified piping schematics of all hydronic systems with two or more chillers, boilers, or heat exchangers should be included at the appropriate scale.

A one-line, simplified schematic diagram for the chilled water or hot water system where two or more chillers or boilers or heat exchangers, including existing equipment, are included in the hydronic system shall be included. The drawing should indicate how the various components relate to one another as well as pumps, control valves, air release tank, two-pipe changeover valves (if applicable), and flow meters. Show flow direction. Avoid line crossings. Do not show gauges, thermometers, isolation valves, strainers, and other minor piping components.

Specifications should be concise, complete, brief, and correct. Two manufacturers and model numbers are sufficient. Only the necessary information should be extracted and used from specifications produced by manufacturers. Thoroughly edit specification sections for the specific project and include appropriate product and installation descriptions. Remove inapplicable sections and paragraphs from typical standard specification sections, etc. Unedited specifications will not be accepted.