NC State University Design and Construction Guidelines
Division 23 Basic Mechanical Requirements

1.0 Purpose

A. These guidelines provide requirements for designers to incorporate into bid documents for mechanical and plumbing systems.

2.0 General Requirements

A. Warranty and Guarantee

1. Specifications shall reflect the following warranty requirements:
   a) Chiller and refrigeration compressors - five years parts and labor
   b) HVAC controls – two years parts and labor

B. HVAC Systems

1. Hydronic systems consisting of chilled water and heating hot water with forced air ventilation will be utilized on campus. Electric resistance heating and DX cooling shall not be utilized for building systems.
2. Unoccupied spaces that require continuous cooling such as telecom rooms and electrical rooms shall be on separate systems. Use of fan coil units is limited to unoccupied spaces that have primarily sensible heat loads.
3. Air handling unit configuration and layout shall optimize the zone within the facility such that areas of similar operating schedule and function are served by the same air handler to maximize energy conservation through scheduling functions.
4. Mechanical rooms that contain electronic control panels, to include Variable Frequency Drives, shall be conditioned to provide temperature and humidity control to allow proper function of electronic equipment at $<85^{\circ}$F and $<60\%$ RH.
5. Installed equipment shall not exceed 80 dBA measured three (3) feet from the equipment
6. Chiller alarms shall be connected to alert NC State Emergency Control Center.
7. Piping
   a) Chilled water piping that is less than or equal to ¾" shall be schedule 80.
   b) Plastic piping shall not be utilized.
   c) Heat recovery piping system: use propylene glycol in lieu of ethylene glycol. Automatic makeup water systems shall be avoided in order to prevent undetected dilution or loss of glycol (a low level liquid alarm shall be used in lieu of an automatic fill line). Glycol shall also be dyed to aid in detection of leaks. An in-line water meter shall be provided to monitor and maintain the proper percentage of glycol in

the system. Provisions shall be made for drain down, storage and re-injection of the glycol into the system.

d) Use of Type L copper tubing only for all small diameter (less than 2-1/2" diameter) hot water reheat runout distribution piping.

e) Clamp type piping (aka Victaulic Piping) in hydronic systems shall not be used (sprinkler piping is only acceptable installation).

f) Install side stream filter systems on building HW loops to improve heat transfer efficiency (and remove iron oxide deposits).

g) Provide a dirt leg on all chilled water supply and returns at coils.

h) Weld-neck flanges only are allowed. Do not use slip-on flanges.

i) F.F. flanges must mate with F.F. flanges. Example: pumps typically have Class 125 or 250 F.F. flanges. If weld-neck flanges are mated directly to this flange, it must have the raised face machined off. Full-face gaskets shall be used at flat-faced flanges.

j) Follow ASTM A207B for bolts when bolting to cast iron flanges, valves, or pumps.

k) Minimum hydronic system pipe size shall be ¾ inch diameter.

l) Pump suction piping shall be kept as short and direct as possible with a minimum length of straight pipe upstream of the pump suction as recommended by the pump manufacturer (usually 5 to 12 pipe diameters), unless using suction diffuser.

m) Pump discharge check valves shall sized so that the check valve is full open at design flow rate. Generally this will require the check valve to be one pipe size smaller than the connecting piping.

n) Install air vents at all high points in water systems (chilled water, heating water, and other closed loop piping). Install valved and capped drains at all low points to allow complete drainage of the hydronic systems.

o) Install manual air vent on chemical feed tank and also pipe drain to floor drain.

p) Do not use malleable iron fittings in glycol systems (i.e., heat recovery piping, etc.).

q) Expansion tanks shall be provided with a sight glass or other means of visually verifying level in tank.

r) Condensate return from equipment shall be gravity fed to the condensate receiver.

8. Air Systems

a) Ducted supply and return systems are required. Return plenums are not preferred.

b) Only exterior insulated supply ductwork is allowed. Short runs of line ductwork may be allowable for noise dampening if the ductwork is easily accessible in mechanical rooms.

c) Terminal reheat shall be provided for all interior zones unless the designer can demonstrate otherwise.

d) For return air systems, the air handler shall include a preheat coil. Exceptions may include AHU's dedicated to core or interior zones. Heating coils in return air systems shall be hot water.

e) Fan rooms shall not be utilized as return or supply plenums.

f) HVAC systems shall include air-side economizer mode to reduce energy consumption.

g) Dampers and louvers shall be fully gasketed, opposed blade, face and bypass dampers.

h) Humidification shall be provided with building steam. The use of clean steam generators shall only be utilized when programmatic requirements dictate.

i) Mechanical rooms shall not be used as return air, outdoor air or mixing plenums.

j) Ducted return air distribution is required. With a return plenum, care must be taken to ensure that the air drawn through the most remote register actually reaches the air-handling unit. The horizontal distance from the farthest point in the plenum to a return duct shall not exceed 50 feet. No more than 2,000 cfm shall be collected at any one return grille. Return air plenums shall be sealed air-tight with respect to the exterior wall and roof slab or ceiling deck to avoid creating negative air pressure in exterior wall cavities that would allow intrusion of untreated outdoor air. All central multi-floor-type return air risers must be ducted.

k) Flexible ducts: sheet metal collars and sleeves shall be beaded to hold drawbands. If beaded sleeves and collars are not used, then the inner core shall be fastened to the fitting using #8 screws equally spaced around the diameter of the duct, and installed to capture the wire coil of the inner liner (3 screws for ducts up to 12" diameter, and five screws for ducts over 12" diameter).

l) Air filters shall be changed within one week of building acceptance by NCSU.

m) Provide at least MERV 13 filters in the return air stream.

n) Provide access doors of sufficient size to access all fire dampers, smoke dampers, smoke detectors, volume dampers, motor operated dampers, humidifiers, coils (steam, hot water, chilled water, electric), and other items located in ductwork which require service and/or inspection.

o) VAV terminal units with reheat must be supplied with access door between damper and reheat coil.

p) Locate all terminal units with unobstructed access to unit access panels, controls and valving. Piping connections must be on same side of unit as control box.

q) Minimum straight duct length upstream of terminal units: three feet.

r) Terminal Unit Installation: group spaces/zones/rooms/areas of similar areas of similar occupancy, i.e.

(1) Offices zoned with offices

(2) Offices shall not be zoned with conference rooms or other dissimilar rooms

(3) East offices shall not be zoned with south offices, etc. Corner offices/spaces shall be zoned separately.

s) Maximum length of flex duct is six feet. Minimize bends in flexible duct, limit total bends on one branch to 90 degrees.

t) Frames of duct mounted dampers shall be totally recessed out of the air stream.

u) Steam reheat/preheat coils where required, shall have sufficient pitch to completely clear the coil in the event of trap failure. Also, steam control valves must be modulating, not two-position.

v) Provide a set of filters on exhaust upstream from heat recovery coils.

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

x) Duct drainage: At duct humidifiers, solder ductwork watertight five feet upstream and 25 feet downstream of the humidifier. Pitch ductwork to a drain located at the humidifier.

y) If possible smoke duct detectors shall be located between the humidifier and the fan.

z) For duct detectors and humidity sensors that must be installed downstream of the humidifier, their location must be 6" beyond the entrainment zone specified by the humidifier manufacturer.

aa) Multiple exhaust fans shall not be manifolded together unless backdraft protection is provided.

9. Valves
   a) Provide isolation valves for all main runs and all branch runs for ease of maintenance. At a minimum, shut off valve on all systems is required on each floor. Provide stand alone isolation valve for hot water reheat on all air terminal boxes. Combination balancing/shut off valve is not acceptable. Balancing and shutoff valves shall be independent of each other, such that using the shutoff valve does not affect the balance of the system.
   b) Isolation valves for all lab systems such as vacuum, air, gas, and water shall be located in single cabinet near the lab entrance.
   c) Pressure independent chilled water control valves will be utilized for all facilities connected to a central chilled water plant to minimize energy consumption and increase temperature differential back to the plant.
   d) Use PICCV (Pressure Independent Characterized Control Valve) in lieu of standard 2-way control with a separate balancing valve in VAV reheats systems.
   e) Provide isolation valves at all pieces of equipment for maintenance and service.
   f) Pump discharge check valves: install check valves with 4 to 5 pipe diameters upstream of flow disturbances (recommended by most manufacturers).
   g) Provide chainwheel operator for all valves in equipment rooms mounted greater than 7-0" above floor level, and chain shall extend to 5-0" above floor level.
   h) All valves shall be installed so that the valve remains in service when equipment or piping on equipment side of valve is removed.
   i) On multi-floor buildings, each floor will have valving installed to allow isolation of each individual floor while allowing continued operation of all other floors.
   j) Each piping branch off of the main supply piping shall have an isolation valve. Example: floor composed of 20 VAV boxes with HW reheat coils. If main branch is served by four laterals (with five VAV's on each branch), then there would be four branch isolation valves. Supply and return piping both require this, bringing the total branch isolation valves required for this example to eight.
   k) Domestic water backflow preventers shall be located in mechanical rooms. Exterior "Hot Boxes" or below grade vaults are not allowed unless prior approval has been received.
10. Gauges
   a) Thermometers shall be installed in both the supply and return piping to all water coils, chillers, boilers, heat exchangers, and other similar equipment.

b) Thermometers and pressure gauges are required on the suction and discharge of all pumps, chillers, boilers, heat exchangers, cooling coils, heating coils and cooling towers. To avoid pressure gauge tolerance errors, a single pressure gauge may be installed, valved to sense both supply and return conditions. For coils with less than 10 gpm flow, provisions for use of portable instruments to check temperatures and pressures shall be made (P/T plugs).

c) Duct static pressure gauges shall be provided for the central air-handling air supply fan discharge, branch take-offs of vertical supply risers and at all duct locations at which static pressure readings are being monitored to control the operation of a VAV system. In the mechanical room, either in the control panel or on the AHU, there must be a duct static pressure gauge that is visually annunciating the control point for the VFD (which is normally 2/3 of the way down the duct).

d) Differential static pressure gauges shall be placed across filters in air-handling units to measure building pressure relative to the outdoors.

e) For critical areas, an airflow monitor is preferred in lieu of a pressure sensor.

f) HEPA filters: Only HEPA filters and filters for critical areas are to have DP sensors tied into the Campus BAS System. Provide Magnehelic or inclined manometer on all other filters.

C. Steam Systems

1. Use a fouling factor of .001 when sizing heat exchangers
2. Heat exchanger tubes shall not be smaller than ¾" O.D.
3. Shell and Tube Heat Exchanger: If system capacity exceeds 2" control valve size, provide two control valves with 1/3 and 2/3 capacity split.
4. Design and installation of steam piping systems will be in accordance with ASME B31.1 to the downstream side of the PRV. From that point on, the design and installation shall be in compliance with B31.3. We waive the requirement that the contractor have a B&PV Code stamp to perform this work, however, the installation shall be in compliance with these Codes in every other respect.
5. Preference is for 300# flanges for steam piping equipment and valves w/in the B31.1 boundaries outlined above. Generally, 150# flanges are acceptable through 15 psig, and 300# flanges above 15 psig.
6. Slip-on flanges are not allowed.
7. FF flanges must be bolted to FF flanges. Steel raised-face flanges must have the faces ground flat when bolting to cast flat-face flanges. Gaskets are required to be full-face also.
8. Flange face alignment tolerances shall be 1/32 in/ft.

9. Install flange bolt and nuts well lubricated by using a high quality anti-seize lubricant to the stud threads and the nut face.
10. Bolts must be of a length sufficient to have 2-3 threads protruding from nut face.
11. Welding procedures used for fabrication must be submitted and approved. Personnel must be qualified to the procedure used. Inspection of welds done for that piping fabricated in accordance with ASME B31.1 must have 100% visual inspection by Qualified Welding Inspector (ex. QC1 rating by AWS).
12. Do not manifold multiple safety relief valves together. Run separate discharge piping for each.
13. Steam velocity for design use: low pressure (0-15 psig) 4,000-6,000 FPM, medium pressure (16-100 psig) 6,000 to 8,000 FPM, high pressure (101-300 psig) 10,000 to 15,000 FPM.
14. HVAC equipment F&T traps (i.e. steam/water heat exchangers and steam water heaters) shall be sized for 2-1/2 times the condensate load at ½ psi differential (to account for cold startup conditions).
15. Strainers shall always be placed upstream of steam traps. Y-strainers shall be mounted horizontally. Y-strainers shall also be installed before modulating valves providing intermittent steam service (i.e. heat exchangers, steam hot water heaters).
16. Pitch steam piping downward indirection of flow ¼" per 10 ft. minimum.
17. Connect all steam branch lines to the top of steam mains.
18. The immediate upstream side of main steam system shut-off valve shall have drain fitted to bottom of pipe.
19. Steam piping shall be installed with eccentric reducers (flat on bottom) to prevent accumulation of condensate in the pipe and thus increasing the risk of water hammer.
20. Drip leg collection points on steam piping shall be the same size as the steam piping to prevent steam condensate from passing over the drip leg and increasing the risk of water hammer. The drip leg collection point shall be a minimum of 12 inches long and include a minimum 6 inch long dirt leg with the steam trap outlet above the dirt leg.
21. Drip legs must be installed at all low points, down fed runouts to all equipment, end of mains, bottom of risers, and ahead of all pressure regulators, control valves, isolation valves, and expansion joints.
22. Traps shall not be bypasses. Traps shall be designed to have a test valve discharging to the atmosphere located between the trap and the discharge shut-off valve.
23. Provide adequate space for pressure reducing stations. Produce detailed drawings (show on plans) to verify adequacy of space delineated in mechanical room.

24. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 100 feet where pipe is pitched downward in the direction of steam flow and a maximum of 100 feet where the pipe is pitched up so that condensate flow is opposite of steam flow.
25. Steam traps used shall be a minimum of ¾" size.
26. Use multiple stage PRV stage reduction where greater than 100 psig reduction is required or where greater than 50 psig reduction is required to deliver a pressure less than 25 psig operating pressure or when intermediate steam pressure is required.
27. Maximum pipe velocity upstream and downstream of PRV: a. 8" and smaller, 10,000 FPM b. 10" and larger, 8,000 FPM c. If outlet velocity exceeds those listed above, use noise suppressor.
28. Safety Relief Valve (SRV) must be capable of handling the volume of steam as determined by the high pressure side of the largest PRV or the bypass, whichever is greater.
29. Provide removable insulation jackets for steam PRVs, steam and condensate meters, and steam trap piping (not trap itself though).
30. All steam piping fittings shall be class 300 malleable iron, cast steel, or forged steel (not cast iron).

D. Equipment Locations

1. Entrances for steam, chilled water, water, fire lines, and other wet area entrances to mechanical spaces shall typically be located in the lowest level with grade level access.
2. Access through the mechanical room shall allow adequate space for replacement of the largest piece of equipment without disassembly.
3. Confined Spaces shall be clearly indicated on drawings with notification to NC State for listing, marking, and inspection. Access to equipment shall be designed to avoid additional permit-required –confined-spaces
4. Locate VAV boxes and terminal units in hallways for ease of access for maintenance without disrupting occupants.
5. Floor drains, convenience outlets (at least 2 duplex GFCI 120 V receptacles on separate 20 amp circuits), and hose bibs shall be provided for all mechanical rooms.
6. Mechanical rooms shall be designed to provide adequate maintenance clearances for all systems and equipment. Clearances around air handlers shall be a minimum of 3 feet, except for coil and fan shaft-pull clearances which are greater. Show required coil/shaft removal space on the drawings.
7. Mechanical room floors shall be coated with the following systems: alkyd gloss enamel, modified with urethane. Color: Gray.
8. Clearances shall be maintained to allow for routine maintenance activities without the removal or disassemble of fixed piping, supports, or equipment.

9. All mechanical rooms that contain boilers, chillers, or other systems that require chemical treatment shall be provided with a combination eyewash/deluge safety shower.
10. All mechanical room with refrigeration equipment shall include refrigerant monitors.
11. Location of exterior mechanical equipment shall be located in screened service courtyards. Rooftop AHU's are not allowed.
12. Three feet clearance shall be provided around equipment to allow adequate access.
13. Ground level air intakes shall be elevated a minimum of 2-feet above grade. Vegetation, mulch, etc shall be a minimum of 3' away from intakes.

E. Sequence of Operations

1. Finned-tube radiation systems shall have individual zone thermostatic control capable of connecting to the BAS DDC system.
2. Controls such as CO2 controls or occupancy sensors shall be used to modulate outside airflow in classrooms and auditoriums, unless demonstrated not to be cost effective.
3. Freeze protection shall be provided on all air handling units utilizing fresh air makeup. Freezestats shall stop the supply fan, close the outside damper, and open the heating coil valve and chilled water valve and start the chilled water pump. Where DDC is used, the freezestat controls shall be completely independent of the DDC system.
4. Individual exhaust fans in custodial closets or single toilet restrooms shall not be used where central systems are available or reasonably achievable. If such individual exhausts are used, they shall be equipped with timers or occupancy sensors to turn fans off after an approved period of time. They must be DDC controlled and respond to the building schedule.
5. Critical exhaust fans (Vivarium, BSL suites, radiation hoods, perchloric acid hoods, etc.) that run continuously shall not have a start/stop function on the DDC system. Further, all such systems shall have redundant fans (100% redundant). Provide a manual hand/off/auto switch and failure alarm to the DDC. Where two fans are provided the "lead" fan will be in the "hand" position and the "lag" fan will be in the "auto" position so the DDC system can start the "lag" fan automatically upon a failure of the "lead" fan.

F. Operation of HVAC Systems during construction

1. Operation of HVAC systems during construction shall not occur until an operations plan is approved by the NC State Construction Manager.
2. All care must be taken to prevent dirt/dust from entering the system. All care must be taken to prevent condensate from being generated that may cause indoor air quality issues. Compliance with the five SMACNA guidelines for indoor air quality during construction is required. RE: www.smacna.org/store/indoor-environmental-air-quality

3. Facility must be fully enclosed, including doors, windows, etc.
4. Utilize 100% outside air if any “dusty” interior work is being performed and freezing conditions do not exist.