PLUMBING AND MECHANICAL SYSTEMS DESIGN GUIDELINES

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A. GENERAL REQUIREMENTS

1. Related Design Guidelines

- EHS Laboratory Buildings Design Guidelines.
- Building Systems: Control System Guidelines.
- Building Systems: BSL3 Laboratory Design Guidelines.
- Energy Modeling Guidelines
- Sustainability Design Guidelines
- Site Utilities Design Guidelines.

2. Equipment Access

- Clearances around equipment including air terminals, reheat coils, and air valves shall be sufficient to allow inspection, service, repair or replacement without removing elements of permanent construction. All trades must coordinate and protect the service area around equipment. It is emphasized that equipment above ceilings must be replaceable without removing conduit, piping, cable trays, or other permanent constructions.
- All serviceable equipment (smoke dampers, fire dampers, control dampers, duct smoke detectors, fans, valves, coils, terminal units, pumps, filters, isolation valves, clean-outs, junctions, etc.) installed behind an inaccessible finished surface requires the installation of suitable access doors. Ensure that access is not blocked by conduit, wire trays, ductwork, etc.
- It is the designer's responsibility to identify, in the contract documents, the minimum size of all access doors.
- Designers are to indicate, on the plans, minimum clear maintenance access for all pieces of major equipment including air handlers, terminal units, heat exchangers, boilers, chillers, air compressors, pumps, motors, fans, control valves (greater than 3"), etc. This should be indicated with a light, dashed line. The designer should generally provide the manufacturer's recommended clearances. Specific requirements which follow may exceed manufacturer's recommendations:
- Air Handlers: 36 inches minimum access for fan compartments with motors 10 hp and larger. Also provide coil pull access for the depth of the coil plus 18 inches and the width of the coil plus 30 inches on both sides.
- Provide a means and a pathway for replacing the entire air handler without major demolition including removing permanent elements of construction.
- Boilers: Provide 24 inches on all sides except the burner, which should have 36 inches minimum.
- Control valves: For valves 3 inches and larger, provide access above the valve of the assembly height plus 12 inches. Install ALL control valves in the vertical position, unless otherwise required by the manufacturer.
- Heat Exchangers: Provide tube pull plus 12" for shell and tube type exchangers.
- The designer should also be diligent with oversight of coordination in the field to prevent reduction to access due to conduit, piping, cable trays, etc.
- For demolition of existing HVAC, specify that all cut pneumatic tubes to be sealed w/ pneumatic plugs. Crimping and taping are prohibited.

3. Procedures during Construction

a. General

- Specify all new and reused equipment installed under this scope of work to be completely cleaned to new condition (inside and outside). Specify required maintenance on reused equipment to ensure it is 'like new'.
- Specify that cleaning solutions may not be discharged to the storm sewer system.
- Spare parts are to be turned over to the owner and not left in the building mechanical rooms.

b. Requirements for operating HVAC equipment during construction

- Building must be fully enclosed, including installation of all doors, windows, etc.
- Set air handler to use 100% OA if construction is still generating dust and when conditions will not allow the coil to freeze.
- If return air is to be used then all exhaust and return ducts/grilles shall be covered with temporary filter media (at a minimum a double layered cheesecloth and all filters media - MERV 8 - required by LEED or other standards) to prevent dust infiltration into ductwork system.
- All chilled water piping shall be insulated.
- Laser alignment of pump shafts shall be completed and reports provided to the designer and also included in the O&M manuals.
- Supply and outside air connections of ductwork to AHU's shall be complete.
- All manual dampers, fire dampers and combination fire/smoke dampers shall be open.
- All main supply ductwork shall be insulated.
- All safety circuits and basic control functions shall be active and fully functional. The contractor is not allowed to operate equipment in the facility during unoccupied times without a fully functional and tested control system.
- Once the conditioning (cooling & dehumidifying) of the building is started, it should stay conditioned.
- Final approval of UNC is required prior to starting AHU's for temporary operation.
- Specify that outside air intakes are covered with 1" roll filter media. Filters should be removed prior to occupancy.
- Specify that the contractor perform all required preventative maintenance on mechanical equipment operated during construction. Require the contractor to provide documentation in the operation and maintenance manuals of preventative maintenance activities completed during this time.
- At the end of the construction period prior to occupancy clean the inside of AHU's and install new pre and final filters.
- AHU UV lights shall be operational and all specified filters installed during all AHU operation.

c. Flushing the domestic water system.

- For all fixtures with aerators, remove the aerator before flushing. After flushing, rinse the aerators and reinstall.
- With all aerators removed, let the water run through the fixtures for 10 minutes at the highest flow rate. If booster pumps are installed in the building, make sure that they are operating, to achieve the highest normal operating pressure during flushing that will occur in the buildings lifetime. This will achieve the highest normal possible velocity in the plumbing lines and maximum cleaning.
- Forming a protective layer on the brass in the system: Turn on the cold water for all faucets in the building, such that some water flows out for 3 days at low flow. Any flow rate from 2 drips per second to a small "trickle" from each fixture is adequate. Very high flow rates should be avoided because they waste water and, if taken to an extreme, might actually prevent formation of a protective layer.
- Notify the EHS Occupational and Environmental Hygiene Manager when building flushing begins and is complete. Provide the building and the site contact information.
- Overflow Lines - Extend all equipment overflow or blow-down lines to a floor sink or floor drain connected to the sanitary sewer system.
- The designer shall specify appropriate cleaning and disinfecting procedures for domestic water piping systems, compliant with AWWA and OWASA (below grade domestic water piping only).

d. Flushing non-domestic piping

- Specify flushing and cleaning for piping systems before they are put in service. Do not utilize building pumps for circulating cleaning fluid to maintain design water velocities for the duration of the test.

4. Testing and Verification

a. General

- Should the University or the Designer have any reasonable doubt as to the proper functioning of any equipment installed under this Contract, at any time during the guarantee period; the University and/or Designer has the right to perform any test deemed practical to determine whether such equipment is functioning properly and performing at specified capacity.
- Specify factory certified start-up and inspection for vacuum pumps, air compressors, pumps, AHU's, fans, boilers, and water heaters.
- Provide a complete list of all required factory certified start-up and inspection in the general or commissioning sections of the mechanical and plumbing design documents.

b. Air and Water Balance

- Specify air and water systems be tested including all ducts and fire dampers.
- Specify that balancing be performed by an independent, certified AABC or NEBB TAB firm.
- Specify that at least one AABC or NEBB certified balance specialist with a minimum of 2 years experience be at the site to perform daily TAB activities.
- Specify TAB activities shall be reviewed by a certified TAB supervisor or Professional.
- Testing and balancing of air systems shall be performed in complete accordance with the latest version of AABC National Standards for Total System Balance, 2002 Edition or NEBB Procedural Standards for TAB Environmental Systems 7th Edition 2005 or subsequent versions.
- Specify that balance reports are sealed as accurate by a professional engineer licensed in the State of North Carolina.
- The designer shall review and approve the qualifications of the balance specialist and the means and methods of testing.

c. Ductwork Leakage Test

- Specify that all high and medium pressure ductwork is tested for air leakage. Testing should be completed before the installation of duct insulation. If duct is insulated before leakage testing is completed and leaks are found, it shall be the responsibility of the contractor to remove insulation from the entire section of the leaking duct, repair the leaks and replace the insulation.
- Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
  - Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
  - Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, then specify the entire system is tested at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Provide the university and the designer seven days' advance notice for testing.
  - Maximum Allowable Leakage: Maximum leakage shall be 1% of total cfm delivered by the air moving device(s).
  - Remake leaking joints and retest at contractor’s expense until leakage is equal to or less than maximum allowable.

d. Hot and Chilled Water Pipe Testing

- Specify pressure testing of all new and reused hot and chilled water piping.

5. Training

- The designer shall specify that the contractor provide on-site orientation for representatives of Facilities Services. The duration shall generally not be less than two days and is required prior to building occupancy.
- The designer shall also specify additional classroom training for temperature control systems and for any system unique to the University. This "systems" training shall be in an appropriate classroom setting and shall be performed by an authorized representative of the system or equipment, and shall be completed prior to project closeout. The designer shall coordinate through the UNC Construction Project Manager with UNC Facilities Services to determine the appropriate training required.
- The designer should direct the contractor to submit training schedules, training syllabus, and resumes of the person(s) giving the training to the University for review and final approval.
- Provide a complete list of all required training in the general or commissioning sections of the mechanical and plumbing design documents.

B. COMMON WORK REQUIREMENTS

1. Common Motor Requirements

- Indicate horsepower ratings for all motors on both Division 15 and Division 16 construction drawings.
- Specify single phase protection for multiphase motors.
- Specify that all motors conform to the latest IEEE or NEMA standards relating to characteristics, dimensions, tolerances, temperature rise, insulation, and ratings for noise and vibration.
- Specify NEMA class F insulation with Class B temperature rise and 1.15 service-factors in an ambient temperature of 40 'C maximum. Bearings shall have an ANSI/AFBMA L-10 rating of 200,000 hours for direct connected service and shall be capable of being re-lubricated.
- Specify 480V, three phase electrical service for motors 1/2 Hp and larger.
- Motor frames and end-bells shall be cast iron for motors 1hp and larger. Specify premium efficiency motors, as defined by NEMA MG-1, for all motors 1 Hp and larger.
- Motors used with variable frequency drives must, at a minimum, meet the requirements of NEMA MG-1, part 31 "Definite Purpose Inverter-Fed Motors".
- All motors shall be mounted on the same base as the rotating equipment they serve (for alignment purposes).
- Base plates for motors shall be constructed to NEMA standards and shall have a minimum of 2 belt tensioning bolts.
- When equipped with VFD's: Provide solid shaft grounding rings (Aegis SGR or equal). Soft carbon brushes shall not be accepted. Split grounding rings shall not be accepted.
- Motors over 100HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor.
- For motors 3hp and greater and equipped with belt drives, belt drives shall be equipped with helical, split teeth, synchronous belts and gears designed for energy efficient and quiet operation. Shall be Eagle NRG or compatible. Provide laser alignment.
- For motors 1 hp and larger, belt drives shall be equipped with fixed pitch sheaves.
- The following manufactures are preapproved: TECO/Westinghouse, WEG, or Toshiba.
- Enclosures for motors shall have hinged covers. Bolt on covers are not acceptable.
- For frames larger than 280T, provide bearings that may be lubricated. For frames 140T - 280T, provide bearings that may be lubricated or equipped with double shields.

2. VFD's

- VFD's shall not be installed within MCC's, AHU's or outside. Refer to the Electrical Design Guidelines for other VFD requirements.

3. Common Electrical Requirements

- Disconnecting means furnished integrally with equipment is considered adequate if the disconnecting means is properly sized and fused.
- Starters
    - For starters located adjacent to the motor served then specify that combination starter type.
    - Specify with integral control transformers, solid state thermal overload protection, 120 volt coils, low voltage protection, indicating pilot lights (neon or LED type), hand-off-automatic switches and all necessary auxiliary contacts. Starters shall be UL508 listed for the available short circuit current. All starters, including skid mounted starters, shall be NEMA rated. IEC rated starters are not acceptable. Specify phase loss protection and adjustable overloads.
- UNC considers the division of work between Division 15 and Division 16 to be reflective of the policy under the N.C. State Construction Guidelines. This states that Division 15 is responsible for electric service for mechanical equipment from the electrical disconnect to the equipment. Division 26 is responsible for electrical service to the disconnect.
- Terminations for motors 5 hp or greater shall be made with split bolts, glass tape, and black tape.

4. Meters and gauges

- Specify pressure/temperature test stations, combination (P/T plug) on supply and return piping of all air handling unit water coils not otherwise provided with pressure and temperature gages. The basis of design shall be Peterson Equipment Company (Pete's plug).
- Water and steam pressure gauges shall be liquid filled.
- Specify a single gauge with isolation valves when reading differential pressure across a piece of equipment.
- Provide water totalizing meter and y-strainer for makeup water lines on hot water boilers, heating water systems, run around heat recovery systems, and other similar closed systems with makeup water lines.

5. Valves

- Combination balancing/shutoff valves shall be independent and using the shut off function should not affect the system balance when the valve is reopened.
- Pressure independent flow balancing devices are not permitted.
- Butterfly valves are not acceptable valves for flow balancing.

6. Vibration and Seismic Control

- All mechanical equipment with rotating, reciprocating or oscillating components shall be mounted on, or suspended from, vibration isolators to prevent transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflection and noise mitigation.
- Specify the vibration isolator type and the static deflection limits. Limit the vibration transmissibility to the building structure at the lower driving frequency of the equipment to a maximum of 1 %.

7. Identification

a. Equipment Identification

- Specify that all major HVAC and plumbing equipment, including air handlers, fans and pumps is properly identified with equipment identification, equipment controlled, electrical ratings and date of installation.
- Equipment should be clearly identified with engraved phenolic plates securely fastened to the equipment with sheet metal screws. Specify phenolic plates with white background and black lettering.

- Specify that all serviceable equipment (fans, reheat coils, V.A.V. boxes, etc.) located in concealed spaces is clearly identified on an adjacent finished surface (location determined by the Designer).

b. Pipe and Duct Identification

- Completely paint piping systems in mechanical rooms with the applicable colors listed below.
- For both piping and ducts, provide stencil or strap-on identification indicating the system and the direction of flow.
- Identification shall be provided as follows: no further than 30 feet apart, at major changes in direction, at each valve or equipment, and on both sides of penetrations.
- The system colors and identifications are as follows:

Piping System	Color	Stencil Identification
Condensate Return	Light Brown	COND
Steam, High Pressure (25-75 psi)	Bright Red	HPS
Steam, Low Pressure (0-25 psi)	Dark Red	LPS #__
Water, Chilled, Supply	Marlin Blue Rustoleum 925	CWS
Water, Chilled, Return	Marlin Blue Rustoleum 866	CWR
Water, Cold Domestic	Dark Green	DOM CW
Water, Distilled	Slate Gray	DSTW
Water, Condenser, to Condensers	Fed. Safety Green	CC
Water, Hot Domestic	Red	DHW
Water, Hot Domestic, Recalculating	Orange	DHWR
Water, Hot, Heating	Light Gray	HWS
Gas	Black	GAS
Air	Dark Gray	AIR
Nitrogen	Pastel Gray	
Helium	Pastel Gray	
Hydrogen	Black	
Vacuum	Beige	VAC
Chemical	Yellow	
Sprinkler	Safety Red	SPKR
Fire Line	Safety Red	FIRE
Ductwork	Light Gray	Supply, Exhaust, Return

- Pipe identification should contrast in color to the pipe colors and be easily readable. The width of color bands should be equal to the size of the stencil indicated below.
- For insulated pipe systems, stencil sizes are as follows:
  - For pipes up to 1 inch, use 1 inch letters.
  - For pipes 1 inch to 2 inches, use 2 inch letters.
  - For pipes 2 inches to 6 inches, use 3 inch letters.
  - For pipes above 6 inches, use 4 inch letters.
- For un-insulated systems, stencil sizes are as follows:
  - For pipe diameters up to 1 inch, use 1/2 inch letters.
  - For pipe diameters from 1 inch to 2 inches, use 1 inch letters.

- For pipe diameters from 2 inches to 6 inches, use 2 inch letters.
- For pipe diameters over 6 inches, use 3 inch letters.

- At each floor level and at roof level identify each exhaust air duct from safety cabinets and fume hoods by 2" tall painted black lettering identifying the room it originates from.

c. Valve Identification

- Specify brass valve tags with chains for isolation and control valves.
- Specify a valve tag chart in the O&M manual.
- Specify a valve tag chart to be mounted in the ME room in a frame with lexan cover.
- Include the tag numbers in the as-built drawings.

C. INSULATION

1. General

- Specify insulation to provide an adequate thermal barrier as well as protection from moisture condensation on exterior of pipe or duct whose surface temperature drops below ambient conditions. In all cases the designer should confirm the size and type of insulation specified is sufficient to prevent surface condensation.
- Specify insulation for all valves, flanges, elbows, tees and other fittings with the same type and minimum thickness as adjoining pipe.
- Specify insulation which provides access to circuit setters, control valves, strainers, unions and flexible connections and which may be removed and reinstalled without damage to the insulation.
- Specify continuous insulation across pipe hangers, air handler casings, sleeves and walls.
- Specify that the Contractor replace fiberglass and calcium silicate insulation which becomes wet during the construction period.
- Insulation for devices on items requiring regular maintenance, such as steam traps, heating water devices, and chilled water devices should be easily removable and able to be reinstalled without damage to the insulation.
- Insulate the following equipment items:
    - Heating water air separator.
    - Hot water converters.
    - Steam traps.

2. Piping

- Specify corrugated aluminum jacketing or PVC jacketing on insulated piping in mechanical rooms from floor level to 8 ft. above finish floor.

a. Cold and Hot Plumbing Piping

- Insulate the following with fiberglass or flexible unicellular:
    - Domestic cold water piping.
    - Industrial cold water piping.
    - Interior roof drain leader and roof drain overflow piping. Include the body of the roof drain and minimum 10 ft. into the building shell.
    - Domestic hot water piping.
    - Industrial hot water piping.
    - Domestic hot water recirculating piping.
    - Industrial hot water recirculating piping.

b. Sub-Zero Piping [Below 0 deg. F (-18 deg. C)]:

- Insulate low temperature refrigerant piping with flexible unicellular.

c. Sub-Freezing Piping [0 to 39 deg. F (-18 to 4 deg. C)]:
- Insulate refrigerant suction lines between evaporators and compressors and brine refrigerant piping with flexible unicellular.

d. Chilled Water Piping [40 deg. F (4.4 deg. C) to ambient]:
- Insulate with:
  - Fiberglass: Not permitted.
  - Cellular Glass.
  - Closed cell foam.
  - Polyisocyanurate (nominal 2 lb./ft3).

e. Hot Low and Medium Pressure Piping [steam up to 75 psi, hot water up to305 deg. F (152 deg. C)]:
- Insulate the following HVAC piping systems with fiberglass, calcium silicate or cellular glass:
  - Steam piping to 25 psi
  - HVAC hot water supply and return piping.
  - Heated fuel piping.
  - Hot gas refrigerant piping.
  - Steam piping from 26 to 75 psi.

f. Hot High Pressure Piping [steam 76 to 200 psi, Up to 450 deg. F (232 deg. C)]:
- Insulate with one of the following types:
  - Fiberglass: Provide Class 13 for superheated steam over 450 deg. F (232 deg. C).
  - Calcium Silicate or Cellular Glass.

3. Ductwork

- Lined duct is not permitted. Designer may consider and recommend on a case by case basis for specific applications such as theaters or performance halls where sound or other considerations apply
- Specify rigid insulation for ductwork installed in mechanical rooms from floor level to 8 ft. AFF. Ductwork installed in mechanical rooms shall be with 8 oz. canvas lagging, minimum.
- Externally insulate all exposed supply, return and outside air ducts with rigid fiberglass insulation.
- Provide continuous insulation on supply duct at joints and throughout duct system from cooling coil to supply air grilles. Insulate all equipment including reheat coils, diffuser necks, fire dampers, and flexible connections.
- Insulate the following ductwork:
  - Outdoor air intake ductwork between air entrance and fan inlet or HVAC unit inlet.
  - HVAC supply ductwork between fan discharge, or HVAC unit discharge, and room terminal outlet.
  - Insulate neck and bells of supply diffusers.
  - HVAC return ductwork between room terminal inlet and return fan inlet, or HVAC unit inlet.
  - HVAC plenums and unit housings not pre-insulated at factory.
- Insulate each ductwork system specified above with one of the following
  - Rigid Fiberglass: 2" minimum thickness in machine, fan and equipment rooms.
  - Flexible Fiberglass
  - Cellular Glass
  - Flexible Unicellular

4. HVAC Equipment

- Insulate the following equipment:
    - Boilers (not pre-insulated at factory).
    - Hot water storage tanks.
    - Water heaters (not pre-insulated at factory).
    - Heating hot water converters
    - Heating water air separators.
- Insulate each item of equipment specified above with one of the following:
    - Fiberglass.
    - Calcium Silicate.
    - Flexible Unicellular: (Do not use for equipment operating above 180 deg. F (82 deg. C).)

D. PLUMBING SYSTEMS

1. General

- Every mechanical room shall have a minimum of one hose bibb.

2. Plumbing Fixtures

a. General

- Any pipe, fitting, or plumbing fixture intended to convey or dispense water for human consumption shall be certified to NSF-61 Annex G or NSF372.
- Design water supply piping for human consumption so that food areas, break-room sinks, and water fountains are not at the end of a plumbing run, and are located so that the water supply has a high rate of turn-over to assure high water quality.

b. Water Closets

- Specify high efficiency china and flush valves both rated for 1.28 gpf or less. China shall be wall hung. Flush valves shall be manual except ADA facilities shall incorporate infrared. The flush valve and china shall remove a minimum of 800 grams of waste in a single flush per MaP testing protocol. Provide the following owner preferred alternates for the flush valves: Sloan, Zurn, and American Standard.

c. Urinals

- Specify china and flush valves rated for 0.125 gpf. Flush valves shall operate by infrared sensor. Provide the following owner preferred alternates for the flush valves: Sloan, Zurn, and American Standard. Water Closets – NSP 61/ASME 61.9 Approved.

d. Lavatories

- Specify low-flow lavatories with faucet aerators with push timed or engaged drop stick metering.

e. Showers

- Specify low-flow showers with single handle that enables off/on temperature maintenance.

f. Floor Drains

- Floor drains, and other commonly used drainage facilities are typically installed in a standard manner throughout buildings without having a specific need or function. The installation of these devices creates a tremendous maintenance problem in maintaining trap seals. The design engineer shall carefully evaluate the need for all such devices and make sure there is a legitimate requirement for their installation. Installing devices in a generic fashion is not acceptable.

- Provide floor drains which require removal of the cover with a "special tool" or by qualified people.
- Floor sinks for exterior stairwells, if required, shall be a minimum of 4" with a 12" x 12" x 6" drain well with grate-type cover.

g. Water Coolers

- Provide manufacturer recommended clearances. Provide ½" piping min. to water coolers to prevent bubbler height bounce with pressure fluctuation. Do not specify remote mounted condensing units. Condensing units should be accessible from the front of water cooler and in same enclosure.
- Remote and stand-alone water coolers will be installed with at least the minimum side, front, rear and floor air flow clearances that are recommended by the manufacture and will not be recessed into areas with poor air flow. The water supply shall not be tied into the same supply water that feeds the rest room fixtures to prevent bubbler height bounce when any flush valve is activated.

h. Sinks

- For BS3 and BSL2+ labs, sinks shall not be stainless steel. Provide sinks designed for bleach use.

3. ***Protection of Potable Water Supply***

- Provide parallel PRV's for building domestic service. Install in a location that may not flood the building such as an exterior hotbox or room with openings only to the exterior.
- Backflow devices requiring maintenance shall be less than 5 ' AFF".
- Specify RPDA backflow preventers, on the domestic water main in accordance to OWASA guidelines.

4. Miscellaneous Plumbing Systems and Equipment

a. Vacuum Pumps and Air Compressors

- Provide 25 micron filter and pressure regulators with isolation valves on each side. Locate in an accessible location and not located behind the equipment.
- Provide one foot clearance in rear to wall and two foot clearance on each side.
- Provide washable condenser filter.
- PLC's: Provide a back-up copy of the programming software, ladder logic and database for all PLC's.

b. Pure-water (RO or DI)

- In closed loop systems equipped with DI beds, provide a resistivity meter in the return piping.
- Provide pressure gauges and sample ports on both sides of each filter and component.

c. Elevator Sump Pumps

- Elevators shall be provided with sumps and sump pumps piped to the sanitary sewer.
- When required, equip with oil separators, high level alarm, and monitor with BAS. Coordinate with architect.

5. Water Conservation

- Domestic water shall not be used as a primary cooling source. Domestic water used as a back-up cooling source shall be reclaimed.
- When domestic or reclaim water is used for back-up cooling, there shall be a separate branch pipe serving the building's back-up cooling needs with a single switch over valve monitored by the BAS.
- Large quantities of domestic water used to create vacuums for lab equipment shall be reclaimed.

E. NON-HVAC AND NON-PLUMBING BUILDING SYSTEM EQUIPMENT

1. Ice Machines

- Provide 25 micron filter and pressure regulators with isolation valves on each side. Locate in an accessible location and not located behind the equipment.
- Provide one foot clearance in rear to wall and two foot clearance on each side.
- Provide washable condenser filter.

2. Autoclaves

- Autoclave trap coolers shall be equipped with automated water conserving devices.
- Provide corrosion-proof drain pans under autoclaves or coordinate with the architect to provide a sloped floor to drain.

3. Snow melt

- Snow-melt shall be controlled by a replaceable moisture / temperature sensor and monitored by the BAS.

F. PIPING SYSTEMS

1. Piping

- The use of float type automatic air vents is not permitted.
- For connections between dielectric materials, dielectric unions are not allowed. Provide brass valves, flanges or equivalent that are not subject to leaking.
- Drain and dirt leg valves shall be full port, line-size for pipe up to 2" and a minimum of 2" for larger pipe.
- For coils, provide isolation valves on individual branch piping whenever combination strainer and isolation valves are provided at the equipment.
- Upon request by UNC, the designer shall provide schematic piping drawings for each system and identify major components and provide enough information to determine design flow, redundant equipment, diversity factors, etc. This will be typically provided for all complex systems.
- Upon request, the designer shall furnish detailed calculations for the highest pressure losses in the piping systems at design flows. Diversity factors and other assumptions shall be clearly identified.
- Piping larger than 2” dia., shown in mechanical rooms, shall be shown double lined to reflect the insulated diameter of the pipe.

2. Pumps

a. General

- Mechanical schedules for circulation pumps shall indicate minimum pumping efficiencies.
- Provide a minimum clearance of 24" on sides and ends of base mounted pumps and motors to allow access for service and repair.
- Specify isolation valves allowing removal of pumps for repair.
- Specify the installation of bleed valves and gauge ports at accessible locations.
- All pumps shall be serviceable without removing the volute from piping connections.
- Specify that all pump mechanical seals shall have ceramic stationary seats.
- Specify a (single) pressure gage with isolation valves on base mounted pumps to provide suction pressure, discharge pressure, and differential pressure.

b. Alignment for Flexible Coupled Pumps

- Specify that the contractor employ a technician certified by the selected pump manufacturer to field align flexible coupled pumps after the base has been grouted and flushing and cleaning procedures are completed.

- Specify that pump and motor is aligned in all four planes: vertical angular, horizontal angular, vertical parallel and horizontal parallel. Alignment shall be within the recommended value by pump manufacturer (not coupler manufacturer) but not over 0.002" parallel and 0.005" angular per radius-inch.
- Specify that the contractor record and submit all results of alignment procedure and the pump manufacturer's alignment specifications to the design engineer. The specifications should also require this approved submittal information is included in the O&M Manual.

3. Building Steam Systems

- This section covers steam piping downstream of the building pressure reducing valve.
- For pipe supplied by modulated steam, locate steam traps a minimum of 12 inches below the condensate outlet.
- Specify a minimum schedule 80 piping for steam and condensate piping 2 inches and smaller.
- Specify steam piping (and associated devices) within the building envelope compliant with ASME Standard B31.1 Power Piping.
- Steam condensate from equipment served by modulating steam control valves shall drain by gravity and shall not be lifted.
- Steam traps and steam control valves shall be insulated with easily removable and reusable insulation jackets.
- Contaminated steam condensate shall go to sanitary sewer. Uncontaminated steam condensate shall return to the steam plant.
- Isolation valves, strainers, blow down valves and other components exposed to full steam pressure shall be steel.
- Provide drip legs before control valves to protect control valve seats. Slope steam supply piping between the drip and the control valve back towards the drip.
- Trap assemblies shall be equipped with a dirt pocket, isolation valves, strainer, unions, test Tee's with test valve.
- Strainers in horizontal steam piping shall be installed pointing to the 3:30 position (slightly down from horizontal). Strainers in condensate piping shall be pointed down (6:00 position).

4. Heat Exchangers

- Specify long-life gaskets for heat exchangers such as spiral wound gaskets or other gasket materials superior to standard compressed fiber gaskets.

5. Boilers

- Specify IRI gas trains on all boilers.
- Condensing boilers are not permitted.
- Specify boiler controls to provide heating hot water year around.

G. HVAC SYSTEMS

1. General Requirements

- UNC-Chapel Hill's standard HVAC system is a fully ducted, centralized, variable volume custom air handling unit serving VAV terminal units with hot water reheat coils.
- HVAC systems should be of heavy commercial/industrial quality construction. Design the system to provide a reliable service life of at least 30 years.
- HVAC should be conservatively sized such that it can maintain proper temperature and humidity levels without having to operate at the top end of its design envelope.
- The equipment shall be outfitted with the necessary sensors and components such that it can self-monitor and provide the necessary information for easy diagnosis of problems.
- The systems must be flexible enough to accommodate space renovations that will occur during its life.

- The systems should strive to centralize and locate points of routine maintenance such that building downtime, occupant interruption, and maintenance time is minimized.
- Recirculation of air from break rooms, mechanical rooms and print/copy rooms is not permitted.
- Heat recovery methods shall be utilized unless proven to be not cost effective by a life cycle cost analysis. Careful coordination with the Architect during schematic design is necessary to provide chases to combine exhaust systems which aid in the incorporation of heat recovery systems.
- Design the system to provide positive pressurization to the building, minimizing infiltration.
- The system shall be fully ducted on both the supply and return side.
- Ductwork shall be externally insulated metal ductwork. Duct liner or exposed insulation anywhere in the system is not permitted.
- The use of non-centralized fan powered devices such as fan powered terminal units and fan coil units are prohibited in occupied spaces.
- The University encourages innovative design, but deviation from these standards must be approved by the University.
- Design HVAC systems which provide air change effectiveness greater than or equal to 0.9, as calculated by ASHRAE 129-1997.
- Air handling equipment including air handling units, exhaust fans, and terminal units shall be shown to scale on the floor plans. HVAC plans (ductwork) at the Construction Document phase (or Later) shall be shown as "double lined" unless duct diameters are less than 10".
- The use of discontinued or soon to be discontinued equipment is not permitted.

2. HVAC Zoning:

- The designer should maximize HVAC zoning, with a zone considered to be the area covered by one terminal unit, to allow flexibility to individual occupants. In general, HVAC zones should not exceed 700 square feet.
- The designer should note this submittal requirement is for UNC review and the HVAC zoning plan does not necessarily need to be included in the final construction drawings.

3. Indoor Design Conditions:

- Indoor Summer Conditions: 75 'F, 50% RH max.
- Indoor Winter Conditions: 70 'F, 30% RH min.
- Mechanical Room Conditions: 50-83 'F, 50% RH max.

4. Heat Transfer Coils

a. General Requirements

- Air handlers providing ventilation air shall be designed with a preheat coil, regardless of outside air percentage or the calculated mixed air temperature.
- Specify that coils shall completely fill unit casing. Do not overlap coils.
- Specify continuous thickness, minimum 0.035 inches, including return bends.
- Specify leak testing at 315 psig minimum.
- Spray Coil Systems: Not permitted.
- Specify for maximum air velocity not to exceed 500 feet per minute.

b. Chilled Water Coils (requirements in addition to General Requirements)

- Refer to UNC Chilled Water Design Guidelines for supply and return water temperature requirements.
- Mechanical schedules for cooling coils shall indicate chilled water velocity in the coil tubes at design conditions.
- Specify stainless steel coil casings, frames, supports, attachment hardware and intermediate troughs for the cooling section. For custom AHU's, fasteners attached to stainless components

shall be 400 series stainless steel or equivalent performance and zinc plated fasteners are prohibited.
- Specify for maximum air velocity not to exceed 450 feet per minute.
- Size coils for a maximum of eight rows at 10 FPI.
- Specify coils with water velocity between 4 and 6 feet per second at full load (design) conditions.
- Specify copper tubes with minimum thickness of 0.035 inches and aluminum fins with minimum thickness of 0.0095 inches.
- Specify 16 gauge stainless steel drain pans and stainless steel intermediate troughs. Cross break pan to drain connection. Drain pans shall be sloped and pitched to allow proper drainage.

5. Cooling Condensate Drain Pans

- Specify that all air handling units have stainless steel drain pans and support framework in the cooling coil section. Specify IAQ packages when available.
- Drain pans shall extend at least 6" on the downstream side of cooling coils.
- Do not install cooling units above ceilings. Where this is unavoidable, or where units are installed in other concealed locations, provide auxiliary drain pans in addition to drain pans provided with the unit. Provide capped drain plug on pan. Provide water detection system(s) in auxiliary pan which shuts unit down and closes the chilled water valve to the coil on detection of water. Do not install auxiliary drain pans in a manner which interferes with service access to the unit. Do not locate units above rigid type ceiling that would require dismantling of ceiling for access to the unit.
- Specify an auxiliary drain pan under the entire air handler when it's installed over occupied spaces.
- For walk-in AHU's, specify aluminum grating over all drain pan sections. Specify pitched and triple sloped drain pans.

6. Cooling Condensate Traps

- Each drain shall be trapped to provide no air leakage at unit and provide complete drainage of unit. Water shall not stand in drain pans. The drain lines shall be 1" dia. minimum. Materials of construction shall be copper.
- Do not route condensate drain lines to storm sewer system or to building exterior.
- Provide cleanout at the bottom of trap and one for rodding straight into the drain pan. Slope drain lines ¼" per foot.
- Specify the minimum A and B dimension of cooling condensate traps on the AHU or coil schedule. For draw through AHU's, the "A" dimension shall be at least local maximum static pressure plus 1".
- For AHU's specify base rail heights adequate to allow for trap installation. For draw through units 3" greater than twice the maximum fan suction pressure. For blow through units specify the minimum base rail height 3" greater than the max fan discharge pressure.

7. Fan Coil Units

- Fan coil units and blower coils are only permitted serving unoccupied spaces and shall not be located above ceilings.
- Fan coil units shall have filter rack in the unit. Provide access for service of unit and filter change with no piping or fixtures located beneath unit or at access panels.

8. Server room AHU's

- For below floor plenums, fan speed shall be modulated to control the plenum static pressure.
- To minimize air-side pressure drops, all cooling units shall remain in operation and shall not be staged.
- Individual fans shall be fully independent and shall not share motors or VFD's.

9. Humidifiers

- Active humidification will usually be required to meet the winter indoor design requirements of 30% RH minimum. See controls sequences. Utilize campus steam, where available, for direct injection humidification.
- Duct mounted humidifiers are preferred for applications in variable volume systems.
- For duct mounted humidifiers, specify welded stainless steel ductwork from the humidifier downstream for a distance of 1.5 times the absorption distance of the humidifier.
- Specify a trapped drain for the stainless steel portion of the ductwork. Drain to a conspicuous location.
- Specify a humidity sensor downstream of the humidifier to alarm upon detection of high humidity and disable the humidifier. Differential pressures switches are not allowed as the only safety for the humidifier.
- Steam humidifier dispersion tubes shall be insulated.
- Provide windows of 6" x 6" minimum size for viewing humidifier operation.
- Provide a minimum of 3" deep; double sloped, stainless steel, drain pan integral to the duct extending the entire length of the humidifier section. Provide a drain with trap.
- Humidification is generally required to maintain minimum relative humidity levels of 30%.

H. HVAC AIR DISTRIBUTION

1. General Requirements

- Location of Air Intakes: The location of air intakes should be remote from sources of pollutants and the building air intake and exhaust outlets shall be remotely located from each other to prevent supply air contamination. Intakes should be located so moisture or odors from landscape materials is not introduced into the air stream. Take special care to ensure that exhaust from hoods, emergency generators, etc., is not pulled into the building through make-up or fresh air intakes. Install ½" x ½" corrosion resistant hardware cloth inside the louver to eliminate leaves, debris, etc. from lodging behind louvers. Paint the hardware cloth the same color as the louvers.
- The designer shall provide indication in the construction documents of areas with critical relative pressurization requirements, such as laboratories. The designer shall designate the pressure differential in CFM or static pressure and require the TAB contractor to balance these zones to the pressurization specified.
- Sound Attenuation. Incorporate necessary attenuation strategies to minimize noise in occupied spaces. ASHRAE's noise guidelines are considered to be the maximum acceptable noise levels.
- Building HVAC systems must be able to operate under the established requirements of the centralized chilled water, steam, and heating hot water systems.
- Upon request, the designer shall furnish for each distinct system a schematic detailing the flow rate and pressure loss for the longest equivalent duct run. Diversity factors and other assumptions shall be clearly identified.
- When redundant equipment is provided, redundancy shall be indicated on the equipment schedule.

2. HVAC Ducts

- All ductwork shall conform to SMACNA HVAC duct construction standards, metal and flexible, latest edition.
- Internally lined duct is not permitted.
- Specify the use of low loss duct fittings. The contractor may use high static loss fittings only in cases where the space prohibits the use of low loss fittings.
- Duct-board is not permitted.
- Metal ductwork shall be sealed as required to pass the leakage test defined in specification section covering Testing, Adjusting and Balancing. In no case shall the ductwork sealant be less than SMACNA Seal Class B.

- Flexible duct connections to grille necks is not acceptable. Specify a 90 degree boot for flexible duct connections to grilles, registers and diffusers.
- A separate minimum OA damper is required for units with OA flow less than 25% of supply air flow. The minimum OA damper shall be located above the maximum OA damper.

3. Duct Accessories

- Splitter dampers are not allowed for use as volume dampers.
- Fire Dampers – Comply with NFPA 90A, 4.3.4 'Air Duct Access and Inspection'. In addition require the contractor to provide a minimum 144 sq. inches of access to the damper on ductwork larger than 14" on one side. On smaller ductwork specify a 2 ft. long removable section of duct for access.
- Access doors shall be 10" x 10" minimum for ducts larger than 10". It is the designer's responsibility to identify, in the contract documents, the minimum size of all access doors.

4. Fans

- Minimum fan construction class required:
  - Buildings serving administrative and classroom functions: design airflow plus 20%.
  - Buildings serving laboratories, research, health care functions: design airflow plus 30%.
- Belt Driven Fans
  - All belt driven fans shall have a minimum shaft size of 1-1/8".
  - Each fan shall have means to re-lubricate the fan shaft bearings.
  - Where necessary, extend grease fittings to an accessible location.
  - Fans shall be checked for balance at all speeds and specified not to exceed manufacture's recommended vibration levels.
  - Each fan shall have the sheaves aligned by contractor prior to acceptance by the University.
  - A spare set of belts for each belt driven fan shall be turned over to University at the end of project.
  - Shall have a NEMA rated adjustable motor base with a minimum of 2 belt tensioning bolts.
- Extend bearing grease lines to an accessible location at the exterior of the air handler.
- Specify minimum fan bearing life of L10 200,000 hours.

5. Air Terminals / Air Valves

- VAV terminal units shall be ARI certified. The unit casing shall be a minimum of 22 gauge galvanized steel. The damper shall be heavy gauge steel with solid metal shaft rotating in Delrin or bronze Oilite self-lubricating bearing. Unit shall be factory leak tested and sealed noting such.
- Fan powered VAV terminal units are allowed only with written approval from the University. The approval request shall include the location of each unit for service.
- The minimum flow rates of air terminals shall be specified as 30% of maximum air flow unless the design requires otherwise.
- Air terminals shall be equipped with a 10" x 10" minimum access door between the air damper and reheat coil.
- When internal liner is provided, provide liner which is resistant to mechanical damage, resistant to mold, shall not shed fibers, and when cooling coils exist, shall provide full insulation capability even when exposed to water.
- Prior to the installation of permanent ID tags, mark air terminals and air valves in a visible location with the equipment identification number using thick black marker or equivalent and 2" characters.

6. HVAC Filtration

- The designer shall specify that the Contractor furnish three (3) sets of filters (pre-filters and final filters) for all air handling units prior to any testing or start-up of systems; with one set installed prior to start-up

of systems; one set installed prior to acceptance of the building and subsequent to testing and balancing; and one set delivered to the University.

- Specify 2" pre-filters and 12" primary filters before the first coil. In walk-in AHU's, filters shall be front-loading. Pre-filters shall be Merve 8. Final filters shall be Merve 11 except specialty facilities such as labs shall be Merve 14. When space is limited 6" or 4" primary filters may be specified upon written approval from Facilities Services. Small package units may utilize 2 inch and 4 inch pleated filters as deemed necessary for unit sizing.
- Specify the filter section access door on the upstream side of the filters.
- On side access units join these filters in a sausage link manner to discourage by-pass air.
- Provide a minimum of MERV 8 filtration for air-flow measurement stations located in outside air ducts."
- All units shall utilize rigid box filters of the synthetic media type with gaskets applied to the filter for ease of replacement at each change.
- Except for specialty applications, filters shall be 2' x 2' or 1' x 2". Approach velocities through filters shall be 500 fpm maximum.

I. MODULAR AND BUILT-UP AHU'S

- Specify an auxiliary drain pan under the entire air handler when it's installed over occupied spaces.
- Wall and roof casing shall be double wall, insulated sandwich panel construction. Outer wall shall be at minimum 0.040" Aluminum, 22 gauge 304 SS, or 22 gauge galvanized steel. Inner walls shall be .040" aluminum, 22 gauge 304 stainless steel or 22 gauge galvanized steel. Insulation shall be 2" polyurethane for walls, floors, and roof having a "U" factor of no more than .066. Fiberglass insulation and insulation utilizing CFC or HCFC blowing agents is not permitted. The floor shall be 3/16" checker plate aluminum or steel.
- Major components shall be supported from the unit framework, not the casing.
- Units shall be specified to require external connection to all coils, drains, electrical, controls, and ducts. All piping connections shall extend 3" through the panel casing and terminate with either flanges or threaded connections as applicable.
- Penetrations shall be insulated, sealed and sandwiched between metal with equivalent materials to the casing construction.
- Lab quality AHU's panel connections shall use aluminum extrusions with a phenolic resin thermal break for no through metal construction. Intersecting extrusions shall be continuously welded to form an airtight seal.

1. Panels and doors

- Access doors shall be sized to provide access to each section. Doors shall be wide enough to remove replaceable unit components. Door construction shall match unit casing. Doors shall be perimeter, airtight, double sealing with replaceable ¾" x 5/16" neoprene gaskets. All doors shall be installed to open against the greater air pressure. Minimum door size shall be 24" W x 60" H unless unit height limits the door height.
- Removable access panels, located at each coil and fan shall be provided to facilitate removal of each coil and fan. Panels shall be constructed the same as access doors and screwed in place on 6" centers. Access panels should facilitate cleaning of coil tubes from exterior of unit without shutting down the unit when removable header coils are specified.
- Provide test ports in all doors.
- AHU door closure hardware shall be metal.
- Specify view panels for all walk in units.
- Removable panels shall be installed and located to facilitate removal of major components such as coils, fans and motors.

2. Maintenance Requirements

- Specify pre-wired lights in each section for all walk in units with a single, with a single on/off switch. Equip switch with an illuminated indicator which indicates when the lights are on. All 120V items shall be wired to a junction box.
- Specify floor drains in all non-drain pan sections.
- Specify that AHU manufacturer provide an integral rail and hoist for air handler motors twenty horsepower and larger.
- Power conductors inside the AHU shall be enclosed within conduit.

3. Gauges

- Specify (differential) pressure gauges across each filter section, across cooling coils and across fans. Pressure gages shall be sized to provide measurement in 1/10 in. W.G. increments or less. Calculated operating point shall be at 50% of full range.
- Mount pressure gauges on to the exterior of air handler and specify copper tubing. Gauges shall not be mounted in the AHU casing walls.
- Specify that the gauges are installed to provide static and differential pressure for each section of the air handler and are equipped with on-off-vent valves.

4. Leakage and deflection requirements

- Specify air handling units to withstand 8" w.g. positive or negative internal pressure, or the fan shut off pressure whichever is greater. Leakage shall be 1/2% of design airflow at 1.25 times operating static pressure.
- For AHU's greater than 40,000 cfm, specify that all units are to be factory and field tested for a maximum of 1% of design cfm allowable leakage at 10" positive and 10" negative pressure. All units will be factory and field tested for deflection based 1/200 of the greatest span at 12" positive and 12" negative pressure. The owner has the option to witness all testing. The unit supplier shall reimburse the owner for all travel expenses (1 person). All testing will be performed by the unit supplier. The designer should discuss this section through the UNC Design Project Manager with a UNC Facilities Services Representative during design.
- All pipe and conduit penetrations shall be sealed air tight. After wire is pulled conduit shall be sealed so that air cannot be transferred into or out of the unit.

5. UV Lights

- Specify ultraviolet (UV) lights on the downstream side of chilled water coils .
- UV lamps and ballast shall be non-proprietary and available from multiple manufacturers. Submittals must provide a list of alternate bulb manufacturers (two minimum) with equivalent cross-reference lamp model numbers
- Specify 360 degree UV coverage.
- Specify stainless steel fixtures.
- Specify 5-year ballast warranty.
- Specify safety switches and safety stickers on doors on both sides of the cooling coil.

6. Dampers

- Control dampers shall be opposed blade type. Prototypical opposed blade dampers shall be Ruskin-CD50 series or approved equal.
- Stratification of cold outside air shall be avoided by premixing the return and outside air streams or providing adequate mixing box depth. Where space limitations result in inadequate mixing, provide parallel-blade control dampers directed at one another or blenders.

7. Flexible Connections

- Specify flexible connections for a minimum 10" wide x 1/16" thick and suitable for duct pressure up to 10" w.g.

8. Field Service and Equipment Startup

- Specify a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections prior to unit startup. Specify a factory-authorized service representative to perform startup service.

J. BUILDING LEVEL TEMPERATURE CONTROL SYSTEM

The building automation system is a Lon based, open protocol system. The specifications are prescriptive in nature and changes to the diagrams must be bubbled and specifications edited with track changes on for approval by UNC Facilities Services. The BAS will be a stand-alone system, capable of operating the building by itself. The University requires the BAS to be connected to a central location called the Energy Management Control System located at the Giles F. Horney building. The 'EMCS" is responsible for BAS front end functions such as graphics, data trending, scheduling, etc. The EMCS 'integration' is performed through the project by UNC Facilities Services, and is funded by a project reserve. The BAS contractor will not manage this scope of work. The designer is responsible for editing and incorporating the sequence of operations and control drawings, BAS contract specifications and assisting with setting the reserve for the integration. Refer to UNC Chapel Hill Controls Guidelines and UNC Controls Preface and Implementation Guidance document for more information.

K. REFRIGERATION SYSTEMS

- Refrigeration compressors shall not be installed directly to floors or on the roofs of ECRs and shall be installed on racks for ease of access. For single compressors, the ideal elevation is 36" AFF.
- The Ice machine make and model shall be approved by the UNC refrigeration shop.
- Refrigeration ball valves shall be provided to allow for the isolation of each component for service without requiring pump-down of the entire system.
- Specify semi-hermetic, scroll, or other as available. Hermetically sealed compressors shall be avoided.
- When equipment using refrigerants is to be installed, the designer shall specify the use of HFC refrigerants in lieu of HCFC refrigerants, where available.