PLUMBING AND MECHANICAL SYSTEMS DESIGN GUIDELINES

PREFACE

Introduction

The designer is required to incorporate the design guideline into the design documents. If a variance is requested, the designer should discuss this with Engineering Services. The designer is recommended to read the design guideline in entirety, underline text which the designer has questions or wishes a variance, and then review the underlined sections with the mechanical reviewer.

Editing

Underlining within the body indicates an edit to the former 2012 Plumbing and Mechanical Design Guideline.

TABLE OF CONTENTS

I. GENERAL REQUIREMENTS

A. *Related Design Guidelines*

1. Control Standards
2. Building Automation Preface and Implementation Guidance
3. Chilled Water Distribution Design Guideline
4. Steam System
5. BSL3 Design Guidelines
6. Laboratory Design Guidelines
7. Non-Potable Water Design Guidelines
8. Environmental Chambers Design Guideline

B. *Applicability*

1. The Mechanical and Plumbing design guidelines apply to all design including formal and informal construction performed by outside contractors and in-house shops.

C. *Manufacturer's Installation Instructions*

1. During design, the designer shall be familiar with the manufacturer's installation instructions for all specified equipment and components. During design, the designer shall incorporate 'recommended' manufacturer's installation instructions into the bid documents in addition to manufacturer's "required" installation instructions. At the time of inspection, the designer shall verify that installations fully comply.
2. The manufacturer's installation instructions shall be available on the job site at the time of inspection and start-up as required by NCMC 304.1.

D. *Submittals*

1. Submittals shall include a copy of all relevant specifications. For each specification section and subsection the submittal shall indicate either "complies" or "deviates" and with explanation. The specification shall precede the product information.
2. Submittals shall contain the manufacturer's installation instructions.
3. General
    a. Clearances around equipment including air terminals, reheat coils, and air valves shall be sufficient to allow inspection, service, repair or replacement without the need to remove elements of permanent construction such as conduits, pipe, ducts, cable trays, etc. All trades must coordinate and protect the service area around equipment. It is emphasized that equipment above ceilings must have access for replacement without the need to remove unrelated systems. Designers shall indicate, on the plans, minimum clear maintenance access for all major equipment including air handlers, terminal units, air valves, fan coils, heat exchangers, boilers, chillers, air compressors, pumps, motors, fans, control valves (greater than 3"), etc. This should be indicated with a light, dashed line, cross-hatch, or within detail drawings.
    b. Suspended ceiling clearances: Provide 2" minimum clearance (or two times the ceiling tile thickness) between the suspended ceiling grid and the overhead building systems and structure to allow for ceiling tile removal. This requirement applies to all construction trades. The MEP designer is responsible for coordinating this requirement with the architect.
    c. Height requirements
        i. Equipment requiring frequent maintenance, such as pumps, motors, control valves, humidifiers, and control valves should be installed below 13' elevation.
        ii. For equipment mounted over 13' elevation, provide fall-protection tie-offs and platforms as required by OSHA.
        iii. For equipment mounted over 15', assure that an extension ladder may be used and provide structural ladder hold-offs as needed and / or an access platform. The NC Mechanical Code requires a permanent means of access for equipment over 16'.

iv. For equipment over 20', provide an access platform. Provide stairs or ship ladder with a cage when possible (to avoid uncaged ship ladders). Avoid alternating stair treads.

d. Lifting means: For heavy equipment that may require occasional replacement and when the equipment weight is in excess of 150 pounds with limited access or when over 8 feet in elevation and in excess of 50 lbs., provide means for equipment replacement such as attachment points for chain-hoists, mono-rails, jib-cranes, etc. Provide permanent lifting chains when attachment points are over 13' elevation. Typical equipment that applies includes large pumps, motors, control valves, tube bundles, etc. Equipment between 150 and 500 pounds and 2 feet to 8 feet elevation may be removed by engine hoist if clear working space is provided.

4. Access doors

a. 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.
b. Refer to "HVAC Air Distribution" for additional requirements for duct access doors.

5. Minimum access requirements

a. Air Handlers: 36 inches minimum access for fan compartments with motors 10 hp and larger. Provide coil pull access for the length of the coil plus 6 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.
b. Boilers: Provide 24 inches on all sides except the burner, which should have 36 inches minimum.
c. Control valves: For valves 3 inches and larger, provide access above the valve of the assembly height plus 12 inches.
d. Heat Exchangers: Provide tube pull plus 12" for shell and tube type exchangers.

E. ***Procedures during Construction***

1. General

a. All new and reused equipment installed under the project scope of work shall be cleaned and in new condition (inside and outside) at the time of acceptance. Reused equipment shall only be used if specified and approved and shall be refurbished to "like new" condition.
b. Cleaning solutions or anything other than water shall not be discharged to the storm sewer system.
c. Spare parts shall be turned over to the owner via the UNC construction manager.
d. The contractor shall be responsible for maintenance until training is complete and the O&M manual(s) are delivered and approved by Building Services.
e. Warranty: Contractors standard 1-year warranty starts at the beneficial occupancy of the area accepted or additional warranties apply to their terms.)

2. Requirements for operating HVAC equipment during construction

a. Building must be fully enclosed, including installation of all doors, windows, etc.
b. Set air handler to use 100% OA if construction is still generating dust and when conditions will not allow the coil to freeze.
c. If return air is to be used then all exhaust and return ducts/grilles shall be covered with temporary filter media, minimum MERV 8, to prevent dust infiltration into the ducting.
d. All chilled water piping shall be insulated.
e. Pump and fans shafts shall be aligned prior to operation. Laser alignment shall be provided for pumps, and reports shall be furnished prior to operation.
f. Supply and outside air connections of ductwork to AHUs shall be complete.
g. All manual dampers, fire dampers and combination fire/smoke dampers shall be open.
h. All main supply ductwork shall be insulated.
i. All safety circuits and basic control functions shall be active and fully functional. If the equipment may operate without a fully functional BAS, then means to prevent damage to ducting due to closed

dampers and means to prevent damage to freezing coils shall be provided. Blow-out doors may be used to protect ducting. Until TAB activities commence, fans and pumps shall operate at no more than 70% of estimated design capacity.

j. Conditioning (cooling & dehumidifying) of the building shall remain once started.
k. Final approval of UNC is required prior to starting AHUs for temporary operation.
l. Cover outside air intakes with 1" roll filter media.
m. The contractor shall perform all required preventative maintenance on mechanical equipment operated during construction and provide documentation in the operation and maintenance manuals of preventative maintenance activities completed during this period.
n. At the end of the construction period and prior to occupancy, clean the inside of AHUs and if more than 50% loaded, then install new pre and final filters.
o. AHU UV lights shall be operational and all specified filters installed during all AHU operation.

3. Cleaning and treating the domestic water system

a. For all fixtures with aerators, remove the aerator before flushing. After flushing, rinse the aerators and reinstall.
b. Operate booster pumps to achieve maximum pipe velocity and flushing effectiveness.
c. With all aerators removed, let the water run through the fixtures for 10 minutes at the highest flow rate.
d. 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.
e. Notify the EHS Occupational and Environmental Hygiene Manager when building flushing begins and are complete. Provide the building and the site contact information.
f. Overflow Pipes: Extend all equipment overflow or blow-down lines to a floor sink or floor drain connected to the sanitary sewer system.
g. 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).

4. Cleaning and treating the hydronic piping

a. Specify flushing and cleaning for piping systems before they are put into service. Do not utilize building pumps for circulating cleaning fluid to maintain design water velocities for the duration of the test. Flush system at 4 fps minimum velocity.
b. For new pipe systems, specify a closed-loop cleaning procedure such as Chem-Aqua TB 3-001.
c. Passivate new systems for a minimum of 5 days.
d. When adding to existing loops, fund a work order for HVAC Services to treat the loop.
e. Bypass all coils during flush and cleaning process. Provide startup pump strainers or temporary pumps during flush and cleaning process.

F. *Testing and Verification*

1. General

a. 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.
b. Specify factory certified start-up and inspection for vacuum pumps, air compressors, pumps, AHUs, fans, boilers, VFDs and water heaters.
c. 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.

d. Air and Water Balance (TAB)

i. Air and water systems shall be tested including all ducts and fire dampers.
ii. The balancing shall be performed by an independent, certified AABC or NEBB TAB firm.

iii. At least one AABC or NEBB certified balance specialist with a minimum of 2 years' experience shall be at the site to perform daily TAB activities.
iv. TAB activities shall be reviewed by a certified TAB supervisor or Professional.
v. 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.
vi. Balance reports shall be sealed as accurate by a professional engineer licensed in the State of North Carolina.
vii. The designer shall review and approve the qualifications of the balance specialist and the means and methods of testing.
viii. Air quantities shall be balanced to no greater than +/- 5% of design values for research buildings or critical spaces and +/- 10% for other buildings.

G. *Training*

1. The contractor shall provide on-site training to University staff prior to occupancy or acceptance.
2. For capital projects, contractor shall provide additional classroom or factory training for new Building Automation System, environmental cold rooms, lab air compressors (>50 hp), vacuum pumps (>30 hp), non-potable water treatment systems, high purity water systems, etc. During design the designer shall specify the appropriate training required through coordination with UNC Engineering Services.
3. The contractor shall submit training schedules, training syllabus, and resumes of the person(s) giving the training to the University for review and final approval.
4. The designer shall provide a complete list of all required training in the general or commissioning sections of the mechanical and plumbing design documents.
5. Training shall not be scheduled until the installation is complete and verified by UNC Engineering Services. Requests for training must be provided to UNC's training coordinator at least two weeks prior to the event. Requests must include a detailed syllabus, times, names and affiliation of instructors, and a specific meeting location (e.g., room number).

H. *Design Document Requirements*

1. When requested by UNC, the designer shall provide schematic drawings detailing the flow rate and pressure loss for the longest equivalent duct or pipe runs. Diversity factors and other assumptions shall be clearly identified.
2. When redundant equipment is provided, redundancy levels shall be indicated on the equipment schedules.
3. When requested by UNC, the designer shall provide an engineering basis of design detailing diversity factors, design velocities, design pressure drops, redundancy values, load calculations, energy model input data, and other criteria used for sizing ducting, piping, equipment, and other components.

II. COMMON WORK REQUIREMENTS

A. *General:*

1. For labs, provide n+1 redundancy. Redundancy requirements are project specific and should be discussed with UNC Engineering Services.
2. Equipment schedules shall indicate electrical power requirements.

B. *Common Motor Requirements*

1. General requirements
   a. Specify NEMA class F insulation with Class B temperature rise and 1.15 service-factors in an ambient temperature of 40 °C maximum.
   b. Specify 480V, three phase electrical service for motors 1/2 hp and larger. Specify single phase protection for multiphase motors.
   c. Enclosures for motors shall have hinged covers. Bolt on covers are not acceptable.
   d. For frames 284 or larger, bearings shall be capable of lubrication. Extend grease lines to an accessible location.
   e. For frames 140T - 280T, bearings shall be re-lubricated or equipped with double shields.
   f. Base plates for motors shall be constructed to NEMA standards and shall have a minimum of 2 belt tensioning bolts.

g. Terminations for motors 5 hp or greater shall be made proprietary connectors and shall be made with split bolts wrapped with a layer of glass tape and then black electrical tape.
h. 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.
i. Indicate the horsepower rating on both Division 15 and Division 16 construction drawings.

2. For motors 1 hp and larger

a. The following manufactures are approved: Baldor Super-E EM/XE (general purpose family) with optional cast iron frame, TECO/Westinghouse ASHH or Max-PE, WEG W22, or Toshiba. In cases of shipping delays, severe duty and IEEE 841 motors shall be considered. Rolled steel frames and aluminum end bells are not acceptable.
b. Motor frames and end-bells shall be cast iron for motors 1 hp and larger. Specify premium efficiency motors, as defined by NEMA MG-1, for all motors 1 hp and larger.
c. Belt drives shall be equipped with fixed pitch sheaves.

3. For motors equipped with VFDs

a. Motors shall meet the requirements of NEMA MG-1, part 31 "Definite Purpose Inverter-Fed Motors".
b. Provide solid shaft grounding rings (Aegis SGR or equal). Soft carbon brushes shall not be accepted. Split grounding rings shall not be accepted.

4. Synchronous belt drives

a. Synchronous belts and gears shall be provided for belt-driven motors 3hp and larger.
b. Synchronous drives shall be designed for quiet, energy efficient operation. Eagle NRG is approved (or equivalent).
c. Prior to start-up, shafts shall be laser alignment. Provide a printed report for review by UNC prior to start-up.
d. Synchronous driven motors shall be equipped with soft start or a VFD.

C. *VFDs*

1. Location

a. VFDs shall be stand-alone and fed from electrical panels.
b. VFDs shall not be installed within or fed from MCCs.
c. VFDs shall not be mounted inside or directly to AHU casings.
d. VFDs shall be located as close as feasible to the motor controlled and in accordance with manufacturer's installation instructions.
e. Show VFDs on the drawings.
f. VFDs should not be located outdoors. When absolutely necessary and approved by UNC Engineering Services, outdoor installations may be considered and generally shall be covered and protected to allow maintenance during adverse weather.

2. Approved brands and labeling requirements

a. The approved manufacturer shall be manufactured by ABB, Schneider (Square D) and Danfoss. No other manufactures will be accepted.
b. VFDs shall bear the original and approved manufacturer's label and shall not be re-branded.
c. The entire project shall provide VFDs by one manufacture. This is typically accomplished through specification of an owner preferred alternate. The owner preferred alternate or basis of design shall be ABB.

3. Harmonic Mitigation

a. Provide an IEEE 519-2014 (or most recent) analysis. For typical buildings, the total harmonic distortion shall not exceed 5%. For buildings with sensitive research or medical equipment, the total harmonic distortion shall not exceed 3% on both normal and emergency power. The VFD manufacturer shall provide mitigation as part of the VFD package. (The designer may specify an alternate harmonic mitigation method).
b. The method of mitigation must be provided to the owner for approval (either through submittal or design review).
c. Specify a dV/dT filter if the motor is greater than 50 hp.

4. Features
    a. Power Supply: The AC Drive system shall consist of an AC Drive and a Bypass circuit. These circuits shall operate independently of each other, and have completely separate switch mode power supplies operating off AC line Voltage. The bypass shall provide motor functionality with the drive removed. The bypass shall automatically respond to the BAS for start and stop while operating in bypass.
        i. Bypass package shall include a main input circuit breaker, disconnect or fused disconnect.
        ii. Bypass shall include a service switch or line isolation contactor to disconnect power to the drive, but not the bypass.
        iii. Drive and bypass package shall be UL listed and have a labeled, short circuit current rating (SCCR) of 100,000 amps.
        iv. Start, stop, speed reference, and safeties to the drive are hard wired. Provide a LonTalk or BACnet compatible transceiver, whichever is compatible with the building for BAS diagnostics.
    b. Disconnect
        i. For any VFD located out of site of the equipment served, provide a disconnect within sight of the equipment served.
        ii. Disconnections shall be equipped with auxiliary contactors and wired to the VFD enable circuit. This eliminates the possibility of a hard start when the disconnect is closed.
5. Redundancy
    a. Specify one VFD for each fan in a fan array.
6. Miscellaneous
    a. VFDs must go into fail safe mode during generator testing.
    b. Provide a schedule /s for VFDs indicating equipment ID, equipment served, HP, minimum rated output amps, volts, phase, UL enclosure type, input disconnect means (circuit breaker or fused disconnect), etc.
7. Training and warranties
    a. The VFD manufacturer shall provide a factory certified technical representative to inspect the contractor's installation, and to test and start-up the VFDs furnished under this specification.
    b. The VFD and bypass warranty shall be 24 months minimum from the date of startup and shall cover parts, travel, labor and shipping required for repair.
    c. Provide all required cables and copies of software required for adjustment of all user adjustable parameters. Provide one Installation and Operations Manual and wiring schematic per VFD at the time of training.
    d. The manufacturer shall provide factory direct warranty and support service.
    e. A representative of the VFD manufacturer shall provide one-day on-site training. For large projects, provide factory training in addition to on-site training.

D. ***Common Electrical Requirements***

1. Disconnecting means furnished integrally with equipment is considered adequate if the disconnecting means is properly sized and fused.
2. Starters
    a. For starters located adjacent to the motor served, specify combination-type starters.
    b. 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.
3. BAS controls panels shall not contain wiring in excess of 24 volts. The division 26 designer shall specify 120 VAC controls circuits for powering BAS control panels. 120 VAC circuits shall terminate in central locations to the control panels served. The division 26 designer shall show the 120 VAC termination point on the electrical drawings which is typically within an ME or EE room. The division 23 controls contractor shall provide necessary step-down transformers and shall field route low voltage power from the 120 VAC termination point to the equipment served.

E. ***Meters and gauges***

1. Provide a strainer and analog water totalizing meter for makeup water supplies.
2. Hydronic pressure gauges exposed to vibrations shall be liquid filled.
3. When providing pressure measurement on each side of equipment, specify a single gauge connected to both sides and equipped with isolation valves for measuring either side independently with the same gauge.

F. ***Flow balance valves***

1. For hydronic applications, specify either PICV control valves or globe balance valve. Globe balance valves shall be equipped with a hand-wheel counter. Automatic (autoflow) balance valves are prohibited. Quarter-turn ball balance valves shall be avoided.
2. Combination balancing/shutoff valves shall be independent and using the shut off function shall not affect the system balance when the valve is reopened.
3. Butterfly valves are not acceptable valves for flow balancing.
4. Balance valves shall be tagged with the model #, terminal unit #, circuit gpm, balance governing head loss, calculated circuit head loss.

G. ***Vibration and Seismic Control***

1. 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.
2. 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 %.

H. ***Identification***

1. Equipment Identification
    a. Equipment shall be clearly identified with engraved phenolic plates securely fastened to the equipment with sheet metal screws. Specify phenolic plates with tag and letter colors in compliance with the SCO electrical design guidelines. Indicate the equip ID number. When appropriate, such as for exhaust fans, indicate at the fan/s and the equipment served the equipment or system served, panel number, and breaker number.
    b. Concealed equipment: All equipment requiring periodic maintenance or testing located in concealed spaces shall be clearly identified on an adjacent finished surface to identify the location of equipment. For equipment mounted above ceilings, provide an ID label on the ceiling below the equipment. Typical concealed equipment includes air terminals, air valves, PRVs, mixing valves, duct and pipe differential pressure sensors, steam traps, fire smoke dampers, etc. Labels shall be clear or white with 0.375" high black letters.
2. Pipe and Duct Identification:
    a. Completely paint piping systems in mechanical rooms with the applicable colors listed below.
    b. Identification shall be provided no further than 30 feet apart, at major changes in direction, at each valve or equipment, and on both sides of penetrations.
    c. For both piping and ducts, provide stencil or strap-on identification indicating the system and the direction of flow.
    d. See table 1 for system colors and identifications. 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.
        i. For insulated pipe systems, stencil sizes are as follows:
            01. For pipes up to 1 inch, use 1 inch letters.
            02. For pipes 1 inch to 2 inches, use 2 inch letters.
            03. For pipes 2 inches to 6 inches, use 3 inch letters.
            04. For pipes above 6 inches, use 4 inch letters.
        ii. For un-insulated systems, stencil sizes are as follows:
            01. For pipe diameters up to 1 inch, use 1/2 inch letters.

02. For pipe diameters from 1 inch to 2 inches, use 1 inch letters.
03. For pipe diameters from 2 inches to 6 inches, use 2 inch letters.
04. For pipe diameters over 6 inches, use 3 inch letters.

e. 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.

f. Valve Identification

i. Specify brass valve tags with chains for isolation and control valves.
ii. Specify a valve tag chart in the O&M manual.
iii. Specify a valve tag chart to be mounted in the ME room in a frame with a clear, shatter-proof cover.
iv. Include the tag numbers in the as-built drawings.

g. Painting

h. Equipment, ducting and piping installed on the exterior of the building shall blend in with the building. Specify appropriate paint colors and coordinate with the architect.

Piping System	**Color**	**Stencil Identification** (Note1)
Ductwork	Light Gray	Supply, Exhaust, Return
Chilled Water Supply	Marlin Blue (925) Note 2	CWS
Chilled Water Return	Marlin Blue (866) Note 2	CWR
Steam Condensate Return	Light Brown	COND
Domestic Cold Water	Dark Green	DOM CW
Domestic Hot Water	Red	DHW
Domestic Hot Water (RECIR)	Orange	DHWR
Heating Hot Water	Light Gray	HWS / HWR
Steam, High Pressure (25-75 psi)	Bright Red	HPS
Steam, Low Pressure (0-25 psi)	Dark Red	LPS #__
Condenser Water	Fed. Safety Green	CC
Pure water	Slate Gray	RO or RODI or DI
Vacuum	Beige	VAC
Gas	Black	GAS
Compressed Air	Dark Gray	AIR
Sprinkler	Safety Red	SPKR
Fire Line	Safety Red	FIRE
Nitrogen	Pastel Gray	N
Helium	Pastel Gray	He
Hydrogen	Black	H
Chemical	Yellow	

Note 1: provide flow arrows.
Note 2: references the RUST-OLEUM® color

I. *Insulation*

1. General

    a. 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.
    b. Do not insulate over tank and vessel labels.
    c. Specify insulation for all valves, flanges, elbows, tees and other fittings with the same type and minimum thickness as adjoining pipe.
    d. 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.
    e. Specify continuous insulation across pipe hangers, air handler casings, sleeves and walls.
    f. Specify that the Contractor replace fiberglass and calcium silicate insulation which becomes wet during the construction period.
    g. 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.
    h. Insulate the following equipment items:

        i. Heating water air separator.
        ii. Hot water converters.
        iii. Steam traps.
        iv. Insulate all cooling condensate drain piping. When necessary, insulate drain piping which collects large quantities of cold condensate.

2. Piping

    a. Insulation

        i. Fiberglass insulation shall not be used on chilled water piping.
        ii. Insulate the body of the roof drains and piping a minimum of 10 ft. into the building.
        iii. See the insulation schedule below.

Service	approved insulation
domestic cold water	fiberglass or elastomeric
domestic hot water	fiberglass or elastomeric
interior roof leaders and overflow piping (note 2)	fiberglass or elastomeric
chilled water > 40 °F (note 1)	**polyisocyanurate (nominal 2 lb. / ft3), elastomeric, or cellular glass**
heating hot water	fiberglass, cellular glass, or calcium silicate
< 75 psi steam	fiberglass, cellular glass, or calcium silicate
75 to 200 psi steam	cellular glass or calcium silicate
low temperature piping (< 39 °F)	elastomeric
hot gas refrigerant piping	fiberglass, cellular glass, or calcium silicate
heated fuel piping	fiberglass, cellular glass, or calcium silicate

    b. Jacketing

        i. Corrugated aluminum jacketing or PVC jacketing is required on insulated piping at the following locations: in mechanical rooms from floor level to 8 ft. above finish floor, inside of AHUs, and exterior to the building.

3. Ductwork

a. Lined duct is not permitted. Sound attenuation liner may be considered on a case by case basis, but is generally NOT ALLOWED. The interior of ducts shall be smooth to avoid trapping dust and shall be a cleanable surface. In very limited cases fiberglass liner with a PSK jacket has been considered.
b. 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 or PVC.
c. Externally insulate all exposed supply, return and outside air ducts with rigid fiberglass insulation.
d. 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.
e. Insulate the following duct systems in entirety:
    i. Outdoor air duct
    ii. Supply duct
    iii. Supply diffusers including the neck and back of the housing.
    iv. Return ducts in areas that noise may be a problem such as large rectangular ducts within ceiling plenums of occupied areas and exposed rectangular duct in occupied areas.
    v. Return duct in mechanical rooms where the duct may take abuse.
    vi. HVAC plenums and unit housings not pre-insulated at factory.
f. Insulate each ductwork system with one of the following:
    i. Rigid Fiberglass: 2" minimum thickness in machine, fan and equipment rooms.
    ii. Flexible Fiberglass
    iii. Cellular Glass
    iv. Flexible Unicellular

4. HVAC Equipment

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

III. PLUMBING SYSTEMS

A. *General*

1. Every mechanical room shall have a minimum of one hose bib.
2. Piping dead legs are prohibited. During renovations, dead end piping must be removed to within six inches of mains (or what is appropriate).

B. *Plumbing Fixtures*

1. General
    a. 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.
    b. 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.
2. Water Closets: Specify high efficiency china and flush valves both rated for 1.28 or less. (consider 1 gpf) China shall be wall hung. Flush valves shall be manual except ADA facilities shall incorporate infrared. The flush valve and china combination shall remove a minimum of 1000 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.

3. 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.
4. Lavatories: Specify low-flow lavatories with faucet aerators with push timed or engaged drop stick metering.
5. Showers: Specify low-flow showers with single handle that enables off/on temperature maintenance.
6. Floor sinks and Drains
    a. Within a 2' radius of floor sinks and drains, slope the floor downward 1/8" per foot towards floor sinks and drains.
    b. Floor sinks and floor drains shall be slightly recessed below the floor.
    c. Prior to the pouring of concrete floors, floor sinks and drains shall be secured anchored into place. The contractor is responsible for reinstalling any floor sinks which are higher than the surrounding floor surface.
    d. For new construction, provide recessed floor sinks or hub drains for each source of equipment condensate. Verify the elevation of floor sinks prior to pouring.
    e. Provide floor sinks in areas prone to flooding and for the collection of condensate.
    f. Do not provide excess floor sinks in areas that are not required.
    g. Provide floor drains which require removal of the cover with a "special tool" or by qualified staff.
    h. Floor sinks for exterior stairwells, if required, shall be a minimum of 4" with a minimum 12" x 12" x 6" drain well with grate-type cover.
7. Water Coolers
    a. 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.
    b. 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.
    c. Specify electric water coolers equipped with bottle filling stations. Specify as the basis of design Elkay EZH20 LZSTL8WSLK for the bi-level and EZH2O LZS8WSLK for the single bottle filling units. The equivalent Halsey Taylor model is approved.
8. Sinks: For areas using large quantities of bleach, such as BSL3, BSL2+ labs, HIV labs, etc., sinks and drains shall be compatible with bleach. Stainless steel is not acceptable for frequent use with bleach.
9. Mixing valves: Mixing valves shall be installed below ceilings.

C. ***Isolation Valves***

1. Provide isolation valves on piping branches.
2. Provide separate piping with a set of isolation valves for each specialty lab and to each bathroom of a bathroom group to allow for outages of individual spaces without affecting the adjacent space. For spaces with restricted access, the isolation valves must be located outside the room.

D. ***Backflow prevention:***

1. Service entrance domestic backflow protection
    a. Provide dual, parallel backflow devices to protect the building domestic supply.
    b. At a minimum, back flow devices shall meet OWASA guidelines.
    c. Backflow devices capable of dumping water (RPZs):
        i. Install in a location that may not flood the building such as an exterior hotbox or heated, above grade room that only opens to the exterior.
        ii. In unusual cases, when RPZs must be located in a room that opens to the interior, RPZs must relieve to a funnel drain connected directly to the exterior. The funnel drain must not be equipped with a backwater valve. Provide an exterior concrete gutter or other means to

conduct relief water 4' to 10' away from the building foundation and coordinate with University landscape architect. Provide a recessed floor sink. Slope the floor towards the drain. Provide a concrete curb or trench drain at the interior door. Walls shall be designed for splashing water. Seal the floor and the bottom 6" of walls to an elevation of 6". Seal the room fairly air tight and provide a door sweep to prevent a negatively pressurized building from drawing exterior air through the relief drain.

d. Backflow devices requiring maintenance shall be less than 5' above the floor.

E. *Water Conservation*

1. Domestic water shall not be used as a primary cooling source. Domestic water used as a back-up cooling source shall be reclaimed.
2. 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.
3. Large quantities of domestic water used to create vacuums for lab equipment shall be reclaimed.

F. *Plumbing Equipment*

1. General

   a. Provide isolation valves on both sides of and all equipment that requires periodic replacement such as equipment, PRVs, meters, pumps, coils, tanks, heat exchangers, etc.

2. Vacuum Pumps, Air Compressors, and Air Dryers

   a. Provide 25 micron filter and pressure regulators with isolation valves on each side. Locate in an accessible location and not located behind the equipment.
   b. Provide one foot clearance in rear to wall and two foot clearance on each side.
   c. Provide washable condenser filter.
   d. PLCs: Provide a back-up copy of the programming software, ladder logic and database for all PLCs.
   e. Air compressor storage tanks shall be a minimum of 4 cft storage for each scfm of compressor capacity.
   f. Desiccant Dryers:
      i. Provide a wet and dry storage tank on each side of the air dryers.
      ii. For desiccant dryer final filters, provide audible alarms, alarm signal to the BAS, and a 4" differential pressure gauge. Alarms shall be powered by 120 VAC, not battery powered.
   g. Provide an exploded view parts drawings with parts numbers with O&M manuals.
   h. Vacuum pump style and features shall be selected to provide minimal water usage.
   i. Liquid ring vacuum pumps shall be equipped recirculating sealant water.

3. Pure-water (RO or DI)

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

4. Sump Pumps

   a. Elevators shall be provided with sumps and sump pumps piped to the sanitary sewer.
   b. Provide a high-level alarm and monitoring with the BAS.
   c. For hydraulic elevators, equip sump pumps with oil-minder features.
   d. Provide lifting rails for sumps deeper than 8'.
   e. Lifting rails and mounting hardware for lifting rail and pump bases shall be stainless steel.

5. High Purity Water Systems (RO and DI Water)

   a. For large systems, RO pretreatment is required. Provide a single, centralized RO system.

IV. SPECIALTY EQUIPMENT

A. *Electric snow-melt system*

1. The snow-melt system shall be connected to the BAS and equipped with a replaceable moisture / temperature sensor and remote override.

B. *Ice Machines*

1. Provide isolation valves, pressure regulators (when required), 25 micron in-line filters, and braided stainless flex connectors on the supply water. Locate the filter and isolation valve in an easily accessible location, such as on the wall beside the ice machine, but not behind the ice machine
2. Provide one foot of clearance in the rear and two feet of clearance on each side.
3. Provide washable condenser filters.
4. *The following brands are approved: Follett, Hoshizaki, or Scotsman.*

C. *Freezers*

1. For each designated freezer space, specify both 120 (NEMA 5-20R) and 208 VAC receptacles.
2. For buildings with more than 10 freezers, specify a dedicated freezer for loaner freezers and equipped with both 120 & 208 VAC.
3. Freezers shall be fed from a panel backed up by the emergency generator.

D. *Autoclaves, Sterilizer, Cagewashers, and Glassware washers*

1. Cagewashers and autoclaves shall be equipped with water conservation features.
2. Provide corrosion-proof drain pans under autoclaves or coordinate with the architect to provide a sloped floor to a recessed floor sink. Leaks shall not be capable of escaping the autoclave room.
3. Drains shall be corrosion resistant such as Orion PVDF.

E. *Purewater Systems (RO and DI Water)*

1. For large systems, RO pretreatment is required. Provide a single, centralized RO system. (RO pretreatment extends the life of resin beds by 6X.)

V. PIPING SYSTEMS

A. *Piping*

1. The use of float type automatic air vents is not permitted except at air / dirt separators.
2. Dielectric unions at reheat coils are prone to leaking due to expansion and contraction and subsequent damage to the union seat. Specify dielectric fittings that are not subject to leaking.
3. Drain and dirt leg valves shall be full port, line-size for pipe up to 2" and a minimum of 2" for larger pipe.
4. For coils, provide isolation valves on individual branch piping whenever combination strainer and isolation valves are provided at the equipment.
5. 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 projects.
6. 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.
7. Piping larger than 2" dia., shown in mechanical rooms, shall be shown double lined to reflect the insulated diameter of the pipe.
8. All take-offs shall be off of the side or top of the horizontal mains and shall not be off the bottom.
9. Provide a dial pressure gauge at the highest point in the system.
10. For heating hot water systems, the pressure relief pipe shall be piped and drain at a visible location such as to the side of the floor drain.

B. *Closed hydronic loops*

1. Provide analog water (dial type) make-up water meters for all closed loops.
2. Provide a make-up flow switch (e.g., McDonnell & Miller FS5-3/4 or equal) connected to a BAS alarm.
3. Heating hot water coils shall be sized for 160 °F supply temperature and 140 °F return temperature. (Exception: Condensing boiler systems shall have a return temperature below the boiler condensing temperature and may require more frequent pasteurization cycles.)
4. For systems prone to freezing specify a minimum of 30% inhibited propylene glycol solution. (glycol solutions below 25% accelerate microbe growth)
5. Provide a glycol make-up tank system (include make-up water meter and alarm contacts for BAS monitoring) for all glycol loops.
6. All closed loops must have owner furnished contractor installed pot feeders with integral filters, Neptune model FTF-5150DB. This is necessary to standardize filters for campus and ensure the treatment tablets fit into the feeder opening.

7. The pot feeder with integral filter must be installed across the pump or supply and return lines (one line on suction side of pump, other line on discharge side) to ensure adequate flow. Supply flow needs to travel in a straight line into the pot feeder intake pipe.
8. Except for sensing tubing, the minimum pipe size is ¾".
9. Each loop must be piped to a sanitary sewer drain to permit flushing.
10. Air and dirt separators shall be the high efficiency, coalescing type. Spirotherm – Dirt and B&G – CRS are approved. Separator media shall be removable. Separators shall be a minimum size of the pipe served.
11. Specify a quarterly pasteurization sequence to heat all piping branches to a minimum of 170 °F for 60 minutes. Typically, this is performed at night and airflow is reduced to avoid overheating spaces.

C. *Pumps*

1. General
    a. Approved pump brands are B&G, Taco, and Armstrong.
    b. Mechanical schedules for circulation pumps shall indicate minimum pumping efficiencies.
    c. Specify that all pump mechanical seals shall have ceramic stationary seats.
    d. Specify a (single) pressure gauge with isolation valves on base mounted pumps to provide suction pressure, discharge pressure, and differential pressure.
    e. Provide a minimum clearance of 24" on sides and ends of base mounted pumps and motors to allow access for service and repair.
    f. Specify isolation valves allowing removal of pumps for repair.
    g. Specify the installation of bleed valves and gauge ports at accessible locations.
    h. All pumps shall be serviceable without removing the volute from piping connections.
2. Alignment for Flexible Coupled Pumps
    a. A technician certified by the selected pump manufacturer shall field align flexible coupled pumps after the base has been grouted and flushing and cleaning procedures are completed.
    b. Align pump and motor in the 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.
    c. 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. For loops equipped with pumps over 10 hp, slip stream filters with depth cartridge filters shall be provided (these are important to project pump seals).

D. *Building Steam Systems*

1. General
    a. This section covers steam piping downstream of the building pressure reducing valve.
    b. Specify a piping inspection prior to insulation and invite UNC Engineering Services.
2. Piping
    a. Specify a minimum schedule 80 piping for steam and condensate piping 2 inches and smaller.
    b. Specify steam piping (and associated devices) within the building envelope compliant with ASME Standard B31.1 Power Piping.
3. Traps
    a. Steam traps and steam control valves shall be insulated with easily removable and reusable insulation jackets.
    b. For coils supplied with modulated steam, locate steam traps a minimum of 12 inches below the coil condensate outlet.
    c. Trap assemblies shall be equipped with a dirt pocket, two isolation valves, a strainer, two unions, and test valve.
    d. Test valves shall be installed on a Tee immediately downstream of the trap. Specify ½" ball valves with locking handles and hand-tight caps. Direct towards the floor.
    e. Provide steam condensate site glasses when the operation of trap testing ports is not advisable such as when installed above ceilings.

f. The designer must specify the minimum and maximum trap size or design capacity for each application. Excessively oversized and undersized traps must be avoided.

4. Condensate
   a. Steam condensate from equipment served by modulating steam control valves shall drain by gravity and shall not be lifted.
   b. Contaminated steam condensate shall go to sanitary sewer. Uncontaminated steam condensate shall return to the steam plant.
5. Piping accessories
   a. Isolation valves, strainers, blow down valves and other components exposed to full steam pressure shall be steel.
   b. 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).
   c. Vacuum breakers: Vacuum breakers are required on the steam inlet side of coils and heat exchangers. Vacuum breakers are also required on the outlet side of modulated coils and converters. Install vacuum breakers on a 15" cooling nipple. Pre-approved models: Hoffman model 62, Barnes and Jones VB 3875. Construction: brass body, stainless steel spring and valve, silicon o-ring. WP 125 psig, WT 350 °F. Typically set pressure: 2" vacuum.
6. Flash Tanks: A vented flash tank shall be provided to cool condensate receivers
7. Drip legs
   a. 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.
   b. Provide steel blow down valves on all drip legs. Install on the side of the dirt leg, 2" up from the bottom. Provide piping to direct the blow-down to an impervious surface (usually downward) and in such a way that building materials will not be damaged during blow-down.

E. *Heat Exchangers*

1. Provide a means to isolate the heat exchanger for inspection, maintenance and replacement while keeping the primary loop pump operating. Typically, two heat exchangers or bi-pass piping is provided. Provide two heat exchangers for large heating hot water systems that require uninterrupted service.
2. Process cooling
   a. If there is any chance of process water mixing with campus water, for example if an emergency bypass is installed around a heat exchanger, then the process loop needs to be treated with non-nitrate chemicals such as phosphates. Provide a placard which reads, “Do not treat with nitrate based chemicals. Treatment chemicals must be compatible with the campus chilled water loop”.

F. *Boilers*

1. Specify IRI gas trains on all boilers.
2. Specify boiler controls to provide heating hot water year around.

VI. HVAC SYSTEMS

A. *General Requirements*

1. 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.
2. HVAC systems should be of heavy commercial/industrial quality construction. Design the system to provide a reliable service life of at least 30 years.
3. 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.
4. 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.
5. The systems must be flexible enough to accommodate space renovations that will occur during its life.
6. The systems should strive to centralize and locate points of routine maintenance such that building downtime, occupant interruption, and maintenance time is minimized.
7. Recirculation of air from break rooms, mechanical rooms and print/copy rooms is not permitted.

8. 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.
9. Design the system to provide positive pressurization to the building, minimizing infiltration.
10. The system shall be fully ducted on both the supply and return side.
11. Ductwork shall be externally insulated metal ductwork. Duct liner or exposed insulation anywhere in the system is not permitted.
12. The use of non-centralized fan powered devices such as fan powered terminal units and fan coil units are typically prohibited in occupied spaces. In certain situations and when approved by UNC Engineering Services, institutional grade fan coils, may be considered when served by outside air makeup units.
13. The University encourages innovative design, but deviation from these standards must be approved by the Engineering Services.
14. Design HVAC systems which provide air change effectiveness greater than or equal to 0.9, as calculated by ASHRAE 129-1997.
15. 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".
16. The use of discontinued or soon to be discontinued equipment is not permitted.
17. For centralized HVAC systems serving DLAM, labs, and other critical areas, provide a minimum of two (2), manifolded AHUs per system to assure continuous HVAC service during AHU outages. Provide isolation dampers, to isolate each AHU during maintenance.
18. Pressure relief: Specify pressure relief doors, when fans are capable of damaging ducts and equipment casings.
19. Cooling equipment larger than 30,000 BTU must be floor mounted.

B. ***Spaces with special considerations***

1. Server and IT Rooms
    a. Provide independent cooling separate from the central HVAC system.
    b. Sources of water leaks must not be located over server and IT equipment.
    c. Typically institutional grade fan coils are provided for cooling. When possible mount fan coils low on a wall as the first choice or outside of the room. All possibilities of leaking water onto the telecom equipment must be eliminated. When provided in the telecom room, provide an auxiliary drain pan with auxiliary float switch. Chilled water piping should stub through the wall and directly into the fan coil valve enclosure. Any leaks or dripping shall be contained within the fan coil enclosure and/or drain pans.
2. Freezer rooms: Provide floor-mounted vertical, up-flow fan coils. Fan coils above the ceiling are prohibited.
3. For spaces with a considerably different thermal loading schedule than the majority of the building, provide an independent HVAC system. This typically applies to spaces with high process loads or spaces with substantially different occupancy schedules.

C. ***HVAC Zoning***

1. 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.
2. 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.

D. ***Indoor Design Conditions***

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

E. ***Heat Transfer Coils***

1. General Requirements
    a. Air handlers providing ventilation air shall be designed with a preheat coil, regardless of outside air percentage or the calculated mixed air temperature.
    b. Specify that coils shall completely fill unit casing. Do not overlap coils.
    c. Specify continuous thickness, minimum 0.035 inches, including return bends.

d. Specify leak testing at 315 psig minimum.
e. Spray Coil Systems are not permitted.
f. Specify for maximum air velocity not to exceed 500 feet per minute.
g. Cooling coils that will have peak demand during the winter shall be sized for 50 °F supply water.

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

a. Refer to UNC Chilled Water Design Guidelines for supply and return water temperature requirements.
b. Mechanical schedules for cooling coils shall indicate chilled water velocity in the coil tubes at design conditions.
c. Specify stainless steel coil casings, frames, supports, attachment hardware and intermediate troughs for the cooling section. For custom AHUs, fasteners attached to stainless components shall be 400 series stainless steel or equivalent performance and zinc plated fasteners are prohibited.
d. Specify for maximum air velocity not to exceed 450 feet per minute.
e. Size coils for a maximum of eight rows at 10 fins per inch.
f. Specify coils with water velocity between 4 and 6 feet per second at full load (design) conditions.
g. Specify copper tubes with minimum thickness of 0.035 inches and aluminum fins with minimum thickness of 0.0095 inches.
h. 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.

F. ***Cooling Condensate Drain Pans***

1. Specify that all air handling units have stainless steel drain pans and support framework in the cooling coil section. Specify IAQ packages when available.
2. Drain pans shall extend at least 6" on the downstream side of cooling coils.
3. 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.
4. Specify an auxiliary drain pan under the entire air handler when it's installed over occupied spaces.
5. For walk-in AHUs, specify aluminum grating over all drain pan sections. Specify pitched and triple sloped drain pans.
6. Condensate traps shall be sized so that water shall never stand in drain pans even with loaded filters.
7. Cooling condensate pumps should be avoided. Provide gravity drains when feasible.

G. ***Cooling Condensate Traps***

1. 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.
2. Do not route condensate drain lines to storm sewer system or to building exterior.
3. Provide a cleanout at the bottom of the trap and one for rodding straight into the drain pan. Slope drain lines ¼" per foot.
4. The total trap height shall be a minimum of 1.5 times the maximum negative differential at that location + 1".
5. Specify on the coil schedule the minimum height above the trap over-flow (dimension A) and below the trap overflow (dimension B). For draw through AHUs, the "A" dimension shall be at least local maximum static pressure plus 1" and the B dimension shall be at least ½ the local maximum static pressure.
6. For AHUs 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.

H. ***Humidifiers***

1. Provide humidification for labs, DLAM, and other specialty spaces to provide a minimum of 30% RH or as required by the user. Whenever available, utilize direct injection campus steam.
2. Duct mounted humidifiers are preferred for applications in variable volume systems; or mount in the AHU before the cooling coil. Ease of access is critical.

3. 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. 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. Drain to a conspicuous location. Steam humidifier dispersion tubes shall be insulated.
4. Provide a minimum of 10" x 10" sweat-free windows for viewing humidifier operation.

VII. HVAC AIR DISTRIBUTION

A. *General Requirements*

1. Location of Air Intakes: Air intakes shall be located to prevent contamination supply air from any pollutants or nuisance odors. Special care must be taken to prevent the introduction of building, fume hood, generator, automobile, or general exhaust, sources of moisture or odors from landscape materials, dumpsters, etc. Intake openings shall be protected with ½" x ½" corrosion resistant hardware cloth installed inside the louver and when necessary, painted to match.
2. Space pressurization: The designer shall indicate on the duct plan drawings areas of room pressures with the use of arrows and CFM values at doorways.
3. 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.
4. Building HVAC systems must be able to operate under the established requirements of the centralized chilled water, steam, and heating hot water systems.

B. *HVAC Ducts*

1. **Internally lined duct is not permitted.** In special cases and when approved by Engineering Services, a fully cleanable and smooth liner, such as PSK faced fiberglass with sealed edges, may be considered.
2. Flexible ducts:
    a. Bends in the flex duct shall be no less than one duct diameter centerline radius. Flex ducts shall extend a few inches past sheet metal prior to bending.
    b. Provide hard elbows or three straight duct diameters at diffuser connections.
    c. Flex ducts shall be supported at least every 5 feet.
    d. Flex ducts shall sag less than ½" per foot.
    e. Flex ducts shall be installed fully extended and not in the compressed state (including pinched between other building components).
    f. The hanger material in contact with flexible ducting shall be a minimum of 1.5" wide.
3. OA damper: A separate minimum OA damper is required when the minimum OA flow less is than 25% of supply air flow. The minimum OA damper shall be located above the maximum OA damper.
4. Pressure drop: Duct fittings shall not have excessive pressure drops. Fan system effects shall be avoided. Excessive pressure drops shall be approved by UNC Engineering Services.
5. Duct fittings shall not have angles of divergence greater than 30 degrees.
6. Duct-board is not permitted.
7. Outside air economizer: Outside air economizers are required.
8. Exterior Ducting: Assure water will not pond on horizontal surfaces. Round or oval duct is generally preferred.
9. Clothes dryers: For clothes dryers, provide smooth aluminum or stainless steel exhaust duct with long radius elbows.
10. SMACNA: All ductwork shall conform to SMACNA HVAC duct construction standards, metal and flexible, latest edition.
11. Ductwork Leakage Test
    a. Duct Leakage Testing: 100% leakage testing shall be provided for all duct 4 i.w.c. or greater. For laboratories, provide 100% leakage testing of 2 i.w.c. or greater ducting.
    b. Duct Seal Class: Provide SMACNA Seal Class A on all metal duct 2 i.w.c. or greater. In no case shall the ductwork sealant be less than SMACNA Seal Class B.
    c. Testing shall 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.
    d. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports.

e. Do not pressurize systems above maximum design operating pressure.
f. Provide the designer, UNC Engineering Services and UNC Building Services at least seven days' advance notice of testing.
g. Maximum Allowable Leakage: Maximum leakage shall be 1% of total cfm delivered by the air moving device(s).
h. Remake leaking joints and retest at contractor's expense until leakage is equal to or less than maximum allowable.

C. *Dampers*

1. Splitter dampers are prohibited.
2. 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.
3. Automatic dampers: A safe means of maintenance access shall be provided for all duct damper actuators and damper access doors. A clear line of site shall be provided for inspection of all damper actuators.

D. *Duct Access Doors*

1. **Specify ultra-low leakage doors.** (Nailor Model 0800 Type M1 Double Flange Frame for rectangular duct and Model 0895 for round duct, or equivalent). Knock-over tab frames are not permitted. Maximum leakage must not exceed British Standard DW144 Class A, B, and C.

   a. Provide a schedule on the drawings specifying the maximum leakage of access doors as follows:

duct size	Minimum Door Size	Maximum Leakage
< 18"	12" x 6"	0.064 cfm
18" to 28"	18" x 10"	0.133 cfm
> 28"	21" x 14"	0.206 cfm
Body access	25" x 17"	0.286 cfm

   b. Access doors shall be shown on the drawings.
   c. Provide a safety chain for doors accessed by ladder. Provide grab handles for doors 18" x 10" and larger when there is a positive pressure greater than 3 i.w.c.
   d. Specify long-life closed-cell gaskets.

E. *HVAC Filtration*

1. Specify 2" pre-filters and 12" primary filters before the first coil. In walk-in AHUs, filters shall be front-loading. Pre-filters shall be MERV 8. Final filters shall be MERV 11 except labs shall be a minimum of MERV 14. When space is limited, 6" or 4" primary filters may be specified upon approval from Engineering Services. Small package units may utilize 2" and 4" pleated filters as deemed necessary for unit sizing.
2. Long-life gaskets and blank-off panels shall be provided to prevent the by-pass of air around filters.
3. Filters shall be standard sizes of 2' x 2' or 1' x 2". Filter face velocities shall be 500 fpm or less.
4. Provide a minimum of MERV 8 filtration upstream of air-flow measurement stations and energy recovery coils.
5. Furnish three complete sets of filters (pre-filters and final filters) for all AHUs. Prior to any testing or start-up of AHUs; the first set shall be installed. The second set shall be installed after testing and balancing, but prior to acceptance of the building. The thirds sets shall be delivered to UNC prior to acceptance. The first set may remain in the equipment during TAB and acceptance if the filters are less than 50% loaded and accepted as is by UNC.

VIII. HVAC EQUIPMENT

A. *Modular and built-up Air Handling Units and Energy Recovery Units*

1. Related Documents

   a. HVAC Air Distribution/HVAC Filtration

b. HVAC Equipment/Fans

2. Casings

a. Casings shall be double wall, insulated sandwich panel construction. Outer wall shall be at minimum 0.040" Aluminum, 22 gauge stainless or 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 a minimum of 3/16" checker plate aluminum or stainless steel for walk-in custom equipment and 18 gauge minimum for all other.
b. Penetrations shall be insulated, sealed and sandwiched between metal with equivalent materials to the casing construction.
c. 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.
d. Major components shall be supported from the unit framework, not the casing.
e. 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.

3. Leakage and deflection requirements

a. Modular AHU's leakage shall be less than 0.5 cfm per sft at +/- 5" w.c or less than 1/2% of design airflow at 1.25 times operating static pressure. For specialty applications utilizing modular AHUs and when welded modules are acceptable, leakage shall be less than 0.232 cfm per sft at +/- 8" w.c.
b. Specify air handling units to withstand 8" w.g. positive or negative internal pressure, or the fan shut off pressure whichever is greater.
c. For AHUs 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 shall 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. All testing will be performed by the unit supplier.
d. All pipe and conduit penetrations shall be sealed airtight. After wire is pulled conduit shall be sealed so that air cannot be transferred into or out of the unit.

4. Doors and Panels

a. 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. Consideration must be taken to allow for access around UV lights, humidifiers, and other features which block the door opening.
b. 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.
c. Test ports shall be provided in all doors.
d. AHU door closure hardware shall be metal with the exception modular AHUs may be equipped with plastic handles rated for high pressure applications.
e. Windows shall be provided in all doors of walk in AHUs. For all other AHUs, windows shall be provided for inspection of UV lights, the fan section, and humidifiers.

5. Drain Pans

a. An auxiliary drain pan shall be provided under the entire AHU when it's installed over occupied spaces.
b. Floor drains shall be provided in all non-drain pan sections of custom walk-in AHUs.

6. Electrical Requirements

a. Pre-wired lights shall be provided in each section for all walk in units 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.

b. All wiring to motors shall be in conduit. No exposed wires allowed. Conduit shall be sealed so that air cannot be transferred into or out of the unit.
c. Power conductors inside the AHU shall be enclosed within conduit.
d. Provide one VFD per fan motor.

7. Maintenance Requirements

a. When equipped with motors 20 hp or greater, an integral rail and hoist or other permanent lifting means shall be provided for motor removal.

8. Gauges

a. Differential pressure gauges shall be provided across each filter section, cooling coils and fans. Pressure gauges shall be sized to provide measurement in 1/10 in. w.g. or less increments. Calculated operating point shall be at 50% of full range.
b. Mount pressure gauges on to the exterior of air handler and specify copper tubing. Gauges shall not be mounted in the AHU casing walls.
c. Gauges shall be equipped with on-off-vent valves for measurement of static pressure at each probe and differential pressure across the probes.

9. UV Lights

a. Specify ultraviolet (UV) lights on the downstream side of chilled water coils. There shall be adequate access for bulb replacement.
b. UV lamps 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. Bulbs shall have a coating to contain mercury upon accidental bulb breakage. UV lights shall provide 360 degree UV coverage. Fixtures shall be corrosion proof. Specify safety switches and safety stickers on doors on both sides of the cooling coil.
c. Ballast shall be installed on the exterior of the AHU. Ballast shall have a 5-year warranty.

10. Dampers

a. Control dampers shall be opposed blade type. Prototypical opposed blade dampers shall be Ruskin-CD50 series or approved equal.
b. 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.
c. Outside air ducting shall be sized for full economizer operation.
d. Provide a separate minimum outside air and economizer damper when the minimum outside airflow is less than 25% of the economizer airflow.

11. Flexible Connections

a. Flexible connections at fans shall be stretched tight without wrinkles. (to avoid fan system effect)

12. Field Service and Equipment Startup

a. A factory-authorized service representative shall inspect the equipment installation, including piping and electrical connections prior to unit startup. A factory-authorized service representative shall perform startup service.

B. ***Air Terminals / Air Valves***

1. 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 a long-life, self-lubricating bearing. Unit shall be factory leak tested and sealed noting such.
2. 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.
3. The minimum flow rates of air terminals shall be specified as 30% of maximum air flow unless the design requires otherwise.
4. Air terminals shall be equipped with a 10" x 10" minimum access door between the damper and reheat coil.
5. 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.

6. 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. Exception: does not apply for permanently exposed equipment.
7. The designer must coordinate the location of air terminals on the drawings so that safe ladder access is available without moving fixed and heavy furniture. Also coordinate with lights, sprinkler heads, life-safety devices, etc.
8. On the design documents, provide a division of work detail for control wiring. Identify controls power wiring to be provided by the mechanical and controls contractor on the mechanical drawings.
9. Air terminal schedules shall indicate the electrical requirements.

C. ***Reheat coils***

1. To facilitate flushing long runs of new steel pipe and to avoid flushing through the coils, provide a bypass valve between the supply and the return before the coil isolation valves.
2. Size reheat coils for 160 °F supply temperature and 140 °F return temperature. Specify a minimum of 2-row reheat coils.

D. ***Fan Coils***

1. Specify institutional grade fan coils as follows
    a. Coiling coil casings shall be stainless steel.
    b. Coils shall have a minimum of 0.025" tube wall thickness.
    c. Drain pans shall be stainless steel or other corrosion proof materials.
    d. Equip with 2" MERV 8 filters.
    e. Insulation shall be impervious to water, and fiberglass insulation is prohibited.
2. When installed above ceilings, specify an auxiliary float switch.
3. Fan coil units and blower coils are not permitted to serve occupied spaces except for (and when approved) renovation projects, housing projects, and equipment rooms. In all cases, a means to dehumidify the building shall be provided.
4. Fan coils shall not be located above ceilings.

E. ***Server room AHUs***

1. For below floor plenums, specify plenum fans. Fan speed shall be modulated to control the plenum static pressure.
2. To minimize air-side pressure drops, all cooling units shall remain in operation and shall not be staged.
3. Individual fans shall be fully independent and shall not share motors or VFDs.

F. ***Fans***

1. Fan maximum operating speed: the fan shall be capable of operating at speeds that will provide the following airflow:
    a. Buildings serving administrative and classroom functions: 120% of the design airflow.
    b. Buildings serving laboratories, research, health care functions: 130% of the design airflow.
    c. Specify the minimum fan wheel size and maximum RPM.
2. Belt Driven Fans
    a. All belt driven fans shall have a minimum shaft size of 1-1/8".
    b. Each fan shall have means to re-lubricate the fan shaft bearings.
    c. Where necessary, extend grease fittings to an accessible location.
    d. Fans shall be checked for balance at all speeds and specified not to exceed manufacturer's recommended vibration levels.
    e. Each fan shall have the sheaves aligned by contractor prior to acceptance by the University.
    f. A spare set of belts for each belt driven fan shall be turned over to University at the end of project.
    g. Shall have a NEMA rated adjustable motor base with a minimum of two (2) belt tensioning bolts.
3. Bearings
    a. When necessary, extend bearing grease lines to an accessible location so that bearings may be lubricated with the fan operating.
    b. Specify long life bearings. Except for small fans, specify L10 at 80,000 hours. For custom AHUs and major fans and when available, specify L10 200,000 hours.

4. Ducts: Ducts shall be aligned within +/- 3/8" tolerance with fan inlets and outlets.
5. Access doors: When available as an option, specify hinged access doors (avoid bolt on access panels when possible).
6. System effect: Designs shall minimize system effect. Avoid inlet swirl. On the outlet side of fans, provide 2.5 straight duct diameters for conditions up to 2500 fpm, and 1 additional duct diameter for each additional 1000 fpm.
7. Materials: Fiberglass fan wheels and housings are prohibited.
8. Airfoil fans should be used whenever possible to improve efficiency. Forward curve fans should only be used on small fans with low external static pressure.
9. When equipping AHUs with multiple fans, specify backdraft dampers.

IX. BAS CONTROLS

A. Refer to the Chapel Hill Controls Standards.

B. The building automation system (BAS) is a BACnet or LON based open protocol system. Consult with UNC Engineering Services regarding which system to use. The UNC Controls Standards are prescriptive in nature. The designer is responsible for editing the controls standards to fit the project scope. The standardized schematic drawings must be edited with changes bubbled. The standardized specification shall be edited in Word format with track changes on for review. Provided the edited digital controls documents to UNC Engineering Services for review. Refer to UNC Controls Preface and Implementation Guidance document for specific instructions.

C. 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 (EMCS) located at the Giles F. Horney Building. The project will provide graphics, data trending, scheduling, etc. Refer to the UNC Chapel Hill controls Guidelines.

D. Connect the following to the Life Safety campus monitoring system: lab freezers, environmental rooms, and lift station high level alarms.

E. Additional controls requirements

1. For demolition of existing HVAC, specify that all cut pneumatic tubes to be sealed w/ pneumatic plugs. Crimping and taping are prohibited.
2. The designer shall provide a controls valve schedule.

X. REFRIGERATION EQUIPMENT

A. Refrigerant isolation valves: Provide refrigerant ball valves at individual components for servicing without the need of pumping the entire system down. This applies to environmental cold rooms, VRF systems or any condensing unit that is not equipped with factory isolation valves.

B. Mini-split AC and heat pumps

1. Approved brands: LG, Mitsubishi or Trane. Specify LG as basis of design. (UNC stocks LG parts)
2. Air-cooled condensing units must not be installed indoors. Provide water-cooled condensing units when process water is available.