C-20 - PLUMBING AND MECHANICAL SYSTEMS

PREFACE

Instructions to the Engineer

The designer is required to incorporate this design guideline into the design document and to enforce during construction. Underlined text has extra emphasis.

If a design guideline variance is requested, contact the appropriate Engineering Services reviewer.

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 Reviewer.

Applicability

These design guidelines apply to:

1. Formal and informal construction and repair performed by outside contractors and University shops, and
2. Mechanical and plumbing systems located in or on the building that are maintained by Facilities Services. Occasionally, such systems are located exterior to the building such as plumbing backflow protection.

These design guidelines do not apply mechanical equipment located within the building that is maintained by Energy Services such as:

1. Chilled water utility piping up to and including the chilled water bridge, or
2. Steam utility piping up to and including the steam meter. The building main steam condensate receiver and condensate piping from the main receiver back to the Cogen plant. The building steam PRV station and relief valve are maintained by Facilities Services.

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I. GENERAL REQUIREMENTS

A. Related Design Guidelines

1. Control Standards
2. Chilled Water Distribution Design Guideline
3. Steam System
4. BSL3 Design Guidelines
5. Laboratory Design Guideline
6. Non-Potable Water Design Guideline
7. Environmental Chambers Design Guideline

B. Architectural and Engineering Coordination

1. Architectural and all MEP designers must coordinate and protect the service area around equipment. It is emphasized that equipment above ceilings and elsewhere must have access for replacement without the need to remove unrelated conduits, pipes, ducts, cable trays, etc.)
2. The A&E shall coordinate the location of ceiling mounted devices such as lights, diffusers, life-safety devices, etc. with above ceiling access requirements. Upon request, the A&E shall provide coordination drawings.
3. The Architect, the Plumbing Engineer and the Mechanical Engineer should review the section "Section IV Specialty Equipment"
4. Suspended Ceilings: Suspended ceilings tiles more than 2' x 2' are generally prohibited with the following exceptions:
    a. Downward opening ceiling tiles are provided and can be easily removed and reinstalled by a single individual.
    b. All components requiring access, including junction boxes, balance damper handles, terminals, are located away from this area
5. Building Materials Storage for new buildings and major renovations.
    a. MEP drawings shall designate and mark out storage space for ladders.
    b. MEP drawings shall designate and mark out storage for spare parts.
    c. Designated storage space shall be marked out on the floor with paint striping or solid paint.
    d. Buildings shall designate dedicated storage rooms for spare ceiling tiles, light bulbs, ballasts and supplies for maintenance and repair of building finishes.
    e. Storage shall not interfere with required egress paths or electrical panel working spaces.
    f. The Engineer must bring these requirements to the attention of the architect.
    g. Refer to the architectural design guidelines for additional requirements.
6. Flooding of electrical equipment:
    a. Any equipment containing water or cooling condensate shall not be installed above electrical panels and equipment.
    b. Chilled water pipe shall not be installed above electrical panels and equipment.
    c. Other pipes should not be installed above electrical panels.
    d. Server rooms, electrical rooms, telecom, and other sensitive rooms.
        i. Bathrooms should not be located above these spaces.
        ii. Care should be taken with routing piping in floors above these spaces.

C. Design Requirements

1. Pipe and duct systems:
    a. Schematic drawings: For large or complex projects or when requested by UNC, the designer shall provide as part of the drawing package schematic level drawings of the mechanical pipe. These drawings will schematically show system layouts on single drawing sheets and will show at least the following level of detail: major equipment with equipment ID's, major equipment design flow rates or entire floor design flow rates, major system accessories, such balance valves and main strainers, expansion tanks, air / dirt separators, etc., major control devices and sensors, pipe main sizes, and

system gauges, for example, the pressure gauge at the top hydronic systems. Indicate in the drawing notes the sizing criteria and any diversity factors used for sizing pipes and any assumptions used. Provide any critical system information that will be useful when the system is modified in the future such as excess capacity, system redundancy, etc.

b. Pressure loss calculations: Upon request, the designer shall furnish detailed pressure loss calculations for the longest equivalent run in the piping or duct system at design conditions. Diversity factors and other assumptions shall be clearly identified.

c. Piping larger than 2" dia., shown in mechanical rooms, shall be shown double lined to reflect the insulated diameter of the pipe.

2. Renovations:
   a. In the area of renovation, the design documents shall show all existing equipment and components that will remain. The documents must show terminals that serve the area of renovation even if they are located outside of the area of renovation.
   b. When existing systems will be modified, Engineering Services may require showing on the drawing existing system components that will remain even if they are outside the area of renovation.
   c. AHU zoning maps: Upon request from Engineering Services, the designer shall provide schematic level floor plans showing the region of the building served by each HVAC system. This will be necessary in existing buildings with numerous AHU's serving multiple floors.
   d. For existing equipment that will remain and will be rebalanced, provide existing and new schedules. The new schedules will become the master schedule.
   e. HVAC load, supply, and outside air calculations:
      i. Provide revised load calculations to the areas served.
      ii. Provide revised supply and outside air calculations to the areas served.
      iii. Recalculation of supply air is especially important for constant volume systems.
   f. Indicate the location and equipment ID of equipment that is part of the HVAC system serving the space. That way the entire construction team can easily locate equipment remote to the primary area of the renovation.
3. Equipment Schedules:
   a. When redundant equipment is provided, redundancy levels shall be indicated on the equipment schedules and indicate the level of surplus capacity.
   b. Schedules are required for control valves and VFD's.
4. Redundancy requirements:
   a. For labs, provide n+1 redundancy for plumbing and mechanical equipment. For other buildings, the need for redundant equipment must be discussed with Engineering Services.
   b. For critical spaces, such as freezer rooms and body coolers, redundant cooling systems will often be required.
   c. When one of the redundant equipment is being repaired or replaced, the remaining equipment shall be designed to remain operational.
5. HVAC:
   a. Space pressurization: For the doorways with pressure differentials, provide flow direction arrows and CFM values must on the duct plan drawings. Provide a note to the TAB contractor that the flow arrows and flowrates are for conveying pressure relationships and that measurement, adjusting and balancing of transfer air is not required.
   b. Schematic drawings: Upon request by UNC, the designer shall provide schematic duct 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. Indicate the duct sizing criteria used and require the contractor to adhere to the sizing criteria. For example, maximum friction loss, maximum duct velocity, etc.

c. Air Handling Units: Provide ½" x 1' scale plan and elevation drawing of AHU's. For very large AHU's, smaller scales may be used. Show all specified features including AHU doors, windows, magnehelic gauges, filters, coils, UV lights, fans, dampers, minimum doors widths and heights, minimum or maximum AHU geometries, etc. Show pipe and duct layouts. Show all room conflicts including the elevation of overhead structures.

6. Engineering Notebook: For large or complex projects or when requested by UNC, provide during design and with the as-builts a digital engineering notebook containing information requested by the University such as specific calculations.

D. Manufacturer's Installation Instructions

1. Equipment and components shall be installed in accordance with the manufacturer's installation instructions including all "optional" and "recommended" installation instructions. Optional and recommended requirements must be incorporated into the project documents. Omission of optional or recommended installation instructions must be approved by Engineering Services.
2. The manufacturer's installation instructions shall be available on the job site at the time of inspection and start-up.

E. Submittals

1. Submittals shall include a copy of the relevant written 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. (Note to the Construction Manager: Plumbing and Mechanical Submittals must be provided to Engineering Services at the time of review.)
4. Provide an exploded view parts drawings with part numbers with the equipment submittals.

F. 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. 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).
6. At the completion of each training agenda, attendance records shall be distributed to the University.

G. Equipment O&M manuals

1. Provide hard copies of the wiring diagrams within the O&M manuals and at the equipment.
2. Provide an exploded view parts drawings with part numbers within the O&M manual.
3. Provide a detailed and complete wiring diagram.

H. Turn-over documents

1. Projects shall turn over digital copies of approved submittals including TAB reports, final approved fire, and sprinkler as-builts, controls as-builts, and approved equipment and other approved submittals.

I. Procedures during Construction

1. General

a. New equipment installed under the project scope of work shall be cleaned and in new condition at the time of acceptance. Reused equipment shall only be used if specified and approved and shall be cleaned and in some cases, rebuilt.
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 the O&M manuals are delivered and approved by Building Services and training is complete.
e. Warranty: Contractors standard 1-year warranty starts at the beneficial occupancy of the area accepted.

2. Requirements for operating HVAC equipment during construction
   a. Building must be fully enclosed, including installation of all doors, windows, etc.
   b. If construction is still generating dust, use 100% outside air when possible and when conditions for freezing coils do not exist. 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.
   c. All chilled water piping shall be insulated.
   d. Pump and fans shafts shall receive final alignment prior to operation. Laser alignment shall be provided for pumps, and reports shall be furnished prior to operation.
   e. Supply and outside air connections of ductwork to AHUs shall be complete.
   f. All manual dampers, fire dampers and combination fire/smoke dampers shall be open.
   g. All main supply ductwork shall be insulated.
   h. 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.
   i. Conditioning (cooling & dehumidifying) of the building shall remain once started.
   j. Final approval of UNC is required prior to starting AHUs for temporary operation.
   k. Cover outside air intakes with 1" roll filter media.
   l. 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.
   m. At the end of the construction period and prior to occupancy, clean the inside of AHUs and replace prefilters one month old. Final filters shall be replaced if
   n. AHU UV lights shall be operational, and filters shall be installed.

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, may 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. For below grade domestic pipe, the designer shall specify cleaning and disinfecting compliant with AWWA and OWASA.

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. The building pumps may be used if the seats and seals are replaced prior to building turn-over. Used seats and seals will be returned to UNC HVAC Services. Flush system at 4 fps minimum velocity.
   b. For new pipe systems, specify a closed-loop cleaning procedure. The basis of design is Chem-Aqua TB 3-001. Passivate new systems for a minimum of 5 days. Notify HVAC Services prior to flushing. Piping shall be drained and filled as quickly as possible to avoid damage to the passivation layer and subsequent formation of rust. Provide startup pump strainers or temporary pumps during flush and cleaning process. Once the pipe is exposed to water, water shall remain in the piping except for flushing procedures and pipe rework. Air will cause rapid corrosion and rusty water.
   c. For modifications to existing pipe systems, the UNC Construction Manager shall place and fund a work order for HVAC Services to test and treat the loop. The contractor shall minimize the quantity of wet pipe that is exposed to air.
   d. Bypass all coils and all heat exchangers during the initial cleaning and flushing process. This to ensure high velocities in piping and to avoid trapping sediments in coils and HX. Prior to completion, flush the coils and heat exchangers and blow-down strainers.
   e. Coordination with UNC Shops
      i. A minimum of 5 working-days' notice is required for assistance from UNC Shops.
      ii. For large projects, a third party should be considered to monitor of the cleaning and flushing process. The monitor shall act as the owner's representative.
      iii. UNC Construction Management, HVAC Services and Engineering Services shall be invited to test the water prior to treatment and shall be invited to inspect the system prior to flushing and cleaning. The chemical shall be approved by HVAC Services. Water samples taken at the end of flushing shall be approved by HVAC Services.
5. Protection of the building drainage system: The contractor shall protect all drains from debris entering the drains. Having drains clogged with nuts, bolts, welding debris has been a problem in the past.

J. 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, or NEBB Procedural Standards for TAB Environmental Systems.
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.
ix. Balance devices shall be equipped with tags, labels and markings recording the following: design flowrate, final setting position, pressure drop when equipped with flow orifices, date of final setting, and TAB Company name. Duct balance damper handles shall be marked with survey tape.

K. New buildings:

1. ME room requirements
   a. Minimum size: must be able to remove all equipment and skids without the need to dismantle unrelated equipment and systems.
   b. Provide laydown areas around large equipment components adequate for performing repair and replacement.
2. Provide an office for technicians
3. Provide a room for MEP stock storage
4. Owner Project Requirements
5. Abandoned mechanical and plumbing equipment in the work area shall be removed. This applies to components above the ceiling such as abandoned pneumatic tubes, humidifiers, ducting, conduit, etc. This also applies to equipment in mechanical areas. Consult with Engineering Services if unsure. Specify "return to owner" or to the return to the specific shop. For equipment that is reusable or can be used for spare parts should be considered for return to Building Services.

II. COMMON WORK REQUIREMENTS:

A. Applicability:

1. This section applies to both Plumbing and Mechanical trades. The plumbing and mechanical Engineers shall coordinate these requirements with other divisions.

B. Access

1. Minimum Clearance Requirements:
   a. Interference with elements of permanent construction:
      i. Clearances around equipment such as skids, pumps, AHU, air terminals, reheat coils, air valves, tanks, PRV's, Heaters, backflow devices, etc. shall be sufficient to allow inspection, service, repair or replacement without the need to remove unrelated elements of permanent construction such as conduits, pipes, ducts, cable trays, etc.
      ii. Drawing Requirements: 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 will be indicated with a light, dashed line, or crosshatch, or within detail drawings.
      iii. Clear path: Assure there is an adequate pathway for replacing equipment without requiring removal of permanent walls.

b. Suspended ceilings:
   i. All MEP components shall be installed a minimum of 2" or two times the ceiling tile thickness above the top of suspended ceilings systems. (Note: The intent is to allow for ease of ceiling tile removal. Jamming ceilings up against cable trays, ducts, etc. is prohibited.)
c. Service clearances: Provide service and replacement clearances as specified throughout this design guideline or as "recommended" by manufacturer's installation instructions.
   i. Control valves: For valves 3 inches and larger, provide access above the valve of the assembly height plus 12 inches.

2. Elevation requirements
   a. Equipment requiring maintenance must be installed below 13' elevation above the finished floor. This applies to pumps, fans, control valves and other controls, coils, terminal units, balance dampers, etc. When exceptions to this requirement must be made, the following requirements shall be followed:
      i. When mounted above 13' and requiring access from a ladder
         01. Isolation valves located above 13' elevation require chain operators.
         02. Other equipment mounted over 13' requires written permission from the Facilities Safety Officer. Engineering Services shall be notified.
      ii. For equipment mounted over 15' elevation, the project will provide an access platform, fixed ladder, extension ladder or scissors lift.
         03. Extension ladders require adequate floor space for a 1:4 slope and may require a ladder holdoff for resting the ladder upon.
         04. Fixed ladders over 20' require an intermediate platform.
         05. Fixed ladders over 24' require a fall arrest system.
   b. Access platforms:
      i. Detailed elevation and plan drawings shall be provided for all required access platforms. Large equipment such as high plume fans and double stacked AHU's shall have approved access platforms that provide safe access to all components that may require inspection, repair, replacement, servicing, or removal.
      ii. Alternating stair treads are prohibited.

3. 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. Access doors shall be labeled indicating the equipment housed within.
   b. Refer to "HVAC Air Distribution" for additional requirements for duct access doors.

C. Means for Equipment Replacement:

1. Provide a means for lifting and removing heavy motors and pumps when the following is met:
   a. Equipment over 150 pounds which may not be reached with a portable engine hoist. Portable engine hoists extend up to 8' elevation and are rated for 150 to 500 pounds depending upon the lift height and required extension of the boom
   b. Equipment over 8 feet elevation above the floor and more than 70 lbs.
2. Means for lifting and removal may include monorails, jib-cranes, and 5000 lb. rated eyehooks and structure.
3. When attachment points are over 13' elevation, lifting chains or other structure must be extending to below 13' elevation.

D. Sound:

1. Specify maximum sound requirements for all equipment that may create nuisance sounds levels.

E. Motor Requirements

1. General requirements
    a. Insulation shall be a minimum of NEMA class F with Class B temperature rise.
    b. Motor service-factors shall be a minimum of 1.15 in an ambient temperature of 40 °C maximum.
    c. Motors ½ hp and larger shall be served by three phase electrical service. Provide single phase protection for multiphase motors. For motors ½ hp and larger, provide 480 VAC power when available.
    d. Enclosures for motors shall have hinged covers. Bolt on covers are not acceptable.
    e. For frames 284 or larger, bearings shall be capable of lubrication. Extend grease lines to an accessible location. For frames 140T - 280T, bearings shall be capable of lubrication or equipped with double shields. Fractional horsepower motors may have sealed bearings.
    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 made with split bolts wrapped with a layer of glass tape and then black electrical tape. (Note: proprietary connectors present servicing challenges.)
    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.
2. For motors 1 hp and larger
    a. The following manufactures are approved: Baldor Super-E EM/XE (general purpose family) with cast iron frames, TECO/Westinghouse ASHH or Max-PE, WEG W22, or Toshiba. In cases of shipping delays, severe duty and IEEE 841 motors shall be considered.
    b. Motor frames and end-bells shall be cast iron for motors 1 hp and larger. Rolled steel frames and aluminum end bells are not acceptable.
    c. Specify premium efficiency motors, as defined by NEMA MG-1, for all motors 1 hp and larger.
    d. 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.

F. Variable Frequency Drives

1. Location
    a. VFDs shall not be installed within or fed from MCCs. VFDs shall be fed from electrical panels.
    b. VFD’s shall be mounted to stands or walls. VFDs shall not be mounted inside or directly to AHU casings.
    c. VFDs shall be located as close as feasible to the motor controlled and in accordance with manufacturer’s installation instructions.
    d. Show the location of VFDs on the drawings.
    e. When possible, VFDs should not be located outdoors. When necessary and approved by UNC Engineering Services, outdoor installations may be considered, but should be covered and protected from rain to allow for maintenance during adverse weather and should be protected from direct sun exposure.
    f. For any VFD located out of site of the equipment served, provide a disconnect within sight of the equipment served. Disconnections shall be equipped with auxiliary contactors and wired to the VFD enable circuit. When the disconnects are in the open position, the VFD’s must be disabled through the safety circuit. (note: This eliminates the possibility of a hard start when the disconnect is closed.)
2. Approved brands and labeling requirements

a. Only the following brands are approved: ABB, Danfoss, and Schneider. No other manufactures will be accepted.
b. VFDs shall bear the original and approved manufacturer's label and shall not be re-branded.
c. It is preferred that the entire project provide VFDs of one brand. This is typically accomplished through specification of an owner preferred alternate brand.

3. Harmonic Mitigation
   a. Provide an IEEE 519-2014 (or most recent version) 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 the 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. Bypass circuit: Bypass circuits are required when it improves system operational reliability and when the motor will not be overloaded at synchronous speed. Bypass circuits are not typically provided for fan arrays.
      i. Bypass circuits shall operate independently from the VFD drive module, i.e. the bypass shall provide motor functionality with the drive module removed. The bypass shall have a power supply separate from the VFD. The bypass shall automatically respond to the BAS start and stop commands when operating in bypass.
      ii. Bypass package shall include a main input circuit breaker, disconnect, or fused disconnect.
      iii. Bypass shall include a service switch or line isolation contactor to disconnect power to the drive, but not the bypass.
      iv. Drive and bypass package shall be UL listed and have a labeled, short circuit current rating (SCCR) of 100,000 amps.
      v. 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.
5. Redundancy
   a. Provide one VFD to serve each motor. Serving multiple motors from a single VFD should be avoided or discussed with Engineering Services.
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, location, HP, minimum rated output amps, volts, phase, UL enclosure type, bypass (if equipped), input disconnect means (circuit breaker or fused disconnect), etc.
   c. Micro-drives can only be considered for motors 1 hp and lower. A minimum of 3% input impedance or harmonic mitigation is still required but is not usually a feature of micro-drives.
7. VFD to Motor Wiring:
   a. General:
      i. Shall be specified in section 23.
   b. Intent: The intent of the VFD to Motor Wiring standard is:
      i. Load side wiring shall be shielded.
      ii. Load side wiring shall resist corona discharge.
      iii. Low impedance grounding shall be provided for conducting high frequency ground currents that commonly occur in load-side VFD wiring.

iv. Load side wiring shall not induce currents in instrumentation wiring.
v. Special inspections are required for load-side wiring.
vi. Two grounding systems shall be provided.

c. Acceptable load-side wiring:
   i. Individual conductors
   ii. Approved VFD cable
   iii. See below for requirements
d. Conductor insulation
   i. The use of THHN wire is prohibited.
e. Shielding
   i. The power conductors and primary ground conductors shall be encased in a continuous electrical shield.
   ii. The ends of the shielding system shall be grounded to the VFD ground bar and the motor conduit box.
   iii. Shielding shall be provided by either metallic raceway or shielded VFD cable.
   iv. When utilizing metallic raceways as the shield, continuous shield continuity shall be provided between the terminations at each end. To maintain continuous continuity, raceway components shall be connected with grounding bushings, grounding straps or other wiring techniques.
   v. Bonding of primary ground conductors to the shield system is prohibited except at the VFD ground bar and motor. Ground conductors shall not be bonded to load-side junction boxes.
f. Grounding
   i. Two separate grounds shall be provided.
      01. The primary ground is shielded (as described above) and is installed between the VFD ground bar and the motor ground termination. The shield is bonded to the ground at both ends.
      02. A secondary ground is required and will be installed to bond the motor frame or skid framing to the building ground system such the ground bar within a panel or building steel. When using the skid as the ground termination, the motor frame shall be bonded to the skid. The secondary ground system may daisy chain between multiple motors and skids.
   ii. The minimum size of the primary grounding conductions shall be the same size as the power conductors. For 25 hp and larger, the ground conductors shall be a minimum of 200% of the load conductors, i.e. two full size ground conductors or equivalent. For 40 hp and larger, the ground conductors shall be a minimum of 300% of the load conductors, i.e. three full size ground conductors or equivalent.
   iii. The primary ground conductors must not have intermediate connections to the shield system such as at junction boxes. (Note: if in doubt to what this means, inquire with Engineering Services)
g. VFD Cable:
   i. Cable shall have low capacitance and impedance design.
   ii. VFD cables shall be terminated per the manufacture's installation instructions.
   iii. Cables shall meet or exceed 600V UL 1277 Type TC-ER, 1000V UL 2277 Type WTTC, IEEE 1202.
   iv. VFD cable conductors shall be XHHW-2 or RHW-2 circuit conductors rated at 90 'C wet/dry.
   v. Cables with armor such as stainless-steel braid, may be installed outside of a raceway, but cables installed in air plenums shall be enclosed in raceway or shall be plenum rated.
   vi. Basis of Design: Less than 40 hp - Belden Classic VFD Cable. Greater than 40 hp- Belden Symmetrical Classic VFD cable. Other brands may be considered.

vii. VFD cable ground wires, drain wires, shielding and armor shall only be grounded at the VFD and the motor. Any of the above ground system must NOT be bonded to disconnects and will be isolated from disconnects with cable insulation, shrink wrap, or other approved means. (note - do not bond ground system to the shield system except at the ends)
viii. Cables shall be equipped with a PVC or equivalent jacket.
ix. VFD conductors shall be constructed from fine, tinned copper strands.
x. Cables with 2 AWG and smaller conductors shall be equipped with a braided armor and copper foil shield. Cables larger than 2 AWG shall have a minimum of copper foil shielding.
xi. Specify round cable geometry for liquid tight connections.

h. Inspections:
i. Each contractor installing VFD to motor wiring shall schedule and conduct a special inspection for the (Engineer, Owner or CxA) to inspect a minimum of one, complete VFD to motor wiring installation.
ii. The inspector will select the specific installation to be inspected.
iii. The contractor shall make visible for inspection the terminations at the VFD, at the motor, at any intermediate junction boxes and the terminations of the secondary ground system. The contractor shall open devices as needed to complete the inspection.
iv. For large projects, inspections shall be completed by the Engineer or the third part CxA.

8. Startup, training, and warranties
a. Factory Start-up: Specify a factory certified start-up and certification. (The factory certified start-up extends the warranty for ABB brand drives). The VFD manufacturer shall provide a factory certified technical representative to inspect the contractor's installation, to test and start-up the VFD's and to provide a certification letter. The factory representative shall review the project requirements for VFDs (specifications and drawings) and shall document in the certification letter if the project requirements are fully met or shall identify any requirements that are not met. The certification letter shall describe and document the actual start-up, training, and certification effort.
b. Training: A representative of the VFD manufacturer shall provide on-site training. For large projects, provide factory training in addition to on-site training. The owner has the option to or not to attend training.
c. Warranty: 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. The manufacturer shall provide factory direct warranty and support service.
d. Accessories: 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.

G. Controls furnished by the original equipment manufacturer (OEM controls)

1. BAS Controls: The Building Automation Controls vendor typically provides controls for HVAC components and for monitoring other equipment controlled by OEM controls.
2. OEM Controls:
a. OEM controls are typically provided for domestic booster systems, air compressors, vacuum pumps, water purification systems, DX (direct expansion) refrigeration equipment including packaged DX AHU's and DX split and mini-split systems, proprietary energy efficiency equipment, and other proprietary and novel equipment.
b. The BAS controls may monitor and provide a start-stop or other controls signal to OEM controls. In such cases, a BACnet interface may be required. Consult with Engineering Services.
c. OEM controls shall be the standard or premium offering and shall not be value engineered. Engineering Services and the Director of Building Services have complete authority to determine the

required components of the controls system which may include optional touch-screen control interfaces, optional safeties, and redundant controls.

d. Provide a back-up copy of the programming software, ladder logic and database for all controls.
e. The OEM shall provide three controls manuals and two complete sets of cables or other communication devices for interfacing with the controls.
f. The OEM shall provide as part of the equipment submittal a detailed and complete written equipment sequence of operations in English text. This written sequence of operations shall be reviewed and approved by the Engineer and Engineering Services. The written sequence of operations shall be of adequate detail to fully understand the operation of all sensors, actuators, and controlled devices with reasonable detail to allow for thorough equipment commissioning, complete troubleshooting, and repair by University staff. Ladder logic diagrams and other controls diagrams may be provided by do not qualify as a written sequences of operations.
g. The OEM shall provide as part of the equipment submittal a detailed and complete wiring diagram.
h. OEM controls shall be warranted for a period of 4 years for parts, labor, travel, and shipping. Warranties shall cover component failures and failures to perform the approved sequence of operations.
i. For large equipment, Engineering Services may choose to specify and provide BAS controls logic for equipment typically controlled by OEM controls. The Director of Building Services and Engineering Services shall both approve this controls approach. In such cases, the Engineer should discuss with the UNC Project Manager any impacts upon their responsibilities, fees, or project delays.
j. The OEM shall provide spare copies of the control program. Exception: if the OEM states in writing that the controls program is proprietary and not provide to any customers.

H. Electrical Requirements

1. The division 23 engineer shall coordinate compliance with these requirements with the division 26 engineer.
2. Division 23 and 26 coordination: The division 26 Engineer shall specify 120 VAC controls circuits for powering division 23 control panels. 120 VAC circuits shall terminate in locations near the control panels served. The division 26 designer shall show the 120 VAC termination point on the electrical drawings. 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. The division 23 and division 26 engineers shall coordinate these requirements.
3. Controls panels shall not contain wiring more than 24 volts. An exception is that terminations more than 24 volts shall be segregated, covered, and/or provide with finger-safe terminals.
4. Roof Mounted Equipment
    a. For equipment located on roofs or locations prone to lightning strikes provide:
        i. Disconnect switches shall be heavy-duty safety switches equipped with integrated, factory wired and UL-listed surge protection devices. For 30 amp and higher, Eaton DH heavy duty safety switches and SP1 and CVX surge protection devices are approved.
        ii. Lightening grounding rods
5. Disconnecting means furnished integrally with equipment shall be properly sized and fused or protected by a breaker.
6. Starters
    a. For starters located adjacent to the motor served, provide combination starters with a magnetic starter and integral disconnect
    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.

7. Design Document Requirements
    a. Equipment schedules shall indicate electrical power requirements.

I. Painting and Identification

1. Exterior equipment.
    a. 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.
    b. Equipment mounted exterior to buildings and in highly visible to students and staff may require approval by the Building and Grounds Committee. Discuss aesthetic impacts of equipment with the UNC Project Manager.
2. Equipment Identification
    a. Equipment for each building shall receive a unique equipment ID. Equipment ID's shall start with an alphabetic abbreviation of the equipment type followed by a consecutive number system starting with "1". When the equipment is on numerous floors, indicate the floor in the numbering system. For example, for VAV air terminals on a 9-story building, floor one will be VAV-101, VAV-102, VAV-103, … For floor nine, VAV-901, VAV-902, VAV-903, …
    b. 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 or system served, panel number, and breaker number.
    c. 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 affixed to the ceiling.
3. Pipe and Duct Identification:
    a. Identify piping and ducting with the labels listed below. At each label, identify the direction of flow.
    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. Label pipe and ducts with text of a size and color that is easily readable from floor level. For pipe, text height should be roughly 1/3 to ½ the actual diameter of the pipe including the insulation. For duct, text should be at least 2" in height.
    d. Completely paint piping systems or utilize colored PVC jackets in mechanical rooms with the applicable colors listed below.
    e. When accessible, identify exhaust duct at each floor level and at roof level with the exhaust fan ID and device served or exhaust system name.

Table 1: System labels and colors

System	Pipe and duct labels	Jacket color
Ductwork	supply, exhaust, return, outside air	N.A.
Chilled Water	CWS/CWR	dark blue / light blue
Process Chilled Water	PCWS / PCWR	dark green / light green
Heating Hot Water	HWS / HWR	orange / yellow
Steam, Low Pressure (0-15 psi)	LPS	dark red

Steam, Medium Pressure (16 - 75 psi)	MPS	dark red
Steam, High Pressure (> 75psi)	HPS	bright red
Steam Condensate Return	LPSC, MPSC, HPSC	tan
Domestic Cold Water	DCW	green
Domestic Hot Water	DHW	orange
Domestic Hot Water (RECIR)	DHWR	yellow
Non-potable Water	NPW	purple
Purified water	RO / RODI / DI	light grey
Natural Gas	NG	yellow w/ black letters per Code
Vacuum	VAC	N.A.
Compressed Air	AIR	N.A.
Nitrogen	N	N.A.
Helium	He	N.A.
Hydrogen	H	N.A.

Notes:

1. "R-O" is RUST-OLEUM color

4. Valve identification
    a. Control valve identification:
        i. Control valves shall be tagged with vinyl or other approved tags that will last the life of the valve.
        ii. Mark the tags with the following: equipment or branch served, design gpm, installed CV, fail position (FC, FO, FLP), installation date, and installer's name/company. When applicable, provide other key information such as measured differential pressure or valve characteristic.
    b. Balance Damper Identification:
        i. Balance dampers shall be identified and labeled.
        ii. For ease of locating the balance dampers, orange survey ribbon shall be hung from unexposed balance dampers such as when above ceilings or in chases.
        iii. Balance damper shall be labeled with the following information on a vinyl tag, permanent adhesive label, or other approved means: design flowrate, final set position, date, balancers name/company.
    c. Balance valves identification:
        i. Balance valves shall be tagged with vinyl or other approved tags that will last the life of the valve.
        ii. Mark the tags with the following: equipment or branch served, design gpm, final set position (if applicable), final measured differential pressure, date, and TAB contractor name
        iii. The following should also be notated on the tag: balance valve brand and model, measured pressure drop at design flow, when applicable, installed cartridge or orifice size.
    d. Isolation Valve Identification
        ~~i.~~ Isolation valves shall be clearly identified in the design drawings on both the pipe layout drawings and the pipe schematic drawings~~.~~
    e. Other specific labeling requirements:

i. Expansion and hydropneumatics tanks: Identify the final set pressure on the tank. This may be done with a vinyl maintenance tag or other permanent means.

J. Insulation and Vapor Barriers

1. Pipe and Duct General Requirements
   a. Thickness: Insulation at accessories and fittings shall be at least the same thickness as the adjoining insulation.
   b. Continuity: Insulation at hangers, sleeves and penetrations shall be continuous with adjoining insulation.
   c. Components that require access: Pipe and duct accessories that require access for periodic inspection, maintenance, repair, or replacement and that are insulated shall be easy identifiable or labeled with a maintenance tag. At these locations, insulation shall be easily removable and re-installable without damage to the insulation. On major projects, accessories should be insulated with form-fitting, clam-shell insulation shells or removable insulation wraps.
   d. Thermal and vapor barriers:
      i. Insulation shall provide an adequate thermal and vapor barrier to prevent condensation under all operation conditions including start-up.
      ii. Insulation shall be provided on surfaces that may give off excess heat such as heating hot water converters, air separators, valve bodies, etc.
   e. Equipment labels: Equipment labels shall be visible. Insulate around equipment labels or affix equipment labels exterior to the insulation.
   f. Insulation damage: The Contractor shall replace all insulation that absorbs water during the construction period. (Note: this especially applies to fiberglass and calcium silicate insulation.)
2. Piping
   a. Insulation
      i. Fiberglass insulation shall not be used on chilled water piping or other surfaces below 55 'F.
      ii. Insulate the body of the roof drains and piping a minimum of 10 ft. into the building.
      iii. Insulate cooling condensate drains. Insulate sanitary sewer drains exposed to air that are primarily conducting cooling condensate.
      iv. Insulation should be per Table 2 below:
   b. Insulation Jackets
      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, exterior to the building, at any location prone to damage.

Table 2: Approved Insulation types

Service	approved insulation
DCW / DHW	fiberglass or elastomeric
interior roof leaders and overflow piping (note 2)	fiberglass or elastomeric
chilled water > 40 °F (note 1)	Polyisocyanurate foam (nominal 2 lb. / ft3), Phenolic Foam, elastomeric, or cellular glass (see requirements below)
HHW	fiberglass, cellular glass, or calcium silicate
LPS and MPS	fiberglass, cellular glass, or calcium silicate
HPS	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

3. Ductwork
    a. The interior of ducts shall be smooth to avoid trapping dust and shall be a cleanable surface.
    b. Duct Liner: Lined duct are generally not permitted. The use of sound attenuation liner shall be approved by Engineering Services.
    c. 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.
    d. Externally insulate all exposed supply, return and outside air ducts with rigid fiberglass insulation.
    e. 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.
    f. 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.
    g. Insulate each ductwork system with one of the following:
        i. Rigid Fiberglass: 2" minimum thickness.
        ii. Flexible Fiberglass
        iii. Cellular Glass
        iv. Flexible Closed Cell Insulation (elastomeric)

K. Pipe and Fittings

1. Grooved Pipe Requirements
    a. Approved uses:
        i. Grooved piping is approved for use on equipment skids, AHU coil connections, and pump installations or for the following:
        ii. When fittings are accessible for inspection and future replacement, the following uses are allowed only when approved by Engineering Services:
            01. Installed in mechanical rooms and other easily accessible areas, or
            02. For limited work where there are issues with obtaining hot work permits.
            03. For limited work that requires very short outages.
            04. For limited work where access limitations greatly impact the ability to perform welding, brazing, or soldering.
    b. 25-year warranty: The warranty shall cover the following:
        i. Reasonable labor, material, and costs to repair or replace failed warranted product and any part of the mechanical system damaged because of the failure of the warranted product.

ii. Reasonable labor, material, and costs to repair or replace parts of the building (such as finishes, furniture, cabinetry, MEP equipment, etc.) damaged as a direct result of the failure of the warranted product.

c. Inspection Services: The manufacturer shall provide inspection services and provide a report. The manufacturer shall visually inspect 100% of all fittings prior to insulation. The report shall state the quantify of fittings of each size and type that are installed, the number that meet the visual inspection criteria, the number that did not initially meet the visual inspection criteria, and detail corrective actions taken for fittings that did not initially pass. Any fittings that could not be inspected due to access or other issues must be individually note and brought to the Engineer's attention. Fittings that pass shall be marked with a permanent means. Fittings that fail shall be temporarily marked with ribbon or other means.

d. Contractor training: The manufacturer shall provide training and certification for each installer of grooved fittings for the Project. The contractor shall maintain a training record and make it available upon request. Only installers receiving training and certification specific to the Project may install grooved fittings on the Project.

e. Approved brands: Victaulic. (no other approved brands). Specify as an owner preferred brand alternate. The base scope will be welded, brazed, or soldered.

2. Copper and steel press-fitting requirements

a. Approved uses:

i. Press-fittings may be used when approved by Engineering Services, and

ii. Typically, only used on small projects or limited scope of large projects, and

iii. Is allowed for work where there are issues with obtaining hot work permits, or

iv. Is allowed for work that requires very short outages, or

v. Is allowed when there are access limitations that greatly impact the ability to perform welding, brazing, or soldering.

b. Approved Brands: Viega. (no other approved brands). Specify as an owner preferred brand alternate or change-order. The base scope will be welded, brazed, or soldered.

3. PEX-A

a. May be used on cold and cool water systems.

b. Requires approval of Engineering Services on heated systems. Will not be approved for high-rises.

c. Shall have a 25-year warranty

d. Pipe and fittings shall be stored indoors. Pipe and materials shall not be stored or installed in direct sunlight.

e. Fittings and pipe shall be provided by the same manufacture.

f. Approved manufacturers: Uponor. Provide an owner preferred brand alternate for Uponor. Specify a base scope with traditional approved materials.

g. 25-year warranty: The warranty shall cover the following:

i. Reasonable labor, material, and costs to repair or replace failed warranted product and any part of the mechanical system damaged because of the failure of the warranted product.

ii. Reasonable labor, material, and costs to repair or replace parts of the building (such as finishes, furniture, cabinetry, MEP equipment, etc.) damaged as a direct result of the failure of the warranted product.

h. Contractor training: The manufacturer shall provide training and certification for each installer of PEX-A for the Project. The contractor shall maintain a training record and make it available upon request. Only installers receiving training and certification specific to the Project may install PEX-A on the Project.

i. For large projects, provide the owner one set of installation tools complete for the sizes provided on the project.

L. Meters and gauges

1. Hydronic pressure gauges exposed to vibrations or condensation shall be liquid filled.
2. 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.

III. PLUMBING SYSTEMS

A. General

1. Every mechanical room shall have a minimum of one hose bib. For large mechanical rooms, provide at least two hose bibs.
2. Piping dead legs are prohibited. During renovations, dead end piping should be removed to within six inches of mains (or what is appropriate).

B. Plumbing Fixtures

1. General
    a. Lead-free: 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. Pipe layout: Domestic water services intended for human consumptions such as serving food areas, breakroom sinks, and water fountains so that the water supply has a high rate of turn-over to assure high water quality. This may be accomplished by serving a bathroom group downstream of the services intended for human consumption.
2. Water Closets and Urinals:
    a. Specify the following Owner preferred brand alternate for flush valves and electronic actuators: Shall be Sloan, Zurn, and American Standard. (Note: coordinate this requirement with the architect.)
    b. Automatic flush valves shall be wired or hydro-generated and equipped with side-mounted operators. Battery powered operators are prohibited. Manual flush valves are preferred in situations where automatic are unnecessary.
    c. Water closets
        i. Flush valves shall be rated for 1.6 gpf in older buildings that may have pitted or poorly sloped drain pipes. 1.28 gpf are acceptable for new buildings especially if there is adequate diversity to keep the main drain flushed clean. (Notes: Dual-flush valves and low flow valves are prohibited due to maintainability. Dual-flush valves require increased maintenance. Low flow from toilets may result in increased sanitary sewer clogs due to pitted or improperly sloped drainpipes.)
        ii. The flush valve and china shall have a MAPP rating of 1000 or greater.
    d. Urinals: China and flush valves shall be rated for 0.125 gpf.
3. Faucets: Specify low-flow lavatories with faucet aerators.
    a. Lavatories: Basis of design for basic faucets: Delta 520. Approved manufactures: Delta, American Standard, T&S Brass.
4. Bar Sinks: Sink drains shall be a minimum of 1 ½". (Note: do not specify bar sinks or any sink with smaller drains which tend to not drain well.)
5. Showers: Specify low-flow showers with single handle that enables off/on and temperature adjustment. Consider the basis of design as Delta Low flow shower head or equivalent with 1.4 GPM at 45 psi, 1.5 gpm at 80 psi, single spray function, with large water droplets with a full spray pattern (H2O Kinetic technology or equivalent).
6. Floor sinks and Drains
    a. Within a 2' radius of floor sinks and drains, slope the floor downward 1/8" per foot towards the drains. (note - this is especially important for floor sinks)

b. Floor sinks and floor drains shall be slightly recessed below the floor. The contractor shall reinstall any floor sinks which is higher than the surrounding floor surface. Prior to the pouring of concrete floors, floor sinks and drains shall be secured and anchored into place.
c. For new construction, provide recessed floor sinks or hub drains for each source of equipment condensate. Verify the elevation of floor sinks and secure prior to pouring.
d. Provide floor sinks in areas prone to flooding and for the collection of condensate.
e. Provide floor drains which require removal of the cover with a "special tool" or by qualified staff.
f. 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.
g. Provide trap primers for floor sinks and drains.

7. Mop Sinks
   a. Provide one mop sink per floor.
   b. Flooring in the vicinity of the mop sink shall be waterproof. Sealed concrete is preferred.
   c. Protect walls from water damage with a splash guard from the mop sink to 12” above the faucet and 6” horizontally past the mop sink.
   d. Mop sinks shall be located near the front of janitor rooms to avoid being blocked by items being stored.
   e. Mop sinks shall be centrally located on the floor plan for convenient access and service to the entire floor.
   f. For very small buildings with a single mop sink, locate the mop sink on the ground floor in a central location or near the elevator.
   g. Provide a smooth drain grate mounted nearly flush to the mop sink to facilitate cleaning.
   h. Mop sinks shall be solid construction. Hollow fiberglass construction is prohibited.
8. Water Coolers
   a. Condensing unit: Condensing units should be accessible from the front of water cooler and in same enclosure. Remote mounted condensing units are prohibited. Shall not be recessed into areas with poor room airflow. Shall be installed with the manufacturer’s recommended clearances for air flow.
   b. Bubbler bounce: To assure adequate and stable water supply pressure, shall be installed with a minimum of ½" piping and piped so that the actuation of flush valves does not influence the bubbler height.
   c. Specify electric water coolers equipped with bottle filling stations and equipped with water filters.
   d. 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.
9. 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.
10. Mixing valves: Mixing valves shall be installed below ceilings.

C. Isolation Valves

1. Provide isolation valves on piping branches.
2. Separate piping services for similar spaces: For each specialty lab and for each bathroom of a bathroom group, pipe separately from other similar rooms to allow for plumbing repairs without affecting adjacent spaces. Provide separate isolation valves for such spaces.
3. Restricted access: For spaces with restricted access, the isolation valves should be located outside the room.
4. Gate valve installation: When installed in horizontal pipes, only install with the stem horizontal.
5. Butterfly valves: Shall be lug-style capable of removing the piping on either side without impacting the functionality of the valve.

D. Plumbing accessories

1. Dielectric unions are prohibited. Specify dielectric flanges or IPT to copper sweat dielectric transition fittings (Victaulic series 647 or equivalent).

E. Backflow prevention:

1. Service entrance domestic backflow protection
    a. Provide **dual**, parallel backflow devices (RPZ) 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 are 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 masonry or concrete to be capable of withstanding the splashing of water. Seal the floor and the walls to an elevation of 6". Seal the room airtight with respect to the rest of the building 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. Backflow valves shall not corrode, and the bodies must be constructed of bronze, stainless steel, epoxy coated cast iron, etc.

F. Pressure reducing valves

1. The use of pressure reducing valves should be minimized. For example, do not equip every floor of a boosted building with PRV's.

G. Water Conservation

1. Domestic water shall not be used as a primary cooling source.
2. Use of domestic water for back-up cooling should be monitored by the BAS with a flow switch and a make-up water meter.
3. When domestic or reclaim water is used for back-up cooling, approval from Engineering Services is required.
4. For numerous equipment requires a means of chilled water backup (such as many cold rooms in a single building), consider a single domestic branch pipe serving this equipment with a single switch over valve and monitor flow with the BAS.
5. Vacuum pumps shall be utilized for sources of vacuum. Domestic water shall not be utilized to create an aspirated vacuum.

H. Plumbing Equipment

1. General
    a. Also refer to the sections "*O&M Manuals*" and "*Controls Furnished by the Original Equipment Manufacturer (OEM controls)"* in section I – "*General Requirements"* of this design guideline.
    b. Provide isolation valves on both sides of all equipment that requires periodic replacement such as PRVs, meters, pumps, coils, tanks, heat exchangers, etc.
2. Vacuum Pumps
    a. Vacuum pump style and features shall be selected to provide minimal water usage.
    b. Liquid ring vacuum pumps shall be equipped recirculating sealant water.
3. Air Compressors and Air Dryers
    a. Provide 25-micron filters and pressure regulators with isolation valves on each side.
    b. Locate in an accessible location and not located behind the equipment.
    c. Provide two-foot clearance on all sides.
    d. Provide washable condenser filters.
    e. Screw compressors are required for large size building compressed air systems. Scroll are required for medium sized compressed air systems.

f. For lab air systems, provide an exterior service connection for connecting to adjacent buildings. When possible, pipe to the adjacent building.
g. For large compressed air systems, air compressor receiver tanks shall provide a total minimum capacity of 4 cft per scfm of compressor capacity. Provide N+1 receiver tanks with a set of isolation valves for each.
h. 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.

4. High Purity Water Systems (RO and DI Water)
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.
c. For large systems, RO pretreatment is required. Provide a single, centralized RO system with redundant features.
d. Design centralized systems to produce Type 4 (200 KOhm) water. Users will provide and maintain point of use polishing systems. In special circumstances, Type 3 water system may be considered although this substantially increases the maintenance costs for the Facilities Services. Type 3 water systems will normally involve RO followed by EDI or DI serving a tank. The building occupants will provide and maintain all components designed to produce water of higher purity than type 3.

5. Sump Pumps
a. Elevator shafts:
    i. Elevator shafts shall be provided with sumps and sump pumps piped to the sanitary sewer.
    ii. For hydraulic elevators, sump pumps shall be equipped with oil-minder features.
b. Monitor the alarm status with the BAS. At a minimum provide alarms for high-level, component failure, and oil detector if required. The controls shall be installed within a MEP room.
c. For large sumps, provide top mounted suction pumps.
d. Submerged pumps:
    i. For submersible sump pumps mounted in sumps exceeding 7 feet in depth, lifting rails and hardware shall be stainless steel.
    ii. Provide means for lifting the entire assembly out of the sump and provide adequate lay down space for maintenance procedures.
    iii. All pump components in a chemical waste pump system shall be corrosion-proof. Typically provide stainless steel pump bases, mounting yokes, check valves and gate valves.

6. Domestic Booster Pumps
a. Each boosted system shall be equipped with a hydrodynamic storage tank.
b. There is a preference for nonproprietary motors; split coupling that allows for seal replacement without removing the motor, stainless steel baseplate and stand, flanged pipe connections, lug style butterfly valves, type 304L stainless steel piping, reversible headers.
c. Provide a touch-screen interface with graphics, trending, and alarm functionality.
d. Provide nonproprietary controllers and controls hardware. Provide a 5-year controls warranty.
e. Provide discharge pressure demand controls. Controls shall comply with AHRAE 90.1.
f. Provide stainless steel pressure transducers.
g. Specify the following owner approved brand alternates: Hyfab and SynchroFlo.
h. Provide a minimum of 5 years of free, factory technical support.
i. Expansion and hydropneumatics tanks: Specify the set pressure in the equipment schedule. Specify for the TAB contractor, CxA or mechanical contractor to mark the final set pressure on the tank. This may be done with long-life maintenance adhesive label, vinyl maintenance tag or other permanent and legible means.

7. Pressure reducing valves: Avoid excessive use of PRV's. Install isolation valves on each side of PRV's.
8. Ice Machine Hookups: At the location of each ice machine (owner or contractor furnished) provide isolation valves, 25 micron in-line filters, braided stainless flex connectors on the supply water, and when required, a pressure regulators. Coordinate with the architect to 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. Having good access to the isolation valve and filter is critical to the service person.
9. Cage and rack washers and bulk cleaning equipment: Drain piping and fittings shall meet chemical waste requirements and shall be corrosion proof. Cast iron pipe and fittings are prohibited. (note: the neutralizer for extreme pH cleaners sometimes runs out and the piping system fails). Consider Orion PVDF or similar. Pipe the drain to the chemical waste pipe system. If a chemical waste pipe system does not exist, provide chemical resistant drain piping to a point where adequate dilution will occur to protect the building drain system piping.

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 on/off.

B. Ice Machines

1. Provide one foot of clearance in the rear and two feet of clearance on each side. Show this service clearance on the design drawings even if the equipment is owner furnished.
2. Specify washable condenser filters.
3. The following brands are approved: Hoshizaki, Follett, or Manitowoc.
4. Refer to the plumbing design guidelines for requirements for ice machine hook-ups.

C. Critical lab freezers

1. This applies to -80 'F freezers.
2. For each designated freezer space, provide both 120 (NEMA 5-20R) and 208 VAC receptacles.
3. For buildings with more than 10 freezers, specify an additional space for temporary rental freezers.
4. Freezers shall be fed from a panel backed up by the emergency generator.

D. Autoclaves, Sterilizer, Cage washers, and Glassware washers

1. Cage washers and autoclaves shall be equipped with optional water conservation features whether owner or contractor furnished.
2. Refer to the plumbing requirements for cage and rack washers.
3. Leaks shall not be capable of escaping the autoclave room. Slope the floor to a floor sink. When it is not possible to slope the floor, other measures are required such drain pans, curbs at doors, epoxy floors and coving. Drain pans shall stainless steel.

E. Fume Hoods

1. The sides of fume hood must be at least 1 foot from room corners. (Note: this is to reduce turbulence at the constrained side of the fume hood which can impact the final face velocity setting and energy efficiency.
2. Provide laminar flow diffusers for any diffuser within 10' of fume hoods.
3. Install intake screens to prevent wipes from sucking into the exhaust system which tends to foul air valves.
4. Occupancy sensor must have an indicator light which indicates the occupancy mode.
5. If there is a chance that the lab supply air may fail and impact opening of doors, specify a "failure mode" in which exhaust terminals reset to a reduce flowrate to allow for exiting. For such situations, specify that the CxA perform commissioning testing to determine the appropriate reduced exhaust flow rates to allow for safe exiting.

V. MECHANICAL PIPING SYSTEMS AND EQUIPMENT

A. Installation requirements

1. Pipe layout: To prevent the build-up of sludge within coils, all pipe branches serving coils shall NOT connect to the bottom of horizontal mains. Connecting to the sides or tops of the horizontal mains is acceptable. Provide detail drawings capturing this requirement.
2. Pressure gauges: Provide a combination pressure and vacuum gauge at the highest point in the system and show on the riser schematic drawings.
3. When coils hook-ups utilize combination isolation valves and strainers, provide additional isolation valves where the coil run-out branches from the main.
4. Provide a line-sized, bypass around all coil and HX hookups which allows for full flow flushing of the branch piping. Equip with full-port isolation valves.

B. Piping Accessories:

1. Valves
    a. Gate valves: Shall be installed with stems in the horizontal position.
    b. Butterfly valves shall be fully lugged and equipped with resilient EPDM seats. For Hot water applications, seats shall be peroxide-cured EPDM. Disks shall be stainless steel or corrosion proof materials. Basis of design: Siemens Resilient Seat Butterfly Valve.
2. Gauges
    a. For heat exchangers, install hydronic pressure gauges to allow for measurement of the differential pressure across the tubes and across the strainer. Install isolation valves on each sensing line. Hydronic pressure gauges are not required across reheat coils or coils under 60 kBTU.
3. Air vents:
    a. Provide manual vents at high points.
    b. The use of automatic air vents is not permitted except at the air / dirt separators.
    c. Provide an air vent at the top of all upward flowing risers. Provide an air vent at the end of long horizontal runs. Show these on the riser diagrams.
4. Drains
    a. Provide a dirt leg and blow down valve at the bottom of all accessible risers and at the end of horizontal runs. Show this on the riser diagrams.
    b. Drain and dirt leg valves shall be full port, line-size for pipe up to 1" and a minimum of 1" for larger pipe. The outlet of drain valves shall be equipped with hose threads and a full pressure rated cap with chain.
    c. Each closed loop must be equipped with a main drain and piped to a sanitary sewer drain to permit flushing.
5. Pressure relief
    a. 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.
6. Dielectric unions:
    a. Dielectric unions are prohibited. (Note: These are prone to leaking due to expansion and contraction and subsequent damage to the union seat.) Specify dielectric flanges, nipples or IPT to copper sweat dielectric transition fittings (Victaulic series 647 or equivalent).
7. Flexible connectors
    a. Spherical, elastomeric pipe vibration isolation fittings shall not be installed in locations where connector failure could flood the building. In such locations, braided steel vibrations isolation connectors may be used. Braided steel vibration connectors shall never be installed in tension or compression.
8. Air / Dirt Separators

a. Air and dirt separators shall be the high efficiency, coalescing type. Spirotherm, B&G – CRS, Armstrong DAS and Thrush Aar-O-vent are approved. Separators shall be at least the size of the pipe served. Separator media shall be corrosion proof. Provide an oversized blow-down valve.

9. Chemical feeders
   a. All closed loops shall be equipped with bypass chemical feeders equipped with integral filter socks.
   b. Basis of design: Neptune model FTF-5150DB. The feeder shall have a minimum of 3.5" opening, shall have a threaded and sealed closure, and shall be rated for a minimum of 300 psi and 200 'F, shall be corrosion proof, closure seals and seal housings shall be designed for long-term reuse, shall be equipped with legs to elevate the feeder off the floor, and the filter bag shall be fully supported by a corrosion-proof filter basket. (This is necessary to standardize filters for campus and ensure the treatment tablets fit into the feeder opening).
   c. The pot feeder with integral filter must be installed across the pump or supply and return lines (one line on suction side of pump and the other line on discharge side.
10. Make-up meters and flow switches
   a. Provide a totalizing water meter for the make-up water for all closed loops. Basis of design: Assured Automation WM-NLC. The optional pulse output is required for large systems and shall be monitored by the BAS.
   b. As an alternate to the optional pulse output, provide a make-up flow switch (e.g., McDonnell & Miller FS5-3/4 or equal) and connect output to the BAS. Flow shall trigger an alarm.
11. Flow balance valves
   a. For hydronic flow balancing, specify the B&G Circuit Setter Plus or Circuit Setter Flo-Setter II or equivalent. Balance valves shall be designed for clog-free operation.
   b. Flow balance valves shall be equipped with differential pressure measurements ports. Flow measurement curves or charts shall be provided with the O&M documentation.
   c. Automatic (autoflow) balance valves are prohibited.
   d. Combination balancing/shutoff valves shall be independent and using the shut off function shall not affect the system balance when the valve is reopened.
   e. Butterfly valves are not acceptable valves for flow balancing.
   f. In most cases, balance valve should be set to a minimum of 1.0 gpm to avoid plugging of piping and small orifices.

C. ***Closed loops design requirements***

1. Heating hot water coils shall be sized for 160 °F supply temperature and 130 °F return temperature.
2. Freeze Protection
   a. For systems prone to freezing specify a minimum of 28% inhibited propylene glycol solution. (glycol solutions below 25% accelerate microbial growth)
   b. Provide an automatic glycol make-up tank system for all glycol loops. Provide a make-up water meter and alarm contacts for BAS monitoring. Basis of design:
      i. Large systems: Advantage Controls Model DAGF-1B Glycol Feed System with standard 55 gallon poly tank and stand, .3.3 GPM @ 100 psi positive displacement pump (or sized as required), digital controls, low level switch with audible and dry contact alarms, pressure relief valve, NEMA 4X enclosure with viewing window, digital pressure sensor and standard pressure gauge, budget price 2019: $3,796.
      ii. Small System: Wessels Company I/O Glymatic Glycol Make-up package – Model GMP-18, 18-gallon capacity, budget price 2019: $1,204
3. Provide a strainer and analog water totalizing meter for makeup water supplies. See the "piping accessories" section for make-up meter requirements.
4. Specify a quarterly pasteurization sequence to open control valves to flush coils. For the heating hot water system, heat the system 170 °F and flush each pipe branch and coil by full opening the controls valves for a

minimum of 30 minutes. Typically, this is performed at night and airflow is reduced to avoid overheating spaces.

D. ***Pumps***

1. General
    a. Approved pump brands are B&G, Taco, and Armstrong.
    b. Pumps 5 hp and larger shall be base-mounted, flexible coupled or split coupled vertical inline.
    c. Pump mechanical seals shall have ceramic stationary seats.
    d. A single pressure gauge with isolation valves to provide suction pressure, discharge pressure, and differential pressure shall be installed on all pumps.
    e. 24" service clearances shall be provided on all sides of pumps.
    f. Isolation valves shall be provided on the inlet and outlet of pumps.
    g. Pumps shall be serviceable without removing the volute from piping connections.
2. Alignment for Flexible Coupled Pumps
    a. For pumps 10 hp and larger, a factory certified technician shall field align flexible coupled pumps three times: prior to the connection of the piping, after the pump is fully installed, and after start-up.
    b. Align pump and motor in the vertical angular, horizontal angular, vertical parallel and horizontal parallel. Alignment shall be within the recommended values specified by the pump manufacturer (not the coupler manufacturer) but not over 0.002" parallel and 0.005" angular per radius-inch.
    c. All results of the alignment procedure and the pump manufacturer's alignment specifications shall be submitted for review and approval.
3. Pump efficiency:
    a. Specify on the pump schedules the minimum pumping efficiency at the design condition and for pumps over 5 hp, the minimum pump PLEV efficiency based on the AHRI Standard 550/590 "IPLV" load profile, 30% fixed head or calculated minimum control head.
    b. The pump efficiency at 100%, 75%, 50% and 25% of flow rate and the associated system differential pressures shall be submitted for review.

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 systems that require uninterrupted service. Piping shall be configured so that the redundant heat exchanger may remain in service while one heat exchanger is being repaired or replaced.
2. Steam fired, Shell and tube heat exchangers:
    a. Clearance shall be provided to pull the tubes from shell and tube heat exchangers without the need to remove the shell from the piping. The clearance shall be marked on the piping drawings. Provide an additional 12" pull clearance.
    b. Steam shall not impinge upon the tubes. The end of the shell should have an area without tubes for the steam to enter. (commentary: condensate in the steam can quickly damage tubes.)
    c. Return water shall enter in the lower tube port.
    d. Specify low leakage head gaskets such as by Flexitaulic ZG or equivalent.
3. Plate and Frame Heat Exchangers: Provide line-sized connections for back flushing.
4. Process cooling
    a. Buildings equipped with closed loop chilled water piping separate from the campus chilled water system, shall not be cross connected with the campus chilled water system. (Note: The building closed loops are treated with nitrate-based chemicals which are not compatible with the campus chilled water loop treatment chemicals.)
    b. If there is any chance of campus chilled water entering a building cooling loop, 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. This is a very unusual situation. In such cases,

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. The following minimum access clearance shall be provided: 24 inches on all sides and 36 inches on the burner side.
2. Specify IRI approved gas trains on all boilers.
3. Specify boiler controls to provide heating hot water year around.
4. Specify factory certified start-up and inspection

G. ***Building Steam Systems***

1. General
    a. This section covers steam piping between the building steam meter and the main building condensate receiver.
    b. When available, steam will be used to produce heating hot water and domestic hot water. Coils for heating air will be served by heating hot water (not steam).
2. Construction Inspections
    a. Piping shall be inspected prior to insulation by the Engineer. Engineering Services shall be invited to all pre-insulation piping inspections. Proper pipe slope and weld quality shall be verified.
3. Piping
    a. Steam and condensate piping shall slope in the direction of flow. Under no exceptions will the pipe be installed with dips or back-sloping with one exception: steam pipe serving control valves shall slope back to the drip or main.
    b. Steam and condensate piping 2 inches and smaller shall be schedule 80.
    c. Steam piping and accessories shall be compliant with ASME Standard B31.9 Building Piping systems.
4. Piping accessories
    a. Isolation valves, strainers, blow down valves and other components after the building steam PRV shall be a minimum of 150 # class.
    b. Strainers: 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 stems. 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.
5. Main PRV’s
    a. Each building steam service shall be equipped with a stream PRV and safety relief valve. Deviations require approval by both Facilities Engineering Services and Energy Services Cogen.
    b. The basis of design for steam PRV’s is the Spence type-E main valve with type D pilot.
    c. Steam PRV’s shall be a minimum of 250 # class.
    d. Drip pan elbows are prohibited. Pipe steam vent drains to a building sanitary drain.
6. Insulation
    a. F&T, bucket traps, isolation valves, steam control valves, strainers and PRV’s shall be insulated in accordance with manufacturer instructions with removable, insulation jackets meeting the following requirements: Jackets shall be removable, preformed thermal jackets by Thermaxx or equivalent with a minimum 5-year warranty for materials and labor, silicone jackets, jacket edges sewn with Kevlar thread (not stapled), jacket secured with Velcro or equivalent and/or straps. Specify damp and wet location jackets when required. Provide resilient tags on the jacket exteriors identifying the device and when specified, device ID’s.
7. Control valve installation

a. Provide drip legs before control valves to protect control valve seats from wiredraw. For short pipe runs serving control valves, the run-out may come off the top of a main and the drip leg may be omitted. Slope steam supply piping back towards the drip or main from the control valve to the.

8. Traps and trap assemblies
   a. For coils supplied with modulated steam, locate steam traps a minimum of 12 inches below the coil condensate outlet. Exception: When shorter distances are required, the Engineer shall thoroughly review and approve the selection of the trap and orifice sized based on the actual installed gravity head.
   b. Trap assemblies shall be equipped with a dirt pocket and blow down valve, two isolation valves, a strainer with blow down valve, two unions, and trap test valve. The Engineer shall provide a trap installation detail drawing for approval.
   c. Dirt pocket blow down valves shall be installed on the side of the dirt leg, 2" up from the bottom. Provide piping to direct the blow-down towards an impervious surface (usually downward) and in such a way that building materials will not be damaged during blow-down.
   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 on the discharge pipe. Direct towards the floor in a visible location.
   e. When the use of test valves is not possible such as when traps are installed above ceilings, provide steam condensate site glasses
   f. Excessively oversized and undersized traps must be avoided.
   g. Specify F&T traps downstream of modulated coils or heat exchangers. Specify Barnes and Jones, Armstrong or Spirax Sarco pressure balanced bellows or F&T traps for drips less than 75 psi.
9. 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 direct to a cooling vessel and then drain to sanitary sewer. Uncontaminated steam condensate shall return to the condensate receiver.
10. Flash Tanks
   a. Vented flash tank shall be provided to cool condensate prior to entering the condensate receiver
11. Condensate receivers:
   a. Condensate receivers shall be the elevated style. Standard elevation receivers may be accepted only when there is not substantial pipe elevation to provide gravity condensate drains.
   b. To provide longer equipment service life, there is a preference for 1750 rpm motors over 3600 rpm motors.

VI. HVAC SYSTEMS

A. *General Requirements*

1. UNC-CH standard HVAC system is centralized, variable volume air handling units with hot and chilled water coils and serving VAV terminal units with hot water reheat coils.
2. HVAC systems should be of heavy commercial/industrial quality and designed to provide reliable service for 40 years or more.
3. HVAC systems should be centralized and should minimize maintenance needs and maximize reliability.
4. HVAC coils should be sized with excess capacity to maintain proper temperature and humidity levels with potential future increases in cooling load and coil fouling. Design for up to 20% increase in outside and supply airflow.
5. The HVAC systems shall provide reliable positive pressurization to the building.

6. Ductwork shall be externally insulated. Duct liner anywhere in the system is not permitted unless approved by Engineering Services during design development.
7. Return air shall be fully ducted unless approved by Engineering Services during the design development phase.
8. The use of non-centralized fan powered devices such as fan powered terminal units and fan coil units are typically prohibited in occupied spaces. Institutional grade fan coils may be considered for renovations under limited circumstance and when served by outside air makeup units.
9. Design HVAC systems which provide air change effectiveness greater than or equal to 0.9, as calculated by ASHRAE 129-1997.
10. HVAC equipment shall be shown to scale on the drawings. HVAC ductwork shall be shown as “double lined” unless duct diameters are less than 10".
11. HVAC systems serving animal holding areas and spaces requiring uninterrupted HVAC, shall have a minimum of two manifolded AHUs with isolation dampers so that the HVAC will continue to operate at design capacity during AHU maintenance.
12. Pressure relief: Specify pressure relief doors when fans are capable of rupturing ducts and equipment casings.
13. Cooling equipment larger than 30,000 BTU must be floor mounted.
14. Recirculation of air from break rooms, mechanical rooms and print/copy rooms is not permitted.

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. Floor mounted fan coils are provided for cooling. Mount fan coils low on a wall as the first choice or mount 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: In addition to providing outside air from the central HVAC system, provide independent cooling equipment. Independent cooling shall be floor-mounted vertical, up-flow fan coils, chilled beams, or radiant panels. Fan coils over 1.5 tons are prohibited from being located above ceilings.
3. For any spaces with a considerably different thermal loading schedules than most 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. When serving multiple rooms on a single zone:
    a. HVAC zones should not exceed 700 square feet.
    b. Rooms shall have similar exterior exposures.
    c. Rooms shall have similar schedules and loading characteristics.
    d. If the project does not follow zoning design guidelines, future changes to the zoning layout will be at the customers expense.

D. ***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.
4. HVAC systems with high outside air percentages and serving spaces that have critical cooling needs must have capacity above typical ASHRAE design conditions

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. Coils shall completely fill unit casing. Do not overlap coils unless required for piping connections.
c. Tube thickness:
    i. For AHU's more than 6000 cfm, coils tubes shall have a minimum thickness of 0.035 inches, and tube bends shall have a minimum thickness of 0.049.
    ii. For fan coils, blower coils, and small AHU's, specify a minimum of 0.025" thick tube walls.
d. Coils shall be leak testing at 315 psig minimum.
e. The maximum air velocity shall not exceed 500 feet per minute.
f. Headers shall be constructed of copper, brass, or other corrosion proof materials. Steel headers are prohibited.
g. Tube turbulators are prohibited.
h. Evaporative cooling (spray coils) are prohibited.
i. Tube velocity at design conditions shall be a minimum of 2 feet per second at design conditions.

2. Chilled Water Coils (requirements in addition to General Requirements)
    a. Chilled water coils should be designed for 45 'F supply temperature and a minimum of 59 'F return temperature. Cooling coils that have peak demand during the winter shall be sized for 50 °F supply water and a minimum of 62 'F return temperature.
    b. Mechanical schedules for cooling coils shall indicate the following: chilled water velocity in the coil tubes at design conditions, required tube wall and fin thickness, maximum face velocity, special construction requirements, design supply and minimum return temperature, maximum fin spacing and number of rows.
    c. Coil casings, frames, supports, attachment hardware and intermediate troughs shall be stainless steel. For custom AHUs, fasteners attached to stainless components shall be 400 series stainless steel or equivalent performance and zinc plated fasteners are prohibited.
    d. The coil maximum face velocity shall not exceed 450 feet per minute. (note - this is to minimize fan energy and to provide future surplus capacity).
    e. Coils shall have a maximum of eight rows at 10 fins per inch. 11 fins per inch is acceptable when necessary, and 12 fins per inch and higher is prohibited.
    f. Tube velocity at design conditions shall be between 4 and 6 feet per second at design conditions.
    g. For AHU's, copper tubes shall have a minimum thickness of 0.035 inches and aluminum fins shall have a minimum thickness of 0.0095 inches. Tubes shall be constructed of copper or stainless steel. Fins shall be constructed of aluminum or equivalent.
    h. Coils are sized for 45 'F CWS and 14 'F minimum temperature differential.
3. Steam Coils
    a. UNC's standard is for heating hot water coils, and steam to air coils should be avoided. Steam coils exposed to air temperatures below 40'F must be a tube within a tube design or other design specifically to avoid freezing.

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

1. Drain pans and support framework within the cooling section shall be stainless steel and comply with ASHRAE IAQ standards.
2. Drain pans shall be stainless steel and intermediate troughs shall be stainless steel. Plastic drain pans may be considered for fan coils. Drain pans shall be sloped and pitched to allow proper drainage. Drain pans for AHU's should be a minimum of 16 gauge.
3. Drain pans shall extend at least 6" downstream of the cooling coils, but typically much further.
4. Drains pans should not be installed above suspended ceilings and shall not be installed above fixed ceilings. Where this is unavoidable, approval from Engineering Services is required and auxiliary drain pans shall be provided and shall be equipped with auxiliary float switches. Auxiliary drain pans shall not interfere with service access to the unit. Equipment shall always be replaceable without the need to remove elements of permanent construction.

5. AHU's over occupied areas and capable of leaking into occupied areas shall be equipped with an auxiliary drain pan capturing leakage from the entire unit and equipped with a float switch.
6. For walk-in AHUs, drain pans should be protected with aluminum grating.
7. Cooling condensate pumps should be avoided. Provide gravity drains when feasible.

G. *Cooling Condensate Traps*

1. Water shall not stand in drain pans even with loaded filters. The drain lines shall be 1" dia. minimum. Materials of construction shall be copper or schedule 80 CPVC.
2. Condensate shall flow to a sanitary sewer and shall not flow to a storm sewer system including draining on roofs and building grounds. (note - chemicals are periodically used for cleaning the coils).
3. Provide a plugged tee for rodding straight into the drain pan and provide two plugged tees at the bottom of the trap for cleaning. Provide a union on both sides of traps.
4. Slope drain lines ¼" per foot.
5. The total trap height shall be a minimum of 1.5 times the maximum negative differential expected at the drain connection to the AHU plus 1".The trap weir shall be a minimum of maximum negative differential pressure plus 1" below the AHU outlet.
6. 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.
7. For AHUs base rails heights shall be specified and shall be adequate to allow for trap installation.

H. Humidifiers

1. Applicability: Provide humidification for labs, DLAM, and other specialty spaces to provide a minimum of 30% RH or as required by the user.
2. Style: When available for larger applications, humidifiers shall be panel style with horizontal supply and condensate headers serving vertical, dispersion tube. Dispersion tubes shall be insulated.
3. Humidifiers will be supplied by campus steam which will be injected into the HVAC systems.
4. Humidifier installation location:
    a. Humidifiers shall not trip the duct smoke detectors. In most cases, humidifiers shall be installed after the AHU supply duct smoke detector.
    b. Access to humidifier components that require periodic inspection, testing, repair, or replacement shall be convenient. Provide portable stairs (roll-around style) or permanent stairs and access platforms for overhead steam humidifiers. Mark on the plans a storage location for portable stairs.
    c. If necessary, humidifiers may be mounted within the AHU but must not wet the fans and must not operate when the cooling is operating.
5. Steam and condensate separation chambers shall be provided and shall be installed on the inlet side of the steam control valves.
6. Control Valve: The humidifier steam control valves shall be carefully sized to avoid excessive oversizing and loss of controllability. The humidifier steam control valves shall be tuned including setting the upper limit of the control valve actuator to limit the humidification capacity.
7. Installation features:
    a. For duct mounted humidifiers, specify welded stainless-steel ductwork from the humidifier downstream for 2 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 valve and pipe to a conspicuous location.
    b. 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 the intake of pollutants, nuisance odors or debris such as automobile and generator exhaust, building exhaust and landscape debris. Intake openings shall be protected with ½" x ½" corrosion resistant hardware cloth installed inside the louver and when necessary, painted to match.
2. Sound Attenuation: Incorporate necessary attenuation strategies to minimize noise in occupied spaces. ASHRAE's noise guidelines are the maximum acceptable noise levels.

B. *HVAC Ducts*

1. SMACNA: All ductwork shall conform to SMACNA HVAC duct construction standards, metal, and flexible, latest edition.
2. Insulation:
    - **a.** Internally lined duct is not permitted.
    - b. Exhaust or relief ducting installed in unconditioned, ventilated attics and spaces must be insulated if there is a chance of condensation forming on the exterior of the duct.
3. Duct Pressure Class: When fan total static pressure could exceed 4" w.c., ducts from the AHU to the fire dampers shall be rated for 6" w.c. pressure class.
4. Flexible ducts:
    - a. Bends in the flex duct shall be no less than one duct diameter centerline radius.
    - b. Flex ducts shall extend a few inches past sheet metal prior to bending.
    - c. Provide hard elbows or three straight duct diameters at diffuser connections.
    - d. Flex ducts shall be supported at least every 5 feet.
    - e. Flex ducts shall sag less than ½" per foot.
    - f. Flex ducts shall be installed fully extended and not in the compressed state (including pinched between other building components).
    - g. The hanger material in contact with flexible ducting shall be a minimum of 1.5" wide.
    - h. Should not be more than 6' in length.
5. Outside air:
    - a. Outside air ducts shall be sized for 100% outside air economizer operation.
    - b. 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.
6. Pressure drop:
    - a. Duct fittings shall not have excessive pressure drops. Consider specifying the maximum allowable pressure drop at critical duct fittings.
    - b. Ducts at the intake and discharge of fans shall be arranged to avoid fan system effect.
    - c. Angles of divergence of duct fittings shall be less than 30 degrees.
    - d. Duct aspect ratios should be less than 4 to 1.
7. Ductwork Leakage Test
    - a. Duct Leakage Testing: 100% leakage testing shall be provided for all ducts rated 4" w.c. or greater. For laboratories, provide 100% leakage testing of 2" w.c. or greater ducting.
    - b. Duct Seal Class: Provide SMACNA Seal Class A on all metal duct 2" 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 ducts are insulated prior to leakage testing and leaks are found, the contractor to responsible to remove the insulation from the entire section of the leaking duct, repair the leaks and replace the insulation.
    - d. Perform the field leakage 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.
i. For large duct systems, specify a maximum external static pressure that the duct installer must not exceed. If the ESP is exceeded, then high pressure drop fittings must be replaced.

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.

C. Dampers

1. Duct splitter dampers are prohibited.
2. Remote manual balance damper operators should be avoided (they tend to prematurely fail). In areas of hard ceilings, provide accessible manual balance dampers.

D. Fire and Smoke Dampers:

1. A safe means of maintenance access shall be provided for all duct damper actuators and damper access doors.
2. A clear line of site shall be provided for inspection of all damper actuators and fusible links.
3. For conditions with limited access to smoke damper actuators, dampers shall be selected with actuators on the inside of the duct, on the bottom of the duct or on the accessible side of the duct.
4. For access to fusible links, on ducts larger than 14", provide access doors of a minimum of 144 sin.

E. *Duct Access Doors*

1. **Specify ultra-low leakage doors.** (Nailor Industries 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. For access doors on reachable by ladder, provide a safety chain attaching the door to the duct.

d. Provide grab handles for doors 18" x 10" and larger when there is a positive pressure greater than 3" w.c.
e. Specify gaskets designed for extra long-life.
f. Note: A lower cost alternate to the Nailor Model 0800 is the Ductmate Sandwich Access Doors, but this may require an adjustment to the maximum leakage. For most projects, the Nailor Model 0800 shall be provided.

F. *HVAC Filtration*

1. Specify 2" MERV 8 pre-filters and 12" primary filters ahead of the first coil. Final filters shall be MERV 11 with the exception that labs shall be MERV 14. In walk-in AHUs, filters shall be front-loading. When space is limited or for small AHU's, 6" or 4" primary filters may be specified. Small package units may utilize 2" or 4" pleated filters as necessary for unit sizing.
2. The filter bank shall be equipped with high quality gaskets and blank-off panels to prevent the by-pass of air around filters.
3. Filters shall be standard sizes, either2' 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 adequate sets of pre-filters and final filters for all AHUs, so that a complete spare set is provided at the time of project turn-over. Prior to start-up of AHUs, filters shall be installed. For projects of especially long duration, in addition to the initial set and spare set, the contractor shall replace pre-filters every three months or when they become loaded, whichever is less. in addition, pre-filters shall be replaced within one month of turn-over.
6. Primary filters shall be Viledon MV85, AAF VariCel VXL or equivalent. 12" primary filters shall be constructed with a minimum of 170 sft of media area per 2' x 2' filter.

G. Outside Air Intakes

1. Louvers must be selected carefully to avoid rain entrainment. Louvers shall be sized to accommodate future increases in design airflow with a minimum of 20% increase for typical occupancies and 30% increase for labs. Entrained moisture must be captured and drained to an appropriate location. Rain must not reach the AHU or filter bank. (note - rain entrainment is an issue at several outside air intakes)
2. Outside air intakes should minimize the entrainment of snow into the AHU. For 100% outside air handlers, especially for critical applications, snow must not reach the filter bank and trigger a high suction pressure alarm.
3. Moisture from unexpected entrained rain and snow must drain to an appropriate location such as the exterior or a floor drain.

VIII. HVAC EQUIPMENT

A. *General Requirements*

1. Lightening protection: For equipment mounted outdoors and equipped with on-board controls:
   a. Disconnect device: specify a heavy-duty disconnect switch with integral surge protection devices. Basis of design: Eaton SP1 and CVX series with integrated SPD and viewing window.
   b. Provide loss of phase and brown-out protection.

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

1. Related Documents
   a. HVAC Air Distribution/HVAC Filtration
   b. HVAC Equipment/Fans
   c. Design Requirements within the General Requirements of this document.
2. Access clearances
   a. Clearance for pulling coils shall be provided. (Note: Show on the plan drawing the coil pull area and denote with a cross hatch. The coil pull will normally be the length of the coil plus 6 inches and the

width of the coil plus 12 inches (or more) on both sides. When walls obstruct coil pull, access openings within walls.

b. Provide a means and a pathway for installing and replacing the air handler modules without major demolition of other systems including building walls.

c. AHU's may be set with one side close to a wall, but 24" clearance shall be provided where equipment and components requiring access are located.

3. 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.
   b. Insulation shall be a minimum of 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. 3" wall thickness is required for AHU over 30,000 cfm or when installed on the exterior of the building.
   c. Floor construction: 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 semi-custom and modular AHU's.
   d. Penetrations shall be insulated, sealed, and sandwiched between metal with equivalent materials to the casing construction.
   e. 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.
   f. Major components shall be supported from the unit framework, not the casing.
   g. Units shall be specified to require external connection to all coils, drains, motor power, and ducts. All piping connections shall extend 3" through the panel casing and terminate with either flanges or threaded connections as applicable.
4. 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 utilized, leakage shall be less than 0.232 cfm per sft at +/- 8" w.c. (alternate approach: Specify AHRAE-111 class 6 casing air leakage rate for modular AHU's.).
   b. Specify air handling units to withstand a minimum of 8" w.c. positive or negative internal pressure, or the fan shut off pressure whichever is greater.
   c. *For AHUs greater than 40,000 cfm and all custom AHU's:*
      i. All units shall be factory tested for leakage and deflection at the contractor's expense. The owner has the option to witness all factory testing.
      ii. All units shall be field tested for leakage at the contractor's expense. The owner has the option to witness all field testing.
      iii. The casing shall have a maximum casing leakage of 0.5% of design cfm t +/- 10" w.c.
      iv. The casing shall have a maximum deflection anywhere on the casing of L/240 at +/-10" w.c.
      v. Floors shall be fully welded construction.
   d. <u>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.</u>
5. Base rails
   a. For AHUs greater than 20,000 cfm: base-rails shall be structural steel or aluminum.
   b. For wet environments and greater than 20,000 cfm, base rails shall be structural aluminum.
6. Doors and Panels
   a. Access doors shall be provided for each section.

b. Doors shall be wide enough to remove replaceable unit components and to allow entry. Minimum door size shall be 24" W x 60" H unless unit height limits the door height. In special circumstances, doors may be a minimum of 16" width. Doors for fan sections of large AHU's should be extra wide (roughly 30" minimum).
c. Consideration must be taken to allow for access around UV lights, humidifiers, and other features which block the door opening. When entry is blocked by UV lights, UV section doors shall be extra wide.
d. Door construction shall match unit casing.
e. Doors shall be perimeter, airtight, with replaceable, ¾" x 5/16" minimum sized, resilient gaskets. Specify automotive style bulb gaskets for custom AHU.
f. All doors shall be installed to open against the greater air pressure. If this is not possibly, equip doors with safety chains and/or latches and warning stickers.
g. Test ports shall be provided in all doors.
h. For custom AHU door closure hardware shall be metal or high strength plastic with three spare handles. For modular AHUs, high strength plastic handles are acceptable.
i. 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.

7. Drain Pans
   a. When installed over occupied spaces, an auxiliary drain pan with float switch shall be provided under the entire AHU. An alternative is to install a 2" high metal angle around the AHU and caulk liquid-tight.
8. Electrical Requirements
   a. Power conductors inside the AHU shall be enclosed within conduit including motor wiring.
   b. 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.
   c. Conduit shall be sealed so that air cannot migrate out of the AHU.
   d. Provide one VFD per fan motor.
9. Maintenance Requirements
   a. When equipped with motors 20 hp or greater (15 hp for fan walls), an integral rail and hoist or other permanent lifting means shall be provided for motor removal.
10. Gauges
    a. Differential pressure gauges shall be provided across each filter section, cooling coils, and fans.
    b. Pressure gauges shall be sized to provide measurement in 1/10 in. w.c. or less increments.
    c. Specify the full scale of pressure gauges. Pressure gauges should be exposed to pressures no greater than 50% to 67% of full scale.
    d. Mount pressure gauges on to the exterior of air handler and specify copper tubing. Gauges shall not be mounted in the AHU casing walls.
    e. Gauges shall be equipped with on-off-vent valves for measurement of both static pressure at each probe and differential pressure across the probes.
11. UV Lights
    a. Specify ultraviolet (UV) lights on the downstream side of chilled water coils. Adequate access shall be provided 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.
    c. UV lights shall provide 360-degree UV coverage for increased air treatment
    d. Fixtures shall be corrosion proof.

e. Safety switches and safety stickers shall be provided on all access doors immediately on both sides of the cooling coil.
f. Ballast shall be installed on the exterior of the AHU. Ballast shall have a 5-year warranty.
g. The minimum intensity striking any point on a plane representing the surface of the coil or component shall not be less than 50 microwatts per square centimeter and average radiation shall be a minimum of 150 microwatts per square centimeter.

12. Outside air intake
    a. Where space limitations result in inadequate mixing, provide blenders, or direct the outside air and return air dampers at one another.
    b. Outside air ducting shall be sized for full economizer operation.
    c. Provide a separate minimum outside air and economizer damper when the minimum outside airflow is less than 25% of the economizer airflow.
13. 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.
14. Service features:
    a. For energy recovery units required to operate without interruption, provide a bypass around the coil and filter for providing filter and coil maintenance.
    b. For manifolded AHU's serving spaces that require continuous supply air, provide means to isolate each AHU for individual servicing and provide adequate redundancy to allow for servicing without compromising system performance.
15. Schedule requirements:
    a. For documentation purposes, optional features and some design guideline requirements must be identified on the schedule including: Coil selection parameters including required tube velocity range, maximum face velocity (air), maximum number of rows and maximum fins per inch, chilled water supply and minimum chilled water leaving temperatures, and maximum water pressure drop; fan wheel minimum diameter, maximum design speed, wheel class, and wheel maximum operation speed (first critical speed).
    b. The schedule must note if the specified cooling discharge temperature includes fan heat.

C. ***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 or when matching existing.
3. Air terminals shall be sized to provide a minimum air flow ring signal pressure of 0.1-inch water column.
4. For energy savings, the minimum cooling flow rates shall be 30% of maximum air flow unless the design requires otherwise.
5. Air terminals shall be equipped with an access door or panel between the damper and reheat coil. Additionally, specify an access door after reheating coils.
6. When internal liner is provided, provide liner which is resistant to mechanical damage, resistant to mold, shall not shed fibers.
7. Prior to the installation of permanent ID tags, mark air terminals and air valves in a visible location with the equipment identification number using a thick black marker or equivalent and 2", neat characters. Exception: does not apply for permanently exposed equipment.

8. 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.,
9. On the design documents, provide a division of work detail for control wiring. Identify the transition point from the electrical contractor to the mechanical or controls contractor.
10. Air terminal schedules shall indicate the electrical requirements.

D. ***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 135 °F return temperature.
3. To avoid damage to the synthetic gaskets and seats, components that contain these shall not be equipped with copper sweat connections and shall be equipped with NPT connections.
4. Balance valve should be set to a minimum of 0.5 gpm to keep the coil and components flushed of sediments.
5. Dielectric unions are prohibited at reheat coils and on hot water systems. Refer to the requirements in the accessories sub-section of the piping section.

E. ***Fan Coils***

1. Fan coils shall be institutional grade or higher quality and meet the following:
    a. Coiling coil casings shall be stainless steel.
    b. Coils shall have a minimum of 0.025" tube wall thickness. (This is normally an optional upgrade.)
    c. Drain pans shall be stainless steel or other corrosion proof materials.
    d. Equip with 2" filter racks. (This is an upgrade from the standard 1”.)
    e. Fiberglass insulation is prohibited in fan coils equipped with cooling coils and in such cases shall be closed cell insulation.
2. When installed above ceilings, specify an auxiliary pan with 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 adequately dehumidify all portions of the building shall be provided.
4. Fan coils shall not be located above ceilings.

F. ***Server room AHUs***

1. For below floor plenums, specify plenum fans. Fan speed shall be modulated to control the plenum static pressure.
2. Individual fans shall each be equipped with its own VFD and motor.

G. ***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 diameter, fan class and maximum design RPM on the schedule.
2. Belt Driven Fans
    a. All belt driven fans shall have a minimum shaft size of 1-1/8".
    b. Fan shaft bearings shall be capable of relubrication when available.
    c. Each fan shall have the sheaves aligned by contractor prior to start up.
    d. A spare set of belts for each belt driven fan shall be turned over to University at the end of project.
    e. Adjustable motor bases shall be NEMA rated and equipped with a minimum of two 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. This requirement is necessary when equipment must operate

continuously and bearing lubrication points are not easily accessible without turning the equipment off.

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. This requirement does not apply to motor bearings.

4. Vibration: Fans shall be factory balanced to BV-3 vibration or higher.
5. Flexible connections: Flexible connections shall be stretched tight and without major wrinkles that will contribute to affects upon the fan performance.
6. Ducts: Ducts shall be aligned within +/- 3/8" tolerance with fan inlets and outlets.
7. Access doors: When available as an option, specify hinged access doors (avoid bolt on access panels when possible).
8. System effect: Designs shall minimize the fan system effect due to poor inlet and outlet conditions. 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.
9. Materials: Fiberglass fan wheels and housings are prohibited. If there is a case where non-metallic is necessary, discuss this with Engineering Services.
10. 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.
11. When equipping AHUs with multiple fans, specify backdraft dampers.
12. Fan array preferences:
    a. Specify n+1 fans.
    b. Size wheels to allow motors to operate close to 60 hz plus or minus 20 % maximum.
    c. Size fan wheels to allow for the use of 1850 RPM motors (if possible)
    d. Specify one VFD per motor and do not equip with a bypass circuit.
    e. Micro-drives are prohibited except motors 1 hp and lower and which may still require a minimum of 3% input impedance and harmonic mitigation. These features are not typically available in micro-drives.
    f. Drives shall not be mounted directly on the AHU.
13. Critical fans
    a. Fans shall be direct drive, arrangement four.
    b. Fan vibration velocity or balance shall be factory tested, certified. Documentation shall be provided in accordance with the requirements of ANSI S204-05 chapter 8. Specify the maximum, factory test vibration velocities for fan assemblies and/or balance grades for rotors in accordance with the latest version of ANSI Standard 204-05.
    c. Fans installed outdoors: Coatings shall exceed 7000-hour ASM B117 salt spray resistance. Provide UV coating protection.
    d. All hardware used for the fan assemblies including the mounting to the structure shall be stainless steel.
    e. Extended bearing grease fittings shall be provided in an easily accessible location. Lube lines shall be constructed of Teflon tubes covered with braided stainless-steel jackets and equipped with relief fittings.
    f. The bearing life at the design operating speed shall be a minimum of L-10 at 200,000
    g. High plume lab exhaust fans
        06. The maximum fan assembly vibration velocity shall be 0.05 in/s.
        07. The maximum peak to peak vibration shall be 0.5 mil.
        08. The minimum material warranty shall be 7 years.
        09. The fan plenums intake plenums shall have a maximum duct velocity of 1500 fpm within three duct diameters of the fan intake.

10. Each fan shall be vibration tested before shipping, as an assembly, in accordance with AMCA 204-05. Each assembled fan shall be test run at the factory at the specified fan RPM. Vibration signatures shall be taken on each fan bearing in the horizontal, vertical, and axial directions. The maximum allowable fan vibration level shall be 0.08 in./sec. peak velocity, filter-in, at the fan RPM when the fan is rigidly mounted. If the fan is to be flexibility-mounted, the .08 becomes .10.

IX. BAS CONTROLS

1. Refer to the UNC Controls Standards.
2. 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. Provide the edited digital controls documents to UNC Engineering Services for review. Refer to UNC Controls Preface and Implementation Guidance document for more detailed instructions.
3. 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.
4. Monitor the following with the campus dial-in monitoring system which is monitored by Public Safety 24-7: lab freezers, environmental rooms, and lift station high level alarms.
5. BAS work room: For new buildings, provide a 12” X 10” enclosed, conditioned room for housing the BAS gateway server, BAS technician workstation and O&M documentation. Refer to the architectural design guidelines for specific requirements.
6. Additional controls requirements
    a. For demolition of existing pneumatic components on a pneumatic system that will remain, specify that all cut pneumatic tubes to be sealed w/ pneumatic plugs. Crimping and taping are prohibited.
    b. The designer must provide a controls valve schedule.
7. Controls Demolition:
    a. The controls contractor shall be responsible for demolition and removal of both digital and pneumatic controls panels, controllers, gateways, devices, conduit, and wiring made obsolete by their replacement with new components included in this project. Demolition of these components shall not be completed by the general contractor.
    b. The controls contractor shall be responsible for removal of points which are no longer used within the controls programming and controls graphics.
    c. Prior to demolition, a UNC controls representative shall be engaged (through the UNC construction manager) to come to the site to coordinate and approve removal of any digital and pneumatic controls panels, controllers, gateways, devices, conduit, and wiring. Demolition of these components shall not begin before approval is received from UNC. If a controls sub-contractor is used to complete the demolition, the subcontractor shall be in attendance with the UNC representative approving controls demolition on site. Any controls infrastructure which is still in use shall not be demolished.
    d. The controls contractor shall be responsible for replacing any digital and pneumatic controls panels, controllers, gateways, devices, conduit, and wiring which has been erroneously demolished which is still in use by UNC.

e. The controls contractor shall be responsible for Notifying UNC EMCS department (through the UNC construction manager) of any obsolete controls systems before they are removed from the UNC supervisor system.
f. A UNC controls representative shall be contacted (through the UNC construction manager) and allowed to inspect and take possession of any existing controls hardware such as controllers, field panels, valves, and sensors prior to controls demolition.

X. REFRIGERATION EQUIPMENT

1. Refrigerant isolation valves: Provide refrigerant ball valves at individual components to allow for replacement without the need of pumping the entire system down. This applies to environmental cold rooms, VRF systems or any condensing units that are not equipped with factory isolation valves.
2. Mini-split AC and heat pumps
    a. Approved brands: LG, Mitsubishi, or Trane. Specify LG as basis of design. (UNC stocks LG parts)
    b. Air-cooled condensing units must not be installed indoors. When installed inside, condensing units shall be water-cooled.
3. BAS Controls:
    a. For each mini-split air conditioner the BAS shall monitor the room temperature and equipment alarm output. The BAS shall provide graphics, trending, and an adjustable high room temperature alarm.
    b. For DX AHU, provide BAS monitoring of the following:
        i. General alarm contactor.
        ii. Specify Discharge Temperature Control for units serving multiple zones.