Division 23 – Heating Ventilating and Air Conditioning

23.1. Introduction

a. The intent of the Old Dominion University Mechanical Design Standards is to provide guidance to A/E firms early in the design process. The mechanical standards are based on previous experiences in the field and contain Facilities Management (FM) preferences in various areas of mechanical design. This is a living standard, if revisions or variances from this standard are necessary, follow the procedures as outlined in the General Project Requirements of these standards.

b. These standards apply to all campus buildings for both new construction and renovation/modification.

23.2. Mechanical Design Procedure and Calculations

a. Unless otherwise noted, indoor design conditions for cooled & heated spaces shall be 75°F dry bulb & 50% relative humidity for summer and 70°F dry bulb for winter.

b. Outdoor design conditions shall be based on the latest version of ASHRAE's climate design information for Norfolk NAS, VA (WMO# 723085) in climate zone 4A:

   i. For heating use the annual 99.6% DB value
   ii. For humidification use the annual 99% DP/MCB and HR values
   iii. For cooling coils use the most stringent between annual cooling 1% DB/MCWB values and dehumidification 2% DP/MCDB and HR values (except on direct expansion dedicated outdoor air systems use 93°F DB / 77°F WB to account for condenser performance)
   iv. For evaporation (cooling towers) use the annual 1% WB/MCDB
   v. Altitude may be sea level (or 17 feet) for all design calculations.
   vi. For heat tracing and portions of glycol for freeze protection use the extreme 50-year minimum dry bulb temperature value

c. Equipment schedules for HVAC equipment should reflect the designer's calculated heating, cooling, and airflow values including values for each designed coil's: entering and leaving air conditions, air pressure drop, entering and leaving water conditions, water pressure drop, and tube velocity. Ambient design conditions must be indicated for direct expansion equipment for each mode of operation. Minimum values for equipment efficiency set by the current Virginia Energy Conservation Code should be indicated along with equipment performance data. Designers are discouraged from indicating manufacturer cooling, heating, and efficiency performance data on HVAC equipment to allow fair competition between manufacturers – code efficiency minimums and calculated net values of performance requirements should be indicated. For custom and specialty equipment, manufacturer's values may be indicated as required to describe equipment performance and quality requirements. For all scheduled HVAC equipment, a basis of design should be indicated on the drawing schedule along with two approved alternates (make & model) listed in the schedule notes.

d. Where required by CPSM, provide life cycle cost analysis (LCCA). All LCCA's must be calculated and formatted in accordance with the requirements of the current edition of the CPSM.

e. Fan pressure drop calculations must include allowances for dirty filters, backdraft dampers, louvers, screens, grilles, balance dampers. All scheduled fans with air filters must indicate dirty filter pressure drop allowance for equal competition between manufacturers.

f. Pump head loss calculations must include allowances for coils, control valves, manual valves, balancing valves, circuit setters, heat exchangers, dirty strainers, etc. All designs with hydronic piping systems over 20-tons cooling and/or 480-MBH heating must include a complete diagram of each piping system that shows the location of all branch isolation valves, balance rate of each connected balancing valve, and the control valve configuration of each connected coil in order to backcheck the pump sizing & minimum pump flow protection, verify the chiller/boiler thermal buffering requirements, to indicate the functionality of the systems to facilities management for maintenance operations & alterations, and to support the testing, adjusting, & balancing (TAB) & commissioning process.

g. Fouling factors must be included in calculations for all water-to-air and water-to-water heat exchangers (i.e. coils, converters, plate-and-frame heat exchanger, water cooled chillers, etc). Indicate fouling factors in equipment schedules.

h. Low pressure (≤2.0 inch water gauge) supply, return, and exhaust ductwork may be sized using the equal friction method. Medium pressure (>2.0 inch water gauge) supply and exhaust systems should be sized using the static regain method. Design air velocity in low pressure ductwork should not exceed 1750 feet per minute (FPM) in any application. Design air velocity in medium pressure duct at sum-of-peak conditions should not exceed 1750 FPM in duct applications exposed to occupants, 2500 FPM above acoustic or gypsum ceilings, and 3500 FPM in shafts. Static pressure calculations must include sum-of-peak velocity along the critical path; where duct systems exceed 25,000 cubic feet per minute (CFM) industry standard static regain software is required to calculate the complete system and verify all duct section sizing. Fan sizing must comply with the requirements of the current Virginia Energy Conservation Code.

i. For hydronic chilled water and condenser water systems, design piping with a maximum 8 feet per second (FPS) velocity and maximum 6 feet head (FT.HD.) per 100 feet friction loss whichever is more stringent per piping section at sum-of-peak conditions. For hydronic heating hot water, design piping velocity with a maximum 6 FPS or max friction loss of 5 FT.HD. per 100 feet whichever is more stringent at sum-of-peak conditions. Provide piping friction loss calculations that indicate both the friction rate and velocity of each piping section along the critical path; for hydronic piping systems serving systems over 200-tons cooling and/or 4,800-MBH heating, industry standard friction loss software must be utilized to calculate the complete system and verify all section sizing.

j. Design quantities of outside air for ventilation of occupied spaces must be in accordance with the current Virginia Mechanical Code requirements. Design quantities of laboratory and hazardous exhaust must be in accordance with the Virginia Mechanical Code, equipment/hood manufacturer’s requirements, ASHRAE standards, user indicated values, or industrial ventilation handbook as acceptable to the code reviewing official (DEB). Ventilation and exhaust calculations must document the codes/standards/sources of values for code review and documentation purposes.

k. Particular attention should be given to humidity control by air conditioning equipment. For VAV systems, design shall include a constant 55 deg F supply temperature. Design VAV reheat coils to a maximum temperature of 95 deg F to avoid stratification.

l. Use the latest revision of ASHRAE Standards and Handbooks for guidance on air quality, comfort conditions, air filter performance, and other design parameters that are not covered in the current edition of the Virginia Mechanical Code or the Virginia Energy Conservation Code.

m. Design natural gas piping systems and provide calculations in accordance with the Virginia Fuel Gas Code. For natural gas piping connections to generators, boilers, and other large equipment provide piping system buffer capacity for equipment startup in accordance with equipment manufacturer recommendations and industry standards. Design natural gas regulators for their intended purpose of use including pressures and variable capacity modulation requirements.

n. Design of all controls must include on-drawing sequences, diagrams, and points lists. All design processes with direct digital controls (DDC) must include a minimum of (2) in person coordination design submissions to Siemens/FM with the first submission prior to the first working drawings submission and the second prior to bid. DDC requirements must be negotiated in detail (including cabling pathways), including value engineering considerations and FM requirements. The A/E bid document controls indicated must match the Siemens bid proposal controls provided. For most projects, the DDC proposal will be a separate quote that ODU will encumber under the general contractor (see DGS-30-220, 'Standard Bid Format').

23.3. Mechanical (HVAC) System Selection

a. Unless otherwise noted, fan powered and non-fan powered single duct (i.e. throttle box or shut-off type) Variable Air Volume (VAV) with zone hot water reheat is the HVAC system for academic and general purpose buildings on campus.
   i. In non-fan powered zone boxes, when specifying minimum air flow; the designer shall consider diffuser dumping and provide as large a quantity of diffusers as is practical to reduce the range of airflow at the diffuser outlets.
   ii. For non-fan powered zone boxes, provide 'dual maximum logic' sequencing in accordance with Virginia Energy Conservation Code (or more current version as applied by current CPSM).
   iii. For all VAV air systems provide multiple static pressure sensors with a reset sequence as required to comply with Virginia Energy Conservation Code (or more current version as applied by current CPSM).
   iv. If an HVAC zone has a large variance of load profile from neighboring zones a fan powered box should be considered to blend room temperatures and avoid dumping at diffusers, or the zone should be broken up into several non-fan powered box zones. (Be aware of the Virginia Energy Conservation Code requirements regarding fan power allowances when selecting VAV terminal box types and comply with the requirements.)
   v. Avoid placing interior and exterior spaces in the same HVAC zone. Exterior zones should be on exterior walls facing the same direction. Provide separate zones for conference rooms. Zoning shall be maximum 4 offices per zone.
   vi. Remote reheat coils in large systems should be provided with 3-way control valves to reduce coil response time, support hydronic pump minimum flow, and support boiler thermal buffering.

b. Chilled beams, active chilled beams, sensible cooling coils or any hybrid or variation thereof is not allowed on campus.

c. Variable refrigerant flow (VRF) systems are not allowed on campus; however, specific applications may be considered as exceptions where there is no other practical option. Even in exception cases, the systems will be limited in capacity (tonnage and number of connected indoor units). An example of where VRF may be allowed is where no multi-split or single-split system can meet the refrigerant line length requirements.

d. Dual temperature (2 pipe) systems are not allowed on campus.

e. Avoid HVAC systems that modulate cooling supply air temperatures unless outside air is separately conditioned. (For all fan coil units, provide 2-position (open/closed) control valves for chilled water.)

f. Except for in residence halls, avoid chilled water fan coil unit (FCU) systems due the high maintenance associated with them. Cooling coil condensate drain pans are especially problematic; if FCU's must be used, ensure adequacy of the drain system (see other standards sections regarding condensate drain pan and piping requirements).

g. Air-cooled scroll chillers should be used for individual equipment smaller than 150 tons. Greater than 150 tons, where practical utilize water cooled chiller systems. Where the load for the structure is 40 tons or less, packaged air-cooled direct expansion (DX) units may be considered on a case-by-case basis.

h. Access to ducted fan coil units in occupied areas should be from corridors; preferably they should be located within a lockable equipment closet. Avoid service paths through offices, classrooms, laboratories, ceilings above furniture, or other occupied spaces where possible.

i. The installation of any cooling coils above ceilings must include an auxiliary drain pan and condensate drain trap float switch directly circuited to the equipment fan. Auxiliary drain pans must be provided with piped drains to a secondary discharge in a visible location. For all auxiliary drain pans, indicate for spacers or separation such that equipment doesn't reduce drain pan capacity.

j. For new building construction, the design must consider the proposed crane location after building completion for future rooftop equipment replacement.

k. The A/E must, in the earliest stage of design development (conceptual, schematic, or preliminary), coordinate the design intended HVAC equipment, locations, and access with the ODU PM.

l. Provide HVAC equipment efficiencies in accordance with the current CPSM's indicated version of Virginia Energy Conservation Code.

m. Avoid ultra-violet (UV) lighting systems in HVAC air systems due to the maintenance costs. Utilize bi-polar ionization instead.

23.4. Mechanical (HVAC) Phasing, Sequencing, and Coordination

a. Designs should account for the capability to shut down major equipment during the off season without detriment to building operation for major HVAC equipment servicing. Example 1: Single boiler serving domestic and building hot water could not be pursued in design since taking the boiler down would affect two systems. Example 2: Lab equipment and cold rooms that are vital to research; provide separate process chiller(s) that will not be affected by the building chilled water system.

b. During the schematic phase of all projects (prior to preliminary design submittals) the architect/engineering service must determine if commissioning is required by the current CPSM and/or the applicable Virginia Energy Conservation Code version and notify the ODU project manager if it is required. Where required, the ODU project manager will establish a third-party independent commissioning agent for the project. In general, enhanced commissioning (that includes commissioning agent review of design submittals prior to building permit application, and preferably as early in the design process as is practical) is desired for all capital projects and encouraged on non-capital projects that include direct digital controls, lighting control systems, and other complex adjustable engineered systems. Where commissioning is not specifically code required, but is recommended by the architect/engineer, the director of ODU Facilities will determine whether or not to include the service in the project. Unless specific approval is provided by the director of ODU facilities, all project commissioning agents must be contracted directly by ODU and must not be a member of the project architect/engineering design team, testing & balancing contractor, direct digital controls contractor, mechanical contractor, or any other service group involved with the project.

c. Coordinate all visible mechanical components (i.e. diffusers, registers, grilles, ductwork, access panels, louvers, etc.) appearance, colors, and finish with the University Architect during the design process.

d. HVAC condensate must not drain into best management practice (BMP) retention ponds for treatment of stormwater runoff (directly or indirectly). HVAC condensate must not discharge to sanitary sewer systems per Norfolk City code guidance (Section 39.1-19). During the preliminary design process, coordinate with the ODU PM how HVAC condensate will be routed and discharged.

23.5. Mechanical Rooms and Equipment Locations

a. Mechanical hydronic equipment, piping, components, and accessories should all be housed within a weather-tight mechanical room, service corridor, or penthouse. Do not locate hydronic coil connection accessories such as strainers, pumps, balancing valves, air vents, etc. above ceilings or within piping cabinets without prior FM approval. Roof mounted equipment that cannot be located in a mechanical room must be discussed on a case-by-case basis during the initial schematic design and estimating phase prior to the first code review submittal.

b. HVAC equipment should not be installed in attics.

c. Keep in mind fall hazards when locating equipment. Provide necessary guards/rails per Virginia Mechanical Code for maintenance access. Avoid placing equipment within 10 feet of roof edge.

d. Refer to **Division 7 – Thermal and Moisture Protection** for roof access.

e. Provide and indicate service paths from the point of roof access, mechanical room entry, and mechanical courtyard entry to all equipment manufacturer's recommended service clearance areas, to all roof areas, and to all components requiring maintenance (i.e. strainers, control valves, dampers, actuators, sensors, etc.). Service paths should be a minimum of 24" wide and 6'-6" tall throughout. Designs must include permanent stairways over obstructions. Trip hazards in service paths such as condensate drain lines, conduit, and other items must be provided with drop over ramps.

f. Provide access for replacement of new and existing equipment at the end of its useful life. During the preliminary design phase coordinate with ODU PM how boilers, chillers, water heaters, storage tanks, etc. will be replaced without demolition of permanent building elements. The largest piece of equipment must be removable without removing permanent walls, large equipment, or any equipment essential to the principal on-going day-to-day building function (including process equipment). Additionally, verify that maintenance access for existing equipment in the project building and all surrounding buildings is not inhibited by the installation of any new equipment.

g. For mechanical rooms approximately 100 net square feet and larger, provide direct access from the exterior with double doors and a removable mullion. for card access Provide interior access for maintenance where practical.

h. Interior equipment in occupied areas such as VAV boxes, fans, motorized dampers, mixing boxes, filters, strainers, sensors, heating coils, etc., must be located to provide unobstructed access. Where equipment, components, devices, etc. are located above solid ceilings, the design must indicate access panels large enough for equipment replacement. Avoid designing any equipment elevated more than approximately 12 feet above finished floor; where it is unavoidable, obtain approval from the ODU PM.

i. Comply with access and service space requirements of the current Virginia Mechanical Code.

j. Where equipment is elevated above grade or above rooftops, designs must include a permanent service platform and stairs. For cooling towers, the service platform should extend completely around the tower to facilitate replacement of intake screens/louvers. For packaged equipment, the service platform should be provided for manufacturer recommended service clearance areas, all condenser coils, and all removable panels. For large air handlers, manufacturer service corridors with permanent stair access should be provided.

k. Mechanical rooms must be ventilated by a thermostatically controlled fan. Hot water unit heaters serving mechanical rooms should be controlled via fan operation (i.e. hydronic control valves should be omitted). Utilize a DDC room temperature sensor for monitoring and alarms.
l. Access to ducted fan coil units on occupied floors shall be from corridors, rather than through offices, classrooms, laboratory ceilings, or other occupied spaces where feasible.
m. The installation of any air handling units with cooling coils above the ceiling level shall include an emergency drain pan with a float switch wired to the BAS, installed beneath the unit. This emergency drain pan shall be piped so the occupant can detect any condensate that collects in the emergency drain pan. Such a flow tube shall terminate to a visible location.
n. Consider proposed crane location after building completion for when replacing rooftop equipment in the event of a failure. Show the area required for maintenance coil pull on all floor plans and enlarged plans; if split coils, demountable screen-walls, flanged/removable duct sections or other conditions are required for coil removal that must be indicated on plans. Show all door swings and section splits for air handling units on floor plans and enlarged plans. For air handlers with hydronic coils, show maintenance access to each coil face for installation of sensors and for maintenance cleaning processes; where space limitations make it impossible to provide access to each coil face obtain approval from ODU FM prior to the working drawings submittal.
o. Variable Frequency Drives (VFD) should be located in air conditioned spaces or NEMA 4X enclosures. ; however, in no situation may an enclosure be field fabricated unless it is provided with air conditioning. VFD’s supporting the operation of critical equipment should be designed with careful consideration of reliability, redundancy, and replaceability.

23.6. Air Handling Units / Roof Top Units

a. Air handling unit casing systems shall be selected to suit the application. Double wall aluminum with no through-metal construction and 3/16” aluminum interior tread plate flooring is preferred for custom air handling units. Composite casings and stainless-steel lined casings may be considered for corrosion resistant applications or under other specific conditions. For packaged equipment, double wall construction should be provided where available.
b. Provide rooftop units with service corridors to house hydronic coil connection accessories. Rooftop unit manufacturer piping cabinets may only be utilized where the coil connection accessories are located in accessible areas away from occupied areas; do not locate coil connection accessories within piping cabinets or above ceilings of occupied areas.
c. Drain pans in air handling units should be stainless-steel. For packaged equipment, plastic drain pans may be provided where stainless steel is not available. Avoid galvanized drain pans in all equipment.
d. Air handling unit access doors should be specified as hinged with non-tool captive latching devices, i.e. captive thumb screws, quarter turn latches, etc. Do not specify or approve access panels that are unhinged and/or retained by sheet metal screws.
e. Air handling equipment should have door hold opens on each operable section.
f. Door handles should be internally connected so that one handle will lock/ unlock entire door; particularly where equipment is outdoors and where equipment is taller than standard height maintenance personnel could reach without the aid of a ladder.
g. For access openings, use quarter turn handles. Screws for access panels are prohibited.
h. Since ODU is located near the Elizabeth River and coal ash industrial areas, design of general use outdoor HVAC equipment casings and coils should include factory applied coastal corrosion protection

coating systems where practical. For outdoor HVAC equipment located near laboratory exhaust discharge or other special conditions, design shall include consideration of local corrosive conditions and provide coatings for equipment and coils accordingly (i.e. phenolic coatings). Capacity of equipment must account for coil coatings. Field coatings are prohibited.

i. Air handling equipment hydronic coils must always be provided in a way that provides full maintenance access to each side of each hydronic coil for cleaning and control sensor access. Any exceptions must be approved by the ODU FM Director of Engineering.
j. Require contractors to provide a listing of the HVAC filters in O&M manuals for each piece of equipment along with their MERV rating, dimensions (width, height and thickness) and types (washable, throw-away, pleated, bag, etc).
k. Air airflow measuring stations (AFMS) are often inaccurate because of wind influences, installation limitations, and calibration errors; consider multi-sensor time-averaged differential pressure based control for these applications with AFMS serving as a monitoring device rather than a control device (where air quantity information is required).
l. For rooftop units, provide the equipment manufacturers insulated roof curb or elevated structural framing; avoid equipment stands due to potential roof leak issues. Where equipment is elevated on structural framing, provide clearance between rooftop and framing for future roof replacement.
m. Provide rooftop units with standing seam metal roofing systems with overhang and gutter system.
n. Do not configure separate air handling units in parallel airflow configuration unless they are redundant where only one unit runs at a time and it isn't possible to provide the user's programing required redundancy within a single unit casing. Exceptions must be approved by the FM Director; for exception applications, the A/E must clearly indicate that there is no other feasible way to install a single larger unit (custom or standard). Examples of exceptions could include replacement of existing units within an existing mechanical room or where an unreconcilable existing structural member is in the only available equipment location area.
o. Wherever practical, air handling unit fans should be internally isolated to avoid flexible (canvas) equipment connections and spring isolation curbs.
p. Specify large air handling units (capacity greater than approximately 10,000-cfm) to be provided with both factory leak testing and field installed leak testing. Coordinate witness testing with ODU FM Director of Operations for both factory and field leak testing.

23.7. Humidifiers

a. Humidifiers must be adiabatic or clean steam type. Decentralized electric, gas-fired, and canister type humidifiers are prohibited.
b. All make-up water to humidifier systems must be treated with reverse osmosis, de-ionization, or other FM approved process. In laboratory buildings and other applications with clean process water, coordinate with the plumbing design to centralize building water purification systems.
c. For adiabatic humidifier systems, design heating coils to compensate for air stream heat loss.
d. Locate humidifier arrays in air handling units upstream of cooling coils (to utilize the cooling coils as an eliminator). Where it is not possible to locate humidifier arrays upstream of cooling coils, provide a minimum of three feet downstream discharge/evaporation area within the air handler (including a condensate drain pan) prior to any duct discharge connections to the unit.

23.8. Energy Recovery Units (ERU)

a. Provide energy recovery where required by the current CPSM's indicated version of Virginia Energy Conservation Code.
b. During the design of ERU systems, verify the code allowable recirculated air for exhaust, and verify with the basis of design ERU system manufacturer representative what the actual leakage/by-pass rate of equipment is. Avoid utilizing 100% exhaust air from showers, restrooms, locker rooms, and other spaces with humidity and/or odors in air recovery streams serving energy wheels, static plate exchangers, and other devices with air leakage.
c. Where energy recovery wheels or static plate exchangers are provided, utilize "lightweight polymer embedded with silica gel dessicant" or similar type of media with a minimum 15- to 20-year manufacturer life expectancy.
d. Where coil-to-coil or plate-to-plate recovery systems are provided, include controls sequences and devices that optimize energy savings through all ambient and discharge conditions.
e. Where coil-to-coil recovery systems are provided in units with humidifiers, consider cooling season humidification of relief air upstream of the discharge air coil to maximize energy savings and exercise water treatment equipment.
f. Where plate-to-plate recovery systems are provided, include the equipment manufacturer's by-pass dampers.
g. Specify filters in outside air and exhaust air inlets upstream of energy recovery devices in accordance with equipment manufacturer recommendations.
h. Provide motorized, low leakage outdoor air automatic isolation dampers.
i. Ensure fan / motor assemblies are provided with vibration isolation.
j. Specify corrosion protection package for all coils exposed to corrosive air (i.e. laboratory exhaust).

23.9. Dedicated Outdoor Air Systems (DOAS) / Make-up Air Units (MAU)

a. Direct expansion (DX) DOAS and MAU designs are strongly discouraged and should only be provided where no other practical option exists. (Make-up air to cooking hoods providing code required tempered air are an acceptable application of DX MAU.)
b. Provide compressors with multiple unloading stages. Four unloading stages are preferred.
c. When scroll compressors are utilized, ensure at least one compressor is capable of maintaining unloading capability to help reduce the likelihood of compressor short cycling
d. Equipment designed for use as DOAS or MAU must be intended by the equipment manufacturer for use in 100% outdoor air applications and all equipment warranties and manufacturer sequences of operation must be maintained.
e. For DOAS and MAU equipment served with chilled water from the centralized chilled water plant, include the chilled water coil in the water-side economizer function of the district plant. In general, chilled water coils in these units' function as tempered heating coils in the air-side economizer function to cool the district chilled water and avoid operating chillers in the plant during cold ambient conditions.

23.10. Variable-Air-Volume (VAV) Terminal Boxes

a. Provide details to require equipment manufacturer's minimum diameters of straight solid ductwork upstream of inlet (sized the same size as the variable-air-volume terminal inlet). Transitions and flexible ductwork are prohibited at inlets due to turbulence yielding inaccurate flow readings; however, they may be located upstream of the manufacturer's minimum straight solid duct requirement. Flexible connections utilized for VAV terminals must be limited in length to approximately 18", must not offset more than approximately 4” between duct centers, and must be specified to be rated for the actual pressure and velocity they will be subjected to.

b. Make sure VAV boxes are provided with adequate access to control panel, valves, and filters. Design documents must indicate all locations and approximate dimensions of access panels where VAV boxes are located behind solid surfaces such as gypsum ceilings and soffits. Access panels must be large enough for unit replacement without demolition of ceilings, soffits, supports, etc.
c. Bottom of VAV boxes should be located maximum 12 inches above suspended ceilings and access panels/doors.
d. Where VAV terminals are designed/located at elevations greater than 16’-0” above finished floor, a service platform, catwalk, or other permanent access must be provided. (Comply with Virginia Mechanical Code requirements, Chapter 3, Access and Service Space for VAV’s and other appliances and equipment requiring maintenance.)
e. Where practical, design/locate VAV terminals grouped together in accessible locations such as mechanical rooms, storage rooms, and equipment closets to centralize maintenance and limit the damage from potential hydronic fluid leaks.
f. In the control sequence, always have the variable-air-volume terminal box enabled prior to starting the AHU fan to prevent series terminal box fans from spinning backwards and burning up the motors at start up and to prevent the AHU fans from operating against closed VAV air dampers.
g. Provide fan speed controllers for box airflow balancing. If boxes are oversized for the airflow required by the zone, the discharge damper can be used to increase static pressure so the speed control is not set on minimum which may result in motor failure at start up.
h. For areas with carbon dioxide controls, make sure the reheat capacity is sized to handle the maximum terminal box primary airflow to avoid zone overcooling.
i. Provide discharge air temperature (DAT) sensor and control valve position.
j. VAV terminal boxes and parallel terminal boxes are both prone to cold air dumping issues as they approach the minimum airflow setting. Ensure diffusers are sized with sufficient velocity to keep the air attached to the ceiling at low airflow conditions to prevent dumping. Also ensure selected diffusers feature acceptable sound power levels at maximum airflow.
k. Where VAV terminals are exposed to occupant view, provide units with double wall construction or removable/re-usable insulating jacket systems. Where hot water re-heat coils are exposed to occupant view, provide removable/re-usable insulating jacket systems for the coil to prevent condensation if the heating hot water supply is shut down.

23.11. Exhaust Fans

a. Provide roof curbs accommodating roof slopes on applicable drawing details. Provide crickets where curbs are located on sloped roofs.
b. Provide disconnect at fan.
c. Show fasteners securing fan to curb.
d. Provide speed controller for single phase motors and include appropriate control algorithm in control sequences.
e. Lab and industrial exhaust fans should be utility set type with motors accessible at roof/floor level. Any outdoor equipment with motors located approximately 4’-6” or higher above roof level must be provided with a permanent access platform. Rooftop equipment layout and design requires review by the University Architect for visibility from adjacent buildings – refer to Chapter 02 – Campus Design.

23.12. Louvers

a. The Engineer AND Architect must coordinate the louver selection and specification. Consideration for the aesthetic appearance, especially in historic building is critical, along with the technical aspects and long term functionality of the louvers.

b. Provide storm type louvers with drainable blades and insect/bird screens. Where practical, provide wind-driven rain type louvers. For all installations, provide duct access doors or other means for removing the insect/bird screen without removing any permanent construction.

c. Design louver free areas large enough to prevent moisture carryover and indicate a required water penetration velocity rating per AMCA Standard 500 on contract documents. Where practical, avoid louver velocities over 900-fpm due to noise issues.

d. Louver coatings and coloring must be factory finished and coordinated with the University Architect during the design process. On renovations, the A/E shall investigate existing nearby louver and building colors and present to the University Architect the proposed size and color for approval. Contract document specifications must include the selection of factory finish colors that include the one approved by the University Architect and must not rely on the limited selection of some manufacturers. Louvers should be specified by the mechanical engineer for performance with aesthetics requirements developed by the architect. Louver finish performance specifications should require a 5-year minimum manufacturer's warranty as defined by the American Architectural Manufacturers Association (AAMA).

23.13. Direct Expansion Split Systems

a. Designs must verify that the lengths of refrigerant piping are short enough to allow oil return and that the total design distance of separation between condensers and evaporators are within the manufacturer's installation allowances (for at least three manufacturers).

b. Designs must address whether compressors must be located outdoors with the condensing units or indoors with the air handling unit. Where compressors are located indoors, the design must address the acoustics of the compressor and locate the air handling unit in an appropriate area.

23.14. Chillers

a. For smaller chillers utilizing scroll compressors, make sure there are at least four compressors to provide a minimum of four stages of unloading, preferably with one that has limited unloading capability out of the four.

b. Multiple chillers serving a common chilled water system are required to be provided with automatic isolation for each chiller.

c. Preference is for water cooled centrifugal chillers larger than 150 tons and scroll type chillers below that.

d. Designs must require a 5-year warranty on compressor parts and labor. 5-year factory service agreement for all parts and refrigerant should be provided where available.

23.15. District Chilled Water Plant

a. The district chilled water plant is a variable primary system with pump speed control based on chiller differential pressure. Each building connection is de-coupled (i.e. bridged or primary-secondary) with all building pressure losses handled by building pumps. For all new connections and modifications to existing connections, coordinate the piping connection configuration with the ODU project manager and ODU FM director, and update the district diagram and connection summary table within the project contract documents.

b. The district chillers are generally shut down for annual service in December and January; however, the pumping system continues to operate in water-side economizer mode utilizing select make-up air coils as a source of cooling. Water-side economizer cooling capacity is limited such that stand-alone air side economizers should be provided wherever practical. Where any new or replacement project equipment cannot include a stand-alone air-side economizer, the capacity requirements must be coordinated during design and approved by the FM Director of Operations during the preliminary design phase of the project.

23.16. Boilers

a. Avoid flue extractor systems where possible. Flue extractor systems should only be applied in renovations/replacements where it is not feasible to replace the existing flue and the capacity of the existing flue is insufficient for the new boilers. In these cases, the existing flue must be inspected during the design process to verify the flue condition is suitable for re-use and the new boilers should be provided with modulating firing control to allow the extractor system controls time to respond to changes in pressure/demand. Shop drawings of the flue extractor system must include the manufacturer's capacity calculations including acknowledgement of the actual boilers being extracted, a 3-D layout of the actual flue system being installed, and specific indication of where every sensor of the system must be installed. Specific attention must be given during installation to prevent condensation from getting into any pressure sensor tubing and the manufacturer's representative must make periodic site visits to ensure the system is being installed properly. Third party commissioning is required for all installation instances of flue extraction systems.

b. Avoid common venting of boilers where possible. Where common venting is applied, include basis of design flue manufacturer sizing calculations that reflect the basis of design boilers in the design submittals and call attention on the construction drawings the required locations of all barometric dampers and other accessories.

c. Room ventilation of combustion air to boilers is preferred. Direct combustion air venting to boilers should only be utilized where room combustion air is impractical.

d. When replacing non-condensing boilers with condensing boilers (or more efficient non-condensing boilers), always provide a room unit heater to prevent freezing conditions.

e. PVC must not be used as a venting material on condensing boilers regardless of manufacturer allowances because there is no ASTM standard addressing PVC piping utilized as vent material and because boilers may be operated at higher temperatures than designed. At a minimum CPVC should be used, but polypropylene and AL29-4C stainless are much better, more reliable materials. Selection should consider project budget.

f. For all new and replacement boiler plants, include a DDC pressure sensor on the main piping near the expansion tank and make-up water connections.

23.17. Cooling Towers and Closed-Circuit Coolers

a. For water cooled chillers, closed-circuit coolers (maximum 10 feet head water pressure drop). Water cooler centrifugal chillers can be coupled with open towers

b. Where closed circuit coolers are provided, include a recirculating pump for the cooler coil, heat tracing on outdoor piping, basin heaters, and fan discharge damper.

c. During the design process, make sure the bottom of the sump is above the centerline of the pump inlet serving it. Verify pump net positive suction head (NPSH).

d. Cooling tower piping must by-pass to the cooling tower sump. This will help minimize potential condenser water pump cavitation.

e. All cooling towers shall be of the induced draft (draw-through) type, stainless steel construction.

f. Provide maintenance platforms and motor davits.

g. Include chemical treatment for all cooling towers.

23.18. HVAC Pumps (Hydronics)

a. In multiple chiller arrangements, provide a dedicated chilled water primary pump and condenser water pump for each chiller. Provide piping and valve configuration that allows each chiller to operate with any primary pump and with any condenser water pump. Provide back-up or standby pumps so that the total system capacity is available with any one pump out of service. Ensure these requirements are being met on every project.

b. Provide hot water pumps in duty/stand-by arrangement with back-up or standby pumps so that the total system capacity is available with any one pump out of service. Ensure these requirements are being met on every project.

c. For variable primary chilled water and heating hot water designs, automatic isolation valves are required. When specifying isolation valves, verify actuator torque is appropriate for the application.

d. In general base-mounted pumps are preferred for capacities up to about 1,000-gpm. Capacities above 1,000-gpm should utilize double-suction type with vertical connection configuration. Vertical multi-stage pumps may be utilized where appropriate to the application.

e. Do not configure HVAC pumps to operate in series; the only potential exception to this would be small ECM type circulator pumps serving water source heat pumps.

f. Triple duty valves are prohibited. Where hydronic pumps are provided with variable frequency drives balancing valves at the pump discharge should be omitted.

g. Provide Y-strainers with blow-down upstream of all pump inlets. (Suction diffuser strainers may not serve as a substitute.)

h. Provide pump volutes with hinged insulation boxes. (Insulation must not be adhered to pumps with mastics, glues, or other chemicals.)

i. Removable, re-usable insulation covers should be provided for pump accessories such as Y-strainers, balancing valves, check valves, isolation valves, and other accessories to inhibit condensation, corrosion, and energy losses.

j. Pressure gauges must be provided with isolation valves or shut-off cocks that allow the gauge to be replaced while the hydronic system remains operational. (When not being read, pressure gauges should be closed to system pressures to avoid damaging the gauge.)

23.19. HVAC Piping (Hydronics)

a. The A/E should include a piping schedule on the contract drawings to indicate the material (and insulation) requirements of each piping system included in the project. In some cases, this information may be located within the project manual specifications; however, the preference is to document the piping material (and insulation) requirements on plans to support TAB, commissioning, maintenance, and future renovation processes. (The A/E design quality control processes must verify there is not a conflict between the contract drawings and specifications.)

b. Provide new hydronic systems with temporary connection taps for use in the event of equipment failure. Temporary connections should be located inconspicuously on the exterior of the building or within mechanical rooms immediately near exterior doors. Temporary connections must be located where it is feasible to park the temporary chiller/boiler equipment trailer and associated generator trailer. Where the temporary connections are exposed to ambient conditions, provide a removable shroud or other means to protect the piping and associated isolation valves.

c. Hydronic chemical treatment systems equipment, chemicals, testing, and other requirements must be included in the design documents as contractor requirements on all projects. For each project verify with the ODU project manager if there is an existing chemical treatment service contract and if so, include contact information in the design documents. Within the design documents indicate contractor requirements to provide chemical treatment services throughout the construction duration and to coordinate turnover to the university at least (30) days prior to project substantial completion such that the university has the opportunity to develop, renew, or update a chemical service contract prior to demobilization of the project. Particularly in small projects, partial renovations, and phased projects, indicate on design documents a requirement for the contractor to be responsible for cleaning all system strainers, venting air, and maintaining chemical balance of the complete hydronic systems affected throughout the project duration; not just equipment in the project area. (For example, new taps or modifications in one area of a piping system may allow debris or air to be caught in in areas outside the main areas of work, which must be addressed for successful balancing and commissioning processes and continued operation of equipment through modifications.)

d. Dielectrics fittings are prohibited. Designer shall incorporate full port brass shut off isolation ball valves with brass unions whenever possible to account for dielectric connection. In the past, FM has encountered constant leaks through dielectric union fittings when hot water systems are temporarily shut down.

e. Provide adequate thermal mass in chilled water systems to ensure proper control and longevity of chillers. For smaller systems, consider buffer tank if there is not sufficient volume recommended by the equipment manufacturer. A/E shall show sufficient volume in HVAC calculations (see other standards sections regarding piping diagram requirements).

f. Provide automatic air vents at all coils and piping system high points. Install isolation valve upstream of vent. Indicate for discharge tubing from vent to termination location at nearest floor drain.

g. Grooved couplings are prohibited in HVAC piping systems except at chiller connections. Press type fittings may be allowed on a case-by-case basis for HVAC and domestic water systems. Press type fittings are prohibited on natural gas piping systems.

h. Hydronic piping systems may be designed with pressure independent type balancing valves or manual balancing valves; however, the balancing valve type of each system must be the same throughout (i.e. do not intermix balancing valve types on any one system).

i. Provide pressure / temperature test ports across all pumps and equipment coils for testing purposes.

j. Provide redundant pumping for all hydronic distribution piping systems (chilled water, heating hot water, and condenser water systems). Boilers, chillers, and hydronic coils may be designed with a single dedicated circulator pump; however, interchangeable service staging piping configurations are preferred where practical.

k. Design and specify bladder type expansion tanks. Diaphragm expansion tanks may be considered where they are determined to be more practical. Provide automatic air relief vents as required by the basis of design expansion tank installation instructions (some tank configurations can be vented at the nearby air separator while others require piping traps that include an additional air vent).

l. All expansion tanks larger than approximately 5-gallons must be floor mounted and located in a mechanical room.

m. In replacement projects for chillers and boilers, expansion tanks should be replaced. Where economics or relative age of expansion tanks determines they can be re-used – the project must include replacement of the complete expansion tank piping connections and accessories. Avoid steel piping in all expansion tank connection piping. (Expansion tank connection piping is susceptible to corrosion due to stagnant fluid and is a common problem in evaluating system pressure issues.)

n. Design must calculate minimum make-up water fill pressure and indicate on contract documents the appropriate pressure reducing valve (PRV) and expansion tank pressure. Consider building height above the PRV location as increased pressure is required for taller facilities when make-up connections and expansion tanks are located on the lower floors.

o. PRV and expansion tank system connections must be within a few feet of each other on system main piping to avoid pressure relief valve cycling. Where practical, indicate for pre-charged expansion tanks with pressure to match the make-up pressure; otherwise, indicate for field charging of expansion tanks.

p. Provide each hydronic system make-up water connection with a backflow preventer and pressure relief valve. Avoid cross-connections between heating hot water and chilled water systems since they are typically treated with different chemicals.

q. Coordinate pressure relief valve settings at make-up water connections and at equipment connections with the maximum system design pressure.

r. Provide air and dirt type separators with manufacturer’s blow down. Coordinate the basis of design selection with the piping specialties manufacturer’s representative and identify variable flow design considerations and estimated block water flow rate to balance air removal efficiency with system water pressure drop in each selection.

s. Provide expansion loops, pipe guides, and pipe anchors in heating hot water and steam piping systems where required by code and where recommended by industry standards. Show locations of all loops, guides, and anchors on drawings and have the design locations certified by a structural engineer. Prefabricated pipe expansion systems may be utilized where approved by the expansion system manufacturer and code reviewer. Designs must require professional structural engineer certified shop drawings for all pipe expansion systems.

t. Indicate coil flushing piping configurations in the contract documents, and require coil flushing at each new coil installation. Provide coil piping configuration requirements for isolation from main piping systems while performing flushing (i.e. isolation valves and hose connections on both supply and return piping to allow counter-flow and normal flow of domestic water while the main hydronic system stays in operation).

u. For chilled and hot water piping less than or equal than 2”, use Type K (buried) or Type L (above ground) copper with wrought copper and bronze solder fittings. For piping greater than or equal to 2.5”, use carbon steel with welded joints or flanged connections.

v. Polypropylene-random (PP-R) [i.e. Aquatherm or equal] piping is an acceptable system for chill water and condenser water systems.

w. Continuous sheet metal support systems should be considered for chilled water piping located above occupied ceilings.

23.20. HVAC (Cold Coil) Condensate Drain Piping

a. Condensate drain systems located above ceilings or exposed outdoors should be ‘DWV’ or ‘Type L’ copper. Avoid outdoor condensate drain traps where practical. On outdoor VAV condensate drain systems, provide traps with heat tracing, insulation, and aluminum jacket.

b. Plastic drainage systems may be applied in mechanical rooms and may be considered on a case-by-case basis in other locations. Where plastic drainage systems are allowed as exceptions above ceilings, they must be provided with supports that comply with, or exceed, code minimum spacing requirements to inhibit sagging and clogging over time.

c. The A/E must provide site observation to enforce the code and contract document piping support interval requirements during the construction phase of the project.

d. Continuous sheet metal support systems that run the full length of above ceiling condensate drain piping should be considered.

e. Discharge HVAC condensate to grade or other approved location. (HVAC cooling coil condensate must not discharge to sanitary sewer systems per Norfolk City code guidance (

23.21. HVAC Steam and (Hot) Condensate Piping

a. Steam systems have a limited presence on campus but are an acceptable system in new designs where they are determined to be the most practical solution.

b. A/E must follow code requirements and industry standard recommendations for steam and condensate pipe sizing, trap selection, and all other design aspects.

c. HVAC steam distribution within occupied facilities should be limited to low pressure (i.e. 15-psi or less), and A/E calculations must account for pressure losses from source to equipment to verify pipe system sizing, all piping accessory pressure losses, and condensate return pressure losses.

d. A/E calculations must be provided for the sizing of condensate receiver systems. Design must avoid short cycling of condensate receiver pumps.

23.22. HVAC Valves (Hydronic and Steam)

a. Include sufficient zone isolation/shut off valves in cold/hot water, heating hot water, chilled water, steam, and other service piping to allow maintenance and replacement of terminal equipment without shutting down an entire building system. Valve locations must be shown on contract document drawing plans and diagrams – it is not acceptable to rely on specification requirements to locate valves.

   i. Install isolation valves on all lines that penetrate the floor from below; set valves approximately 12” above floor, or below deck, to allow clearance for future valve replacement. For risers that penetrate multiple floors, isolation per riser may be considered.

   ii. Include lockable, properly sized access panels for all valves located behind permanent construction such as soffits, gypsum ceilings, block walls, etc.

   iii. Install valves on all lines at locations such that each floor can be isolated independent of main building.

   iv. Install valves on all branch lines off of main lines.

   v. Install valves at all terminal equipment (Fan Coil, VAV boxes, etc.)

   vi. Install drain/ fill valves at low points of system. Use ball valve with threaded cap.

b. Install control valves where they can be reached from the floor where possible.

c. Butterfly Valves: Only high-performance type shall be specified/used.

   i. High Performance Butterfly Valves shall be double offset design in accordance with ANSI Class 150, 300 or 600, as required and MSS-SP68 “face to face”.

   ii. Blow-out proof stem and in accordance with API 609. Full lug end pattern. Valve shall have lugs on both sides to allow removal from either side.

   iii. Valves 2 ½ “ and smaller must be provided with lock handles. Valves 3” and larger must be provided with manual hand wheel worm gear.

   iv. For all valves, provide extended necks to accommodate insulation thickness.

d. Full port threaded or flanged Ball valves are preferred for isolation.

23.23. Ductwork

a. The A/E should include a duct construction schedule on the contract drawings to indicate the duct seal, pressure class, leakage test rate (where applicable), and insulation type/thickness requirements of each duct system included in the project, as well as, any special materials considerations for specialty applications (i.e. laboratory exhaust, hazardous exhaust, exposed prefabricated duct, etc.). In some cases, this information may be within the project manual specifications; however, the preference is to document the duct construction requirements on drawings to support TAB, commissioning, maintenance, and future renovation processes. (The A/E design quality control processes must verify there is not a conflict between the contract drawings and specifications.)

b. All new ductwork must be seal class A, including all joints, seams, and wall penetrations.

c. Where duct is exposed to occupant view, obtain approval of all aesthetics from the University Architect, including, but not limited to: duct finish/color, diffuser finish/color, and acoustic design considerations. All exposed duct should be provided with paintable surface characteristics (i.e. galvannealed) and all insulation concealed from view.

d. Design documents must include requirements for contractor duct cleaning of complete building duct systems prior to TAB and substantial completion for any new and existing HVAC systems that are operated during construction. Duct cleaning procedures should be required to be provided in accordance with NADCA or other industry standard duct cleaning procedures.

e. Exposed exterior roof top ductwork should be avoided where practical. Where exposed exterior duct work must be provided:

    i. Specify prefabricated outdoor duct systems with seamless heat formed corners or welded seams that carry a manufacturer’s approximately 10-year limited warranty.

    ii. Where practical, provide round duct rather than rectangular to help avoid standing storm water.

    iii. Avoid flexible connections at rooftop equipment connections – where practical, equipment fans should be internally isolated.

    iv. For duct penetrations through roofs, provide curbs of sufficient elevation to maintain clearance for roof system insulation, flashing, and counter-flashing. Duct roof penetration details and rooftop duct support curb details should be included in the design documents to require a minimum of 12” from the top of the finished roof membrane (at the tallest point of potential insulation) to the top of the curb. The duct penetration detail should also indicate a welded support apron, duct insulation membrane extended to the edge of the bottom of the apron, and counter-flashing between the apron & curb. (The A/E must verify all roof related supports, curbs, etc. with the current version of the DEB special roofing requirements.)

f. Provide double wall insulated duct for all supply air systems designed for 2” w.g. pressure class and above. Where practical, include all insulation thermal requirements between the double wall sheet metal layers to avoid the cost and clearances of additional duct wrap. For new systems, provide double wall ductwork with solid metal liner (rather than perforated) to extend duct system life expectancy.

g. Prefabricated double wall internally insulated ductwork shall be used for duct applications exposed to occupant view. Exposed ductwork shall be factory paint-ready (galvannealed or other manufacturer process) and the colors of all diffusers and duct finishes must be coordinated during the design process and verified with the end user. Provide samples as required to indicate to end users the difference in appearance of aluminum diffusers and galvanized ductwork and how the system will appear at completion of construction. Exceptions for exterior insulation in occupant exposed duct applications may be provided by the ODU FM director, and if applied should be paintable and have the color/finish selected by the University Architect.

h. Provide round or flat oval ductwork systems for primary air on all variable-air-volume supply systems. Utilize round ducts for supply, return, and exhaust whenever space availability permits.

i. Provide no more than 6 feet of flexible ductwork for final connection to a supply diffuser or any piece of laboratory equipment exhaust. Do not allow changes in direction of flexible duct more than 45° in any direction – indicate requirement for solid duct elbows to reduce flexible duct angles.

j. Provide ducted return for all systems. Return plenum systems are discouraged and may only be applied with approval of the ODU .AVP of Facilities Management & Construction.

k. Designs must indicate duct access doors on drawing plans for fire, smoke, & combination dampers; motorized dampers; barometric dampers, insect/bird screens, and other duct accessories. Duct access doors must be large enough and located for maintenance access to reset positions, make adjust, and replace parts. Where the duct access door is behind solid construction, the design must also include a larger access door in the building construction to facilitate access to the duct access door and device(s) within the duct.

23.24. Ductwork Leakage Testing

a. All Medium Pressure ductwork over 3.0" w.g. should be provided with duct air leakage testing (DALT) in accordance with the SMACNA HVAC Leakage Test Manual.

b. All Medium Pressure ductwork 3.0" w.g. and below should only be considered for DALT where duct is located outdoors and/or where duct systems convey 100% make-up air.

c. A/E must verify current code requirements for DALT of each project in the Virginia Mechanical Code and Virginia Energy Conservation Code along with any applicable project standards requirements.

d. Where DALT has been required by contract documents, contractor submittal documentation must be reviewed by the A/E of record and included in the project close-out as-built documents along with the final approved testing, adjusting, and balancing (TAB) report.

23.25. Grilles, Registers, and Diffusers

a. Utilize extruded aluminum (or stainless-steel) diffusers, registers, and grilles with factory finish and hardware with matching materials.

b. The A/E must coordinate all diffuser finishes, colors, and types with the University Architect prior to the working drawings phase of design.

c. All grilles, registers, and diffusers (GRD) must be provided with factory applied paint and finishes. Avoid field painting where possible; where unavoidable (such as a change in user requirements during construction), follow the diffuser/register/grille manufacturer's written installation instruction regarding priming requirements.

d. Avoid relying on integral GRD dampers for balancing; air balancing should be performed with duct mounted volume dampers located in the mid-point of duct runouts to avoid whistling and other air noise generation at the GRD.

e. During the design process the A/E must verify throw, noise, and air flow variance. In general, designs for GRD's should seek to provide a larger quantity of diffusers where flow variance is large to limit the range of velocity at each air terminal through variable air flows.

23.26. Insulation

a. General:

i. Where practical, provide continuous insulation through walls and floor slab penetrations.

ii. For all through penetrations and membrane penetrations of horizontal assemblies and fire-resistance-rated wall assemblies, comply with code requirements and penetration system manufacturer's written installation instructions. All designs that utilize piping penetration systems, fire dampers, smoke dampers, and/or combination fire/smoke dampers must have system selection cut sheets included as an appendix in the project manual.

iii. For ductwork and piping in high abuse indoor areas (mechanical rooms, janitor's closets, etc.), provide PVC, aluminized, or metal (aluminum/stainless) jacketing from finished floor level to approximately 6'-0" above finished floor.

b. Duct:

i. Interior ductwork fabric and fiber type insulating lining is not allowed except for in passive transfer air ductwork to accomplish sound attenuation and in low pressure (< 1.0" w.g.) prefabricated ductwork exposed to occupant view where a perforated metal liner or thermoset resin is applied.

ii. Consider use of multi-layered flexible elastomeric duct insulation with offset seams and no penetrating fasteners. Mastics, jacketing, and supports should be designed to hold ductwork and insulation in place without the use of any air-stream penetrating fastener. Minimum (2) insulating layers, but (3) layers is recommended.

iii. Where concealed from view and away from high abuse areas, board or blanket mineral fiber insulation with foil-skrim-kraft (FSK) jacketing is acceptable.

c. Piping:

i. Chilled water piping should be insulated with flexible elastomeric (ASTM C 534, Type I, Grade 1) or cellular glass (ASTM C 552, Grade 6). The University continually experiences condensation issues in our buildings, even brand-new ones. This entails long term maintenance issues and costs. The A/E shall discuss with the University options to mitigate condensation including providing jacketed insulation, upsized insulation and/or a continuous sheet metal support/drain system when chilled water piping is run over occupied spaces

ii. Use rigid insulation on all outdoor piping and in all indoor piping in high abuse areas such as mechanical rooms, janitor's closets, rooftops, courtyards, etc. Cellular glass is preferred on outdoor chilled water pipes and other pipes below ambient temperature.

iii. Use aluminized or metal (aluminum/stainless) jacketing on all outdoor piping on rooftops, in courtyards, and all other outdoor locations throughout the outdoor piping installation. Provide pre-manufactured removable, re-usable insulation cover systems for all outdoor isolation valves and other hydronic accessories (unless the devices are ingress protection (IP) rated IP55 or higher).

iv. Do not specify mineral fiber on chilled water piping systems.

23.27. Controls

a. For each project, coordinate with the ODU PM to determine if sole source controls will be utilized for the project. If utilized, the A/E must support the DDC proposal negotiations process and the CO-18 approval process. DEB approval of the CO-18 must be obtained prior to project bidding. (See 'Mechanical Design Procedure and Calculations' section of this standard for additional information and requirements regarding controls design.)

b. The A/E must verify airflow measuring stations (AFMS or AFMA) are designed to be provided with the manufacturers required upstream and downstream straight ductwork lengths for stable and accurate readings. The A/E must also verify that all AFMS are located in accordance with manufacturer's installation instructions regarding air quality (air filtration or screening) and insect protections. Consider including pressure based controls to assure the design intended outside airflow rate is achieved.

c. Always include a dead band for chiller staging; avoid using identical set points to stage down and stage up chillers.

d. For all plants and air systems, include sequence descriptions that include when to enable and disable complete systems. For example, when all heating coil control valves associated with a particular hydronic heating hot water system are commanded closed, the associated heat generating equipment should be disabled and the associated pumps stopped after a run-off delay. When sufficient demand is created by open coil valves, the controls should start the associated pumps and enable the heat generating equipment. Another similar example is chilled water systems where an air-side economizer is present. The A/E must consider the run conditions of each system and include design sequences for each on the contract documents.

e. Variable primary flow:
   i. Always maintain chiller and boiler minimum flow requirements through manual (3-way) or modulating bypass to avoid starving chillers and boilers. Verify minimum flows with manufacturer requirements of actual equipment provided.
   ii. Where practical, locate by-pass(es) in remote system location(s) to maximize thermal buffering.
   iii. Consider 3-way valves on remote equipment at end of piping runs to support thermal buffering, hasten coil response time, and prevent dead-heading pumps.

f. Primary-secondary (bridged) flow:
   i. Increase the size of the common (bridged) piping section to reduce friction to the extent practical. In general, the simultaneous sum of both maximum primary and maximum secondary flow through the common pipe should provide a velocity less than 4-fps and a friction rate of less then 1 ft.hd. loss per 100’.
   ii. No check valve should be located in any common pipe.
   iii. The only acceptable isolation valve that may be utilized in a common pipe is a knife-gate type, and should only be used where absolutely necessary.

g. Interface all water and energy meters back to DDC front end server for the energy management office. Energy meters are required to be provided by contractors.
   i. Discuss sub metering scheme with Facilities Management during the schematic design phase.

h. Variable-air-volume air handling unit control:
   i. Designed controls must match the application intent of the equipment and sensor manufacturers.
   ii. Designed controls must account for building pressurization and make-up air requirements to maintain minimum outdoor air requirements at all times.
   iii. Avoid oversized variable volume relief or return fans. Fan motor speed turndown is typically limited to 20 hertz. Provide relief air dampers to reduce the relief airflow once the relief fan has reached its minimum allowed safe motor speed.

i. CO_2 control:
   i. Consider project location ambient air CO_2 levels being introduced into air handling units when setting alarm setpoints and opening outside air dampers to reduce facility CO_2 levels. (In general, alarm at >1500 ppm and control CO_2 limit at <1000 ppm.)

ii. For large high occupancy areas such as arenas, fixed seat lecture halls, auditoriums, and other such spaces, provide multiple CO2 sensors for accurate measurement of the occupied areas.

j. Humidity control:

i. Make sure coils have been located in the reheat position (downstream of cooling coil) with the capacity to maintain zone temperature at setpoint at full airflow.

ii. Locate room type humidity sensors in high occupancy zones and other worst-case areas.

iii. Where outdoor humidity sensors are utilized, provide sensors rated for IP55 (or better) connected to the building level controller.

k. Building pressurization control:

i. A general rule of thumb is to provide additional outside air equivalent to 10 percent of supply airflow or 0.02 CFM/SF for facility pressurization.

ii. Avoid relieving air from facilities until the set point of approximately positive 0.05 inches water gauge is exceeded.

iii. Where backdraft dampers are used for barometric relief, counter-balanced type backdraft dampers must be provided and adjusted/calibrated. (An exception to this may be provided for small, packaged equipment where the counter-balanced option is not available and where powered exhaust is not practical.)

iv. Utilize pressure based controls when using relief air fans.

23.28. **Thermostats / Room Sensors**

a. Thermostats and sensors in private offices, conference rooms, reception areas, hospitality, and athletics areas shall be capable of temporary adjustable temperature set point override (with a limit of 5 degrees up or down from the design set-point for a duration of approximately 2 hours).

b. In residence hall dwelling units and public spaces, design for remote temperature sensors and locate thermostats in secure locations. Lockable covers may be considered where equipment is not compatible with remote sensing capabilities or where no suitable secure location is available.

c. Avoid using the DDC system to emulate thermostat functions, it is preferred to maintain a bottom-up logic control system for zone temperature controls. The DDC system should be provided with supervisory control of thermostats and room temperature sensors to the extent practical.

d. For HVAC equipment serving IT closets, mechanical rooms, sprinkler service entrances, etc. flat plate room temperature sensors should be used for DDC alarms rather than complex controls systems.

e. Where DDC sensors/thermostats are used to control fan coil units (in private spaces other than dwelling units), provide sensors with fan speed control in addition to temperature control features. Where fan coils are designed to be capable of dehumidification, include humidity control (RH setpoint) at the user interface sensor as well.

23.29. Minimum Control and Monitoring Points for Typical HVAC Equipment

a. Hydronic Systems (Heating Hot Water, Chilled Water, and Energy Recovery)

i. Enable/disable (include consideration for equipment unloading with disable commands)

ii. System supply water setpoint / reset temperature

iii. System gauge pressure (near expansion tank / make-up fluid connections)

iv. System distribution water flow rate

v. System distribution return temperature

vi. System distribution supply temperature

vii. BTU metering (calculated based on flow rate and entering/leaving temperatures)

b. Air-Handling Units
   i. Enable/disable
   ii. Supply air discharge temperature
   iii. Supply air fan status (current sensing relay / VFD frequency / etc.)
   iv. Damper command (economizer / outdoor air / return air / etc.)
   v. Mode (heat / cool / economizer / dehumidification / standby / etc.)
   vi. Heating control (control valve command / stages / etc.)
   vii. Cooling control (control valve command / stages / etc.)
   viii. Humidification control (control valve command / hot gas reheat activated / etc.)
   ix. Supply air static pressure setpoint / reset (for VAV applications)
   x. Supply air static pressure (for VAV applications, include all system sensors)
   xi. Pressurization control (for return air fan applications, indoor/outdoor differential pressure, etc.)
   xii. Return air temperature (for units over approximately 17.5 tons)
   xiii. Mixed air temperature (for units over approximately 17.5 tons)
   xiv. Leaving pre-heat coil temperature (for unit over approximately 17.5 tons)
   xv. Freeze-stat status (for hydronic pre-heat coil applications)
   xvi. Supply fan airflow rate (for VAV applications)
   xvii. Outdoor air intake airflow rate (for VAV applications)
   xviii. Filter array differential pressure (include dirty filter alarm)
   xix. Equipment run hours
   xx. Equipment controller alarms (error codes / etc.)

c. Hot Water Boilers
   i. Enable/disable
   ii. Supply water setpoint temperature / reset temperature (from system)
   iii. Boiler leaving water temperature
   iv. Boiler entering water temperature
   v. Isolation valve position (variable primary applications)
   vi. Circulator pump start/stop (primary-secondary applications)
   vii. Equipment run hours
   viii. Equipment controller alarms (error codes / etc.)

d. Cooling Towers
   i. Enable/disable
   ii. Leaving water temperature / reset temperature (from system)
   iii. Isolation valve command (for variable-primary applications)
   iv. Circulator pump start/stop (for staged applications)
   v. Low temperature by-pass valve command
   vi. Entering water temperature
   vii. Leaving water temperature / basin temperature
   viii. VFD Fan Frequency
   ix. Basin heater status
   x. Blow-down/bleed flow rate (for use with deduct metering)
   xi. Make-up water flow rate (for use with deduct metering)

xii. Equipment controller alarms (error codes / etc.)

e. Terminal Boxes
   i. Enable/disable
   ii. Airflow rate
   iii. Reheat coil discharge air temperature
   iv. Heating control (control valve command / stages / etc.)
   v. Zone temperature setpoint
   vi. Zone pressurization control (for laboratory controls where applicable)
   vii. Equipment controller alarms (error codes / etc.)

f. Pumps
   i. Start/Stop,
   ii. Pump status (differential pressure / current sensing relay / etc.)
   iii. Speed command (for VFD applications)

23.30. Utilities – Submetering

a. Building total electricity consumption and demand (KW, PF, kWh, Hz, etc.)

Building total domestic cold water consumption

23.31. HVAC Preferred Equipment List. (See next page)

*No magnetic bearing chillers; all three listed must use the same refrigerant type

** All three listed must use the same refrigerant type

***Must use manufacturer's recommended control sequences – utilize only where chilled water is not available.

****Virginia Manufactured Product - see CPSM section on 'Virginia Manufactured Products'

*****For use only where an exception is provided - see 'Mechanical (HVAC) System Selection' section.

General Note on Preferred Equipment: Intent is that each project's design documents indicate three equipment manufacturers from three separate vendors to promote competition.

Equipment	Basis of Design	Alternate	Alternate
Air Cooled Chillers**	Daikin****	York/JCI	Trane or Carrier
Bi-polar ionization	GPS	Active Air	American Ion
Centrifugal Chillers*	Daikin****	York/JCI	Trane or Carrier
Commercial Ceiling Fans	Hunter	Big Ass Fans	Macroair
Computer Room Units	Liebert	Stultz	Data Aire
Condensing Boilers	Lochinvar	Fulton	Thermal Solutions
Cooking/Grease Fans	Captive Air	Greenheck	Cook
Cooling Towers	Evapco	BAC	Marley
Custom Air Handlers	Buffalo Air Handling****	Environmental Air Sys	Air Enterprises
DX Make Up Air / DOAS units***	Innovent	Engineered Air	AAON
Exterior Duct Systems	MKT	Thermaduct	Q-Duct
Fabric Duct Systems	Duct Sox	KE Fibertec	Q-Sox
Fan Coils	IEC, York/JCI, or Titus	Price/ Trane	Krueger
Fire & Smoke Dampers	Ruskin	United Enertech	Nailor
General Exhaust Fans	Twin City	Greenheck	Cook
Grease/Chimney Duct Systems	Shebler	Jeremias	Ampco or Selkirk
Grills, Registers & Diffusors	Titus	Price	Krueger
Heat Exchangers	Wessels or Paul Mueller Co.	B&G / ITT or Taco	Sondex
Humidifiers	GoFog	Neptronic	Carel
Hydronic Coils	Aerofin****	Capital Coil & Air	Greenheck
Hydronic Pumps	Bell and Gossett (B&G)	Armstrong	Grundfos
Industrial Fans	Cincinnati Fan	Greenheck	Cook
Laboratory Exhaust Air Valves	SIEMENS	Antec	Accutrol
Laboratory Exhaust Fans	MK Plastics	Strobic	Greenheck or Cook
Louvers	Greenheck	Ruskin	United Enertech
Mini splits	Mitsubishi	Daikin	Samsung
Modular Air Handlers	York/JCI	Trane	Daikin
Multi-Stage Hydronic Pumps	Bell and Gossett (B&G)	Grundfos	Pentair / Aurora
Packaged Rooftop Units (DX)RTU	Trane	York/JCI	Daikin
Packaged Split Systems (DX)X	Trane	York/JCI	Daikin
Pool Dehumidification***	Dectron	Symco	Seresco
Scotch Marine Boilers	Cleaver Brooks	Superior	Burnham
VAV Terminals	Titus/ JCI	SIEMENS	Price
VFD	ABB	Siemens	Danfoss
VRF System*****	Mitsubishi	Daikin	Samsung
Water Source Heat Pumps	Florida HP, Bosch, or Aaon	Trane	Water Furnace
Water Tube Boilers	Cleaver Brooks	Bryan	Burnham