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

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 redundanasplowfaaea2(onsing.3(cle t5.3(n)-(onsit. W)-4.8sroosueEny exceations)TJ-24.56 0 TD-.0011 Tc.0033 T(ns mbw

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 System s (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

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.

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 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

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:

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

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