

**SAM HOUSTON STATE UNIVERSITY
DESIGN AND CONSTRUCTION STANDARDS**

**DIVISION 23 00 00
MECHANICAL**

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23 00 00 GENERAL MECHANICAL

- A. This standard is intended to provide useful information to the Professional Service Provider (PSP) to establish a basis of design. The responsibility of the engineer is to apply the principles of this section and the ones that follow so that the Sam Houston State University may achieve a level of quality and consistency in the mechanical design of their facilities. Deviations from these guidelines must be justified through LCC analysis and submitted to the University for approval.
- B. Provide a full-sized set of MEP drawings in the main mechanical room following all new construction and major renovation projects.
- C. For equipment providing critical services, provide N+1 redundancy. Definition of “critical services” to be evaluated during design with SHSU.
- D. Roof-top HVAC equipment is not allowed without prior approval by SHSU.
- E. Locate a wall or roof hydrant within 50-ft of all outdoor HVAC equipment including air handling units, condensing units, and air-cooled chillers to allow for coil cleaning.
- F. Any exterior mounted louver used for mechanical purposes must meet and exceed AMCA 500-L Wind Driven Rain test procedures.

23 05 00 COMMON WORK RESULTS FOR HVAC

23 05 13 COMMON MOTOR AND CONTROLLER REQUIREMENTS

- A. Motor Manufacturers:
 - 1. General Electric.
 - 2. Toshiba International Corp.
 - 3. US Motors.
 - 4. WEG.
 - 5. Baldor-Reliance motors are NOT ALLOWED.
- B. General Motor Requirements:
 - 1. Motors used with variable-frequency controllers to be premium-efficiency “inverter-ready” motors.
 - 2. The PSP should avoid arbitrarily requiring electronically commutated motors (ECMs). Economic justification for ECMs should be evaluated.
- C. Variable-frequency drive (VFD) Manufacturers:
 - 1. ABB, preferred manufacturer.
 - 2. Toshiba International Corp.
 - 3. Yaskawa Electric Corp.
- D. General VFD Requirements:
 - 1. VFDs should be capable of Hand/Off/Auto operation.
 - 2. VFDs should be provided with a bypass.
 - 3. The PSP should avoid arbitrarily requiring VFDs.
 - a. Fan and pump motors 2-HP and greater, except where constant speed operation is required.
 - b. Where required by the energy code.

23 05 17 SLEEVES & SLEEVE SEALS

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. Where sleeves are installed in floors, provide with integral water stop.
- C. Where sleeves are installed in floors of mechanical equipment areas or other wet areas, extend sleeve 2-inches above the finished floor.
- D. Where sleeves are installed in exterior concrete walls, concrete slabs-on-grade, and other waterproofed membranes, provide a mechanical-type, water-tight modular sealing-element unit equal to GPT LINK-SEAL.

23 05 18 ESCUTCHEONS

- A. Install one-piece, cast-brass, polished, chrome-plated finish escutcheons with setscrew fastener for piping passing through walls, ceilings, and finished floors in exposed spaces. Use deep-pattern escutcheons if required to conceal protruding fittings.

23 05 19 METERS & GAGES

- A. City Domestic Water Metering:
 - 1. Installation of the building main domestic water meter should meet all requirements of the local jurisdiction including meter brand, calibration certification, and meter reading equipment. The City of Huntsville requires Badger Meter for domestic water.
 - 2. Include isolation valves on water meter inlet and outlet and a valved bypass around the meter unless prohibited by the local jurisdiction.
- B. Campus Metering & Submetering:
 - 1. The following building utilities should be metered or submetered for billing purposes: chilled water, heating water, domestic cold water, domestic hot water, irrigation water, and natural gas.
 - 2. Metering instrumentation should be compatible with the current SHSU campus building automation system.
 - 3. For buildings with mixed occupancy (E&G and non-E&G), provide sub-metering to properly allocate utility costs between organizations. Coordinate sub-metering requirements with SHSU during design.
 - 4. For domestic hot water systems that require sub-metering, provide separate, isolated recirculation loops.
 - 5. Locate hydronic, domestic water, and irrigation water metering instrumentation within a building mechanical room.
 - 6. Provide isolation valves and a lockable bypass valve around building meters to allow for maintenance.
 - 7. Provide thermal-energy meters for chilled water systems comprised of an ultrasonic flow sensor, chilled water supply and return temperature sensors, transmitter, indicator, and required wiring.

23 05 23 VALVES

- A. Valve Requirements:
 - 1. Globe Valves:
 - a. Bronze body; rising-stem type; integral seat and screw-in or union-ring bonnet; bronze stem and disc; asbestos-free packing; threaded ends.
 - b. Iron body; rising-stem type; bolted bonnet; bronze trim; asbestos-free packing; flanged ends.

2. Ball Valves: Bronze body; two-piece; full-port; stainless-steel trim; Teflon seat; threaded or flanged ends.
 - a. Preferred manufacturers: Watts and Nibco.
 3. Butterfly Valves: Ductile iron body; lug type, suitable for bidirectional dead-end service at rated pressure without use of downstream flange; EPDM seat; one or two piece stainless-steel stem; aluminum bronze, nickel-plated, coated ductile iron, or stainless-steel disc.
 - a. Preferred manufacturers: Pratt, Bray, Nibco, Keystone.
 4. Spring Loaded Check Valves:
 - a. Bronze body; in-line spring lift check; silent closing; Teflon disc; integral seat; threaded ends.
 - b. Cast iron body; wafer style; bronze seat; center guided bronze disc; stainless steel spring and screws; flanged ends.
 5. Valve class and pressure/temperature rating should be adequate for system fluid.
 6. Valves installed in insulated piping should include minimum 2-inch stem extension. Operation of handle should not damage vapor barrier or disturb insulation. Memory stops should be fully adjustable after insulation is installed.
- B. Valve Applications:
1. Throttling, Bypass, or Manual Flow Control Service, all sizes: Ball or globe valves.
 - a. Copper tubing: Bronze valves.
 - b. Steel piping: Iron valves.
 2. Shutoff, Isolation, and Drain Service:
 - a. 2-inches and smaller: Ball valves.
 - b. 2-1/2-inches and larger: Butterfly valves.
 3. Pump-Discharge Check Valves: Spring loaded check valves.
 - a. 2-inches and smaller: Bronze valves.
 - b. 2-1/2-inches and larger: Cast iron valves.
 4. Underground Service: Ductile iron butterfly valves.
 5. Gate valves are NOT ALLOWED.
- C. Valve Installation:
1. Locate valves for easy access and provide separate support where necessary (access doors, chainwheels, etc.). For example, valves located out of reach from a ceiling access door is not considered accessible.
 2. Coordinate access door locations with Architect.
 3. Install shut-off valves at each floor, at each branch connection to supply and return mains, and at connections to each piece of equipment. Locate valves close to mains and equipment.
 4. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
 5. Install air handling unit control valves no more than 5-feet AFF. Where mounted 8-feet AFF, provide a service platform, catwalk, or chainwheel operator with safety trimmed chains. Do not block equipment access when locating control valves.
 6. Install valve vaults or boxes, as conditions demand, to provide access to valves installed below grade. Connect vault drain to storm sewer.
 7. Refer to design standard 23 20 00 for additional valve installation requirements.

23 05 29 HANGERS & SUPPORTS

- A. Pipe Hangers & Supports:
1. Carbon-steel, factory-fabricated components, pre-galvanized, hot-dip galvanized, or electro-galvanized, continuous-thread rod, nuts and washer made of carbon steel.

2. Provide stainless steel hangers and supports in corrosive environments.
 3. Provide coated or copper-plated steel for copper pipe and tube hangers.
 4. The use of pipe hooks, chains, and perforated iron piping for support is prohibited.
- B. Thermal-Hanger Shielded Inserts:
1. Insulation insert material for cold piping, use cellular glass or phenolic foam insulation with vapor barrier.
 2. Insulation insert material for hot piping, use calcium silicate, cellular glass, or phenolic foam insulation with vapor barrier.
 3. Pipe shield to be galvanized sheet steel and to extend 2-inches beyond each side of support. Secure shield with 2 bands at each end.
 4. For trapeze or clamped systems, insert and shield should cover the entire circumference of the pipe.
 5. For clevis or band hangers, insert and shield should cover lower 180 degrees of the pipe.
 6. Insert length should extend 2-inches beyond sheet metal shield for piping below ambient air temperature.

23 05 30 ROOF ACCESSORIES

- A. Roof curb requirements for roof-mounted equipment:
1. Height above roof: Minimum of 14-inches or higher as required to maintain roof warranty. Coordinate overall curb height with roof insulation thickness.
 2. Material: Galvanized steel.
 3. Style: Prefabricated, insulated with fully welded corners.
 - a. Roof curb should be insulated with the same R-value as the roof, coordinate requirement with Architect and roofing subcontractor.

23 05 53 MECHANICAL IDENTIFICATION

- A. Equipment Labels: Brass, stainless-steel, aluminum, or anodized-aluminum, or multi-layer plastic with black lettering and white background.
- B. Pipe Labels: Plastic, preprinted, color-coded, lettering indicating service, flow direction, in accordance with ASME A13.1.
- C. Valve Tags: Brass, stamped or engraved, lettering indicating piping system and valve number, predrilled or stamped holes, brass or stainless-steel chain. Include O&M requirements for a valve schedule on letter sized paper with valve number, piping system, system abbreviation used, location of valve, normal operating position, and any special use designation (emergency shut-off).
- D. Ceiling Tacks: Color coded to identify above ceiling HVAC equipment, fire/smoke dampers, plumbing valves, and HVAC valves.
- E. All exterior identification should be UV-resistant and specifically manufactured for exterior applications.

23 05 93 TESTING, ADJUSTING, & BALANCING

- A. TAB specialist shall be an independent contractor, approved by the University, and certified by AABC, NEBB, or TABB.
1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC, NEBB, or TABB.
 2. TAB Technician: Employee of the TAB specialist and certified by AABC, NEBB, or TABB as a TAB technician.

- B. Instrumentation type, quantity, accuracy, and calibration shall comply with requirements in ASHRAE 111, Section 4.
- C. Meet all applicable ASHRAE/IES 90.1, Section 6.7.2.3 – “System Balancing” requirements.

23 07 00 HVAC INSULATION

- A. Insulation products that have contact with stainless steel shall have a leachable chloride content of less than 50 PPM when tested according to ASTM C871. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.
- B. All insulation materials should have a maximum flame spread rating of 25 and a maximum smoke development rating of 50 per ASTM E 84. PVC products are NOT ALLOWED from use in plenums.
- C. All required mastics, coatings, adhesives, and sealants should be compatible with insulation materials, jackets, and substrates.

23 07 13 DUCTWORK INSULATION

- A. Materials by Location Type:
 - 1. Interior, concealed: Flexible, glass fiber duct wrap, ASTM C1290, Type III, factory-applied FSK jacket. This location type applies to conditioned, unoccupied spaces and return air plenums.
 - a. Mesh and Mastic: 3" wide Chil-Glas #10 glass fiber reinforcing mesh, Childers CP-34 vapor-retarder mastic.
 - b. FSK and FSP tapes are not allowed.
 - 2. Interior, exposed: Double wall insulated duct with metal inner lining, perforated or solid, by United McGill Acousti-K27 or equal. Duct should be paintable. This location type applies to conditioned occupied spaces.
 - 3. Interior, unconditioned: Closed-cell elastomeric foam duct wrap, ASTM C534, Type II. This location type applies to above ceiling spaces with ducted return, ventilated attics, crawl spaces, mechanical and electrical rooms.
 - 4. Exterior:
 - a. Closed-cell elastomeric foam duct wrap with heavy duty silver UV-resistant laminate jacket, ASTM C534, Type II.
 - b. Prefabricated exterior ductwork with interlocking connections (no metal flanges) by ThermaDuct, AQC Q Duct, Spot PhenoliDuct, or equal.
- B. Duct Liner:
 - 1. Duct liner may be used for through-wall return air transfer ducts.
 - 2. The use of sound attenuators or double wall insulated duct is preferred for noise reduction, however, duct liner *may* be considered in some cases for value engineering purposes.
 - 3. Duct liner may be used for noise reduction *only when approved by SHSU*, in ducts with velocities less than 1,500 FPM, and for a maximum of 10-FT length. Duct liner should **NOT** be used on duct connected to fan discharge or ducts in interior, unconditioned spaces or exterior ducts.
 - a. Round Ductwork: Flexible duct liner, glass fiber, ASTM C1071, Type I.
 - b. Rectangular Ductwork: Duct liner board, glass fiber, ASTM C1071, Type II.
- C. General Installation Requirements:
 - 1. Insulate all interior, concealed return air ductwork. Exposed return air ductwork does not require insulation where the temperature difference is less than 15 degrees F.
 - 2. Insulate all interior, unconditioned outside air and boiler combustion air ductwork.
 - 3. Insulate general exhaust ductwork when exhausting humidified spaces.
 - 4. Insulate all interior, unconditioned and exterior exhaust ductwork. Extend insulation 2 feet inside of the conditioned space from exterior wall or roof.

5. Insulate kitchen grease exhaust ductwork as required by local codes.
6. Do not permanently insulate over duct access doors, including access doors in fire wrapped kitchen grease duct.
7. Install insulation with tight longitudinal seams and end joints. Bond ALL seams and joints with adhesive recommended by insulation material manufacturer.

23 07 16 EQUIPMENT INSULATION

A. Materials By System Operating Temperature:

1. 34 deg. F and Below:
 - a. 2-inch thickness, flexible elastomeric cellular, ASTM C534.
 - b. 2-inch thickness, Cellular glass, ASTM C552, Type II, pure glass, vapor barrier required in unconditioned and exterior areas. FOAMGLAS by Owens Corning is not allowed.
2. 35 to 60 deg. F:
 - a. 1.5-inch thickness, flexible elastomeric cellular, ASTM C534.
 - b. 1.5-inch thickness, Cellular glass, ASTM C552, Type II, pure glass, vapor barrier required in unconditioned and exterior areas. FOAMGLAS by Owens Corning is not allowed.
3. 100 to 200 deg. F:
 - a. 1.5-inch thickness, Glass fiber ASTM C547, rigid molded, noncombustible.
 - b. 1.5-inch thickness, Calcium silicate, ASTM C533, Type I.

B. Insulation is required for, but not limited to the following types of equipment:

1. Cold refrigeration equipment not factory insulated.
2. Water pumps handling media at or below 60 deg. F
3. Duct mounted coils
4. Drip pans under equipment operating at or below 60 deg. F
5. Air handling equipment not factory insulated.
6. Heat exchangers
7. Buffer and storage tanks
8. Expansion and air separator tanks
9. Water softeners
10. Hot water generators

C. Do NOT insulate heating water pumps.

D. Do not insulate over nameplate or ASME stamps. Bevel and seal insulation around nameplates.

E. Field-applied jackets for equipment needing regular maintenance shall be removeable and reusable.

23 07 19 PIPING INSULATION

A. Materials by System Type:

1. Chilled Water:
 - a. 2-inch piping and smaller: Flexible elastomeric cellular, ASTM C534.
 - b. 3-inch piping and larger:
 - (i) Phenolic, CFC & HCFC-free, ASTM C1126, Grade 1, Type II and III, vapor barrier required in unconditioned and exterior areas. For 3-inch piping, use 3-lb density insulation. For 4-inch piping and larger, use 5-lb density insulation.
 - (ii) Cellular glass insulation is not allowed.
2. Condenser Water: Exterior piping only, flexible elastomeric cellular, ASTM C534.
3. Heating Water:
 - a. Interior:
 - (i) Glass fiber ASTM C547, rigid molded, noncombustible.

- (ii) Calcium silicate, ASTM C533, Type I.
 - b. Exterior: Flexible elastomeric cellular, ASTM C534.
 - 4. Refrigerant Piping: Suction line (both lines for heat pumps), hot gas heat recovery, and VRF 3rd line, flexible elastomeric cellular, ASTM C534.
 - 5. Domestic Cold Water: Above ground, flexible elastomeric cellular, ASTM C534.
 - 6. Domestic Hot Water:
 - a. Interior: Glass fiber ASTM C547, rigid molded, noncombustible.
 - b. Exterior: Flexible elastomeric cellular, ASTM C534.
 - 7. HVAC Condensate and Below Ambient Drain Piping: Includes all drain pipes accepting water from cold sources such as ice machines, flexible elastomeric cellular, ASTM C534.
 - 8. Storm, Rainwater, and Overflow Drain Piping: Includes the roof and overflow drain bodies and horizontal piping from the drain body to the first elbow down or the first 15-ft from the drain body, whichever is a greater distance, flexible elastomeric cellular, ASTM C534.
- B. Piping Insulation Jacketing:
- 1. Interior, concealed locations: All service jacket.
 - 2. Interior, exposed locations including mechanical rooms: PVC or aluminum, removable and reusable for service to piping.
 - 3. Exterior locations:
 - a. Aluminum, removeable and reusable for service to piping.
 - b. For piping 1.5-inch and smaller insulated with flexible elastomeric insulation, factory-applied polymeric protective covering designed to be UV-resistant and prevent damage from other outdoor hazards.
- C. General Installation Requirements:
- 1. Prior to insulation installation, coat 300 series stainless steel piping with an epoxy primer and finish (5 mils thick each) if handling media between 140 deg. F and 300 deg. F.
 - 2. Prior to insulation installation, coat carbon steel piping with an epoxy finish if handling media between 32 deg. F and 300 deg. F.
 - 3. Install insulation continuously through roof, floor, interior wall and partition, and above grade exterior wall penetrations. For below grade exterior wall penetrations, terminate insulation flush with sleeve seal.
 - 4. Install insulation with tight longitudinal seams and end joints. Bond ALL seams and joints with adhesive recommended by insulation material manufacturer.
 - 5. Install field-applied jackets in strict accordance with manufacturer's instructions and with seams on bottom side of horizontal pipe.
 - 6. Insulate fittings, valves, strainers, suction diffusers, in-line flanged flow meters, flanges, mechanical couplings, unions, and other specialties.
 - a. Use preformed fitting insulation made from the same material, thickness, and density as that of adjacent pipe. If unavailable, use mitered or sectional pipe insulation fittings.
 - b. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removeable, reusable insulation cover. Maintain vapor barrier for below-ambient services.
 - c. Insulate flanges, mechanical couplings, and unions using a section of removeable, oversized preformed pipe insulation to fit. Label the outside insulation jacket at each union, matching size and color of pipe labels.
 - 7. Plumbing System Omissions: Omit insulation on chrome-plated exposed piping (except where required for ADA compliance), air chambers, drain lines from water coolers, drainage piping located in crawl spaces or tunnels, buried piping, fire protection piping, pumps, and pre-insulated equipment.

8. HVAC Piping System Omissions: Omit insulation on hot piping within radiation enclosures or unit cabinets, on cold piping within unit cabinets provided piping is located over drain pan, on heating piping beyond control valve, located within heated space, on flexible connections, and expansion joints.

23 20 00 HVAC PIPING AND PUMPS

23 21 10 PIPES AND TUBES

A. Piping Material by System Type:

1. Chilled and Heating Water:

a. 2-inch piping and smaller:

(i) Type L copper, hard drawn tubing, ASTM B88 with wrought copper fittings per ASME B16.22 with soldered joints (95% tin, 5% silver per ASTM B32).

(ii) Standard weight carbon steel, ASTM A53, Grade B, Type E or S with Class 150 malleable iron fittings per ASTM A197, ASME B16.3 with threaded joints.

b. 3-inch piping and larger: Standard weight carbon steel, ASTM A53, Grade B, Type E or S with standard weight carbon steel fittings per ASTM A105, ASME B16.5 with butt-welded joints per ASME B31.9. Flanges to be Class 150 carbon steel ASTM A105, ASME B16.5.

c. Polypropylene piping (Aquatherm or equivalent) is to be considered an acceptable alternate.

2. Condenser Water:

a. 2-inch piping and smaller: Standard weight carbon steel, ASTM A53, Grade B, Type E or S with Class 150 malleable iron fittings per ASTM A197, ASME B16.3 with threaded joints.

b. 3-inch piping and larger: Standard weight carbon steel, ASTM A53, Grade B, Type E or S with standard weight carbon steel fittings per ASTM A105, ASME B16.5 with butt-welded joints per ASME B31.9. Flanges to be Class 150 carbon steel ASTM A105, ASME B16.5.

3. Refrigerant Piping: Type ACR copper tubing, ASTM B280, clean, dry, and capped with wrought copper fittings per ASME B16.22 with brazed fittings per AWS A5.8.

4. Grooved joint fittings may be specified for carbon steel piping 3-inches and larger. Standard weight carbon steel fittings per ASTM A234, ASME B16.9 with grooved joint ductile iron couplings for standard weight carbon steel piping per ASTM A536 with Grade 65-45-12 EPDM gaskets.

a. Install in strict accordance with manufacturer's instructions using manufacturer's pipe roll groove tools.

b. Provide warranty on the grooved joint fittings AND installation. Warranty should include contractor training by the manufacturer and final inspection of every grooved joint by a manufacturer's representative.

5. Direct Buried Chilled and Heating Water Piping: HDPE, NO EXCEPTIONS.

a. Install tracer wire between supply and return piping to aid in buried pipe detection.

b. Prevent corrosion to the metal pipe where the direct buried piping system connects to the building piping system due to a buildup of static electricity. Install a grounding system for the buried piping or a dielectric flange kit at the HDPE-to-metal joint.

6. For main loop campus chilled water distribution piping, refer to Section 33 00 00.

B. General Installation Requirements:

1. Piping shall be installed plumb and square with the structure and walls in a good workmanship manner. Use eccentric reducers to maintain top of pipe distance AFF.

2. Install piping above accessible ceiling to allow sufficient space for ceiling panel removal.

3. Install piping to permit valve and fitting servicing.

4. Provide means for access where valves and fittings are not exposed. Valve or fitting must be located within reach of means of access.
 5. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves. Provide a minimum 2-inch clearance between insulated piping and other piping, structural members, and other building components.
 6. Install drains, consisting of a tee fitting, $\frac{3}{4}$ -inch ball valve, and short $\frac{3}{4}$ -inch threaded nipple with cap, at low points in piping system mains and elsewhere such that any isolated section of the system can be properly drained. Install drains at all mechanical equipment, located to completely drain equipment for service and repair.
 7. Install sufficient unions, flanges, and valves to permit removal of equipment.
 - a. Install unions in piping 2-inch and smaller, adjacent to valves and at final connections of equipment.
 - b. Install flanges in piping 2-1/2-inch and larger, at final connections of equipment.
 8. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - a. For piping 2-inch and smaller, use dielectric nipples.
 - b. For piping 2-1/2-inch and larger, use dielectric flange kits.
 - c. Dielectric unions ARE NOT ALLOWED.
 - d. Install shutoff valve immediately upstream of each dielectric fitting.
 9. Branch taps in carbon steel piping up to 4-inch to be equal to Bonney Forge "Weldolet" or "Thredolet". Branch taps SHALL NOT BE LESS THAN $\frac{3}{4}$ -INCH.
 10. 3-1/2-inch and 5-inch piping IS NOT ALLOWED.
 11. All piping and fittings shall be DOMESTIC MANUFACTURED.
- C. Field Quality Control:
1. SHSU reserves the right to inspect the welds (at owner's expense) by any means normally accepted in the industry including but not limited to; visual, dye-penetrant, mag-particle, and radiograph. All weld inspections will use the procedures as outlined by the American Society for Non-Destructive Testing (ASNT).
 2. Prepare hydronic piping according to ASME B31.9 and as follows:
 - a. Leave joints, including welds, uninsulated and exposed for examination during test.
 - b. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - c. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - d. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - e. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
 3. Perform the following tests on hydronic piping:
 - a. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 - b. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 - c. Isolate expansion tanks and determine that hydronic system is full of water.
 - d. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of

- vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
- e. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 - f. Prepare written report of testing.
4. Perform the following before operating the system:
- a. Open manual valves fully.
 - b. Inspect pumps for proper rotation.
 - c. Set makeup pressure-reducing valves for required system pressure.
 - d. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 - e. Set temperature controls so all coils are calling for full flow.
 - f. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 - g. Verify lubrication of motors and bearings.
- D. Adjusting and Cleaning:
1. Clean and flush all new piping systems in accordance with following requirements:
 - a. Pipes stored at construction site shall have ends covered.
 - b. Do not connect new pipe to existing until the flushing and cleaning has been complete.
 - c. During the fusion process and after facing of pipe joint, pipes shall be separated to have all "shaving ribbons" removed.
 - d. After installation pipes shall be filled with water and flushed.
 - e. Ends of supply and return pipes shall be connected after testing and flushing has been completed.
 - f. Circulate water at 5 to 8 fps until no debris is caught at 5 micron strainer for 24 hours.
 - g. Provide flushing machine with adequately sized pump to provide the flow required to reach stated velocities.
 - h. Record test.
 2. Chemical treatment: refill piping systems, adding caustic soda to maintain ph of 8.0 to 8.5 and sodium sulfate in amount of 1/3 caustic soda or to maintain residual of 30- to 4- ppm in system. add trisodium phosphate to make hardness of 0-ppm and residual of approximately 30-ppm in system. repeat measurements daily with system under full circulation and apply chemicals to adjust levels until no change is apparent.
 3. Coordinate cleaning, flushing, and chemical treatment with SHSU preferred vendor.
- E. Piping Specialties:
1. Install shut-off-duty valves at each branch connection to supply and return mains and at connections to each piece of equipment. Locate valves close to mains and equipment.
 2. Install shut-off-duty valves at each level of a multi-story building.
 3. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere such that any isolated section of the system can be properly vented.
 4. Install automatic air vents at high points in piping in mechanical equipment rooms only. Pipe discharge to drain using copper tubing routed at 90 deg angles and secured to main piping or supports.

23 21 20 PUMPS

- A. Manufacturers:

1. Aurora.
 2. Armstrong.
 3. Goulds.
 4. Peerless.
 5. Taco.
 6. Bell & Gossett, *preferred manufacturer*.
 7. Paco, *preferred manufacturer*.
- B. Pump Selection:
1. Evaluate the pump system conditions and select the optimum pump type and configuration based on efficiency and pump characteristics. Where feasible, provide pumps as follows:
 - a. Up to 50 GPM - in-line circulating pumps or close-coupled end suction pumps
 - b. Between 50 and 500 GPM - base-mounted end suction pumps
 - c. More than 500 GPM - horizontal split case, double-suction pumps
 - d. Larger in-line pumps may be considered for specific situations where floor space is limited. Larger vertical in-line pumps require approval.
 2. Select pumps on the ascending side of the efficiency curve. All pump motors should be non-overloading to the end of the pump curve.
 3. Size pumps at middle of the pump curve to allow for future load.
 4. Select pumps that are sized for a critical speed of at least 115% operating speed at 60 Hz.
 5. Select pumps that are free of flashing and cavitation at all flow rates between 25% and 125% of design flow under the suction conditions of the pump installation.
 6. Select pumps that are designed to operate to 1,750 RPM unless directed otherwise.
 7. Modulate water pumps 5 HP or greater with variable frequency drives.
 8. If the pump is not redundant and the service is critical, provide a means to bypass the pump VFD.
- C. Chilled Water Pumps:
1. Chilled water pumps should typically be end suction type with mechanical seals and bronze fitted.
 2. Provide building chilled water pumps to handle full building differential pressure. Provide bypass line with check valve and isolation valves around building chilled water pumps.
- D. Installation:
1. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
 2. Install check, shutoff, and throttling valves on discharge side of pumps.
 3. Install Y-type strainer or suction diffuser and shutoff valve on suction side of pumps.
 4. To prevent leaks minimize the use of flexible connectors. If needed, provide pump suction and discharge pipe flex connectors. Flex connectors should be constructed with 304 stainless steel protective wire braided covers with flanged tie rods.

23 30 00 HVAC AIR DISTRIBUTION

23 31 00 HVAC DUCTS AND CASINGS

- A. Material by System Type
1. Supply Air: Galvanized sheet metal per SMACNA, +2 in. wg.
 2. Return Air: Galvanized sheet metal per SMACNA, -3 in. wg.
 3. Primary Supply Air: Galvanized sheet metal per SMACNA, +4 in. wg.
 - a. Primary supply air ductwork is upstream of terminal units.
 4. Final Air Device Connections: Pre-insulated flexible round duct.

5. Unconditioned Outside Air: Galvanized sheet metal per SMACNA, +2 in. wg.
 6. General Exhaust: Galvanized sheet metal per SMACNA, -3 in. wg.
 7. Boiler Combustion Air: Galvanized sheet metal per SMACNA, -2 in. wg.
 8. Boiler/Water Heater Flue: Flue vent materials and installation should be as specified by the appliance manufacturer. Metallic ductwork only.
 9. Kitchen Exhaust Air:
 - a. Type 1 Hoods: Double-wall, type 304 stainless steel inner, aluminized steel outer or single-wall type 304 stainless steel where duct is exposed, -6 in. wg., fully welded, 1-inch ceramic insulation, Metal-FAB G Series or Jeremias DW Series factory-built pressure rated grease exhaust duct or equal.
 - b. Type 2 Hoods: Single-wall, type 304 stainless steel, -6 in. wg., fully welded, Metal-FAB PSW Series or Jeremias SW Series factory-built pressure rated exhaust duct or equal.
 10. General Fume Exhaust: Type 304 stainless steel sheet metal per SMACNA, -3 in. wg., minimum 1-inch lap joint per SMACNA. Provided welded seams in corrosive fume applications.
 11. Flammable Exhaust: Galvanized sheet metal per SMACNA, -3 in. wg., minimum 1-inch lap joint per SMACNA.
 12. Fibrous glass ductboard is not permitted.
 13. Refer to design standard 23 07 00 for prefabricated exterior duct and double-wall insulated duct.
- B. General Installation Requirements:
1. All metal duct should be constructed per SMACNA standards. Metal tape should not be allowed as metal duct sealant unless specifically noted otherwise. Seal all ducts in accordance with SMACNA Seal Class A, including all joints, seams, and all applicable wall penetrations.
 2. Provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains and discoloration, and other imperfections, including those which would impair painting.
 3. All duct should be installed in accordance with SMANCA HVAC Duct Construction Standards and manufacturer's recommendations were applicable. Installers of factory-fabricated ducts must be certified by the manufacturer.
 4. Exposed duct is preferred to be round or flat oval.
 5. Exposed duct should be paintable.
 6. Exterior ductwork to preferred to be round. Locate longitudinal seams on bottom of duct. Where rectangular ductwork is required, slope top of duct to avoid standing water.
 7. Where applicable, provide drain to prevent build up of water in low points of ductwork.
 8. Provide all mitered elbows with turning vanes.
 9. Provide radiused rectangular elbows with center line radius to width ratio (R/W) of 1.5.
 10. Provide round elbows with center line radius to diameter ratio (R/D) of 1.5 or 1.0.
 11. Ductwork taps should be conical or clinch collar with 45 degree or boot connections.
 12. Flexible duct runs should be a maximum of 5-feet. Connections to air devices and changes in direction should be made with hard sheet metal duct elbows.
 13. Additional Installation Requirements for Type 1 Hood Exhaust Duct:
 - a. Install factory-fabricated Type 1 exhaust ducts in accordance with manufacturer's instructions; mechanical code; NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operation"; SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; and SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines" including slope, joint types, access openings, wall penetrations, etc.

- b. Install all ducts without dips and traps that may hold grease and sloped a minimum of 2 percent to drain grease back to the hood.
 - c. All joints should be welded and should be telescoping, bell, or flange joint as per NFPA 96.
 - d. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet or as required by local code requirements in horizontal ducts, and at every floor for vertical ducts.
 - e. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.
 - f. Submit shop drawings by the manufacturer indicating all necessary installation requirements and details. Provide expansion joint requirements as recommended by the manufacturer based on ductwork layout.
14. Additional Installation Requirements for Type 2 Hood Exhaust Duct:
- a. Install factory-fabricated Type 2 exhaust ducts in accordance with manufacturer's instructions; mechanical code; SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; and SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines" including slope, joint types, access openings, wall penetrations, etc.
 - b. Install dishwasher exhaust ducts and other exhaust ducts from wet, high-humidity locations without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to dishwasher or toward drain.
 - c. Provide a drain pocket at each low point and at the base of each riser with a 1-inch trapped copper drain from each drain pocket to open site floor drain.
 - d. Minimize number of transverse seams.
 - e. Do not locate longitudinal seams on bottom of duct.
15. Additional Installation Requirements for Fume Hood/Laboratory Exhaust:
- a. Install ducts in accordance with NFPA 45, "Fire Protection for Laboratories Using Chemicals."
 - b. Install exhaust ducts without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to hood or inlet. Where indicated on Drawings, install trapped drain piping.
- C. Duct Pressure Testing:
- 1. Comply with the latest version of ASHRAE 90.1 and SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. Ducts with a positive or negative Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
 - 5. Test for leaks before applying external insulation.
 - 6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - 7. Repair leaks and repeat tests until total leakage is less than 1% of system design airflow when the system is pressurized to the design duct pressure class rating.

D. Duct Accessories:

1. Provide balancing dampers with inspection ports at supply, return, and general exhaust branches when connected to larger ducts, as required, for air balancing.

23 34 00 HVAC FANS

- A. Direct drive fans are required. Belt driven fans are not permissible.
- B. Provide TEFC NEMA Premium Efficiency rated motor rated for compatibility with variable frequency drives where applicable. ODP motors are acceptable where TEFC is not required.
- C. Select non-overloading motors at all points on the RPM operating curve.
- D. Motors rated for compatibility with variable frequency drives shall be equipped with a conductive shaft grounding ring.
- E. Provide all fans with factory supplied and mounted NEMA 1 disconnect switch. For roof-mounted equipment, provide NEMA 3R disconnect switch.
- F. Where applicable, provide fans with the following options:
 1. Wall collar.
 2. Motor-side guard.
 3. Motorized discharge damper and damper guard.
 4. Weather hood.
 5. Access doors.
 6. Drain connection.
 7. Inlet and outlet guards.
 8. Bird screens.
 9. Neoprene or spring isolators.
 10. Hinge kit (required for all kitchen exhaust rooftop fans).
 11. Grease trap or pan kit (for kitchen exhaust fans only).
- G. Install flexible connectors to connect duct to fans.

23 36 00 AIR TERMINAL UNITS

- A. Manufacturers:
 1. Nailor
 2. Price
 3. Titus is NOT ALLOWED.
- B. Single-Duct Variable Air Volume Units & Fan-Powered Variable Air Volume Units:
 1. Casing: Galvanized steel, single wall.
 2. Casing Liner: Fiber-free flexible elastomeric duct liner. Fiberglass liner is not permitted.
 3. Radiated Noise Level: Less than 25 N.C.
 4. Discharge Noise Level: Less than 25 N.C.
 5. Heating Coils:
 - a. Hydronic Heating Coils: Seamless copper tube with mechanically bonded aluminum fins spaced not closer than 0.1-inch and copper headers. Aluminum tubes and headers are NOT ALLOWED. Include manual air vent and drain valve.
 - (i) Piping accessories should include shutoff valve, strainer, control valve, P/T test ports, union or flange on the supply and shutoff valve, balancing valve, P/T test ports, union or flange on the return.
 - b. Electric Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and

- secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
- (i) SCR versus staged heat.
 - (ii) Access door interlocked disconnect switch.
 - (iii) Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
 - (iv) Nickel chrome 80/20 heating elements.
 - (v) Airflow switch for proof of airflow.
 - (vi) Fan interlock contacts where applicable.
 - (vii) Fuses in terminal box for overcurrent protection (for coils more than 48 A).
 - (viii) Disconnect Switch: Factory-mounted, fuse type.
- 6. Fan & Motors for Fan-Powered Variable Air Volume Units: Forward-curved centrifugal, PSC with SCR fan speed controller to aid in balancing.
 - 7. Filters for Fan-Powered Variable Air Volume Units: 1" thick, MERV-8.
 - 8. Velocity Sensors: Multipoint center averaging velocity sensor on all unit inlets.
 - 9. Attenuator Sections: Construction should be the same as the base unit.
 - 10. Furnish all terminal units with the following:
 - a. Single-point electrical connection, including controls transformer.
 - b. Factory-mounted, wired, and calibrated DDC controllers, airflow sensor, and damper actuator.
- C. Dual Duct Terminal Units:
- 1. Not allowed for new construction.
- D. Critical Environment Air Control Valve:
- 1. Application: Laboratory where toxic chemicals will be present and precise airflow and room pressurization control is required.
 - 2. Description: Venturi valve assembly with factory-calibrated pressure-independent controls.
 - 3. Manufacturers:
 - a. Phoenix
 - b. Siemens
 - 4. Casing: Spun aluminum with continuous welded seam. Stainless steel casing or corrosion resistant coatings may be specified as required by project.
 - 5. Casing Insulation (Supply Valves Only): Factory-installed, external, flexible elastomeric insulation.
 - 6. Internal Assembly: Composite TEFLON shaft bearings and spring grade stainless steel spring in the slider assembly.
 - 7. Accuracy: +/-5% of airflow command signal.
 - 8. Heating Coils: Comply with previously described requirements in section above.
- E. General Installation Requirements:
- 1. Contractor to install a discharge air temperature sensor for all units. Comply with DDC System Construction Standards.
 - 2. Make connections to both sides of unit with flexible connectors.
 - 3. Install with manufacturer required straight duct length upstream of unit.

23 50 00 CENTRAL HEATING EQUIPMENT

23 52 00 BOILERS

- A. Manufacturers:

1. Advance Thermal Hydronics (condensing only).
 2. Aerco (condensing only).
 3. Raypak (condensing only).
 4. RBI (condensing & non-condensing).
 5. Patterson-Kelley (condensing & non-condensing).
 6. SHSU approved equal.
- B. Preferred Manufacturers for Resident Life Buildings:
1. Raypak (condensing and non-condensing).
- C. System Description: For new projects and full system replacements, install condensing boilers with a return water temperature of 120 deg. F or less. The overall system shall be sized for N+1 redundancy. For equipment replacements, non-condensing boilers are allowed. All projects should take care to achieve required minimum flows and minimum return temperatures (non-condensing boilers only) with use of appropriately sized end of loop 3-way control valves, primary-secondary pumping arrangement, and thermostatic mixing valves.
- D. Boilers should be rated for a maximum allowable working pressure of 100-psig.
- E. Boilers should be provided with:
1. Modulating controls capable of minimum 5:1 turndown.
 2. Factory mounted circulator pump.
 3. Factory mounted and wired controls including circulator pump start/stop control.
 4. Flow switch.
 5. Low water cutoff.
 6. ASME pressure relief valve set at 100-psig.
 7. Stainless steel or CuNi heat exchanger for condensing boilers.
 8. Condensate trap and neutralization kit (clear sides for viewing) for condensing boilers.
 9. Single point power connection.
- F. Provide multiple boiler control system for boiler sequencing and reset control.
- G. Provide factory installed hardware and software to enable the campus building automation system to monitor, control, and display boiler status and alarms.
- H. Provide a 100-ppm CO monitor for boiler rooms that is hard-wired to boiler controls and requires a manual reset.
- I. Gas train and safety controls shall conform to the requirements of Factory Mutual (FM).
- J. Flue Requirements:
1. Flue and combustion air duct sizes are the size of the connection on the boiler.
 2. Flues should be installed per manufacturer's requirements.
 3. Submit shop drawings created by the flue vendor showing detailed intake and flue routing, fittings, and sizes prior to order and installation. Shop drawings to be reviewed and signed-off by the boiler manufacturer.
 4. Flues terminations should be located and installed to avoid causing corrosion and acid or steam damage to other buildings systems, structure, or finishes (e.g. copper roofing).
 5. Route flue drain to condensate neutralization kit.
- K. Boiler Emissions: Not to exceed allowable ambient-air quality standards in governing jurisdiction. Provide with flue gas recirculation system if required to meet emissions requirements.

23 60 00 CENTRAL COOLING EQUIPMENT

- A. As of 2020, the EPA is developing a plan for the phasedown of HFC refrigerants. The PSP shall be responsible for selecting equipment that is in compliance with this plan. HFC refrigerants are expected to be slowly replaced by the next-generation of refrigerants, HFO's and HFO blends.

23 64 00 WATER CHILLERS

- A. Microchannel condenser and evaporator coils are NOT ALLOWED.
- B. Water-cooled chillers:
 - 1. Preferred Manufacturers:
 - a. Trane.
 - b. York.
- C. Air-cooled chillers:
 - 1. Preferred Manufacturers:
 - a. Carrier, Aqua Snap.
 - b. York.
- D. Evaporator Tubes:
 - 1. Individually replaceable from either end and without damage to tube sheets and other tubes.
 - 2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets such as with tube clips.
 - 3. Material: Copper or copper-nickel alloy.
 - 4. Nominal OD: $\frac{3}{4}$ inch or 1 inch.
 - 5. Minimum Wall Thickness Throughout Entire Tube Length: 0.025 inch.
 - 6. External Finish: Manufacturer's standard.
 - 7. Internal Finish: Enhanced.
- E. Condenser Tubes:
 - 1. Individually replaceable from either end and without damage to tube sheets and other tubes.
 - 2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets such as with tube clips.
 - 3. Material: Copper or copper-nickel alloy.
 - 4. Nominal OD: $\frac{3}{4}$ inch or 1 inch.
 - 5. Minimum Wall Thickness Throughout Entire Tube Length: 0.035 inch.
 - 6. External Finish: Manufacturer's standard.
 - 7. Internal Finish: Rifling or enhanced for service with cooling tower water. Enhanced for service with heating hot water system (heat pump chiller).

23 65 00 COOLING TOWERS

- A. This section covers packaged cooling towers only. Field erected cooling towers with reinforced concrete structure will require custom specifications that are closely coordinated with and approved by SHSU.
- B. Preferred Manufacturers:
 - 1. Marley/SPX Cooling Technologies
 - 2. Baltimore Aircoil Company
- C. General Design Characteristics:
 - 1. Design Criteria: Ambient temperature of 98 deg. F dry-bulb and 90 deg. F wet-bulb, minimum condenser water delta T of 10 deg. F.
 - 2. Arrangement: Open-circuit, induced-draft, crossflow. Other arrangements may be allowed with prior approval by SHSU.
 - 3. Design for variable condenser water flow.
 - 4. Filter 5% of circulating flow using either sand filters or mechanical vortex filters.
 - 5. Design for N+1 redundancy for condenser water pumps and cooling tower cells.
 - 6. All internal components shall be stainless steel.

7. Cooling towers materials of construction shall be suitable for either low pH or high pH water treatment.
- D. Casing & Frame:
 1. All stainless-steel construction.
 2. Hardware should be galvanized steel only when connected galvanized steel components and stainless steel when connecting all other materials.
 3. Watertight joints and seams with continuous welded connections.
- E. Collection Basin & Sump Chamber:
 1. Arrangement: Basins and sump tanks shall be 100%, fully drainable. Each cell of a multi-cell tower shall have a dedicated basin that can be isolated without draining adjoining basins. Provide open-circuit multi-cell towers with removeable flume plates between adjacent basins and connections for field-installed equalizer piping.
 2. Material:
 - a. Stainless steel basins shall be one-piece design without gasket seams. Welded seams are acceptable provided the basin material is Type 316L stainless steel.
 3. Provide basin heater.
 4. Provide factory option basin sweeper piping. Provide basin sweeper pump and filter skid assembly with onboard controls capable of integration with campus BAS.
- F. Make-up Water Assembly: Make up water to basin must be installed in such a way to facilitate maintenance of make-up valve without draining basin. All make up valve floats or level sensors shall be installed in a stilling well.
- G. Water Distribution Systems: Either spray-type or gravity-type. If spray-type, system should be designed for even distribution over fill through the entire flow range without need for balancing valves and nozzles should be easily removeable, non-clogging. If gravity type, provide stainless steel hot water basin with weirs to optimize tower performance at reduced flow conditions.
- H. Fill: PVC with structural fiberglass fill support.
- I. Drift Eliminators: High efficiency drift eliminators designed to reduce water carryover to 0.001% of design flow.
- J. Fan and Drive Assembly:
 1. Axial fan with corrosion resistant shaft, field adjustable blade pitch, and extended (remote) lubrication lines to an easily accessible location.
 2. Gearbox drive type with vibration switch to shut down fan upon sensing excessive vibration.
 3. TEFC motor, inverter-duty rated, severe-duty rating, mounted outside of the cooling tower airstream.
- K. Aluminum or fiberglass gratings on tower pumps preferred.

23 70 00 CENTRAL HVAC EQUIPMENT

23 73 00 INDOOR CENTRAL-STATION AIR-HANDLING UNITS

- A. Preferred Manufacturers:
 1. Air Enterprises.
 2. Carrier.
 3. Energy Labs Inc.
 4. Haakon Industries.
 5. Temtrol Inc.
 6. Thermal Corporation.
 7. York.

8. Daikin is not an acceptable manufacturer.
 9. Trane is not an acceptable manufacturer.
- B. General Design Characteristics:
1. Mechanical rooms must be large enough to allow for manufacturer recommended clearances, coil pull space, filter replacement, UV lamp replacement, motor replacement, and any other manufacturer recommended routine maintenance or repairs. Clearance spaces should be noted on the drawings and should not require disassembly of the unit cabinet or modifications to any other MEP components including piping, ductwork, wiring, etc.
 2. Roof-top air handling units are not allowed without prior approval by SHSU.
 3. Built-up air handling units are not allowed without prior approval by SHSU.
 4. The PSP should evaluate exhaust air energy recovery during preliminary stages of design.
- C. Unit Casing:
1. Welded structural steel base frame.
 2. Double-wall galvanized steel construction with solid inner casing wall. The outer wall to be minimum 18-gauge and the inner wall to be minimum 20-gauge. The casing insulation to be minimum 2-inches thick closed-cell foam and compliant with the currently adopted energy code. Rooftop units should have aluminum exterior construction.
 3. Thermal break construction, no through-casing metal in unit walls, floors, or roofs.
 4. Access sections should be at least 24-inches wide with double-wall access panels or doors (with windows) at least 20-inches wide. Access panels or doors should be located on both sides of each coil, fan, filter, damper, access section, etc. Access sections should be provided up and downstream of coils and provide access to inspect and clean the drain pan. Arrange doors to be opened against airflow.
 5. Provide vaporproof service lights with individual switch located outside adjacent to each access door.
 6. Provide one convenience outlet on outside of unit.
 7. Condensate drain pans should be IAQ style, double-wall insulated, stainless steel. The minimum slope and length should comply with the currently adopted version of ASHRAE 62.1. Stacked coils should have intermediate drain pans.
- D. Fans, Drives, and Motors:
1. Shaft bearings should be self-aligning, anti-friction with an L-10 rated life of 200,000 hours. Where grease-lubricated bearings are specified, grease lines should be extended to outside the unit.
 2. Plenum fan arrays are strongly preferred. Provide backdraft dampers at each fan inlet to prevent short circuiting of flow if one fan is not operating. Provide fan outlet with safety screen that has no measurable pressure drop at full fan speed. Provide fans with integral airflow measurement stations.
 3. Factory-mounted direct drive fans are required.
 4. Belt-driven fans are not allowed.
 5. Fans should be provided with internal vibration isolation.
 6. Motors should be premium-efficiency “inverter-ready” for use with variable-frequency controller.
 7. Each fan and motor assembly should be accessible and removeable through an access door. Provide internal chain fall rails to facilitate fan/motor removal.
 8. Fan selections should comply with the currently adopted version of ASHRAE 90.1 fan power limitations.
- E. Coils:

1. All hydronic coils should be self-draining, fin and tube type with aluminum fins mechanically bonded to seamless copper tubes and headers.
 2. Aluminum tubes and headers are not allowed.
 3. Chilled water coils should have a minimum 6-rows and maximum 10-FPI with 5/8-inch diameter copper tubes, 0.008-inch thick aluminum fins, and stainless steel casings.
 4. Heating water coils should have a minimum 1-rows and maximum 10-FPI with 1/2-inch diameter copper tubes, 0.008-inch thick aluminum fins, and galvanized steel casings.
 5. The maximum face velocity for a chilled water coil is 450-FPM.
 6. The maximum face velocity for a heating water coil is 700-FPM.
- F. Air Filtration:
1. Minimum filter efficiency should be MERV 13 for all airstreams, including recirculated or return air.
 2. Filters should be standard size and locally stocked. Custom dimensioned filters are not allowed.
 3. Filter media should be coated with an antimicrobial agent.
 4. Install filter gauges at each filter bank for comparison with DDC instrumentation.
 - a. Provide surface mounted pressure gauge, Dwyer Magnehelic, with integral leveling screw, graduated to read appropriate pressure range based on maximum dirty filter pressure loss.
 - b. Provide static-pressure tips, tubing, gauge connections, and mounting bracket.
- G. Dampers:
1. Factory-mounted modulating outside air, return air, and relief air dampers are preferred. Field installed modulating dampers are allowed where required for system arrangement.
- H. Antimicrobial UV Lamp Systems:
1. Install UV-C lamps downstream of cooling coil section.
 2. Provide inspection port in UV-C lamp section.
 3. All components internal to air handling unit shall be rated for temperatures 34 to 158 deg. F, 100% relative humidity, at any velocity.
 4. All components exposed to UV-C lamps shall be constructed of UV-resistant materials.
 5. Provide quantity of UV-C lamps required for full coverage of cooling coil.
 6. Provide mechanical interlock switch on access panels and doors to UV-C lamp section (or section within view of UV-C lamp system) to ensure system will be de-energized when accesses are opened.
 7. Provide safety signage on access panels and doors to disconnect power source before servicing.
- I. Electrical Requirements:
1. Provide single point electrical connection for all loads over 120-V.
 2. Provide single point electrical connection for all 120-V loads including cabinet lights, convenience outlet, and unit controls.
- J. General Installation Requirements:
1. Condensate drains should be routed directly to a floor drain. Do not route condensate drains to the floor or ground outside of a building.
 2. The PSP should not leave the condensate drain trap design up to the contractor. Trap design should be specific to unit type (blow-through or draw-through). Coordinate trap height requirements with the housekeeping pad and unit base frame heights.
 3. Install the following coil supply piping accessories: shutoff valve, strainer with blow-down valve, test port with extended neck for insulated piping, thermometer with thermowell, pressure gauge assembly with shutoff valve, and union or flanged connections.

4. Install the following coil return piping accessories: shutoff valve, strainer with blow-down valve, test port with extended neck for insulated piping, thermometer with thermowell, pressure gauge assembly with shutoff valve, control valve, balancing valve, and union or flanged connections.
5. Install pressure gauge at unit discharge for comparison with DDC instrumentation.
 - a. Provide surface mounted pressure gauge, Dwyer Magnehelic, with integral leveling screw, graduated to read appropriate pressure range based on unit discharge static pressure.
 - b. Provide static-pressure tips, tubing, gauge connections, and mounting bracket.

23 80 00 DECENTRALIZED HVAC EQUIPMENT

- B. As of 2020, the EPA is developing a plan for the phasedown of HFC refrigerants. The PSP shall be responsible for selecting equipment that is in compliance with this plan. HFC refrigerants are expected to be slowly replaced by the next-generation of refrigerants, HFO's and HFO blends.
- C. Microchannel condenser and evaporator coils are NOT ALLOWED.
- D. Install auxiliary drain pans below all suspended, concealed fan coil units. Where applicable, extend drain pan 6-inches beyond the water coil connection side of the unit to catch leaks from coil connection piping accessories.
 1. Auxiliary drain pans may not be omitted without prior approval by SHSU.
- E. All fan coil units should be installed with a condensate float switch that is interlocked to shutdown the fan coil unit.
 1. For concealed fan coil units, a float switch should be installed in the auxiliary drain pan.
 2. For vertical fan coil units and other installations without an auxiliary drain pan, an inline float switch should be installed in the condensate drain.
 3. Level type float switches are NOT ALLOWED.
- F. All fan coil units should be provided with factory or field mounted pumps.
- G. Condensate drains should be routed directly to a floor drain. Do not route condensate drains to the floor or ground outside of a building.

23 81 00 UNITARY AIR CONDITIONING EQUIPMENT

- A. Preferred Manufacturers for Resident Life Buildings:
 1. Carrier.
 2. Trane.
- B. General Installation Requirements:
 1. For DX split systems, the condensing and evaporator equipment should be located as close as possible to minimize refrigerant piping lengths.
 2. Install and size refrigerant piping in accordance with manufacturer's instructions. Refrigeration piping shall be designed for shortest possible return of oil to compressor location. Exceptions may be approved by owner for large loads on a case-by-case basis. In such cases, owner shall approve locations of condensing compressor.
 3. Project specifications to include manufacturer warranty coverage for premature evaporator coil failure when installed in a standard indoor conditioned environment.

23 81 29 VARIABLE REFRIGERANT FLOW SYSTEMS

- A. Preferred Manufacturers for Resident Life Buildings:
 1. Daikin.
 2. Mitsubishi by Trane.
 3. Toshiba by Carrier.

B. Design Phase Requirements:

1. Refrigerant piping must be modeled in REVIT for appropriate space allocation and clash detection with other trades. Pipes may be modeled as a rectangular block in lieu of each pipe individually.
2. Show access requirements for all equipment on drawings, including access for routine filter replacements. Where filters are to be replaced from below, coordinate auxiliary drain pan dimensions to maintain access.
3. Concealed fan coil units that do not have integral filter racks should be modeled with filter rack accessory.
4. Show access requirements for branch selector units.

C. Manufacturer Submittal Requirements:

1. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing.
2. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
3. Include design calculations showing that maximum refrigerant piping and controls cabling horizontal and vertical distances are not exceeded.

D. Installation Requirements:

1. Installation to be by a manufacturer certified technician. Installed must also have prior documented experience with the specific manufacturer of the VRF system.
2. Engage a manufacturer's service representative to advise and assist installers, witness testing, and observe and inspect components, assemblies, and equipment installations, including controls and connections.
 - a. Project specification should clearly outline the expectations of the manufacturer's service representative. These expectations should be reviewed with SHSU during the design phase. Expectations include but are not limited to the following:
 - (i) Frequency of on-site visits during construction.
 - (ii) Written field observation reports for each visit that should include deficiencies with photo documentation and recommended corrective action.
 - (iii) Final inspection requirements which should include all system equipment and operating components regardless of project size.
 - (iv) Test witnessing including leak testing, operational testing, and controls and safeties testing.
 - (v) Startup supervision and Owner training.
 - b. Kick-off Meeting:
 - (i) Participants to include SHSU, design engineer, installer, manufacturer's service representative, and all other related trades.
 - (ii) Review all relevant VRF system information including contract documents, specifications, drawings, submittals, and manufacturer requirements.
 - (iii) Review expectations for manufacturer's service representative oversight.
 - c. VRF system testing to include refrigerant tubing positive pressure testing, refrigerant tubing evacuation testing, and all other tests as recommended by the manufacturer.

23 82 10 FAN COIL UNITS

F. Manufacturers:

1. Carrier.
2. EMI.
3. Johnson Controls.

4. Trane is not an acceptable manufacturer.
 5. SHSU approved equal.
- G. Ducted Fan Coil Units:
1. Unit Casing:
 - a. Unit chassis to be fabricated from heavy gauge galvanized steel panels.
 - b. Unit cabinet to be galvanized steel. Plenum boxes to match cabinet construction and insulation.
 - c. All external panels to be insulated with 1-inch foil-faced fiberglass or fiber-free flexible elastomeric.
 - d. Condensate drain pans should be IAQ style, insulated, galvanized steel. The minimum slope and length should comply with the currently adopted version of ASHRAE 62.1. Provide overflow switch.
 2. Heating Coils:
 - a. Hydronic Coils: Seamless copper tube with mechanically bonded aluminum fins spaced not closer than 0.1-inch and copper headers. Aluminum tubes and headers are NOT ALLOWED. Include manual air vent and drain valve.
 - (i) Piping accessories should include shutoff valve, strainer, control valve, P/T test ports, union or flange on the supply and shutoff valve, balancing valve, P/T test ports, union or flange on the return.
 - b. Electric Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
 - (i) SCR versus staged heat.
 - (ii) Access door interlocked disconnect switch.
 - (iii) Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
 - (iv) Nickel chrome 80/20 heating elements.
 - (v) Airflow switch for proof of airflow.
 - (vi) Fan interlock contacts where applicable.
 - (vii) Fuses in terminal box for overcurrent protection (for coils more than 48 A).
 - (viii) Disconnect Switch: Factory-mounted, fuse type.
 3. Fan & Motors:
 - a. Double-width, forward-curved centrifugal.
 - b. Use ECMs when available for variable speed operation.
 - c. Use PSC with SCR fan speed controller to aid in balancing for constant speed operation.
 - d. Use TEFC motors for draw-through configurations or high humidity applications.
 4. Filters: 1" thick, MERV-8 or as required by ASHRAE, standard sizes and locally stocked.
 5. Furnish all terminal units with the following:
 - a. Single-point electrical connection, including controls transformer.
- H. General Installation Requirements:
1. Contractor to install a discharge air temperature sensor for all units. Comply with DDC System Construction Standards.
 2. Make connections to both sides of unit with flexible connectors.
 3. Where unit is concealed above ceilings, install a galvanized steel secondary drain pan with float switch wired to shut down the fan coil unit.

25 00 00 BUILDING AUTOMATION SYSTEMS

- A. Preferred Manufacturers:
 - 1. EcoStruxure by Schneider Electric.
 - 2. Substitution: Other manufacturers may be approved by SHSU on an as needed basis.
- B. Provide a fully integrated building automation system (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control. Projects in existing buildings should extend and/or upgrade the existing DDC system for renovated areas.
- C. Systems or building components to be monitored and/or controlled include, but are not limited to, the following:
 - 1. Temperature control
 - 2. Humidity control
 - 3. Start/stop and monitoring of all major equipment
 - a. Commercial kitchen equipment
 - b. Lab equipment
 - 4. Fire Alarm System (monitor only)
 - 5. Generators (monitor only)
- D. Systems should be integrated using BACnet/IP. Gateways are not an acceptable means of integration.
 - 1. Equipment with proprietary controls is not acceptable without approval by SHSU. The intent is to minimize the number of systems that do not integrate with the campus BAS.
- E. The DDC system should not be able to modify the Fire Alarm System and should not interfere with the operation of the Fire Alarm System.
- F. For off-campus projects and small-scale on-campus, the BAS requirements should be coordinated with SHSU and at a minimum provide the means for night, weekend, and holiday set-backs.
- G. Provide metering of utilities with indication and totalization capabilities.
 - 1. Plumbing utilities
 - 2. Chilled water
 - 3. Heating water
 - 4. Electrical building meter
 - 5. Electrical submetering:
 - a. HVAC equipment
 - b. Building miscellaneous loads
 - 6. All utility submeters required for user billing
- H. All DDC controllers should be listed by BACnet Testing Laboratories (BTL) with appropriate classification.
- I. All available BACnet points should be integrated, do not exclude available points for a given piece of equipment.
- J. During design, the PSP should coordinate with the controls contractor to determine the number of DDC panels required. DDC panel locations should be shown on the plans. Do not mount DDC panels on equipment.
- E. Communication:
 - 1. The control system will consist of a high-speed Ethernet network utilizing BACnet/IP communications between system controllers and an operator interface.
 - 2. Communications between system controllers and custom application or application specific controllers should use BACnet/MSTP or BACnet/IP.
 - a. Each communication interface should be ANSI/ASHRAE Standard 135.
 - b. Power over ethernet (PoE) controllers are not acceptable.

- c. Communication lines to controllers should be wired.
 3. Do not provide an operator workstation.
- F. System Graphics: Include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point.
 1. Use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
 - a. Floorplan graphics for all spaces included in the scope of work are required.
 - b. Locate all field-mounted devices on floorplan graphics.
 - c. Imbedded room numbers must be adjustable.
 2. Use animated graphics to illustrate changes in object status.
 3. Indicate areas or equipment in an alarm condition using color or other visual indicator.
 4. Include user-friendly display of sequences of operation.
- G. Instrumentation and Control Devices:
 1. All devices to be Schneider Electric.
 2. Location of field-mounted devices to be noted on the drawings and identified on the BAS front-end graphics.
 3. All instrumentation that can be damaged from construction dust or smoke must be protected prior to beginning of construction. This includes all fire and smoke devices that are a part of the Fire Alarm System.
- H. BAS Closeout Submittals:
 1. In addition to the standard operation and maintenance data, the contractor should provide redlined drawings indicating the location of every field-mounted control device.
- I. Sequences of Operations and Controls Diagrams:
 1. Detailed HVAC control sequence of operations and controls system schematic diagrams should be included in the plans and specifications. Complete I/O points summary should be included in the controls submittal for review by engineer and SHSU.
 - a. Provide discharge air temperature sensors for all cooling and heating equipment.
 - b. Provide differential pressure sensors across all filter banks.
 2. Required Airside Sequences:
 - a. Comply with minimum requirements of ASHRAE 90.1, currently adopted version. This includes but is not limited to the following:
 - (i) Zone thermostatic control deadband of at least 5 deg. F.
 - (ii) Off-hour controls including night setbacks and optimum start.
 - (a) Provide night setback temperature control on classroom/office buildings.
 - (b) Laboratory temperature setback shall be evaluated based on specific environmental requirements of laboratory space.
 - (iii) Motorized dampers for all outdoor air intake and exhaust systems that can be closed when building is unoccupied.
 - (iv) Demand control ventilation.
 - (a) Control air handling system outside air ventilation rates using a carbon dioxide-based demand ventilation control strategy to reduce the total supply or outside air during periods of reduced occupancy. Monitor the carbon dioxide levels in the zones and vary ventilation rates to track a carbon dioxide offset consistent with ASHRAE 62.1 recommendations.
 - (v) 100% airside economizer with means to relieve excess outdoor.

- (vi) Simultaneous heating and cooling limits.
 - (vii) Supply air temperature reheat limit.
 - (viii) VAV systems to be provided with variable frequency drives for fan static pressure control and include static pressure setpoint reset sequence.
 - (ix) Supply air temperature setpoint reset.
 - (x) Exhaust air energy recovery.
3. Required Waterside Sequences:
- a. Comply with minimum requirements of ASHRAE 90.1, currently adopted version. This includes but is not limited to the following:
 - (i) 100% waterside economizer.
 - (ii) Chilled water temperature setpoint reset.
 - (iii) Hot water temperature setpoint reset.
 - b. Boiler sequencing and reset control to be by manufacturer controller.
4. All control sequences are to contain power failure recovery mode requirements. Control device fail positions should be indicated on the controls diagrams. Typical device fail positions are listed below. All fail positions should be evaluated on a case-by-case basis to protect building occupants and prevent damage to the equipment.
- a. Air Handling Unit:
 - (i) Chilled water control valve – fail in place
 - (ii) Preheat heating water control valve – fail open
 - (iii) Outside air damper – fail closed
 - (iv) Return air damper – fail open
 - (v) Relief/Exhaust air damper – fail closed