



DIVISION 23 00 00 HEATING, VENTILATION, AND AIR CONDITIONING

1. GENERAL.

- A. Hydronic systems utilizing chilled water and hot water with forced air ventilation systems shall be utilized on campus. Electric resistance heating and DX cooling shall not be utilized for building systems.
- B. Unoccupied spaces that require continuous cooling such as telecom room and electrical rooms shall be on separate systems.
- C. Contractor shall obtain and pay for all permits, licenses and inspections.
- D. Design chilled water systems with a 45°F entering water temperature and minimum 10°F temperature differential.
- E. When stated by the manufacturer, equipment shall be installed by personnel certified by the manufacturer.
- F. Rooftop air handlers are prohibited.
- G. Visible duct work on the roof or exterior of the building is prohibited.
- H. Major heating and air conditioning equipment such as chillers, pumps, steam regulating stations, expansion tanks, etc. shall be located in accessible mechanical rooms preferably on the ground floor exterior wall with exterior access.
- I. Construction moisture must be allowed to escape or be mechanically removed after the building is enclosed and prior to the startup of mechanical equipment.
- J. Install drains with valves, hose ends and caps at all low points to facilitate complete drainage of the systems and equipment.
- K. The installing contractor shall supply a list of all equipment filters. The list shall include room number, quantity, type, and size(s).
- L. Floor drains in mechanical areas shall be located near equipment to minimize trip hazard from equipment drains.
- M. Identify all pipe with paint, stenciling, or laminated printed labels attached by cable ties to indicate pipe contents and direction of flow at least once in each space. Decals/stickers are not acceptable alternatives. Piping identification should not include contractor or manufacturer names, logos or other advertising.
- N. Show all equipment service requirements on the drawings with a minimum clearance of 2'-6" from any wall adjacent to the mechanical equipment.



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- O. Mechanical rooms shall be designed to provide adequate maintenance clearances for all systems and equipment. Clearances around air handlers shall be a minimum of 3 feet on each side, excluding coil and fan shaft pull clearances which are greater. Show required coil/shaft removal space on the drawings.
- P. Clearances shall be provided for maintenance activities for all equipment without the removal of equipment, pipe or supports.
- Q. Generally avoid the use of the phrase "or equal" in specification documents. Only list approved manufacturers as noted in these guidelines. If there are any questions as to preferred manufacturers, please verify with TTU representative.

SECTION 23 05 13 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

- 1. GENERAL.
 - A. Electric motors shall be new NEMA Standard size.
 - B. Any motor used with a variable speed controller shall be VFD compatible and provided with shaft grounding rings.
- 2. PRODUCTS.
 - A. APPROVED MANUFACTURERS:
 - 1. General Electric
 - 2. Lincoln Electric
 - 3. Emerson
 - 4. Baldor
 - 5. U.S. Motors

SECTION 23 29 23 VARIABLE-FREQUENCY MOTOR CONTROLLERS

- 1. GENERAL.
 - A. A manual bypass contactor shall be included in the bypass circuitry for constant speed motor operation when the VFD is taken out of service. Include isolation switch to allow operation of the motor while performing maintenance for the VFD.
 - B. The VFD shall be warranted by the manufacturer for 36 months from the date of startup.
 - C. During construction, VFD is to be covered with plastic/cardboard to protect it during the construction period. If the VFD is to be operated while construction is ongoing, the cooling intake fan shall be covered with filter media to prevent construction dust from entering into the unit.
 - D. PRODUCTS.
 - 1. APPROVED MANUFACTURERS:
 - a. Schneider Electric
 - b. Toshiba
 - c. ABB



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SECTION 23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC

1. GENERAL.
 - A. Equipment and systems shall be installed free of objectionable noise and vibrations. Installed equipment shall not exceed 80 dBA measured three (3) feet from the device.
 - B. Inertia bases (when provided) for pumps shall incorporate the complete pump with suction diffuser, and inlet/outlet pipe support.
 - C. Provide flexible pipe connections for pump suction and discharge piping.

SECTION 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC

1. GENERAL.
 - A. Perform system balance in accordance with AABC or NEBB National Standards for total system balance.
 - B. The TAB contractor shall be AABC or NEBB certified.
 - C. TAB contractor shall submit a written report to the designer and owner of all job site visits.
 - D. Provide flexible fabric connections at any fan/duct connections.
 - E. Install spring/neoprene vibration isolation mounts on any hanger supporting a motor driven device (i.e. ceiling mounted exhaust fans or isolation pumps.)
 - F. Install spring vibration isolators on pipe hangers immediately upstream and downstream of motor driven devices.

SECTION 23 08 00 COMMISSIONING OF HVAC

1. GENERAL.
 - A. Commissioning shall be performed for all mechanical equipment and controls.
 - B. Functional Performance Test (FPT) procedures provided for each piece of equipment shall be approved by the Designer.
 - C. Coordinate the schedule to allow the Designer and Owner to be present during FPT.

SECTION 23 09 23 DIRECT-DIGITAL CONTROL FOR HVAC

1. GENERAL.
 - A. The campus standard is Schneider Electric StruxureWare Building Automation System. No substitutions are allowed.



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- B. Building controls shall interface with the existing Chiller Plant Control system.
- C. Controllers shall be StruxureWare bacNet compatible. Programming of the controller shall be achieved through the StruxureWare software.
- D. Provide a schedule of DDC points, control diagram, and comprehensive sequence of operations for each type, piece, and configuration of HVAC equipment (e.g. fans, air handler units, fan coil unit, chillers, etc.). Specify only those points necessary to operate the system in accordance with the design intent. The sequence of operations should address occupied and unoccupied operating modes. The BAS shall minimize or shut off outside air and eliminate reheat during unoccupied periods and control humidity during both occupied and unoccupied periods.
- E. Provide automatic restart of all equipment to normal operation following a power outage. Controllers shall have flash memory to utilize this function.
- F. Provide graphical interface panels for systems and equipment.
- G. Prior to Substantial Completion of the project, demonstrate complete operating system to the Owner. Provide basic training to the operator's maintenance staff for programming, alarm functions, and operation. Supply one (1) hard copy and one (1) electronic copy of the control operation and instruction manuals.
- H. Warranty service shall be provided by factory trained full-time employees of the control system manufacturer.
- I. Thermostats in public areas shall be equipped with keyed, tamper-proof covers.

SECTION 23 21 00 HYDRONIC PIPING AND PUMPS

1. GENERAL.

- A. Where dissimilar metals are joined, utilize dielectric nipples. Use of dielectric unions is prohibited.
- B. Provide isolation valves, flanges, unions, and couplings for servicing equipment. Connections shall allow minimal disassembly for replacement of components.
- C. Install reduced pressure backflow preventers on make-up lines to closed loop water systems. Backflow preventers are to be located where they can be easily tested and repaired.
- D. Locate thermometers and pressure gauges in accessible areas no higher than 7 feet above finished floor elevation.
- E. Install air vents at all high points in water systems. Automatic float type vents shall be used in equipment rooms only and piped to a floor drain. Manual vents shall be furnished with minimum ¼" ball valve and soft copper shepherd's hook suitable for a rubber hose connection.

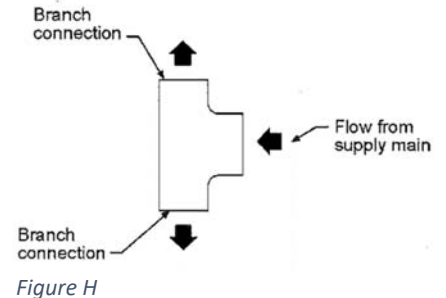


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F. PICCV's (Pressure Independent Characterized Control Valve) shall be used in lieu of standard 2-way valve with separate balancing valve in VAV reheat systems and chilled water systems. PICCV's are utilized to minimize energy consumption and increase system temperature differential.

G. Supply and return distribution pipe shall have an isolation valve for each branch.

H. Fluid in the supply side of a hydronic system shall not enter a tee fitting through the branch opening (known as a bull head tee connection). Figure H



I. Thermometers shall be required on the supply and return of all cooling coils, heating coils, heat exchangers, chillers, boilers, and cooling towers. A thermometer shall be installed at the discharge of all pumps.

J. A single pressure gauge with interconnecting piping shall be required upstream and downstream of all pumps, strainers, cooling or heating coils sized 10 GPM or larger, heat exchangers, chillers, boilers, and cooling towers. A single ball valve shall be installed at each pressure tap, manifold valve fittings shall not be used. Figure J.

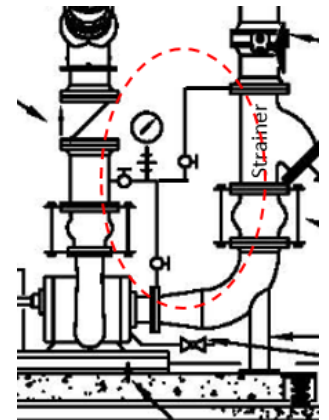


Figure J

2. PRODUCTS.

A. For shut-off and isolation of equipment use ball valves for pipe sizes 2" and smaller and butterfly valves for sizes 2-1/2" and larger.

B. Heating water and chilled water pipe (above grade) shall be black steel, schedule 40, or copper tubing, Type L.

C. Water condensate drain piping shall be Type M copper tubing. Drains shall be gravity fed, condensate pumps are prohibited.

D. Gaskets for chilled water and hot water shall be made of Teflon.



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- E. Butterfly valves to be lug style, extended neck, EPDM seat, aluminum-bronze disc, 10 position lever handle.
 - 1. APPROVED MANUFACTURERS:
 - a. Stockham
 - b. Nibco
 - c. Milwaukee
 - d. Hammond

- F. Coalescing Air-Dirt Separator; full flow, removable head, maximum entering velocity 10 FPS. Separator drain is to be hard piped to nearby floor drain.
 - 1. APPROVED MANUFACTURERS:
 - a. Spirotherm
 - b. Taco
 - c. Bell and Gossett

- G. Pressure Gauges shall be glycerin filled, 3-1/2" dial, impulse damper
 - 1. APPROVED MANUFACTURERS:
 - a. Tetric
 - b. Norgren
 - c. Wika

- H. Digital Thermometers: Supply solar digital vari-angle Weiss Instruments Model DVU-35 with adjustable angle. Thermometer to be self-powered and within 1% accuracy.

SECTION 23 21 23 HYDRONIC PUMPS

- 1. GENERAL.
 - A. Centrifugal end suction pumps are to be used.

 - B. Base mounted.

 - C. 75% minimum efficiency.

 - D. Bronze impeller, keyed to shaft.

 - E. Carbon seal rotating against stationary ceramic seat.

 - F. Pumps that use a VFD shall be supplied with a shaft grounding ring for the motor.

 - G. Install Rexnord Omega elastomeric style coupling with split-in-half flex element and polyurethane to metal bond.

 - H. Triple duty valves shall not be used. Install separate isolation balancing and non-slam check valve. If a VFD controls the pump, a balancing valve is not required.



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- I. After the pump frame has been grouted and before startup, use a dial indicator or laser alignment to certify pump alignment. Submit written documentation that this certification is performed.
2. APPROVED MANUFACTURERS:
 - A. Bell & Gossett Series 1510
 - B. Taco FI Series
 - C. Armstrong 4030

SECTION 23 22 00 STEAM AND CONDENSATE PIPING AND PUMPS

1. PRODUCTS.
 - A. Steam Piping
 1. Steel Pipe, ASTM A52, Schedule 40, Black
 2. All steam pipe fittings shall be class 300 malleable iron, cast steel, or forged steel (not cast iron).
 3. Welded joints
 4. Teflon gaskets rated for 500 degrees Fahrenheit
 5. Steam piping shall be installed with eccentric reducers (flat on bottom) to minimize accumulation of condensate in the pipe and the risk of water hammer.
 - B. Steam Condensate Piping
 1. Steel Pipe, ASTM A52, Schedule 80, Black
 2. Size 2" and larger welded joints, size 1-1/2" and smaller threaded joints
 3. Teflon gaskets rated for 500 degrees Fahrenheit
 - C. Valves
 1. Ball valve
 - a. Size 2" and smaller
 - b. APPROVED MANUFACTURERS:
 - i. Flow-Tek
 - ii. FlowServe
 - iii. Jamesbury
 2. Butterfly valve
 - a. Size 2-1/2" and larger
 - b. Ductile iron
 - c. APPROVED MANUFACTURERS:
 - i. FlowServe
 - ii. ABZ
 - iii. Jamesbury
 - iv. Nibco



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3. Globe valve
 - a. Used for bypass valves
 - b. APPROVED MANUFACTURERS:
 - i. Stockham
 - ii. Nibco
 - iii. Crane

- D. Condensate Pumps
 1. Cast Iron Tank
 2. Unit shall incorporate duplex pumps
 3. Hand-Off-Auto switch with pilot light for each pump
 4. APPROVED MANUFACTURERS:
 - a. Aurora, Skidmore
 - b. ITT-Hoffman
 - c. Shipco
 - d. Weinman

- E. Steam Traps
 1. Free-Float Ball Trap – float and thermostatic design
 2. APPROVED MANUFACTURERS:
 - a. Nicholson
 - b. TLV
 - c. Spence

- F. Pressure Reducing Stations
 1. Pilot Operated
 2. Provide adequate space and clearance to service steam reducing stations.
 3. APPROVED MANUFACTURERS:
 - a. Spence type ED
 - b. ITT-Hoffman Series 200
 - c. Fisher

SECTION 23 30 00 HVAC AIR DISTRIBUTION

1. GENERAL
 - A. Specify on the plans that HVAC equipment installed above the ceiling, such as VAV boxes, shall be mounted as low as possible for ease of maintenance. Avoid installing such equipment over hard ceilings, tall spaces (such as entrance lobbies) or close to critical noise areas such as conference rooms. If installation above a hard ceiling is unavoidable, an access panel of sufficient size for maintenance shall be provided.

 - B. Rectangular ceiling diffusers shall include volume damper adjustable from diffuser face.

 - C. The maximum length of flexible duct shall be 6'-0". The total limit shall be one 90 degree bend for each branch.



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- D. Flexible duct shall not be used in exposed applications.
- E. Rectangular ell or tee fittings shall be equipped with turning vanes. Turning vanes are not required if a full radius elbow is used.
- F. Preference that duct insulation to be external where feasible.

SECTION 23 57 16 STEAM-TO-WATER HEAT EXCHANGER

- 1. GENERAL.
 - A. Shell and tube, U-Bends, with removable tube bundle.
 - B. Provide two modulating steam control valves with 1/3 and 2/3 capacity if system capacity exceeds 2" control valve size.
 - C. Tube bundle shall be supplied with copper tubes: minimum 3/4" diameter; 0.049" (18 gauge) minimum wall thickness.
 - D. Baffles, tie rods, spacers shall be brass.
 - E. Install with isolation valves and connections to allow removal of the tube bundle with minimal disturbance.
- 2. PRODUCTS.
 - A. APPROVED MANUFACTURERS:
 - 1. Armstrong
 - 2. Bell & Gossett
 - 3. Taco

SECTION 23 70 00 AIR HANDLING UNITS

- 1. GENERAL.
 - A. Rooftop air handlers are prohibited.
 - B. Systems shall include air-side economizer mode to reduce energy consumption.
 - C. Double wall panel construction
 - D. Stainless Steel drain pans
 - E. Ground level air intakes shall be elevated a minimum of 2-feet above grade. Vegetation, mulch, etc. shall be a minimum of 3 feet away from intakes.
 - F. Access doors full size to allow service and removal of coils, fan, bearings, motor and filter. Access for each coil shall be provided upstream, downstream and at each end.
 - G. AHU access sections shall be equipped with internal lights.



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- H. Hot Water and Chilled Water Coils shall have aluminum fins, aluminum casing, copper tubes minimum 0.025" wall thickness.
- I. Provide a dirt leg with blowdown valve on all chilled water supply and returns at the coil.
- J. Coil vent and drain connections shall be extended to outside of the AHU cabinet and fitted with a ball valve and plug.
- K. Provide extensions to lubricate fittings which are difficult or hazardous to reach.
- L. Steam preheat coils shall be used for outside air. Coils shall have sufficient pitch to completely drain the coil in the event of a trap failure. Controls shall utilize a 2-position control valve with modulating face/bypass damper for temperature control.
- M. Freeze protection shall be provided on all air handling units utilizing fresh air makeup. Freezestat shall stop the supply fan, close outside air damper, open heating coil valve and open cooling coil valve. Freezestat shall alarm to the DDC system and require a manual reset.
- N. Provide factory-built filter section with minimum MERV 8, 2" thick pleated filters. Only filters for critical areas are to have DP sensors connected to the campus BAS System. Provide Magnehelic or inclined manometer on other filters.
- O. Install new filters at substantial completion. Submit written documentation indicating the date and equipment where new filters are installed.
- P. Fans shall be mounted on spring isolators, ensure shipping chocks are removed.

2. PRODUCTS.

A. APPROVED MANUFACTURERS:

- 1. Trane
- 2. Daikin
- 3. Carrier
- 4. York-JCI

SECTION 23 82 19 FAN COIL UNITS

1. GENERAL.

- A. DP sensors are not required for fan coil unit filters.
- B. Condensate removal shall be gravity flow. Condensate pumps are prohibited unless specifically approved by the owner.
- C. Provide extended end pockets for piping, controls, and accessories.
- D. Hot water coil shall be in the reheat position.



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- E. Early in the project, construct a mock-up installation for one fan coil. Mock-up shall be typical of piping, wiring, accessories and controls. Mock-up shall be approved prior to shipment of the remaining units from the factory.
 - F. The campus DDC system shall control fan speed (Hi-Med-Low), cooling valve, and heating valve.
 - G. Hot Water and Chilled Water Coils shall have aluminum fins, aluminum casing, copper tubes minimum 0.025" wall thickness.
 - H. Filter shall be 1" thick, throw-away type located in the return air.
 - I. At the end of the project, clean all units of construction debris by:
 - 1. Vacuum clean coils and inside of cabinets
 - 2. Repair or replace construction damage to maintain new factory finish
 - 3. Install new filters at substantial completion
2. PRODUCTS.
- A. APPROVED MANUFACTURERS:
 - 1. Trane
 - 2. Daikin
 - 3. York-JCI
 - 4. IEC