23 00 00 – Heating, Ventilating, and Air-Conditioning (HVAC)

23 00 00 General Information

1. Architects and Engineers are responsible for the design of HVAC systems that will meet the primary objective of providing environmental comfort for building occupants. The HVAC system design package shall be complete, coordinated, and technically correct. In addition, the HVAC systems shall be safe, easily accessible for repairs and maintenance, energy efficient, and in compliance with the prescribed noise, seismic and vibration levels. Any deviations from this guideline must be made through consultation with CCU’s Facilities Management staff.

2. HVAC systems shall combine together with other building systems to meet the project’s energy target. HVAC systems must be coordinated and integrated with all other building systems and features. HVAC systems shall generally be designed to exceed the minimum performance requirements of ASHRAE Standard 90.1 and incorporate cost effective energy conservation measures that do not compromise building performance or occupant comfort.

3. Reference Standards:
   - ASHRAE: Standard 52.2: Method of Testing: General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
   - ASHRAE: Standard 62: Ventilation for Acceptable Indoor Air Quality
   - ASHRAE: Standard 100: Energy Conservation in Existing Buildings
   - ASHRAE: Standard 135: BACnet: A Data Communication Protocol for Building Automation and Control Networks
   - ASHRAE: Guideline #4: Preparation of Operating and Maintenance Documentation for Building Systems
   - ASHRAE: Guideline #12: Minimizing the Risk of Legionellosis Associated with Building Water Systems
   - SMACNA: HVAC Duct Construction Standards: Metal and Flexible
   - SMACNA: HVAC Air Duct Leakage Test Manual
   - SMACNA: Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
   - SMACNA: Seismic Restraint Manual Guidelines for Mechanical Systems
   - NFPA Standard 96
   - All applicable regulations and requirements of local utility companies having jurisdiction

4. Generally, rooms that house Information Technology (IT) and communication equipment shall be conditioned. This shall be coordinated with the CCU Project Manager for each project.
23 05 10 Mechanical Coordination

1. Contractor shall prepare a set of coordination drawings showing the coordination of the major elements, components and systems of the mechanical work, and showing the coordination of mechanical work with other work. Prepare drawings at accurate scale and sufficiently large to show locations of every item, including clearances for installing, maintaining, insulating, breaking down equipment, replacing motors and similar requirements. Drawings shall indicate coordination with all other trades including, but not limited to, lighting, structural, plumbing and architectural items. Where applicable, existing conditions shall be accounted for. Prepare drawings to include plans, elevations, sections and details as needed to conclusively show successful coordination and integration of the work. Submit drawings for review by the Architect/Engineer.

23 05 13 Common Motor Requirements for HVAC Equipment

1. Specify all motors greater than 1 HP as NEMA premium efficiency type. NEMA Publications MG 1 and MG 2 shall apply to alternating current, fractional and integral horsepower motors. Motor enclosures shall be NEMA types which are most suitable for the environmental conditions where the motors are being installed.

2. Motors less than or equal to 1/2 HP shall be specified as single phase. Motors greater than 1/2 HP shall be specified as three phase. Exception: motors less than 1 HP may be single phase provided the manufacturer of the proposed equipment cannot supply three phase.

3. Energy Efficient Motors (Motor Efficiencies): All permanently wired polyphase motors 1 HP or greater shall meet the minimum full-load efficiencies as indicated in the following table. Motors 1 HP or more with open, drip-proof or totally enclosed fan-cooled enclosures shall be NEMA premium efficiency type, unless otherwise indicated.

4. WEG motors shall not be used.
Minimum Efficiencies

<table>
<thead>
<tr>
<th>Rating kW (HP)</th>
<th>1200 RPM</th>
<th>1800 RPM</th>
<th>3600 RPM</th>
<th>Rating kW (HP)</th>
<th>1200 RPM</th>
<th>1800 RPM</th>
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<td>86.5%</td>
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<td>7.5</td>
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<td>93.6%</td>
<td>74.6 (100)</td>
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<td>95.4%</td>
<td>94.1%</td>
<td>93.3 (125)</td>
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<td>94.1%</td>
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<td>95.0%</td>
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<td>95.0%</td>
<td>149.2 (200)</td>
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<td>96.2%</td>
<td>95.4%</td>
</tr>
</tbody>
</table>

19 Meters and Gauges for HVAC Piping

1. Specify full line size valved bypass with ball or butterfly valve for liquid service meters.
2. Specify one pressure gauge per pump, with taps before strainers and on suction and discharge of pump.
3. Specify pressure gauges with pulsation dampeners. Specify gauge cock to isolate each gauge. Pressure gauges shall have maximum readings approximately two times the expected working pressure.
4. Specify gauges and thermometers to be in locations where they are easily read from normal operating level, to be installed vertical to 45 degrees from vertical.

5. Specify test plugs to be installed adjacent to thermometers and thermometer sockets.

6. Provide temperature gauges in lieu of thermometers.

7. Differential pressure gauges, switches, transmitters, sensors and transducers, flow meters and flow switches, and liquid level switches: Emerson Process, Orange Research, or Yokogawa.

8. Applications: Monitoring filtration equipment, compressors and heat exchangers.

9. Pressure Gauges: Ashcroft, Dwyer Instruments, Inc; Moeller Instrument Co., Inc; Tre- rice, Weksler

10. Dial Thermometers: Ashcroft, Dwyer Instruments, Inc; Moeller Instrument Co., Inc; Trerice; Weksler Glass Thermometer Corp

Static Pressure Gauges: Ashcroft, Dwyer Instruments, Inc; Omega Engineering, Inc; Trerice; Weksler Glass Thermometer Corp.

23 05 23 General Duty Valves for HVAC Piping

1. HVAC Water Systems:
   a. Bronze Ball Valves
      i. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
            a. Apollo 77C 140 Series (Basis of Design).
            b. NIBCO T-585-70-66.
            c. Milwaukee BA 400S.
         2. Description:
            b. SWP Rating: 150 psig.
            c. CWP Rating: 600 psig.
            e. Body Material: Bronze.
b. Iron Ball Valves

i. Class 125, Iron Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo (Basis of Design)
   b. Kitz Corporation - #90/91.
   c. Watts Regulator Co.

2. Description:
   b. CWP Rating: 200 psig.
   d. Body Material: ASTM A 126, gray iron.
   e. Ends: Flanged.
   f. Seats: PTFE or TFE.
   g. Stem: Stainless steel.
   h. Ball: Stainless steel.
   i. Port: Full.

C. Iron Butterfly Valves

i. All lug style, 200 CWP, Iron Body Butterfly Valves with EPDM Seat and Aluminum-bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

b. Demco NEC5114351.

c. Kitz Corporation - #6123E/6121E.

2. Description:

a. Standard: MSS SP-67, Type I.

b. CWP Rating: 200 psig.

c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.

d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.

e. Seat: EPDM.

f. Stem: One- or two-piece stainless steel.

g. Disc: Aluminum Bronze.

d. Iron Swing Check Valves

i. Class 125, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. NIBCO F-918-B

b. Milwaukee F-2974-A

c. Crane 373

d. Kitz Corporation - #78.

2. Description:

a. Standard: MSS SP-71, Type I.

b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.

c. Body Design: Horizontal Swing

d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.

f. Disc: Bronze.ASTM B 584

g. Gasket: Synthetic Fibers

2. Shutoff Valves: Valves 2 inches and smaller for hydronic service shall be ball valves.

3. Shutoff Valves: Valves 2-1/2 inches and larger for hydronic service shall be lug type butterfly valves.

4. Check Valves for hydronic and domestic service shall be swing type.

5. Check Valves for hydronic and domestic service shall be swing type.

5. Drain Valves: Valves shall be bronze construction with a composition disc, angle body, hose end connection and bronze cap and chain. HVAC Drain Valves: Kitz 58CC, Powell 503HS, Crane 117, Jenkins No. 372.

6. Handle extensions shall be provided on valves to ensure accessibility above pipe insulation.

7. Valves shall be full port to support reduced friction loss.

23 05 29 Hangers & Supports for HVAC Piping and Equipment

1. Specify hangers for all insulated domestic supply lines as clevis type.

2. Trapeze hangers are acceptable for multiple pipe runs. Where insulated pipe is installed on top of trapeze, insulation shall be hard self supporting type for a distance of 12” each side of trapeze. Specify 12” long 16 gauge galvanized steel saddle for bottom half of insulation circumference between insulation and trapeze. Insulated domestic supply lines shall be specified with a shield. Uninsulated copper lines installed on top of trapeze shall be wrapped with Unistrut Uni-Cushion elastomer material and P-2600 clamp to isolate copper from steel trapeze and pipe clamp.

3. Shields shall be a minimum of 12” inches long. Shields for all pipe sizes shall be 18 gauge galvanized steel.

4. Hangers for domestic hot and cold water lines and refrigerant lines shall be copper plated band type with adjusting nut.

5. Hangers for HVAC Water lines 2-1/2 inches and larger shall be roller type.

6. Hangers for HVAC Water lines 2 inches and smaller shall be the standard Clevis type.

7. Products:
   a. Domestic Water Clevis Type Hangers: Michigan, Model 403 or approved equal
b. Hangers for domestic hot and cold water lines and refrigerant lines: Michigan Fig. 101, Grinnell, Fig. CT 69, B-Line Fig. B 3172CT, Carpenter & Patterson Fig. 800 CT, or F & S Fig. 87 CT.

c. Hangers for cast iron or plastic drain and vent piping: Michigan Fig. 400, Clevis type, B-Line Fig. B 3100, Carpenter and Patterson Fig 100 or F & S Fig 86.

d. Hangers for HVAC Water lines 2-1/2 inches and larger: B-Line Fig. B 3110 or Michigan Fig. 610 for overhead support of single lines and B-Line Fig. B 3118 SL or Michigan Fig. 619 adjustable roller chair for base mounted hangers.

e. Hangers for HVAC Water lines 2 inches and smaller: B-Line Figure B3100 or Michigan Fig. 400. Equivalent by Carpenter & Patterson or F & S are acceptable.

23 05 33 Heat Trace for HVAC Systems

1. Specify UL Listed, CSA Certified, or FM Approved system of heating cables, components, and controls to prevent pipes from freezing, provide freeze protection of sprinkler system piping, provide flow maintenance of grease lines, and/or provide flow maintenance for fuel oil. The self-regulating heater shall consist of two nickel-plated copper bus wires embedded in a radiation cross-linked semiconductive polymer core. The heater shall be capable of varying its heat output along its entire length, allowing the heater to cross over itself without overheating. The heater shall be covered by a polyolefin dielectric jacket rated 300 VAC at 105°C and a tinned copper braid (12 AWG equivalent wire size).

2. In addition to a tinned copper braid, the heating cable shall be covered by a polyolefin outer jacket for protection from aqueous inorganic chemicals.

3. The heater shall operate on a line voltage of 110-120 VAC without the use of transformers.

4. The heating cable shall be suitable for use on metallic and nonmetallic piping. On nonmetallic piping, the cable shall be attached to the pipe with a parallel covering of aluminum tape.

5. The heating cable shall be controlled by a bimetallic pipewall sensing thermostat preset at 40°F with a switch rating of 22 amps at 120/240/277 VAC based on current loads for each circuit. Where the load of the heating cable exceeds the rating of the thermostat, the heating cable shall be controlled through an appropriately sized contactor by the control thermostat.

6. All heating cable core shall be permanently marked with the manufacturer's identification number for traceability.

7. Acceptable products and manufacturers: FLXTM cable and accessories as manufactured by Thermon or equal by Raychem, or Nelson.
8. Refer to the manufacturer’s freeze protection design guide for design details, insulation requirements, maximum circuit lengths and accessory information.

23 05 48 Vibration and Seismic Controls for HVAC Piping and Equipment

1. It shall be the Contractor’s responsibility to provide the Manufacturer all information necessary to properly determine the appropriate vibration isolation, wind load and seismic bracing techniques required for each piece of equipment.

2. Contractor shall be required to submit stamped calculations and installation instructions and drawings from a Registered Professional Engineer (PE) for each piece of equipment that requires wind load and/or seismic bracing. Calculations shall provide proof against catastrophic failure generated by wind load forces and seismic acceleration as outlined in International Building Code.

3. The following equipment/piping installation scenarios shall be addressed: Floor mounted equipment, platform/pad mounted equipment, suspended equipment/piping, and roof mounted equipment.

4. Noise Criteria:
   a. Noise levels in all 8 octave bands due to equipment and duct systems shall not exceed following NC levels:

<table>
<thead>
<tr>
<th>TYPE OF ROOM</th>
<th>NC LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditoriums, Theaters</td>
<td>35</td>
</tr>
<tr>
<td>Bathrooms and Toilet Rooms</td>
<td>40</td>
</tr>
<tr>
<td>Chapels</td>
<td>35</td>
</tr>
<tr>
<td>Conference Rooms</td>
<td>35</td>
</tr>
<tr>
<td>Corridors(Public)</td>
<td>40</td>
</tr>
<tr>
<td>Dining Rooms, Food Services/ Serving</td>
<td>35</td>
</tr>
<tr>
<td>Gymnasiums</td>
<td>50</td>
</tr>
<tr>
<td>Kitchens</td>
<td>50</td>
</tr>
<tr>
<td>Laboratories</td>
<td>45</td>
</tr>
<tr>
<td>Laundries</td>
<td>50</td>
</tr>
<tr>
<td>Lobbies</td>
<td>40</td>
</tr>
<tr>
<td>Locker Rooms</td>
<td>50</td>
</tr>
<tr>
<td>Offices, large open (3 or more occupants)</td>
<td>40</td>
</tr>
<tr>
<td>Offices, small private (2 or fewer occupants)</td>
<td>35</td>
</tr>
</tbody>
</table>
Recreation Rooms  |  50  
Shops           |  50  
Warehouse       |  50  

b. Internal duct liner is not permitted. Ducts shall be equipped with sound attenuators for sound critical applications.

5. Products:
   a. Mason Industries, Vibration Mountings and Controls, Amber Booth

23 05 53 Identification for HVAC Piping and Equipment

1. All piping, ductwork, and equipment shall be labeled.

2. General: Product manufacturer's standard pre-printed, flexible or semi-rigid, permanent, color-coded, plastic-sheet pipe markers, complying with ANSI A13.1. Indicate type of service, direction of flow, and service.


4. Valve Tags: Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and valve number shall be installed on all valves, except those valves installed on supplies at plumbing fixtures. Tags shall be 1-3/8 inch minimum diameter and marking shall be stamped or engraved. Indentations shall be black, for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain, or plastic straps designed for that purpose.

   a. Plastic Labels for Equipment:
      i. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
      
      ii. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
      
      iii. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
      
      iv. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
v. Fasteners: Stainless-steel rivets or self-tapping screws.

vi. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

b. Label Content: Include equipment's Drawing designation or unique equipment number.

c. Equipment Label Schedule: For each item of equipment to be labeled, provide the following on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number, identify Drawing numbers where equipment is indicated (plans, details, and schedules), and list the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

5. Duct Labels

a. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

b. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

c. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

d. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

e. Fasteners: Stainless-steel rivets or self-tapping screws self-tapping screws.

f. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

g. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

i. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

ii. Lettering Size: At least 1-1/2 inches high

iii. Where multiple systems of the same generic name are shown and specified, provide identification which indicates the individual system number as well as the service; for example, Heat Pump No. HP-1, Exhaust Fan No. EF-1.
6. Fire Damper Identification:

a. Fire Damper Access Doors shall be provided with a plastic label as described above (ie FD-1, FD-2, etc.).

b. Ceiling tiles shall be provided with a corresponding plastic label so that fire damper access locations can be identified from below.

c. At conclusion of work, the contractor shall provide a fire damper schedule and a corresponding plan that shows the locations of all fire dampers and their corresponding marking (ie FD-1, FD-2, etc.).

23 05 93 Testing, Adjusting, and Balancing for HVAC

1. Required testing, adjusting, and balancing include:

a. All air conditioning equipment including air distribution devices, supply ducts, air handling units, fans, coils, and related equipment.

b. All hydronic systems including pumps, water distribution systems, coils, and related equipment.

2. Specify that the Contractor provide a copy of the TAB Report within each operating and maintenance manual.

3. Specify that TAB Contractor include an extended warranty of 90 days after submission of a completed balancing report, during which time the Owner may request a recheck of no more than 10% of total number of terminals, or resetting of any outlet, coil, or device listed in the test report. This Warranty/Guarantee must meet one of the following programs: TABB International Quality Assurance program, AABC national project performance guarantee, or NEBB’s Conformance Certification.

23 07 13 Ductwork Insulation

1. All supply, return and outdoor air ducts shall be insulated with duct wrap. Rectangular supply and return ductwork located in the mechanical room shall be externally insulated with rigid fiberglass board insulation.

2. Products:

a. Owens Corning, Manville, or Certainteed.

23 07 19 HVAC Piping Insulation

1. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells.

a. Products: Subject to compliance with requirements, provide one of the following:
b. Pittsburgh Corning Corporation; Foamglas Super K.
c. Block Insulation: ASTM C 552, Type I.
d. Special-Shaped Insulation: ASTM C 552, Type III.
e. Board Insulation: ASTM C 552, Type IV.
f. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
g. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
h. Factory fabricated shapes according to ASTM C 450 and ASTM C 585.

2. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
   a. Products: Subject to compliance with requirements, provide one of the following:
      i. Aeroflex USA Inc.; Aerocel.
      ii. Armacell LLC; AP Armalflex.

3. Mineral-Fiber, Preformed Pipe Insulation:
   a. Products: Subject to compliance with requirements, provide one of the following:
      i. Johns Manville; Micro-Lok.
      ii. Knauf Insulation; 1000 Pipe Insulation.
      iii. Owens Corning; Fiberglas Pipe Insulation.
   b. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   c. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, without factory-applied jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

4. Aluminum Jackets shall be provided on all exterior insulated pipes and all pipes located in mechanical rooms where pipe is less than 8'-0" above finished floor. Jacket shall be corrugated, embossed or smooth sheet, 0.016 inch nominal thickness, ASTM 8 209, temper H14, type 3003, 5005 or 5010.

5. Above Ground Heating Water Supply and Return: Fiberglass 1 inch thick for piping up to and including 1-1/2 inch diameter. 2 inches thick for piping 2 inches diameter and greater. Insulation shall be preformed, two-piece, heavy density fiberglass with self sealing ASJ jacket conforming to ASTM C547, Type I. Valves and fittings shall be insulated with fiberglass insulation of the same material thickness as insulation on adjacent pipe and having a molded PVC jacket. Jackets shall be Certainteed Snap-Form or Zeston PVC.

6. Above Ground Chilled Water: Cellular Glass Insulation 1-1/2 inches thick for pipe sizes up through 4 inch diameter. 2 inches thick for pipe sizes 5 inch through 12 inch diameter. Jacketing for indoor applications shall be all purpose type of Kraft
paper/aluminum foil/vinyl coating construction by Lamtec Corporation, Compac, or Alpha Associates. Jacketing for outdoor applications shall be 0.016 inch aluminum. Insulation on elbows and fittings shall be finished with PITTCOTE 404 coating or equivalent reinforced with white open weave membrane with maximum mesh opening of 10 X 10 per inch. All joints and seams shall be sealed full depth (i.e. from inner surface to outer surface) with PITTCOTE 444N Sealant or equal.

7. Cooling Condensate Drains: Closed Cell Foam 1/2 inch thick for all sizes.

8. Refrigerant Suction Lines: Closed Cell Foam 1/2 inch thick for all sizes.

9. Heat Pump water and Cooling tower piping: Fiberglass 1 inch thick for all sizes. Vapor Barrier Jacket: Self Sealing White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E 96/E 96M of 0.02 perm-inches (0.029 ng/Pa s m).

10. HVAC Drain Piping, HVAC Pumps, All Hydronic specialties, HVAC Air separators: Flexible Closed-cell Elastomeric Insulation meeting ASTM C534. APArmaflex, APArmaflex W, APArmaflex SS, or APArmaflex SA.

23 09 13 Variable Speed Drives

1. Except for when Variable Frequency Drives (VFD) are used in conjunction with Direct Expansion (DX) systems, controls contractor (CMI) shall provide the VFD’s.

2. Products: ABB, Danfoss, Siemens

23 09 23 Direct-Digital Control System for HVAC

1. Specify that the Building Automation System (BAS) manufacturer furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and a complete temperature control system.

2. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specifically for a project. Require that all systems and components have been thoroughly tested and proven in actual use for at least two years.

3. Products: Siemens (extend existing Siemens campus network control systems). Contact: Control Management, Inc.: (803) 765-9070

23 21 13 Hydronic Piping

1. Copper Tube And Fittings
a. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

b. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

c. Wrought-Copper Fittings: ASME B16.22.

d. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
i. Anvil International, Inc.
   
ii. S. P. Fittings; a division of Star Pipe Products.
   
iii. Victaulic Company.


3. PVC Pipe and Fittings
   
a. Pipe and fittings shall schedule 40 or 80 manufactured from PVC compound with a cell class of 12454 per ASTM D 1784 and conform with National Sanitation Foundation (NSF) standards 14 and 61. Pipe shall be iron pipe size (IPS) conforming to ASTM D 1785. Socket fittings shall conform to ASTM D 2467; threaded fittings shall conform to ASTM D 2464 or D 2467. Flanges shall be 150# type per ANSI/ASME B 16.5.

b. All pipe and fittings to be produced by a single manufacturer and to be installed in accordance with manufacturer’s recommendations and local code requirements. Buried pipe shall be installed in accordance with ASTM F 1668. Solvent cements shall conform to ASTM D 2564, primer shall conform to ASTM F 656. PVC pipe and fittings shall be manufactured by Charlotte Pipe and Foundry or approved equal.

4. Steel Pipe and Fittings
   
a. Steel Pipe: ASTM A 53 Grade B, seamless or ERW, Schedule 40.

b. Stainless Steel Pipe. ASTM A312, Schedule 40.

c. Butt Welding: ASME B16.9 with same wall thickness as connecting piping.

d. Forged Steel, Socket Welding or Threaded: ASME B16.11.

e. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.


g. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.
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h. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

i. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

j. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:


l. End Connections: Butt welding.

m. Facings: Raised face.

n. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

5. Joining Materials

a. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

b. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

c. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

d. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

e. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.


g. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

h. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

i. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

j. Solvent Cements for Joining Plastic Piping: Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Piping Applications

a. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:
   i. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints for NPS 1 and smaller, and brazed joints for NPS 1-1/4 to NPS 2.
   ii. Schedule 40 steel pipe; 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

b. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:
   i. Schedule 40 steel pipe, wrought-steel fittings and forged-steel flanges and flange fittings, and welded and flanged joints.

c. Hot-water heating piping installed belowground and within slabs or valve boxes shall be either of the following:
   i. Schedule 40 steel pipe, wrought-steel fittings and forged-steel flanges and flange fittings, and welded and flanged joints. Flanged connections or fittings shall not be allowed below grade unless enclosed in a valve or distribution box.

d. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
   i. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints for NPS 1 and smaller, and brazed joints for NPS 1-1/4 to NPS 2.
   ii. Schedule 40 steel pipe; Class 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

e. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:
   i. Schedule 40 steel pipe, wrought-steel fittings and forged-steel flanges and flange fittings, and welded and flanged joints.

f. Chilled-water piping installed belowground and within slabs shall be:
   i. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints. Flanged connections or fittings shall not be allowed below grade unless enclosed in a valve or distribution box.
g. Condenser-water piping, aboveground, NPS 2 and smaller, shall be any of the following:

i. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints for NPS 1 and smaller, and brazed joints for NPS 1-1/4 to NPS 2.

ii. Schedule 40 steel pipe; Class 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

h. Condenser-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

i. Schedule 40 steel pipe, wrought-steel fittings and forged-steel flanges and flange fittings, and welded and flanged joints.

i. Make-up-water piping, aboveground, NPS 2 and smaller, shall be any of the following:

i. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints for NPS 1 and smaller, and brazed joints for NPS 1-1/4 to NPS 2.

ii. Schedule 40 steel pipe; Class 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

j. Make-up-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

i. Schedule 40 steel pipe, wrought-steel fittings and forged-steel flanges and flange fittings, and welded and flanged joints.

k. Rainwater Harvesting piping, below grade, NPS 2 and smaller, shall be the following:

i. Schedule 80 PVC pipe and fittings.

l. Rainwater Harvesting piping, below grade, NPS 2-1/2 and larger, shall be the following:

i. Schedule 80 PVC pipe and fittings.

m. Rainwater Harvesting piping, aboveground, all sizes, shall be any of the following:

i. Schedule 40 Stainless Steel with Socket or butt weld fittings.

n. Cooling Condensate Return piping, below grade, NPS 2 and smaller, shall be the following:
i. Schedule 80 PVC pipe and fittings.

o. Cooling Condensate Return piping, below grade, NPS 2-1/2 and larger, shall be the following:
   i. Schedule 80 PVC pipe and fittings.

p. Cooling Condensate Return piping, aboveground, NPS 2 and smaller, shall be the following:
   i. Schedule 40 Stainless Steel with Socket or butt weld fittings.

q. Cooling Condensate Return piping, aboveground, NPS 2-1/2 and larger, shall be the following:
   i. Schedule 40 Stainless Steel with Socket or butt weld fittings.

r. Condensate-Drain Piping: Type M or DWV, drawn-temper copper tubing or PVC schedule 40 DWV, wrought-copper fittings, and soldered joints or PVC fittings.

s. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

t. Chemical Feed Piping:
   i. Steel: ASTM A53 Grade B, seamless or ERW, schedule 40, ¾” size minimum.
   ii. Fittings: Forged steel, socket welding, ASME B16.11.

u. Air-Vent Piping:
   i. Inlet: Same materials and joining methods as for piping specified for the service in which air vent is installed.

      Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

   ii. Safety-Valve-Inlet and -Outlet Piping for Chilled and Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

v. Make-up water and expansion tanks shall be provided on hydronic systems, even if the systems are served from a campus central loop.

23 21 23 Hydronic Pumps

1. Furnish and install, as indicated on the plans and specifications, end-suction, base mounted centrifugal pumps. The pump shall be single, end suction type with radially
split, top center-line discharge, self-venting casing. The casing-to-cover gasket shall be confined on the atmospheric side to prevent blow-out possibility. Pump construction shall be cast iron, bronze fitted (all iron, all bronze, ductile iron) and shall be fitted with a long-life, product lubricated, drip-tight mechanical seal, with O-ring silicone carbide seat retainer, designed for the specified maximum temperature and pressure.

2. The shaft shall be fitted with a Stainless Steel shaft sleeve and be supported by two heavy duty ball bearings. The design shall allow Back Pull Out servicing, enabling the complete rotating assembly to be removed without disturbing the casing piping connections.

3. The pump shall be mounted on a rigid baseplate, designed to ANSI/HI 1.3.5 rigidity standards, for grouting or freestanding, and connected by flexible coupling, with OSHA guard, to an open drip proof enclosure squirrel cage, induction type motor of Federally approved premium efficiency level and suitable for across-the-line (wye-delta, part wind) starting. The housing shall be hydrostatically tested to 150% maximum working pressure. The unit shall be suitable for the conditions shown on the pump schedule.

4. Water pump motors such as those used in chilled water, hot water, and condenser water systems are recommended to be Totally Enclosed Fan Cooled (TEFC) type motors.

5. Cooling Tower fan motors and other motors placed outside shall be TEFC type motors.

6. If inline pumps are utilized, they shall be installed so that they are accessible from the ground. They shall not be installed up high where maintenance becomes more difficult.

7. Products: Armstrong, Bell and Gossett, Peerless

23 25 13 HVAC Water Treatment

1. Acceptable Vendors:
   
   
   b. Nalco.
   
   c. ChemTreat, Inc.
   
2. Products:
   
   a. Chemical Feed Bypass Feeders: Provide bypass feeders with a capacity of 5 gallons. The feeder shell shall be constructed of 10 gauge steel minimum. Tank heads shall be a minimum of 9 gauge steel. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      
      i. Neptune (basis of design)
      
      ii. A&F Machine Products
iii. Automatic Chemical Feed Systems:

i. Description: Include a microprocessor based controller, three (3) chemical feed pumps (two biocide, one corrosion inhibitor/dispersant), three (3) injection fittings, and an electric motorized ball-type blow down valve assembly with strainer and inlet isolation ball valve, inlet and outlet isolation ball valves, inlet strainer, sample connection, flow switch assembly, and conductivity elements. Provide controllers, pumps, piping, valves, fittings, and wiring all factory packaged, piped, wired and assembled on a corrosion resistant wall panel.

ii. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advantage Controls (Basis of Design).
2. Pulsafeeder.
3. Walchem.

c. Chemical Feed Pumps:

i. Description: Diaphragm type metering pump, adjustable single head, 12 gallon per day maximum flow, 150 psig, 115 volts, self-priming, 4 foot suction lift, 100:1 turndown ratio, ABS plastic body material, PVC/polyethylene tubing material, PTFE seals and O-rings, ceramic ball, PTFE faced diaphragm, polypropylene head and fittings, and adjustable speed and stroke controls. Pump shall include foot valve/strainer assembly, backpressure injection valve assembly, bleed valve, 4 feet suction tubing, 8 feet discharge tubing, and 4 feet bleed valve tubing.

ii. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Pulsafeeder Model LB03SA-PTC1-G19 (basis of design)

iii. Piping:

1. Steel: ASTM A53 Grade B, seamless or ERW, schedule 40, ¾” size minimum.
2. Fittings: Forged steel, socket welding, ASME B16.11.

iv. Bleed Valve Assembly:

1. Provide with fully ported ball valves, motorized open with spring return for fail-safe operation. Maximum pressure 150 psig at 212
degrees F. Valve body shall be nickel plated brass, with chrome plated brass ball and stem, and Teflon seals. Provide ¾” size minimum. Actuator shall be 115 volt.

NOTE: The chemical system requirement is a liquid chemical feed system only. No dry chemical systems allowed.

23 31 13 HVAC Ducts and Casings

1. All supply, return and outdoor air ducts shall be insulated with duct wrap. Rectangular supply and return ductwork located in mechanical rooms shall be externally insulated with rigid fiberglass board insulation.

2. All supply, return, exhaust, relief, and outside air systems shall be fully ducted between the fans and air inlets/outlets. Use of the space between the structural ceiling and the suspended ceiling is not permitted as an air plenum

3. Products:
   a. Owens Corning, Manville, or Certainteed.

23 33 00 Air Duct Accessories

1. Venturi Air Valves (serving Lab exhaust/supply air):
   a. Products: Siemens

2. Fire Dampers:

   a. See section 23 05 53 for additional information on Fire Damper Identification.

   b. All fire dampers shall be provided with an access door so that linkage can be tested, maintained, and replaced. The access door shall generally be 2” smaller than the ductwork (i.e. 12”x12” access door provided in a 14” wide duct); however it shall be no smaller than 8”x8”.

23 36 00 Air Terminal Units

1. Shutoff boxes shall be the minimum standard.

2. Consider parallel and series fan-powered boxes for “free” heating aspects.

4. Units shall be listed and labeled by UL as a complete assembly including electric heater.

5. Units shall be ARI-880 performance certified. Units shall be acoustically tested and rated per ARI-885

6. Provide factory mounted disconnect switch and control power transformer.
7. Fabrication
   a. Casings: Units shall be completely factory-assembled, manufactured of corrosion protected steel, and fabricated with a minimum of 18-gauge metal on the high pressure (inlet) side of the terminal unit damper and 22-gauge metal on the low pressure (outlet) side and unit casing.
   b. Plenum air filters shall be provided on all fan powered units.
   c. INSULATION – 1” thick Foil Faced or Dual Wall.
   d. INSULATION EDGE TREATMENT - All cut edges of insulation shall completely enclose by metal.
   e. Assembly: Primary air control damper, airflow sensor, fans, controls and optional heating coil in single cabinet.

8. Primary Air Control Damper Assembly
   a. Locate primary air control damper assembly inside unit casing.
   b. Provide damper assembly with integral flow sensor.
   c. Provide Hot Water or Electric Heating Coil as required by project.
   d. Provide electric heaters with mercury contactors for quiet heater staging.
   e. Electric heater shall be complete with automatic reset cutout and manual reset cutout.

9. Fan Assembly
   a. Unit shall be provided with series or parallel fan arrangement as indicated on drawings or schedule.
   b. Fan assembly shall be forward curved centrifugal fan with direct drive permanently lubricated, permanent split-capacitor type, thermally protected motor.

10. Direct Digital Controls
    a. Terminal unit manufacturer shall include factory mounting of direct digital controls provided by automatic temperature controls contractor.

11. Terminal Units shall be properly tagged and identified matching the design drawings. The identification in the electrical panel that serves terminal units shall be consistent with the identification on the terminal unit.

12. Terminal units shall be installed so that they are accessible and maintainable with a ladder no larger than 8’.

23 37 13 Diffusers, Registers, and Grilles

1. Supply Grilles: where 2x2 lay in ceilings are utilized, the preferred 4-way blow diffuser is the square plaque type. Where high ceilings are present, linear slots shall be considered.
2. Return Grilles: where ceiling mounted grilles are installed in 2x2 lay in ceilings, the preferred return grille are the eggcrate face type.

3. Perforated air distribution shall not be used.

4. Air distribution shall be constructed of aluminum, with a baked enamel finish.

5. Manufacturers: Price (Basis of Design), Metalaire, Titus.

**23 60 00 Central Cooling Equipment**

1. Packaged Water Chillers
   a. Evaluate and justify the choice of refrigerant for each project. The refrigerant shall be fully compatible with all local, state, and federal regulations. The refrigeration equipment selection shall be based on the EPA-approved refrigerants such as HFC 410a and HFC 134a. Design shall comply with the latest versions of ASHRAE Standard 15, Safety Code for Mechanical Refrigeration and ASHRAE Standard 34, Designation and Safety Classification of Refrigerants.
   
   b. Capacity of a single chiller shall not exceed 1,250 tons of refrigeration when rated at ARI conditions. All chillers shall be by a single manufacturer.
   
   c. Optimization: The chilled water supply and the chilled water temperature differential (between entering and leaving temperatures) shall be optimized during the system selection process. Consider selecting a chilled water supply temperature lower than 44°F and a chilled water temperature differential greater than 10°F.
   
   d. Design the mechanical cooling system based on hermetically sealed chillers. Include a note on the Contract Documents requiring the contractor to increase the cooling capacity to accommodate for open-centrifugal chillers.
   
   e. Air-cooled Chillers: air-cooled condenser coils shall be specified as extended-surface fin-and-tube type. Condenser coils shall be specified to be constructed of copper tubes and aluminum fins.

3. Products: Trane, Carrier, York

**23 5216 Condensing Boilers**

1. Description: Boiler shall be natural gas fired, fully condensing, fire tube design. Power burner shall have full modulation (the minimum firing rate shall not exceed 200,000 BTU/HR input. Boilers that have an input greater than 200,000 BTU/Hr at minimum fire will not be considered) and discharge into a positive pressure vent. Boiler efficiency shall increase with decreasing load (output), while maintaining setpoint. Boiler shall be
factory-fabricated, factory-assembled and factory-tested, fire-tube condensing boiler with heat exchanger sealed pressure-tight, built on a steel base, including insulated jacket, flue-gas vent, combustion-air intake connections, water supply, return and condensate drain connections, and controls. Basis of design boiler shall be Aerco Benchmark series, or approved equal by Buderus, Laars, Lochinvar, and Patterson-Kelly.

23 65 00 Cooling Towers

1. Provide a multi-cell induced draft, crossflow type, factory assembled, film fill, industrial duty, stainless steel cooling tower located as shown on the plans. Basis of design shall be SPX (Marley) with other acceptable manufacturers being BAC and Evapco.

23 70 00 Central HVAC Equipment

1. Indoor Central Station Air Handling Units
   a. The capacity of a single air-handling unit shall not exceed 40,000 CFM.
   b. Use of the blow-through air-handling units is not permitted, as fully saturated air leaving the cooling coil causes damage to the filters and sound attenuators on the downstream side.
   c. Chilled water and DX cooling coils shall be copper tube and aluminum fin construction. Select cooling coils for maximum face velocity of 500 Feet/Minute, with fin spacing not to exceed 132 Fins/Foot.
   d. Air handlers shall not be placed above ceilings due to maintenance accessibility concerns.
   e. Condensate pumps shall be avoided whenever possible. Little Giant is an acceptable manufacturer when absolutely necessary.
   f. Products: Trane, Carrier, York,

2. Custom Central Station Air Handling Units: Trane Custom, Webco, EAS, Annexaire, or Air Enterprise