23 00 00
GENERAL MECHANICAL REQUIREMENTS (HVAC)

1. **GENERAL**
   A. Related sections:
      i. 00 00 07 – Design Professional Design Process Requirements
      ii. 00 00 08 – Design Professional Documentation Requirements & Deliverables
      iii. 00 00 13 - Designing Learning Environments
      iv. 01 75 00 – Starting and Adjusting
      v. 01 77 00 – Project Closeout
      vi. 01 81 00 – Facility Performance Requirements
      vii. 01 91 13 – General Commissioning Requirements
      viii. 02 22 00 – Existing Conditions Assessment
      ix. 07 00 00 – General Thermal and Moisture Protection Requirements
      x. 11 53 13 – Laboratory Fume Hoods
      xi. 22 00 00 – General Plumbing Requirements
      xii. 23 05 14 – Variable Frequency Drives
      xiii. 23 05 19 – Meters and Gages
      xiv. 23 05 23 – General-Duty Valves for HVAC Piping
      xv. 23 05 29 – Hangers and Supports for HVAC Piping and Equipment
      xvi. 23 05 53 – Identification for HVAC Piping and Equipment
      xvii. 23 05 93 – Testing, Adjusting and Balancing for HVAC
      xviii. 23 07 13 – Duct Insulation
      xix. 23 07 19 – HVAC Piping Insulation
      xx. 23 09 23 – Building Automation and Temperature Control System
      xxi. 23 20 00 – HVAC Piping and Pumps
      xxii. 23 21 13 – Hydronic Piping
      xxiii. 23 21 23 – Hydronic Pumps
      xxiv. 23 22 13 – Steam and Condensate Heating Piping
      xxv. 23 22 16 – Steam and Condensate Heating Piping Specialties
      xxvi. 23 25 00 – HVAC Water Treatment
      xxvii. 23 31 13 – Metal Ducts
      xxviii. 23 33 13 – Dampers
      xxix. 23 41 33 – High Efficiency Particulate Air (HEPA) Filtration
      xxx. 23 64 46.13 – Air-Cooled Water Chillers
      xxxi. 23 64 16.16 – Water-Cooled Water Chillers
      xxxii. 23 65 00 – Cooling Towers
      xxxiii. 23 73 00 – Indoor Central-Station Air Handling Units
      xxxiv. 26 00 00 – General Electrical Requirements
   B. The Design Professional is recommended to refer to sections 00 00 07 Design Professional Design Process Requirements, 00 00 08 Design Professional Documentation Requirements and Deliverables, and 01 81 00 Facility Performance Requirement before beginning design.
   C. HVAC Design
      i. On schedules specify basis of design by make and model including all options. Design Professional shall verify all model numbers and determine if products are still currently in production.

ii. All equipment on design documents shall have unique ID including VAV terminals. This ID shall be maintained for all pipe and duct layout shop drawings and controls diagrams and graphics. Design Professional to discuss with Project Manager the equipment ID requirements.
iii. Design documents shall include a project specific owner approved Training Plan. The CxA, if employed on the project, shall assist in the preparation of the training plan.
iv. Design Professionals shall determine and specify R-values for AHUs, duct and pipe insulation thicknesses to prevent condensation on all cold surfaces inside the building run in spaces such as un-air-conditioned mechanical rooms attic and, crawl spaces under all operating conditions. R-Value of equipment and piping outside the building shall operate without condensation and shall be selected to prevent freezing under all operating conditions.
v. All equipment specified shall be suitable for the anticipated ambient conditions; electronic equipment such as temperature controls, VSDs, etc., in particular, shall be rated (or de-rated) to suit.
vi. All outdoor air intakes shall have separate minimum outdoor air damper sections.
vii. Check fan selection to insure fan can unload properly and maintain stability under the anticipated operating range. Fan system curves on VAV systems shall have the zero flow point at the set-point of the duct static controller, typically about 1.25” – 1.5”.
viii. Specify direct drive fans with VSD for all applications. Applications where use of a direct drive fan with VSD is not feasible shall be discussed with UGA and an approved variance obtained in writing. Belt drives using ‘cogged’ belts may be permitted through the variance process.
ix. The curb on all roof mounted exhaust fans shall be sealed to eliminate induction of air.
x. Fan static pressure calculations shall be based on filter 50% loaded conditions, and take into account, system effect, internal cabinet losses, external duct losses, and all internal losses due to coils, dampers, humidifiers, etc. Confirm all losses with basis of design manufacturer to ensure motors/fans are properly sized.
xi. The use of air side or water-side economizers shall be discussed with the Project Manager early in the design process.
xii. Once-through water cooled condensing units, heat pumps, etc., and including research/scientific equipment, growth chambers, cold rooms, x-ray machines and similar shall not be cooled with domestic water.
xiii. Flow measuring stations, dampers (including damper authority), sound attenuators (where required) shall be scheduled on the drawings.
xiv. Fan static pressure calculations shall be based on filter 50% loaded conditions, and take into account, system effect, internal cabinet losses, external duct losses, and all internal losses due to coils, dampers, humidifiers, etc. Confirm all losses with basis of design manufacturer to ensure motors/fans are properly sized. All fan motors shall be selected so the BHP at design does not exceed 85% of the motor nameplate Hp.

xv. See section 07 00 00 General Thermal and Moisture Protection Requirements – Roof Drains & Roofs for design requirements related to equipment on roofs.
xvi. Duct smoke detectors to be specified in Division 23 and shall be compatible with the new or existing fire alarm system.
xvii. Electrical equipment, disconnects, conduits, etc., shall be independently supported and not secured to mechanical equipment and ductwork.
xviii. In general, electrical equipment shall not be attached using a screw/bolt attachment through the equipment casing. When conditions do require attachment, attachment shall be made utilizing a stud type bonding fastener with perforated base adhered to the equipment casing with a compatible high strength structural adhesive.
xix. Fan coil unit drain pans shall be 16 gauge stainless steel.
xx. Sequences shall be provided and shown on the drawings for all packaged equipment, even if the controls are integral (not provided by BAS vendor). The documents shall clearly indicate what devices are provided by equipment vendor and what is provided by BAS vendor.
xxi. Packaged equipment provided with integral controls shall be provided with factory installed ALC controls when possible. If ALC controls are not provided at the factory, then a BACnet interface shall be provided. The equipment manufacturer shall provide as a minimum the following, as a part of the shop drawing submittal process:
    1. Specified project specific BACnet I/O point list for the unit with point names and addresses as shown on the drawings.
    2. Specified project specific sequence of operation for each unit
    3. Specified project specific control wiring diagram for unit
xxii. The Design Professional shall review all equipment. For equipment that requires interfacing with BAS, the Design Professional shall review equipment submittals with UGA BAS Contractor.

D. Design for Access
i. AHUs and FCUs are not allowed to be placed above a ceiling.
ii. Mechanical rooms at grade shall have exterior doors to grade level; mechanical drawings shall indicate path of travel for removal and replacement of the largest piece of equipment located in mechanical rooms, attic spaces, etc.
iii. Area required for coil pulls shall be shown to scale on drawings.
iv. Access doors/panels - shall be hinged, camlocked (not fixed by screws/bolts), airtight on ducts and AHUs; provide access to all devices with duct probes such as duct static sensors, humidifier manifolds, smoke detector probes, AFMS, etc.
v. VAV terminals, controllers and water valves shall be easily accessible. Locate in hallways or at entry to space where furniture or equipment will not be placed; access door/panel shall be provided upstream and downstream of re-heat coils to allow easy cleaning of coil.
vi. Access ladders shall be safe, shall not be vertical fixed to wall and shall allow maintenance personnel to scale with ease while carrying toolbox, filter, box or similar.
vii. All mechanical equipment shown to be located in an attic/penthouse mechanical area shall be coordinated with existing structure. Mechanical area accessibility shall be coordinated to provide the capability to remove and

replace mechanical equipment. Accessibility shall be indicated on drawings and shall be sufficient to allow removal of largest component of the mechanical equipment installed in the space. Coordination with other trades shall ensure that clear and safe paths to equipment are provided.

viii. Grease ducts shall be designed to minimize horizontal runs. Horizontal runs shall not exceed 10 feet, and shall be sloped in accordance with the governing codes. Each kitchen exhaust hood shall be provided with a single dedicated exhaust fan. Kitchens shall be provided with dedicated, mechanically cooled make-up air systems.

ix. When Heat Trace is specified, an indicator Light shall be provided. The heat trace shall be indicated on the BAS graphics.

x. Frost-free spigots shall be installed at cooling towers and at air-cooled chillers/condensing units to allow for field cleaning.

E. Design for Classrooms

i. General layout of fans, ductwork, and diffusers should take into account the layout of the classroom. To avoid excessive noise at the instructor station and movement of projector screens, do not locate ductwork and/or air diffusers near these areas.

ii. Locate mechanical equipment in the plenum requiring routine maintenance outside of the classroom space. This will allow the equipment to be serviced during classroom use, without causing disturbance. When above-ceiling equipment must be located within the classroom, locate it where it may easily be accessed by latter, preferably in an area where seating is not provided. Ensure that adequate space is provided to service equipment, to that issue will not arise later which impact the overall life cycle of the equipment.

iii. Building, mechanical, and machinery noise and vibration must be isolated from classrooms. Keep in mind the noise or vibrations from elevator, HVAC equipment and ducts, and light fixtures. Refer to ANSI/ASA S12.60- 2002 for maximum sound and vibration levels allowable at classrooms.

iv. It is important that HVAC equipment with the proper noise criterion (NC) ratings is provided in classroom spaces to reduce background noise levels. Proper installation of equipment is essential to ensuring that mechanical equipment does not transfer unwanted noise. Avoid locating main ductwork runs within classrooms spaces, and provide ductwork stiffening as needed. General classrooms should have HVAC equipment with NC 35 or less. Large classrooms with over 100 seats should have equipment with NC rating of 25 or less. In classrooms where video conferencing and/or distance learning take place, equipment should have a NC rating of 25 or less.

v. Consider providing tamper-proof thermostat covers. Ensure that thermostats are not located away from markerboards, cabinets, and away from heat producing equipment located within the room.

23 05 14
VARIABLE FREQUENCY DRIVE

1. **GENERAL**
   A. Related sections:
      i. 01 19 13 – General Commissioning Requirements
      ii. 01 75 00 – Starting & Adjusting
      iii. 01 77 00 – Project Closeout
      iv. 23 00 00 – Heating Ventilation and Air Conditioning
      v. 26 00 00 – General Electrical Requirements
2. **PRODUCTS**
   A. Acceptable manufactures are:
      i. ABB ACH 500 with by-pass mounted on the side of the VSD (basis of design)
      ii. Danfoss-Approved equivalent to above
      iii. Yaskawa-Approved equivalent to above
   B. Variable Speed Drive (VSD) and Variable-Frequency Drive (VSD) terms are interchangeable.
   C. Fan replacement shall be "plug-in" replaceable with the drive running and shall not require removal of components and /or opening of the drive enclosure.
   D. Variable Speed Drive (VSD) shall have integral reactive filters.
   E. Conduits shall be metal, separate for power input, power to the motor and controls;
   F. VSD shall have a built-in 5% impedance reactor / filter, I/O's for communication shall be integral with the drive enclosure.
   G. VSD shall be capable of withstanding a 10,000 volt spike, 50 joules of power, and input voltage variations from 408v up to 528v without tripping.
   H. VSD shall be rated (de-rated) for the anticipated operating conditions;
   I. Enclosure shall be NEMA 12. Note NEMA 12 enclosure is larger than NEMA 1. If space is a premium coordinate with Project Manager to confirm, through variance process, if NEMA 1 will be accepted.
   J. Warranty, including parts and on-site labor, shall be 36 months from Material Completion.
   K. VSDs shall have a manual by-pass switch.
   L. VSDs shall be native BacNet compatible and firmware shall allow the device MAC address to be manually configured. The VSD shall be capable of interfacing without the need for gateways. The controls contractor shall program the VSD to report, at minimum, fan power (Kw), air supply (cfm) to the Building Automation and Control System and trended.
   M. All motors driven by VSDs with shaft grounding rings shall be grounded to their source ground with no more than 25 ohms in resistance measurement.
   N. Drive of other approved manufacturer shall be provided with all optional extras required to meet the specification implied by the basis of design drive.
   O. Motors for equipment served by variable speed drives shall be Inverter-rated motors conforming to NEMA MG-1, Part 3, 1.15 service factor and class “F” insulation.
   P. Motors served by VSDs shall incorporate means to protect motor bearings from VSD-induced currents. To eliminate fluting, motor bearings shall have grounding ring to safely redirect shaft currents along a low-impedance path to ground. On new motors ring shall be factory installed. Existing inverter rated motors shall be field retrofitted by

adding a shaft grounding ring. The shaft grounding brushes shall be virtually frictionless, cause no wear and be unaffected by dirt, grease, or other contaminants. The grounding rings shall be AEGIS™ SGR split ring or approved equal installed in accordance with the manufacturer's instructions and recommendations.

Q. The VFD manufacturer shall provide CFM or GPM output to BAS vendor.

3. **EXECUTION**

A. The manufacturer or a factory trained authorized representative shall do, or be present at, the start-up. Start-up documentation certifying proper installation and start-up shall be included in the O&M manuals. See sections 01 75 00 – Starting & Adjusting and 01 77 00 – Project Closeout.

B. The CxA shall be responsible for coordinating with the drive manufacturer/vendor controls contractor and the TAB agency to ensure that VFDs are adjusted so that harmonic frequencies are skipped.

23 05 19
METERS AND GAGES

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 09 00 – Instrumentation and Control for HVAC
      iii. 23 09 23 – Building Automation & Temperature Control systems (BAS)
      iv. 33 00 00 – Utilities
   B. Utilities: All utilities serving the building/system shall be metered. Design professional shall discuss metering requirements with UGA.
      i. Steam - 100psi
      ii. Steam Condensate
      iii. Domestic Water
      iv. Natural Gas
      v. Chilled Water
      vi. Cooling tower make up water
      vii. Cooling tower blow down
   C. The intent of the metering is to allow accurate measurement of the building systems energy consumption for the purpose of:
      i. Monitoring and managing efficient energy use.
      ii. Billing of utilities supplied to buildings (or part thereof) managed by other units on campus that directly pay their utility invoices.

2. **PRODUCTS**
   A. Chilled water flow and btu meter shall be have matched 1000 ohm resistance temperature detectors and be equal to ultrasonic flowmeter Flexim FLUXUS ADM 7x07 or GE Panametrics.
   B. Steam flowmeter shall have a 100:1 turn down; basis of design shall be Gilflo ILVA. A properly sized steam separator shall be provided upstream of a steam flow meter.
   C. Meters shall have electronic BACnet compatible outputs capable of being interfaced with the BAS.
   D. Condenser water make-up meter: An appropriately sized make-up water meter shall be provided and installed in the cooling tower make-up water line. Meter shall have a 100 gal/ contact pulse contactor that will send a dry-contact pulse signal to the DC-4500 which will actuate the inhibitor feed and will allow for feed proportionate to load. Provide meter equal to Seametrics MJ Series.

3. **EXECUTION**
   A. Meters shall be installed strictly in accordance with the manufacturer's installation instructions and recommendations. A factory trained and authorized representative shall inspect and verify that meters are installed correctly and that the read-outs are accurate. They shall also be verified by the TAB subcontractor and CxA.
   B. Coordinate with the controls subcontractor during preparation of shop drawings to ensure that tappings for sensors are provided and are located to ensure accurate sensing and control.
   C. See Section 23 09 23, Part 3 – Execution, for items to be provided and installed by the mechanical sub-contractor in coordination with the controls sub-contractor.

23 05 23
GENERAL-DUTY VALVES FOR HVAC PIPING

1. **GENERAL**
   - A. Related sections:
     - i. 27 00 00 – General Mechanical Requirements (HVAC)
     - ii. 23 09 23 – Building Automation and Temperature Control Systems
     - iii. 23 22 16 – Steam and Condensate Heating Piping Specialties
   - B. Isolation Valves
     - i. Provide isolation valves for each
       - a. Independent item of equipment and fixture.
       - b. Floor and mechanical room.
         1) Provide a valve at each floor in branch line serving that floor (provide 2 valves if system is looped).
         2) Provide a valve in at entry to mechanical room on each service.
         3) Provide a valve on each branch line to a heating coil or group of heating coils. If the branch to a single heating coil is less than 25 feet then the isolating valve at the coil valve cluster will suffice. If longer than 25 feet then provide valve at coil and at branch.
         4) Design Professional shall determine need for any application specific additional valves that may be required and show these on the plans.
     - ii. Locate isolation valves outside the coil pull line to allow coil removal without disruption of hydronic service to other equipment and to keep piping disassembly to a minimum.
   - C. Coil Control Valves
     - i. Locate coil control valve clusters to allow easy visual (operator position) and maintenance access to components and allow free opening of access doors, filter removal, etc.
     - ii. Design Professional shall show control valve locations on the drawings (plan view and at least one section/elevation).
   - D. All components on PRVs, control valve assemblies, etc., excluding the control valve itself, shall be full line size.
2. **PRODUCTS**
   - A. Hydronic systems control valves
     - i. Shall be 2-way modulating.
     - ii. 3-way valves are not allowed without UGA variance approval.
   - B. Valves, 6 inches and greater in size, located 6 feet or greater above the floor shall be chain operated.
   - C. Valves on plumbing, heating hot water, chilled water and condenser water systems shall be quarter turn ball or butterfly valves; Gate valves are not allowed on plumbing, heating hot water, chilled water, or condenser water services.
   - D. Motor operated butterfly valves shall have a lug style body, shall have the double-offset design, have field-replaceable seats and shall be equal to Keystone K-LOK® Series 36.
   - E. Butterfly valves utilized for manual isolation shall have lug style body, shall have stainless steel stem and disc, shall provide bubble-tight shut-off up to 250 psi, and shall be equal to Keystone Figure 222.

F. Vibration isolators for piping shall be braided stainless steel type rated for no less than 150 psi. Victaulic flexible grooved couplings (no less than three in series) may be provided in the place of the braided stainless steel isolator.
G. Manual balancing valves shall be calibrated, multi-turn type with hand-wheel and numeric indicator displaying number of turns in increments of tenths, and shall be Tour & Anderson STAD or equal.

23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

1. **GENERAL**
   A. Related sections:
      i. 23 07 13 - Duct Insulation
      ii. 27 00 00 – General Mechanical Requirements
   B. Provide 4” high minimum concrete pads for all floor mounted equipment.
   C. Equipment housing cooling coils shall be provided with additional base frames as necessary to allow installation of condensate drain traps of adequate depth.
   D. Refer to 23 07 13 Duct Insulation “Trapeze Hanger Insulation Detail” for specific requirement regarding the trapeze hanger insulation details and requirements.
   E. When providing roof-mounted equipment mounted atop structural steel, ensure that 24” is provided between all mechanical components and roof deck to allow for re-roofing of the deck.
   F. Structural steel columns (mounted on roof decks) shall be round rather than angle to allow for ease of flashing during future reroofing projects.

23 05 53
IDENTIFICATION FOR HVAC PIPING & EQUIPMENT

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements
   B. Pipeline and valve identification on all new work, as well as unidentified existing valves and pipes that are within the a renovation area that are being reused, shall comply with latest ANSI standards. The contractor shall submit ANSI color-coding and identification for all services with equipment submittals.
   C. The Contractor shall provide identification labels per this section for all new construction as well as unidentified existing valves and pipes that are within the renovation area that are being reused.
   D. Summary
      i. Extent of mechanical identification work required by this Section is indicated on Contract Drawings and/or specified in other Division 23 Sections.
      ii. Types of identification devices specified in this Section include the following:
         1. Brass Valve Identification Tags.
         2. Equipment Identification Plates.
         3. Pipe Contents and Identification Markers.
      iii. This section specifies the color schemes for identifying piping.
      iv. Mechanical identification furnished as part of factory-fabricated equipment, is specified as part of equipment assembly in other Division 23 sections.
      v. Refer to Division 26 sections for identification requirements of electrical work; not work of this section.
   E. Submittals
      i. Product Data: Provide manufacturers' technical product data and installation instructions for each type of identification device specified.
      ii. Samples: Provide samples of each color, lettering style, and other graphic representation required for:
         1. Brass Valve Identification Tags.
         2. Plastic Equipment Identification Plates.
         3. Pipe Contents and Identification Markers.
      iii. Valve Identification Schedule: For each piping system provide a proposed valve numbering scheme and schedule. Reproduce on standard-size bond paper. Tabulate valve number, piping system, system abbreviation as shown on tag, room or space location of valve, normal-operating position (open, closed, or modulating), and variations for identification. Mark valves intended for emergency shut-off and similar special uses. Besides mounted copies, furnish copies from maintenance manuals specified in Special Conditions.
      iv. Equipment Label Identification Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
      v. Pipe System Label Identification Schedule: Include a list of all piping systems indicating a proposed nomenclature. Where a manufacturer's standard pre-printed nomenclature does not match up exactly with what is specified, proposed nomenclature will be evaluated for acceptance.
   F. Quality Assurance

i. Codes and Standards:
   1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

G. Coordination
   i. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
   ii. Coordinate installation of identifying devices with locations of access panels and doors.
   iii. Install identifying devices before installing acoustical ceilings and similar concealment.

2. PRODUCTS

A. Mechanical Identification Materials
   i. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division 22 and 23 sections. For each identification type, provide all tags from same manufacturer with same text, style, color, shape, and other identification features.

B. Brass Valve Identification Tags
   i. Description: For the purpose of identifying manual valves, control valves, meters, pressure regulating valves, and steam traps, the Contractor shall provide on each item an engraved brass identification tag. This identification tag shall be in addition to any valve identification plates designated for the valve. All valves shall be identified, even those provided as part of a package for a piece of equipment.
   ii. Lettering: Symbol letters and numerals shall be not less than 3/16 inch high and shall be engraved into the metal tag. Letter and numeral engraving shall be filled black.
   iii. Size and Shape: Round, minimum 1-1/2 inch diameter with a minimum 0.032-inch thickness.
   iv. Fastening: Attach through punched hole on side of tag to valve body or yoke, not the valve handwheel.
   v. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks
   vi. Terminology: Include the following:
      1. System Identification, i.e. “HPS”
      2. Equipment Designation, i.e. “-001”

C. Pipe Contents and Identification Markers
   i. Description: The Contractor shall provide pre-coiled, semi-rigid, pre-printed snap-on type pipe markers for each piping system for all new piping that is provided under this contract. Pipe markers shall indicate line contents, and direction of flow.
   ii. Material: Fade-resistant, vinyl material. All markers shall have a service temperature of -40°F to 175°F and be rated for outdoor service. Material shall be compatible with carbon steel pipe, stainless steel pipe, plastic pipe, all service jackets, Canvas jacketing, and aluminum jacketing.
   iii. Arrangement: For external diameters (including insulation) equal to or greater than 1-1/2", rectangular pipe contents indication marker shall contain only one line of text and appear on both sides of the pipe with a flow direction arrow roll wrapping 360 degrees around at both ends of the pipe contents indication

marker. For external diameters less than 1-1/2", provide full-band marker extending 360 degrees around pipe. The wording of each marker shall be spelled out in the direction of the travel of the pipe.

iv. Color, Size and Shape: Depending on service, yellow markers with black lettering or green markers with white letters. Content markers minimum text height shall be as follows:

Overall OD Including Insulation	Min. Letter Size
3/4" to 1-1/4"	1/2"
1-1/2" to 2"	3/4"
2-1/2" to 6"	1-1/4"
8" to 10"	2-1/2"
Over 10"	3-1/2"

v. Basis of Design: Seton Products

3. EXECUTION

A. General Installation Requirements

i. Coordination: Where identification is to be applied to surfaces which require insulation, painting, acoustical ceiling concealment or other covering or finish, install identification after completion of covering and painting. In addition, provide pipe markers only after each line has been completed, erected, purged, tested, and/or painted.

B. Valve System Identification

i. Valve Schedule: Contractor shall provide aluminum framed, glass encased, valve and equipment schedules for placement each in the control room (all equipment and valves), chiller room (chiller room equipment and valves only), and boiler room (boiler room equipment and valves only), etc. Tabulate valve number, piping system, system abbreviation as shown on tag, room or space location of valve, normal-operating position (open, closed, or modulating), and variations for identification. Mark valves intended for emergency shut-off and similar special uses. Besides mounted copies, furnish copies from maintenance manuals specified in Special Conditions.

ii. Items Tagged: Install valve identification tags on manual valves, control valves, meters, pressure regulating valves, and steam traps. This identification tag shall be in addition to any valve identification plates designated for the valve.

1. Provide a brass identification tag for every manual valve, no matter what size, including gate, globe, ball, check, plug, diaphragm, angle, butterfly, and stock which indicates the valve type identification.
2. Location: Attach tag to valve body or yoke, not the valve handwheel.

C. Equipment Signs And Markers

i. Install engraved plastic-laminate signs or equipment markers on or near each major item of mechanical equipment. Include signs for the following general categories of equipment:

1. Boilers, deaerators, water softeners, brine tanks, condensate polishers, condensate return units, etc.
2. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
3. Fire department hose valves and hose stations.

4. Control System equipment panels.
5. Meters, gauges, thermometers, transmitters, and similar units.
6. Boilers, steam generators, and similar equipment.
7. Pumps, compressors, chillers, condensers, and similar motor-driven units.
8. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
9. Fans, blowers, primary balancing dampers, and mixing boxes.
10. Packaged HVAC central-station and zone-type units, air handlers and condensing units.
11. Tanks and pressure vessels.
12. Strainers, filters, humidifiers, water-treatment systems, air separators and similar equipment.

ii. Mark location of equipment above ceilings with identifying "buttons" to help in identification for maintenance.

iii. Special Instructions:

1. Split System Condensing Units shall be provided with the following additional information on the equipment marker: ID Unit - Rm #-###. (This information will help locate the associated indoor unit)
2. Exhaust fans shall be provided with the following additional information on the equipment marker: Serves Rm #-###. If the fan serves multiple rooms, than state the following: Serves: Multiple Rms.

D. Pipe System Identification

i. General: Provide pipe markers on every system including pipe contents service (such as supply and return) and flow direction. Locations of all markers shall be subject to final approval by the Owner.

ii. Location:

1. Locate pipe markers in a conspicuous manner at a minimum distance of every 40 feet as follows:
    a. Upstream of each control valve and pressure regulating valve station.
    b. Downstream of every pressure regulating valve station.
    c. Near each branch.
    d. On both sides of a wall, floor, ceiling, or roof within 4 feet of the barrier.
    e. Near all origination and termination points of all equipment (tanks, pumps, etc.).
    f. Near the inside and outside of concealed points.
    g. Outdoors at each major elevation.
    h. Where pipes run parallel to each other, identify each pipe in the same general location.

E. Pipe Identification Color Scheme

i. Use color scheme as follows for identifying piping:

Piping System or Service	Finish Type[1]	Finish Color[2]	Label Background Color	Label Letter Color
High/Medium/Low Pressure Steam	Aluminum	None	Yellow	Black
Condensate Return	Aluminum	None	Yellow	Black
High/Medium/Low Pressure or Pumped Condensate	Aluminum	None	Black	White
Domestic Cold Water	PVC	White	Blue	White
Domestic Hot Water	PVC	White	Red	White
Non Potable Water	PVC	Purple	Blue	White
Tempered Water	PVC	White	Blue	White
Chilled Water Supply	PVC	Dark Blue	Blue	White
Chilled Water Return	PVC	Light Blue	Blue	White
Loop Supply	PVC	Dark Blue	Blue	White
Loop High Pressure Returnn	PVC	Light Blue	Blue	White
Loop Low Pressure Return	PVC	Light Blue	Blue	White
Condenser Water Supply	Painted	Dark Green	Blue	White
Condenser Water Return	Painted	Light Green	Blue	White
Heating Water Supply	PVC	Orange	Yellow	Black
Heating Water Return	PVC	Tan	Yellow	Black
Equipment Drain	Painted	System Color	Grey	White
Refrigerant Vent	Painted	Black	Orange	Black
Exposed Sanitary DWV	Painted	Brown	White	Black
Chemical Feed	Unfinished	-	Black	White
Natural Gas	Painted	Safety Yellow	Yellow	Black
Compressed Air	Unfinished	-	Orange	White

Piping System or Service	Finish Type[1]	Finish Color[2]	Label Background Color	Label Letter Color
Fire Protection	Painted	Red	White	Red
Nitrogen N_2	Per NFPA 99_5.1.11	Per NFPA 99_5.1.11	Black	White
Oxygen O_2	Per NFPA 99_5.1.11	Per NFPA 99_5.1.11	Green	White
Nitrous Oxide NO_2	Per NFPA 99_5.1.11	Per NFPA 99_5.1.11	Light Blue	White

Notes :

1. PVC finish types are to be provided in mechanical rooms and plants only. Steam and condensate in steam vaults shall be finished with stainless steel jackets. Coordinate with insulation type specified for Project for finish type.
2. PIC Plastics is the design basis for PVC finish colors.

ii. Colors shall be approved by the Owner after a sample is shown submitted next to some existing identified piping for each service.

iii. All steel piping and all types of insulated piping (except flexible elastomeric type) in the plant shall be identified unless otherwise noted, according to the guidelines listed below.

1. Piping shall be cleaned and prepped either on-site or prior to shipment
2. Piping shall be inspected before primer is applied, re-cleaned and re-prepped as required.
3. Piping shall be coated with a rust inhibiting primer. Primer shall be re-applied as required if bare pipe is exposed after primer has been applied. (if piping is to be insulated, insulation is applied between steps 3 and 4)
4. Contractor shall apply 2 (two) coats of semi-gloss, industrial grade finish coat to steal pipe or pipe insulation as applicable.
5. Paint shall be reapplied as required if bare pipe or primer is exposed after paint has been applied.

iv. Do not paint aluminum or PVC jacket. Do not paint copper, cast iron, stainless steel, or galvanized piping.

F. Adjusting and Cleaning:

i. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this section or other sections.

ii. Cleaning: Clean face of identification devices.

iii. Painting and Insulating: Do not paint or insulate over any identification tags. Tags shall be installed and after all painting is completed or shall be covered during painting.

23 05 93
TESTING, ADJUSTING, & BALANCING (TAB) FOR HVAC

1. **GENERAL**
   A. Related sections:
      i. 01 32 16 – Construction Progress Schedule
      ii. 01 75 00 – Starting and Adjusting
      iii. 01 77 00 – Project Closeout
      iv. 01 91 13 – General Commissioning Requirements
      v. 23 00 00 – HVAC
      vi. 23 31 13 – Metal Ducts
      vii. 25 09 23 – Building Automation and Temperature Control System
   B. The Design Professional shall include in the TAB specification any special control sequences that will require the assistance of the TAB subcontractor. For example this may include fan tracking, economizers, demand control ventilation systems, life safety systems, etc.
   C. A balancing plan prepared by the TAB subcontractor shall cover balancing techniques and testing procedures for all individual systems and equipment as well as for the overall system. The selected TAB subcontractor shall submit the balancing plan to the Contractor who will then submit it to the Design Professional and Project Manager. The balancing plan shall be submitted at the same time as mechanical submittal data. The TAB subcontractor shall follow up with the Contractor to ensure that the balancing plan has been properly reviewed and incorporated within the construction schedule. The balancing plan shall include:
      i. A list of the test instruments that are planned to be used in the testing and balancing process.
      ii. A description of the testing procedure for each HVAC system to be tested. List all of the equipment to be tested for each system and the techniques to be used for the testing procedure. Standard forms used by the TAB subcontractor shall be completed to reflect all equipment and systems identified by system and/or model number specific to the project. Blank, “sample” forms are unacceptable.
      iii. A list of the all subcontractors that are required to assist with the testing and balancing process along with the expectations of each of the contractors to successfully complete a total system balance. Most importantly, the expectations of the temperature controls contractor shall be listed. This shall include provision of automation software for balancing, timely automation system access, and the development of global overrides for system maximum performance testing.
      iv. An outline of the required construction completeness prior to starting the testing and balancing process
      v. A realistic estimate of the time required to complete the testing and balancing process; the plan shall describe in detail the required time to complete balance of sub-systems and total system balance. The Contractor shall recognize that the balancing process is sequential and not a process that can be shortened by simply putting more technicians on the project to complete the process faster. Buildings with direct digital control systems require a great deal of the testing and balancing process to be performed through adjustments to the HVAC

systems via the automation/control system. Network access limitations and/or control software may prevent more than one operator from communicating with the automation/control system at a time. This makes it inefficient to have too many balancing technicians on a single project if the majority of the adjustments can only be made through one computer terminal.

vi. A listing of the necessary uninterrupted accessibility to the building to completely test HVAC equipment and sub systems.

vii. The Contractor shall allow time in the balancing plan schedule to allow the TAB subcontractor to address any issues in the design or installation, which prevents a system from operating at design performance. The Contractor shall take the time for resolution of these issues by the responsible party into account in the balancing schedule. A 'contingency' of an additional week or two should be incorporated into the balancing plan schedule to accommodate additional time required for the responsible party to correct any minor issues preventing design performance of the building. The TAB final report shall be scheduled to be completed three weeks prior to Material Completion.

viii. With the balancing plan the TAB subcontractor shall submit a sample reporting form that includes project specific information with the specified AHU, pumps, etc. by item number identified on the drawings. It shall show intended location of duct traverses, all units that will have static pressure profiles, AFMS, etc. The final completed version shall also include manufacturer and model numbers.

D. Building accessibility during balancing: The Contractor shall provide the TAB subcontractor with uninterrupted access to all areas of the building. Large HVAC systems may require the access to the same area several times throughout the balancing process. Finishing processes of the building construction such as laying carpet and tile flooring, waxing floors, construction cleaning, and fire alarm testing that require the HVAC systems to be shut down shall be identified in the balancing plan to inform the Contractor of possible conflicts who shall attempt to schedule the testing and balancing process around them. Some building accessibility issues to address in the balancing plan include the following:

i. Flooring work, such as carpet laying and tiling, must be performed either before or after the testing and balancing process for a particular system serving the area in which the flooring work is to be done. If the completed flooring will restrict the use of boom lifts, the testing and balancing of the system serving that area shall be completed before the floor work if the HVAC system components are inaccessible by ladder.

ii. Final building cleaning that would prevent further access of contractors shall be delayed until the testing and balancing is completed.

iii. If fire alarm testing will affect the HVAC system, the balancing contractor should be notified in advance when fire alarm testing is scheduled. For example, closing fire dampers or shutting down air handling units can disrupt total system balancing.

2. **PRODUCTS**

A. Provide all instruments, charts, materials, and equipment required to develop a complete TAB report.

3. **EXECUTION**

A. The TAB subcontractor shall be required to be contracted directly by the Construction

Manager; the TAB subcontractor shall not be contracted to the mechanical subcontractor. Additionally, unless approved otherwise by UGA, be an Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB) certified member and the TAB Work shall be performed by an AABC or NEBB certified test and balance technician.

B. As a minimum, the TAB subcontractor shall test, adjust and balance:
    i. Each supply air, return, exhaust and outdoor air distribution system, including operation and adjustment of all manual and automatic air volume control dampers, particularly outdoor air dampers, including static pressure profile across AHUs and duct pitot traverses. Final measurements shall be made after balancing at outlets/inlets and main duct traverses to determine and record the amount of leakage.
    ii. Each hydronic system.
    iii. Each control system including calibration of all control elements and check operation including all interlocks.
    iv. Overall air balance in building and individual spaces.
    v. Adjust systems to optimize energy use; adjust air distribution systems for fan pressure optimization to control system static to lowest level while maintaining flow requirements in all zones; adjust hydronic systems to optimize pump pressure to force at least one valve to full flow. Document all index runs.

B. Test and balance shall include all equipment and distribution systems and shall be reported, as a minimum, as outlined in Para 1.5 of the AABC National Standards, sixth edition, 2002, on forms as published in the standards manual, appendix 1, or NEBB equivalent, at least equal in scope. Standard forms submitted for approval (as shop drawings) shall be filled out and be project specific with specified AHU, fans, pumps, etc by item number identified on the drawings; shall show intended location of duct traverses, all units that will have static pressure profile, AFMS, etc. The approved forms shall then be completed after approval of shop drawings to identify manufacturer, model numbers, etc.

C. Measure and record the dry bulb and wet bulb temperatures, humidities, and pressures in all spaces served when the outside temperature is above 85 degrees (summer TAB) and below 50 degrees of (winter TAB) record outside dry bulb and wet bulb.

D. Reports shall include manufacturer's performance curves, tables and graphs with specified design and actual, measured/"as-balanced" duty points marked up on these. System effect on AHUs shall be measured, recorded and plotted on the fan duty curve, The curves shall clearly show efficiency, brake horsepower, speeds, etc. for design and actual.

E. The TAB subcontractor shall check the controls system operation for proper calibration and operation and a report on the operation and adjustment shall be submitted to the owner. The TAB subcontractor shall verify by check measurements in the field to ensure that the controls indication is accurate; every safety and alarm interlock shall be checked. The interface with the building fire alarm system shall be checked. Check and provide statement that all smoke detectors are operating properly and are installed in accordance with the manufacturer's installation instructions and recommendations. Sensor shall be checked for proper location, space temperature sensors shall be free from drafts, heat sources and other factors that can affect the accuracy of the control system.

F. The Contractor and the TAB subcontractor shall check all the systems operating together, in all modes of operation, to ensure that the air-conditioned spaces are under an overall positive pressure; shall check and report that the building envelope is properly sealed and uncontrolled air leakage into the building does not occur; shall check that return and exhaust ducts located outside the air-conditioned space are sealed; shall check supply air ducts for leaks to ensure that cold air leakage does not cause condensation on duct, equipment and building surfaces above the ceiling (during summer TAB); shall check return and exhaust grilles for proper seal at duct connections to ensure that air does not enter these ducts through un-air-conditioned walls, chases, etc.

G. The Contractor and the TAB subcontractor shall, immediately following award of the contract, review the proposed systems installations drawings and determine all measuring and balancing devices required for proper test and balance of the systems are specified and sized correctly. These shall include, but shall not be limited to, manual air volume balancing dampers, etc. the contractor shall be responsible for providing these in the locations recommended by the TAB subcontractor, in addition to any shown on the drawings. These devices shall be provided under the Contract. Check that duct layouts allows TAB subcontractor to do duct pitot traverses to determine overall air flows. Any factors that prevent the proper TAB of the systems shall be brought to Project Manager's attention for a decision prior to proceeding with the Work.

H. The TAB subcontractor shall check refrigeration lines for compliance with the equipment manufacturer's installation instructions and recommendations shall check superheat settings on all systems with lines longer than 50 feet.

I. The TAB subcontractor shall test condensate drains and drain pans for proper drainage under operating conditions and that all condensate drains from pans.

J. Instruments used for testing and balancing shall have been calibrated within a period of six months of the time of the testing and balancing and such instruments shall be checked for accuracy prior to start of work. Submit verification of certification to the owner; submit purchase invoices for all instruments identified as "new".

K. Three copies of the complete test report shall be submitted to the Design Professional and the Project Manager prior to Material Completion of the project plus at least one complete copy in searchable electronic format.

L. Balancing and Adjustment after Final Completion: After the building is accepted and occupied, and after testing and preliminary balancing are completed, send qualified personnel, at no additional cost, to the building for not less than one period during summer and one period during winter, observer temperatures throughout conditioned spaces, consult with Project Manager as to need for additional balancing or adjustment, then perform such work as indicated. Schedule these visits at a time agreeable to the Project Manager during December through February for heating, and July through August for cooling.

M. The TAB report shall include a list of all deficiencies found during the preliminary testing and a contractor response indicating remedial action taken for each item. The TAB work shall not be deemed complete without this report.

N. The TAB final report shall be submitted to the Design Professional and the Project Manager at least three weeks prior to Material Completion.

2.23 07 13
DUCT INSULATION

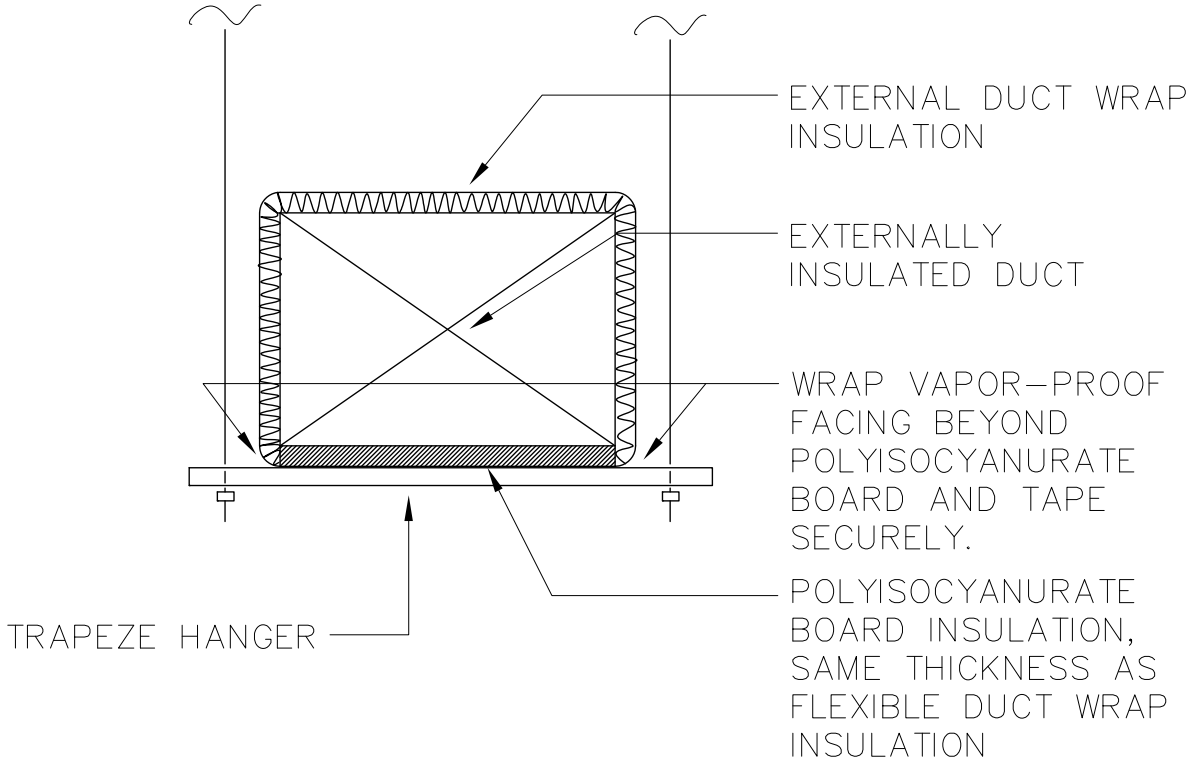
1. **GENERAL**
   A. Related sections:
      i. 27 00 00 -- General Mechanical Requirements
      ii. 27 05 29 – Hangers and Supports for HVAC Piping and Equipment
   B. UGA does not allow the metal duct to be penetrated by either the duct insulation fasteners or the fasteners associated with hanging the ductwork. Refer to the Trapeze Hanger Insulation Detail included in this section.
   C. If sound attenuation is a project requirement, the method to be utilized shall be approved by the Project Manager in writing.
2. **PRODUCT**
   A. Ductwork inside mechanical rooms shall be insulated with 2” thick 3 lbs/cu.ft. aluminum foil faced board.
   B. Duct insulation for exterior location:
      i. All ductwork exposed to ambient conditions, including, but not limited to, in crawlspaces and attics and ductwork located in mechanical rooms shall be insulated with minimum 3" thick aluminum foil faced board type insulation (R12, installed) having a minimum density of 6 lbs./cu. ft.
      ii. Insulation on round, oval or curved ducting located outside the building shall be minimum 6 lbs./cu. ft. board with fibers arranged perpendicular to the board surface to allow insulation to closely fit the curved surfaces. Pre-score rigid insulation board where necessary to conform to curved surfaces. The insulation shall be faced with an all-purpose Kraft paper bonded to aluminum foil. Insulation basis of design is Johns Manville 817 Series Spin Glass or approved equal.
   C. Outer covering (in mechanical rooms and where subject to ambient conditions):
      i. The flexible membrane basis of design shall be multilayer, aluminum polyester laminate; self-adhering 5mil membrane, Foster Vapor-Fas 62-05 (embossed), VentureClad or approved equal.
      ii. The color shall be aluminum or white as required by UGA (verify color with Project Manager).
   D. Internal duct liner anywhere downstream of filter banks, including inside equipment such as AHU’s, FCU’s, VAV terminals, etc. is prohibited (unless otherwise approved in writing by UGA Project Manager).
3. **EXECUTION**
   A. General
      i. Apply the insulation on clean, dry surfaces. Observe manufacturer’s recommended temperature limits during application. The ducts must be sealed and leak tested before application of the insulation. The Contractor and the insulator shall inspect ducts to verify that the ducts are properly sealed prior to insulating and shall review duct leakage test reports provided by the TAB subcontractor where duct leakage testing is specified.
      ii. All insulation joints shall be firmly butted and sealed. Adhere insulation to ducts with 100% coverage of fire retardant manufacturer approved adhesive Foster 85-15;

iii. For ducts over 24 inches wide, impale insulation on the bottom of the ducts on metal pins, on maximum 12 inch centers, welded to the duct and secure with speed washers. Minimum compression is to be used to assure firm fit and still maintain thermal performance.
iv. Vapor retarders should overlap a minimum of 2" (51 mm) at all seams and be sealed with appropriate pressure-sensitive tape and mastic Foster 30-65. When applying pressure- sensitive tapes, the tape must be firmly rubbed with a proper sealing tool to make sure the closure is secure. Follow tape manufacturer's instructions and recommendations.
v. Fasteners shall be located a maximum of 3" (76 mm) from each edge and spaced no greater than 12" (305 mm) on center.
vi. Prior to application of the outer weather proofing layer all penetrations and facing damage shall be repaired with tapes or mastic Foster 30-65 with a minimum of 2" (51 mm) overlap. Tapes should be applied using a sealing tool and moving pressure.
vii. The insulation on the top surface of the ductwork shall be tapered for positive drainage. Maintain specified minimum thickness as at the low side.
viii. Insulation shall be installed, sealed and vapor-proofed, continuous through penetrations. Seal penetrations to outside of insulation as required.

B. Exterior weatherproof covering:
i. Apply a commercially available flexible, self-adhering, aluminum waterproofing system/product specifically made for the application, installed in accordance with the manufacturer’s installation instructions and recommendations to the insulated duct and pipe to provide a vapor barrier, water and weather seal.
ii. The insulation shall be secured prior to applying the waterproofing layer which shall not be used as a means of securing the underlying materials.
iii. Observe manufacturer’s recommended temperature limits during application.
iv. Apply the material to shed water over the laps. Sheets shall be continuous on underside of ducts.
v. The insulation sub-contractor shall inspect the outer coverings after the TAB work is complete and shall plug and seal all tappings holes found with sealant, insulation and outer covering.
vi. After completion of final inspection, adhere sheets of the outer covering over access doors and around other duct penetrations/openings.

TRAPEZE HANGER INSULATION DETAIL

SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



23 07 19
HVAC PIPING INSULATION

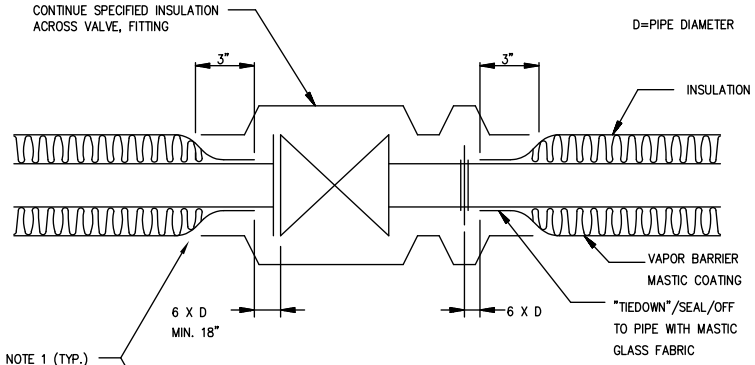
1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 21 13 – Hydronic Piping
2. **PRODUCTS**
   A. Heating hot water piping insulation inside buildings shall be fiberglass with vapor barrier all service jacket.
   B. Chilled water pipe insulation inside buildings shall be equal to closed cell ITW Trymer Green phenolic 2.5 lb/cu ft (0.15 Btu·in./hr·ft2·°F@75°F mean) with Saran 560 or Pittsburgh Corning foam glass with approved wrap. For renovations, when an existing cold line to be modified has fiberglass insulation, patching with fiberglass insulation may be allowed with owner's approval.
   C. On fittings/elbows, apply vapor retarder coating equal to Foster 30-80 AF with reinforcing mesh Foster 42-24 Mast a Fab; with 9x8 opening/ sq. inch.
   D. All seams, butted joints, and terminations shall be sealed with a product equal to Foster 95-50 and vapor proofed with a product equal to Foster 30- 80 AF meeting ASTM D5590 before the piping 'goes cold' in such a manner to prevent any moisture laden air getting in the insulation system.
   E. Exterior above grade insulation may be equal to Trymer PIR, 2.5 lb/cu ft, (25/450 flame spread/smoke developed) wrapped and coated as above.
   F. Limited use of flexible closed cell insulation similar to "Armaflex" may be permitted with owner approval at piping at valve clusters, etc., provided no condensation occurs on cold surfaces.
3. **EXECUTION**
   A. Chilled water pipe insulation shall be sealed ("tied down") to pipe every 40 ft, 3 ft from equipment, up and downstream of valve clusters, etc. and vapor proofed.
   B. Pipe insulation and vapor proofing shall be continuous through all building penetrations.
   C. Non-compressible insulation inserts, extending beyond hanger, wrapped and vapor proofed before hangers is 'closed', shall be installed at hangers in such a way that the insulation and vapor proofing is continuous through the hanger.

INSULATION TIE DOWN/SEAL OFF POINTS FOR CHILLED WATER PIPE DETAIL

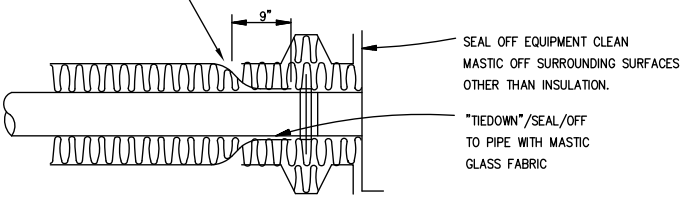
SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY

NOTES:

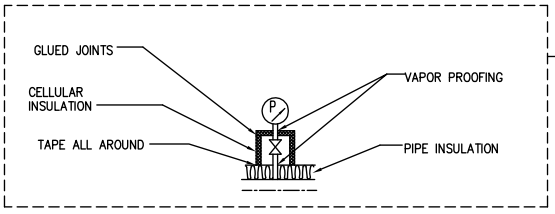
1. IDENTIFY ALL "TIE DOWNS" INCLUDING ON STRAIGHT RUNS OF PIPE WITH 4" WIDE PLASTIC ADHESIVE BANDS TAPED ALL AROUND AND MARKED "VAPOR PROOFED TO PIPE". PROVIDE TIE–DOWNS EVERY 21 FEET ON STRAIGHT RUNS OF PIPE.
2. DO NOT DAMAGE VAPOR BARRIER/TIE DOWNS ON EXISTING WORK WHEN ADDING NEW WORK. REPAIR ANY DAMAGE DONE.
3. PROVIDE INSULATION ON ALL INSTRUMENTS, VALVES, PROBES, PETE'S PLUGS, TO PREVENT CONDENSATION/DRIPPING. INSULATION MAY BE "ARMAFLEX" OR OTHER APPROVED FLEXIBLE CELLULAR INSULATION FIXED WITH MANUFACTURER'S APPROVED ADHESIVE OR "NO DRIP" TAPE NEATLY APPLIED. THE CELLULAR INSULATION SHALL BE FORMED INTO A "CUP" OF SUITABLE DIAMETER TO FIT OVER THE VALVE, PROBE, ETC. AND TAPED TO THE SURFACE OF THE PIPE INSULATION.

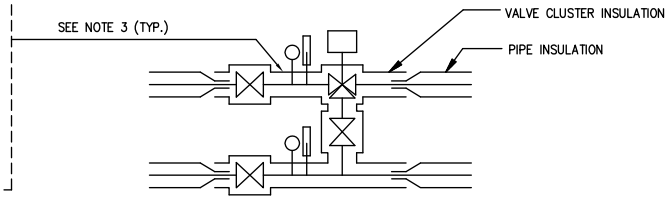


INSULATION TIE DOWN AT FLANGES, VALVES & UNIONS COLD PIPING



INSULATION TIE DOWN AT EQUIPMENT COLD PIPING





23 09 23
BUILDING AUTOMATION AND TEMPERATURE CONTROL SYSTEM (BAS)

1. **GENERAL**
   A. Related sections:
      i. 00 73 01 – Sole Source / Sole Brand
      ii. 01 91 13 – Commissioning Requirements
      iii. 23 00 00 – General Mechanical Requirements (HVAC)
      iv. 23 05 93 – Testing, Adjusting, and Balancing for HVAC
      v. 27 00 00 – Communications
      vi. 27 15 00 – Communications Horizontal Cabling
      vii. 23 05 19 – Meters and Gages for HVAC Piping
   B. The BAS shall utilize direct digital control (DDC) technology to maintain the space conditions and provide automatic control of the associated mechanical equipment.
   C. For the UGA Athens campus, the building automation controls system main software and hardware reside at server racks located at the Boyd Graduate Research Center. The Design Professional shall coordinate with the Project Manager and FMD to determine if any front-end computing hardware upgrade / replacements are required as part of the Project. If needed, the Design Professional shall include specifications for the installation of a 24 port Brocade ICX switch in the Project. The Contractor and controls subcontractor are additionally responsible for including any required software or hardware upgrades specific to the selected controls system in the Cost of the Work or Bid.
   D. The Design Professional is responsible for coordinating the connection locations of the direct digital controls system to the UGA network.
      i. Refer to 27 15 00 Communications Horizontal Cabling for data cabling requirements.
      ii. The Design Professional shall locate all required ethernet points / drops to the Project Manager and the Project Manager shall request IP address assignments from FMD IT. The Contractor shall provide the Project Manager with the date that the data connection points utilized by the DDC are required to be active. The DDC system shall be actively connected to the UGA network prior to the start of TAB to allow TAB subcontractor, CxA and Design Professional to check the Work before completion and handover.
      iii. All information technology related issues shall be communicated promptly to Project Manager.
   E. The Contractor shall coordinate with the controls subcontractor during preparation of shop drawings to ensure that tappings for sensors are provided and are located to ensure accurate sensing and control.
   F. Provide instrumentation across all heat exchangers plus P/T plugs. P/T plugs and wells for pressure gauges and thermometers shall be provided across all heating and cooling coils, control valves and strainers. Provide differential pressure sensors across all filter banks on AHUs and elsewhere, where indicated. These shall have an analog output connected to the BAS. Filter status shall be displayed on AHU graphic. Display shall indicate ‘as tabbed’ filter ‘clean’ DP and filter clean-out, as specified – shown as ‘dirty’ DP and actual DP in inches WG. Display shall change to “CLEAN FILTER” when ‘filter dirty’ set=point is reached. Transmitter shall be equal to Dwyer Photohelic gauge if there is no BAS and, with Owner’s prior approval, equal to Magnahelic if no power is available.

G. Utilities to building shall be independently metered and trended via the BAS.
H. Control drawings shall show schematic control diagrams for all systems; show, as minimum, symbols for sensors, controllers, actuator; sequences referencing these sensors, controllers, actuator symbols; i/o summaries; system architecture/riser. Input and output numbering shall be descriptive to indicate the function (Use SAT1, OAD1, etc., in lieu of AI1, DI1, etc.); every actuator shall, unless specified otherwise, have a dedicated output and independently adjustable control range.
I. Control system devices and panels shall have suppressors to protect against lightning damage; power supply surges; induced voltage from other equipment such as transformers or electric motor operations; and electronic transmission/relay such as may be caused by radio/TV broadcasting towers, radars and high-voltage transmission lines.
J. Thermometers and pressure gauges shall be mounted to be easily readable by observer standing on the floor and adjusting the device concerned.
K. Provide leaving air temp sensor on all AHUs and VAV terminals.
L. Humidity sensors for HVAC applications shall be equal to Vaisala, model HMD60/70 (or HMD50 with INTERCAP replaceable sensors), HMW82/83 or HMT120/130 to suit the application, and output required. Sensor to be interchangeable in the field and calibration-free. Accuracy is ±3% RH from 0 and 90% RH. Sensor to have a stability of a ±2% RH over a two year period. Transmitter shall operate over a humidity range of 0 – 100%. Sensors shall be warranted for 2 years from date of installation and shall be NIST-certified/traceable calibration. Wall-mounted devices shall have replaceable sensor kits. Where dewpoint sensing is called for, the transmitters shall be equal to Vaisala HMW110B1VA1NN for wall-mounted and HMD 102B1VA1NN for duct-mounted; 2% accuracy, 3-point NIST-certified/traceable calibration; on-site calibration using HM70 hand-held meter or PC connection. Output parameters to be selectable with a PC connection.
L. Sensors shall be warranted for two (2) years from date of installation and shall be NIST-certified/traceable calibration.
M. The controls contractor shall verify the specified sizes of control devices, (valves, dampers, etc.) to ensure the devices have the correct system authority for proper, stable, control.
N. HVAC systems shall be zoned for a maximum of 3 thermally similar spaces per zone. All non-common areas shall have separate adjustable sensors.
O. The controls contractor shall provide the applicable version of the Building Automated Systems (BAS) software required by the TAB subcontractor to do the Test and Balance work specified at no extra cost to the Contract or the TAB subcontractor.
P. Upon completion of the project, the controls contractor shall provide, to the owner, all software and design tools required for system design, programming, graphics, etc.
Q. Graphic User Interface: (shall be available through the web browser)
    i. Building Graphics
        a. General
        b. GRAPHICS specific to this project as follows:
        LEVEL ONE: Shall identify location of building on the site.
        LEVEL TWO: Shall show each floor plan such as basement, first, second, and roof showing terminal devices with link to its schematic diagram.
        LEVEL THREE: Shall show mechanical rooms linked to level four devices.
        LEVEL FOUR: Shall show each individual system, chiller, air-handling units, terminal units, fans, etc.
        c. On all screens, the entire graphics screen should be visible in full screen

mode, i.e. no scroll bar required to view entire screen and should be printable with a white back ground.

d. A legend should be provided on all screens where graphical colors are used. Provide an active link to a comprehensive project specific legend that explains all abbreviations used.
e. Floor plan graphics should be uniform design for all projects: simple, easy to read, intuitive, uncluttered and organized. Floor plans should be 2 dimensional only. (No 3D floor plans)
f. Graphic displays shall show all I/O points including set points, dynamic, real time values of temperature, pressure, status, etc., alarm settings and any current alarm/alert conditions; shall show air flows in CFM and temperature, actual and set-point, for outdoor air, return air and supply on AHUs and primary air on VAV terminals. Fan amp and Kw shall be shown at each device. Graphics for VAV terminals shall so maximum, minimum, dual minimum, etc., as applicable and the actual real-time CFM.
g. Graphic screens shall include a complete system schematic layout showing real-time values and set-points for all points. For VAV systems, the airside shall show AHU serving the system, air terminals, duct static-pressure sensor location(s) with an active link to floor plan(s) showing actual installed locations, etc. For water side, the graphic shall show control valves and pump status. The graphic screen shall show design goal for monitored points and set-point and the real-time current temperature, humidity, static pressure, flow rate, etc., as well as status of all fans associated with the system; to include, real-time air flow rate, with maximum and minimum cfm sert-points (as specified). All air flows shall be shown in an air balance schedule on the graphic screen, as well as the space static pressure for the system or, depending on the amount of information on the graphic screen, accessible via an active link. The air balance schedule shall show the actual net positive or negative air flow in the summary. The graphic shall show all control air flow damper positions and re-heat, hot water valves, or electric heat control, as a percentage open or closed.
h. All outputs should be able to be overridden from the graphical interface. Clear intuitive means of indicating when any point is overridden to a manual position shall be provided on the graphic. This could be done by text changing color from a normal state or a hand icon appearing next to the over-ridden point. Piping schematics shall be two dimensional to clearly identify service (CHW Supply, CHW Return, CW Supply, CW Return, MP Steam, Pumped Condensate, Make-up, etc.). Display shall use bold colors (rather than shades).
i. Piping schematics shall be two-dimensional to clearly identify service (CHW Supply, CHW Return, CW Supply, CW Return, MP Stream, Pumped Condensate, Make-up, etc.). Display shall use bold colors (rather than shades).
j. Graphics shall show water flow in real-time and set-point for GPM, temperature and pressure drop and pump amps draw and Kw.

k. All points shall be trended and provided historical trending with enough memory for up to 1 year of data.
l. Point names shall be process specific, unique and intuitive on control drawings with the same on graphic screen and in the program (do not use AI1, DO1, T1, P1, but LAT1, SDSP1, etc). Special attention shall be given to pump point naming; names shall consistent across graphics, control drawings and in programming.
m. A point naming legend shall be provided on the control drawings and graphic screens. Link the legend to pump graphic icons.
n. Graphics shall clearly differentiate between normal operating mode, manual over-ride, alarm, etc.
o. Economizer control shall be dry-bulb unless the application requires control of space humidity levels in which case enthalpy control shall be used.
p. Graphic screens showing floor plans and zones shall be color coded based on temperature setpoints (not actual temperature). Zone, area, and building information shall be displayed using colors to indicate conditions. Relative temperature conditions, based on setpoint, are displayed in a series of colors indicating the zone performance to represent comfort within a given zone.
q. Graphics shall be viewable, over the web, on mobile devices such as phones and tablets without need for installing “Apps”
r. Control drawings shall be linked to the graphics, allowing the user to verify intended sequence of operations for all controlled equipment.
s. As-built mechanical drawings shall be linked to the graphics.

ii. Building Level Graphics
a. This level should include an overall building plan, illustrating all floors (if possible). The overall floor plans will indicate comfort status displayed via color codes. The intent is to allow the building engineer to quickly see problem areas within the facility.
b. Main building screen should indicate major building systems that are in alarm and those elements that have lost connectivity with the server.
c. Main building screen should provide active links to as-built control drawings, basis of design documentation, and sequence of operations.
d. Outside air temperature and relative humidity should be displayed.
e. “Global” Building heating and cooling set-points shall be indicated at this level and shall be able to be modified for all associated building systems.

iii. Floor Plan Level
a. Floor plan level graphics should display the comfort status of all rooms on that floor via color codes incorporated into the actual floor layout. Comfort status should include actual status of all controlled variables: temperature, humidity, indoor air quality (CO2 level), etc. Active links to change the set points of these variables should be incorporated.
b. Zone boundaries should be able to be determined by means of color-coded floor plans at this level.
c. Web page should identify the building, i.e. “Pharmacy 2nd Floor”, clear

at the top of the page, centered, just above the floor plan(s)
d. Active links to other floors in the building should be provided
e. Layout and location of system components: duct, boxes, etc. should be provided with color code according to use (supply, return)
f. Identify AHU(s) and central exhaust fan(s) with name and location serving the floor with active link to its graphic.

iv. Zone Level
a. All "%" indicators of valves or dampers should indicate "open" or "closed"
b. Should indicate air handler supplying the zone on the page and provide a dynamic link to that page
c. Occupancy status and temperature should be graphically represented via a color bar chart
d. Entering and Exiting temperatures should be shown at the device
e. Indication of air flow through box should be shown graphically
f. Actual components of box should be shown graphically
g. All points should have process specific, intuitive, names on every graphic screen (not T1, P1, but LAT1, SDSP1, etc. (see 'project specific legend') – to be used consistently across all graphics and for all projects. (ex. Don't use 'discharge air temp' and 'leaving air temp')
h. Provide zone level environmental index and building performance dashboard.
i. The system shall provide equipment fault diagnostics, with analysis, and detection alarms.

v. System Schematics
a. Graphics should include a system schematics page showing all major components of any given monitored system (chilled water system, hot water system, AHU and all associated terminal units, etc.) and all measured variables as required to give the building engineer an overall perspective of any given system.

R. Trending/Reporting
i. General
a. System should allow user to create new trends/reports from the browser mode without the need for any programming.
b. All points – software, hardware, calculated/virtual, - shall be trended continuously. System shall be delivered to owner in this way without need for any additional programming,
c. Trends and reports should be pre-formatted, requiring minimal user effort to establish a quick trend or report for system troubleshooting.
d. System should allow user to copy, using simple operating system menu commands, trend /report data to a spreadsheet that management can use for trouble shooting, energy reporting, etc.

ii. Programmed Trends/Reports
a. System should provide a drop-down menu, by page, of all equipment where programmed trends/reports are available and link directly to these for viewing.

iii. Configured Trends/Reports

a. Within browser mode, user should be able to select any controlled point for trending and reporting.
b. New graphical trends should be able to show up to 5 user selectable points concurrently.
c. User should have the ability to save new trends and reports and view at later time showing all data since trend/report was created.

iv. Standard and Custom Reports
a. Standard reports shall include, but not be limited to, locked points report, commissioning reports, network points, hardware points.
b. Commissioning reports shall at a minimum identify date, technician name and action.
c. Custom reports shall be configurable by the use/operator.
d. An audit log report identifying system changes by action, date, password, etc. shall be included in the BAS.

S. Programming
i. General
a. Programming pages for the whole campus shall be accessible through the web browser from the graphics display window, without requiring additional logon or opening new windows.
b. Active links to programming should be available from all levels of graphics screens, i.e. floor plan, zone, etc. Link should access pertinent areas of programming for that screen.
c. Programming function should accept multiple concurrent users, without 'bumping' a current user offline when an additional user logs on. Further, only one user can have access to a specific system at a time for programming purposes.
d. Graphical programming shall be with live graphic function blocks in a continuous program without opening multiple screens.

ii. Editing
a. Edit capabilities should be available on programming pages
b. Programming pages should be graphical representations of live programming, i.e. pages should show actual data values as they change.
c. Over-ride capabilities should be directly accessible from programming pages.
d. Troubleshooting capabilities for each component should be confined to a single page.

iii. Scheduling
a. Scheduling should be available for each individual device.
b. Group scheduling should be provided whereby multiple device schedules can be modified concurrently without having to modify each schedule individually. Individual devices shall be assignable to multiple groups.
c. Scheduling shall be hierarchical allowing all devices below a given device to follow the same schedule. All devices shall have override capability to allow deviation from the hierarchical schedule.

iv. Energy Saving Strategies
a. The BAS software shall include energy saving strategies such as, but not

limited to the following:

b. Demand Limit Control
    1) Demand control settings should be provided whereby individual and group set points are relaxed in response to energy pricing signals.
    2) Three demand levels should be provided by device.
    3) Source temperature optimization. Zone conditions and actual load demand will reset and optimize air side and water side equipment.

v. User Help Files
    a. Video training modules and context sensitive help shall be provided with the BAS system software through a 'help' function.

T. Information Technology

i. General
    a. Server control software shall be platform independent and shall reside on UGA's Linux (open source) operating system.
    b. Web client should be accessible via multiple browser systems other than Internet Explorer. System shall support unlimited simultaneous users at no additional cost to owner.
    c. All future versions of the control system software should be compliant with older versions.
    d. Server software will be virtualized using enterprise platforms such as VMware ESX or Microsoft HyperV.
    e. All trend data, including historical trend data shall utilize an Oracle database. Trend data whether current or historical shall be readily available to user through the web browser.

ii. Architecture
    a. System should be able to operate as an intranet without connectivity to campus backbone for setup and testing.
    b. System should operate via a single Internet Protocol (IP) address for each building, not multiple IPs.
    c. Any data within the system must be available either through database or flat-file exports.

iii. Alarms
    a. System should be configured with a single alarm screen where alarms from multiple buildings are displayed.
    b. Active links should be provided from the alarm screen to the device in alarm for troubleshooting purposes.
    c. Remote alarm notification via e-mail, mobile devices, text messaging shall be included in the software and setup as required by users at no extra cost. Users shall also be able to set up alarms and alarm notifications without additional programming.

iv. Configurable User Access
    a. The owner shall have the ability to assign access privileges (such as programming, view only, specific buildings, etc) to various operators and users.

2. **PRODUCTS**
   A. This is a sole source of equipment by Automated Logic Corporation: 770-429-3000 and procured through Automated Logic – Georgia: 770-421-3280. For renovation projects that utilize a different brand, the decision to change to Automated Logic Corporation or modify the existing system will be made on a case by case basis.
      i. The Construction Manager shall contract with Automated Logic Georgia as a direct subcontractor.
      ii. Automated Logic Georgia shall not, for example, be in a sub-subcontract relationship with the mechanical subcontractor.
   B. DDC Control Modules
      i. All modules shall be native BACnet, fully programmable, including zone modules (down to lowest control level)
      ii. Non-customizable routines are not acceptable.
      iii. Air handling unit and plant control modules require manual override switches on all outputs.
      iv. All modules shall have stand-alone capability including trending.
      v. All outputs shall be isolated. TRIAC outputs are not acceptable.
   C. All equipment interfacing with the BAS shall have BACnet communication interfaces.
   D. Gauges:
      i. Gauges shall be 4.5” diameter.
      ii. Pressure gauges across all chiller heat exchangers shall be equal to Orange Research Delta-P gauges. Install with dirt legs and means of draining.
   E. Digital temperature indicators across all chiller heat exchangers shall be equal to Weiss Instruments or equal approved. Provide models that can send analog signal to front end. Solar or light powered devices shall not be provided.
   F. Control valves on AHU cooling and heating water coils and steam coils shall have 300:1 rangeability/turn-down. Valves on terminal reheat coils may be 100:1 minimum turndown. All valves and associated actuation shall be selected to operate and close tight at a valve differential pressure of 1.5 times the pump design head or the pump shut-off head. Basis of design control valves for AHUs shall be Valve Solutions – Vee Ball. Valve actuators shall be direct coupled.
   G. High occupancy spaces shall have demand control ventilation (DCV). Basis of design CO_2 sensors shall be Telaire model 8002.
   H. CTs shall be adjustable equal to Veris H708. On VSDs the CTs shall be self-calibrating equal to Veris H904; wet media differential pressure transducers shall be equal to Veris PW Series (or PW2 Series depending power supply availability). The Design Professional shall identify the correct locations of differential pressure sensors based on pipe calculation and shall, if necessary, require the contractor to re-locate the sensors to a better location based on TAB results.
   I. Measuring station shall be capable of continuously monitoring the airflow volume of the duct served and electronically transmitting a signal linear to the airflow volume, Airflow measuring devices shall be of the insertion type, or built into ductwork to suit the system configuration and shall be capable of measuring velocity over the range 375 to 7000 FPM with +/- 2% accuracy. Devices shall be selected by the manufacturer or authorized representative, and installed in accordance with the manufacturer’s installation instructions and recommendations, Standard Materials shall be aluminum bars with aluminum and ABS or aluminum sensors. Support bars over one foot in length shall be

supported on both ends; in corrosive air streams, sensors and support bars, shall be of corrosion resistant materials. Velocity sensors shall not be affected by dust, lint, temperature, pressure, or humidity. The sensors shall be passive in nature, with no active parts within the air stream. The output from individual sensors shall be linear with respect to airflow velocity and shall be capable of sensing airflow in one direction only. The velocity sensors shall not require calibration. The transmitter shall provide a scale-able output over the full range of control of the unit, via on- board adjustments. The output signal of the transmitter shall be industry standard electronic signals, selectable on-board via jumpers or switches, for 4-20ma, 1-5vdc or 2-10vdc. Power requirement for the transmitter shall be 24VAC or DC. The device and associated controls shall be native Bacnet compatible Measurement system accuracy shall be plus or minus 2% of volumetric airflow rate. Turndown capability shall be at least 15:1.

J. The airflow measuring device shall be Vortek VT series (IAQ 2000 for outdoor sensor) manufactured by Tek-Air Systemsor or approved equal.
K. Basis of design for Actuators shall be Belimo.

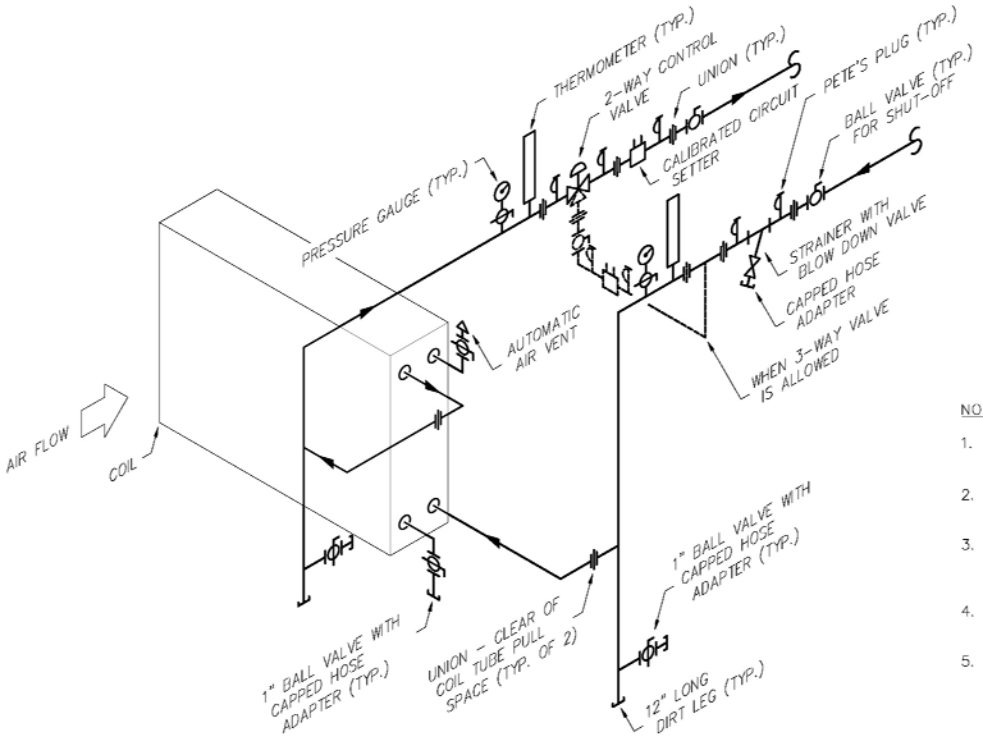
3. **EXECUTION**
   A. For all equipment with which the controls contractor will be interfacing, the controls contractor shall be responsible for reviewing the equipment submittals to ensure that the equipment is being supplied with appropriate accommodations to interface with the BAS as specified.
   B. Work required under paragraphs 1.E, 1. F, 1.J, and 2.C shall be provided by the mechanical contractor in coordination with the controls contractor.
   C. Locate instrumentation, sensor wells, to allow removal and replacement without having to cause damage to or having to remove insulation, etc. show, to scale, on piping shop drawings. Well and sensor shall be matched to ensure accurate measurement of the medium
   D. Label all control elements to clearly indicate function; labels to match control wiring diagrams, schematics and BAS and graphics. Provide legend for each symbol used on both control drawings and graphics.
   E. Control sequences shall be written clearly and stated in a logical progression of events and/or actions for all modes of. Sequences shall be provided for both DDC controlled equipment and “packaged equipment”. The graphic screen for each item of equipment and system shall have a link to the associated ‘as-built’ sequence of operation. Package equipment suppliers shall provide sequences of operation specific for the equipment provided. (Although the packaged equipment may not be internally controlled by the BAS, UGA needs to understand the internal operation of the equipment and how it relates to the external system.)
   F. Electrical supply serving controls shall be permanently energized; one circuit will be provided per floor, all wiring and electrical work, including surge protection, from electrical termination point will be by the controls provider. Control panels associated with the HVAC BAS, the wiring in the panels, and the connections to the panels and all control elements shall be executed by the controls subcontractor. Subcontracted electrical work associated with the HVAC BAS shall be confined to conduits and wiring between panels and controls devices. Control wiring shall be run in conduit. For exceptions permitted in the specification, wiring shall be independently supported, run continuously tight to and fixed to structure, J-hooks at approved spacing will be accepted. New wireways shall be installed in walls or chases. Surface mounted conduit and wire molding shall not be used without

written approval.

G. The controls contractor shall submit an as-built electronic copy of all programming done, including point-to-point wiring, VAV terminal coefficients as set and calibrated by the TAB subcontractor. This shall be updated to as-built at the end of the warranty period. An electronic zip file after all TAB and Cx with all final programming loaded shall be provided to UGA to allow reloading of the complete program in the event of a 'crash'.
H. Controls drawings shall be laminated and bound and placed within a pocket inside each control panel.
I. Service
    i. Two year warranty on parts and labor required.
    ii. Maximum of 5 working days response time to warranty items required.

23 20 00
HVAC PIPING & PUMPS

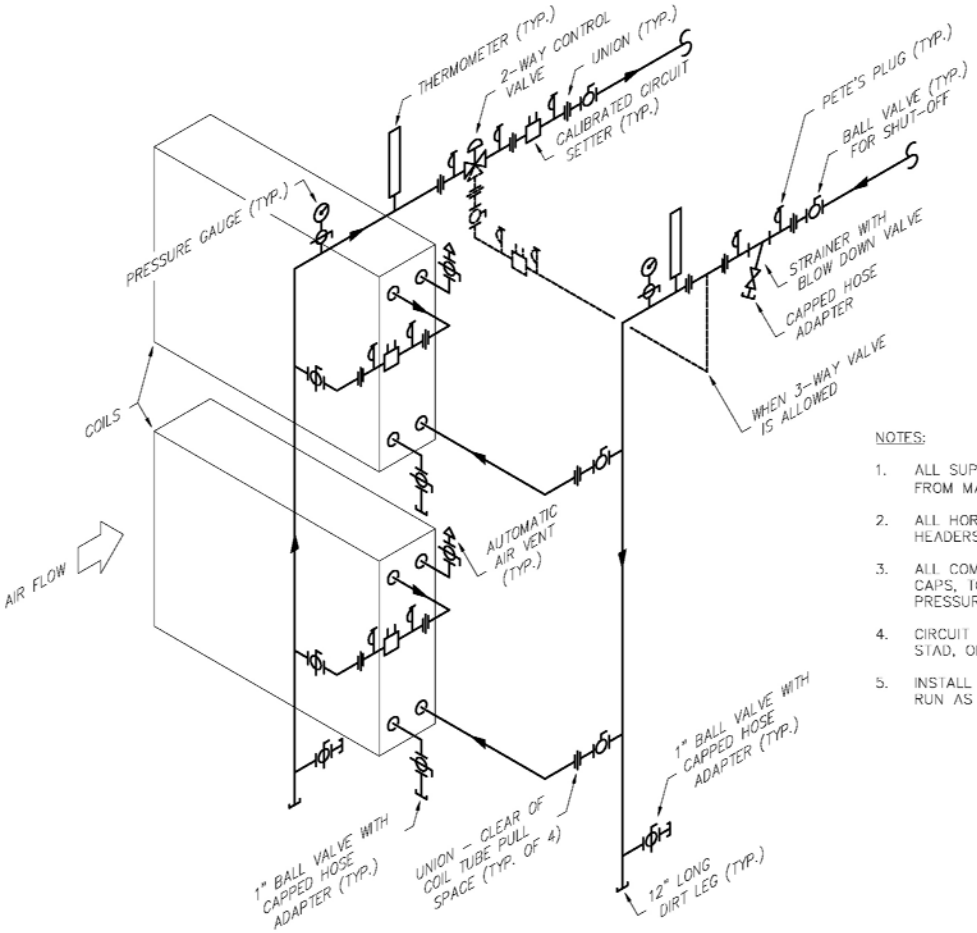
1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 20 00 – HVAC Piping & Pumps
      iii. 23 21 13 – Hydronic Piping
   B. A.H.U. Coil Piping Detail – Single Coil
      SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



NOTES:

1. ALL SUPPLY AND RETURN HEADERS TO BE FULL SIZE FROM MAIN (SEE PLANS FOR PIPE SIZE).
2. ALL HORIZONTAL CONNECTIONS TO COILS FROM VERTICAL HEADERS TO BE SIZE OF COIL CONNECTIONS.
3. ALL COMPONENTS, INCLUDING DRAIN VALVE ADAPTER CAPS, TO BE RATED FOR FULL SYSTEM OPERATING PRESSURE.
4. CIRCUIT SETTER SHALL BE TOUR AND ANDERSON, MODEL STAD, OR APPROVED EQUAL.
5. INSTALL CONTROL VALVE PACKAGE IN HORIZONTAL PIPE RUN AS REQUIRED TO FACILITATE COIL REMOVAL.

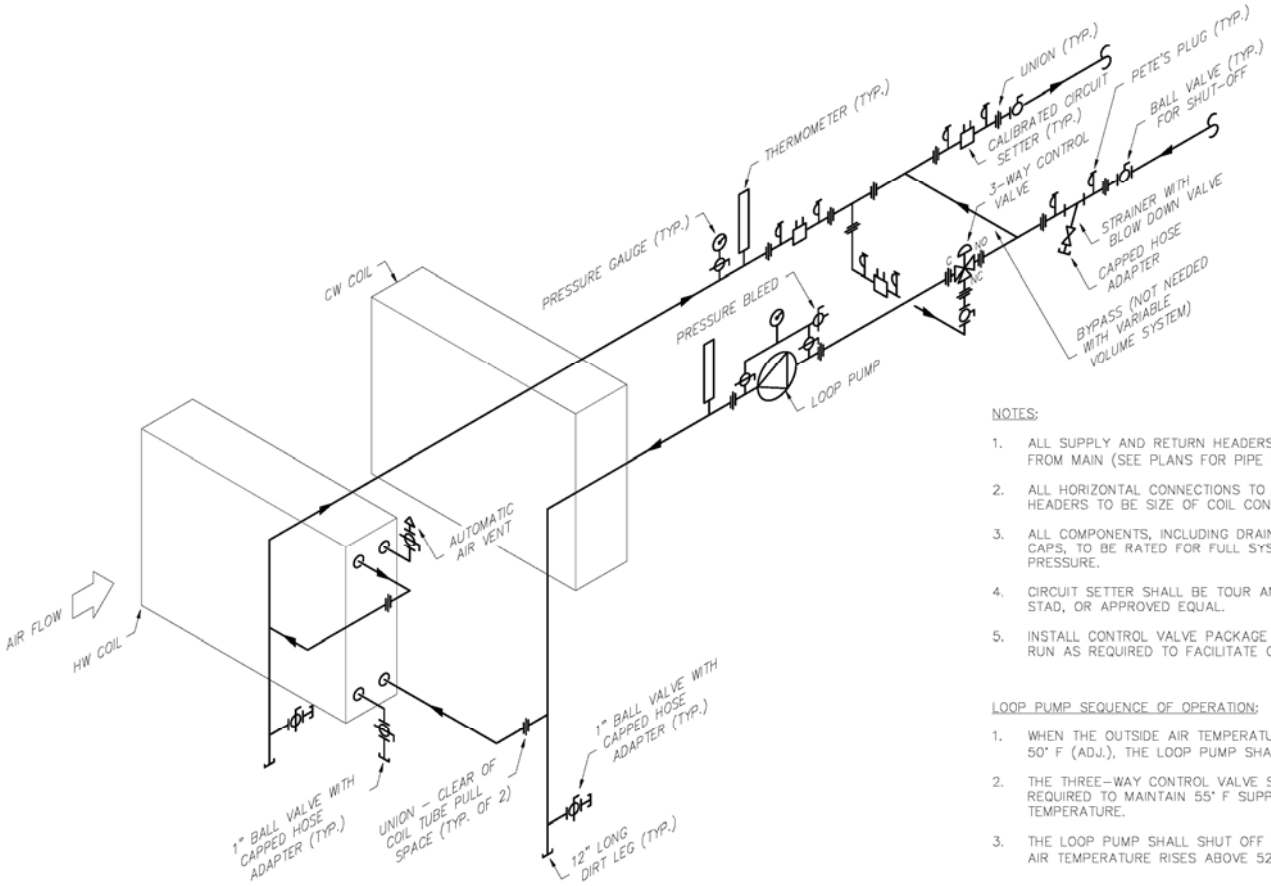
C. A.H.U. Coil Piping Detail – Multiple Coils
SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



NOTES:

1. ALL SUPPLY AND RETURN HEADERS TO BE FULL SIZE FROM MAIN (SEE PLANS FOR PIPE SIZE).
2. ALL HORIZONTAL CONNECTIONS TO COILS FROM VERTICAL HEADERS TO BE SIZE OF COIL CONNECTIONS.
3. ALL COMPONENTS, INCLUDING DRAIN VALVE ADAPTER CAPS, TO BE RATED FOR FULL SYSTEM OPERATING PRESSURE.
4. CIRCUIT SETTER SHALL BE TOUR AND ANDERSON, MODEL STAD, OR APPROVED EQUAL.
5. INSTALL CONTROL VALVE PACKAGE IN HORIZONTAL PIPE RUN AS REQUIRED TO FACILITATE COIL REMOVAL.

D. A.H.U. Coil Piping Detail – Hot Water Coil With Loop Pump
SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



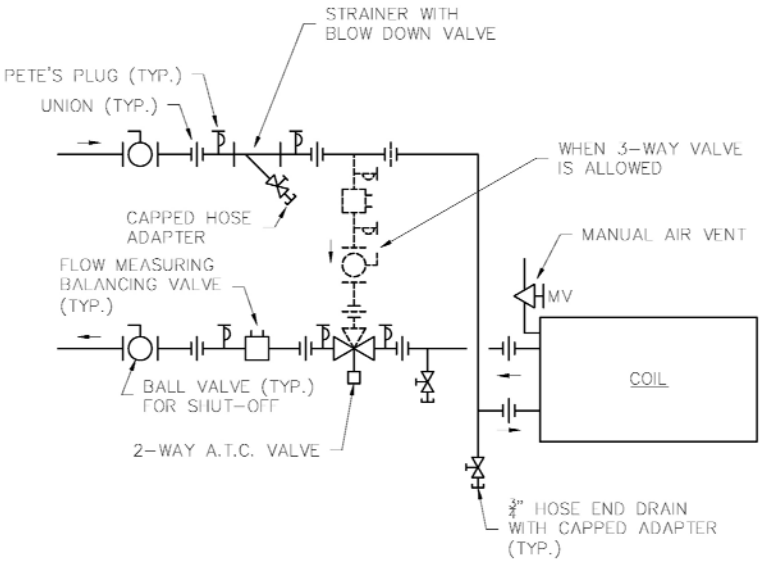
NOTES:

1. ALL SUPPLY AND RETURN HEADERS TO BE FULL SIZE FROM MAIN (SEE PLANS FOR PIPE SIZE).
2. ALL HORIZONTAL CONNECTIONS TO COILS FROM VERTICAL HEADERS TO BE SIZE OF COIL CONNECTIONS.
3. ALL COMPONENTS, INCLUDING DRAIN VALVE ADAPTER CAPS, TO BE RATED FOR FULL SYSTEM OPERATING PRESSURE.
4. CIRCUIT SETTER SHALL BE TOUR AND ANDERSON, MODEL STAD, OR APPROVED EQUAL.
5. INSTALL CONTROL VALVE PACKAGE IN HORIZONTAL PIPE RUN AS REQUIRED TO FACILITATE COIL REMOVAL.

LOOP PUMP SEQUENCE OF OPERATION:

1. WHEN THE OUTSIDE AIR TEMPERATURE DROPS BELOW 50° F (ADJ.), THE LOOP PUMP SHALL BE ENERGIZED.
2. THE THREE-WAY CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN 55° F SUPPLY AIR DISCHARGE TEMPERATURE.
3. THE LOOP PUMP SHALL SHUT OFF WHEN THE OUTSIDE AIR TEMPERATURE RISES ABOVE 52° F (ADJ.).

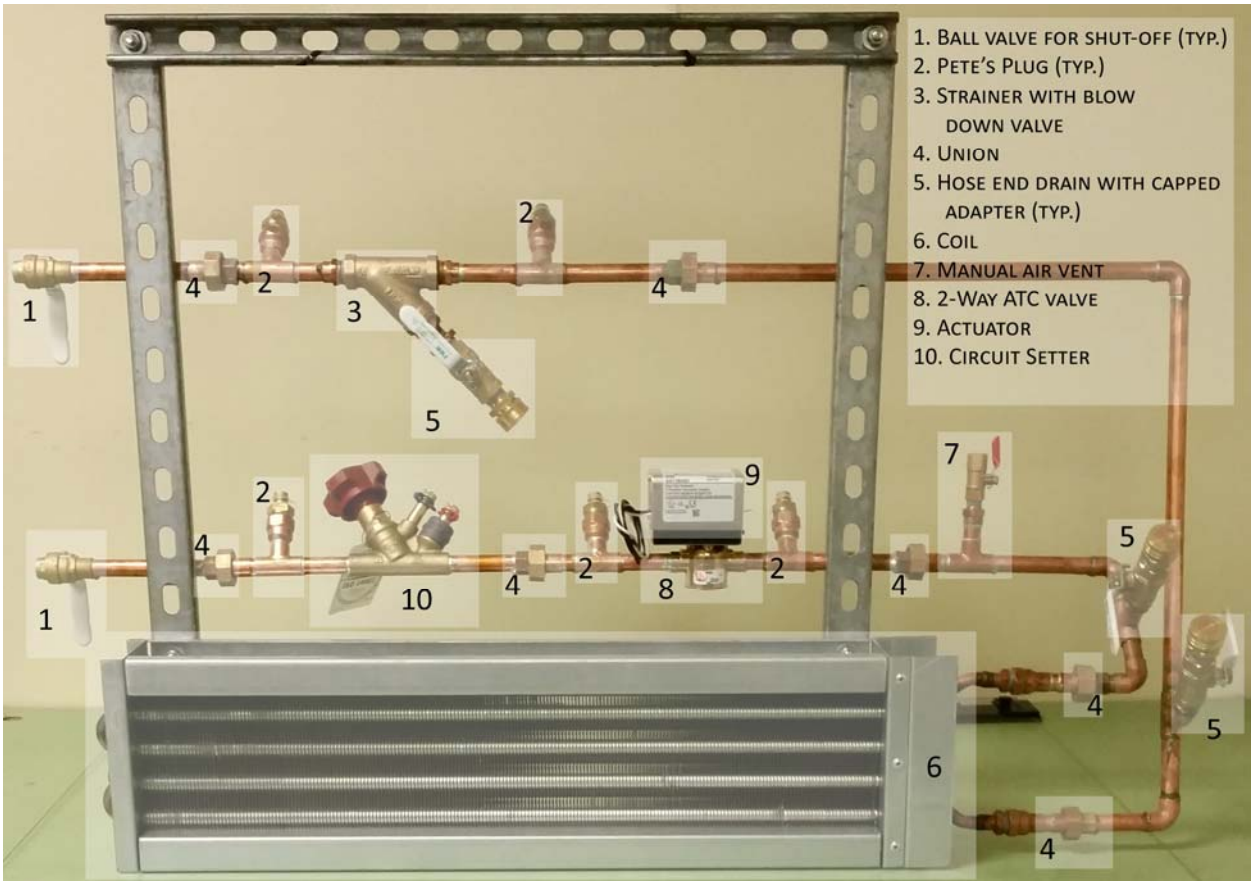
E. Fan Coil Unit & Terminal Unit Coil Piping Detail
SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY.
See mockup 1.F this section.



NOTES:

1. ARRANGE ALL PIPING TO ALLOW REMOVAL OF COIL.
2. PIPING SHOWN IS DIAGRAMMATIC.
3. ALL COMPONENTS, INCLUDING DRAIN VALVE ADAPTER CAPS, TO BE RATED FOR FULL SYSTEM OPERATING PRESSURE.
4. CIRCUIT SETTERS SHALL BE TOUR AND ANDERSON, MODEL STAD, OR APPROVED EQUAL.

F. Fan Coil Unit & Terminal Unit Coil Piping Mockup
MOCKUP FOR GENERAL REFERENCE ONLY



23 21 13
HYDRONIC PIPING

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 07 19 – HVAC Piping Insulation
      iii. 23 20 00 – HVAC Piping & Pumps
      iv. 23 21 23 – Hydronic Pumps
   B. Design Professional drawings shall show piping in mechanical rooms particularly at connections to coils and shall not leave piping installation to be left up to the Contractor. Provide at least one elevation view.
   C. The Contractor shall submit shop drawings for all gasket materials on jointing which shall include installation instructions and recommendations.
   D. Reference drawings are provided at the end of this section for Automatic Air Vent Detail and Manual Air Vent Detail.
2. **PRODUCTS**
   A. Underground chilled water supply and return piping shall be equal to Thermacor FERRO-THERM SC steel piping system with HDPE jacket ASTM D-1248, 0.1" thickness (minimum) for up to 12" diameter pipe, polyurethane foam insulation and a carrier pipe of the schedule indicated above. Fittings shall be factory insulated with pressure testable joint closure; leak detection wiring, connectors and monitoring panel.
   B. Red rubber gaskets are acceptable on chilled water lines but only with flat-faced flanges on both mating flanges. (Note: mis-matched flat and raised face flanges, on pipe and/or valve flanges, shall not be used).
   C. Pipe system air and dirt removal basis of design shall be Spirovent; devices shall be selected for 100% free, 100% entrained and 99% dissolved air removal; shop drawings shall clearly indicate this performance.
   D. Grooved fittings shall not be used on chilled water or heating hot water without variance approval.
   E. Dielectric unions shall not be used. Dielectric flanges and insulating kits may be used and shall be rated for 300F degrees at 150 psig minimum.
3. **EXECUTION**
   A. Welding:
      i. All welding for above ground piping shall be done in accordance with ASME B31.9 (latest edition), Code for Building Services Piping. All welding done below ground shall be done in accordance with ASME 31.1 (latest addition), code for Power Piping.
      ii. All welding procedures, welder qualification, quality, and testing shall conform to the requirements of ANSI B31.1, Code for Pressure Piping; and to the ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications. The Contractor shall be responsible for the procedures, quality and visual testing of all welding performed by him and his employees.
      iii. The WPQs shall be performed under the witness of an independent agency. The witness shall be a representative of an independent testing agency, Authorized Inspector, or consultant, any of which must be approved by the National

Certified Pipe Welding Bureau. The qualifying test segment must be a 2 inch nominal pipe size with wall thickness within range of the WPS. Tests position shall be “6G” per ASME Section IX.

iv. Welding procedures, and all welder qualifications (WPQs and Evidence of Continuity) shall be maintained on the jobsite.

v. A third party testing firm shall perform Ultrasonic testing of 100% of the full penetration welds for all underground piping and any above ground welds that the owner chooses. Fillet welds shall be tested using a dye penetrant. Contractor shall be responsible for all labor, material and travel expenses involved in the re-inspection and retesting of any welds found to be unacceptable.

B. Buried pre-insulated pipe shall be installed in accordance with the manufacturer’s installation instructions and recommendations and shall be laid on a minimum 6" deep sand bed and a minimum 12" backfill of sand on top of pipe.

C. Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried utility. Locate 6” above sand bed. Provide a second tape 6” below grade for pipes buried at 6 feet, or greater depth.

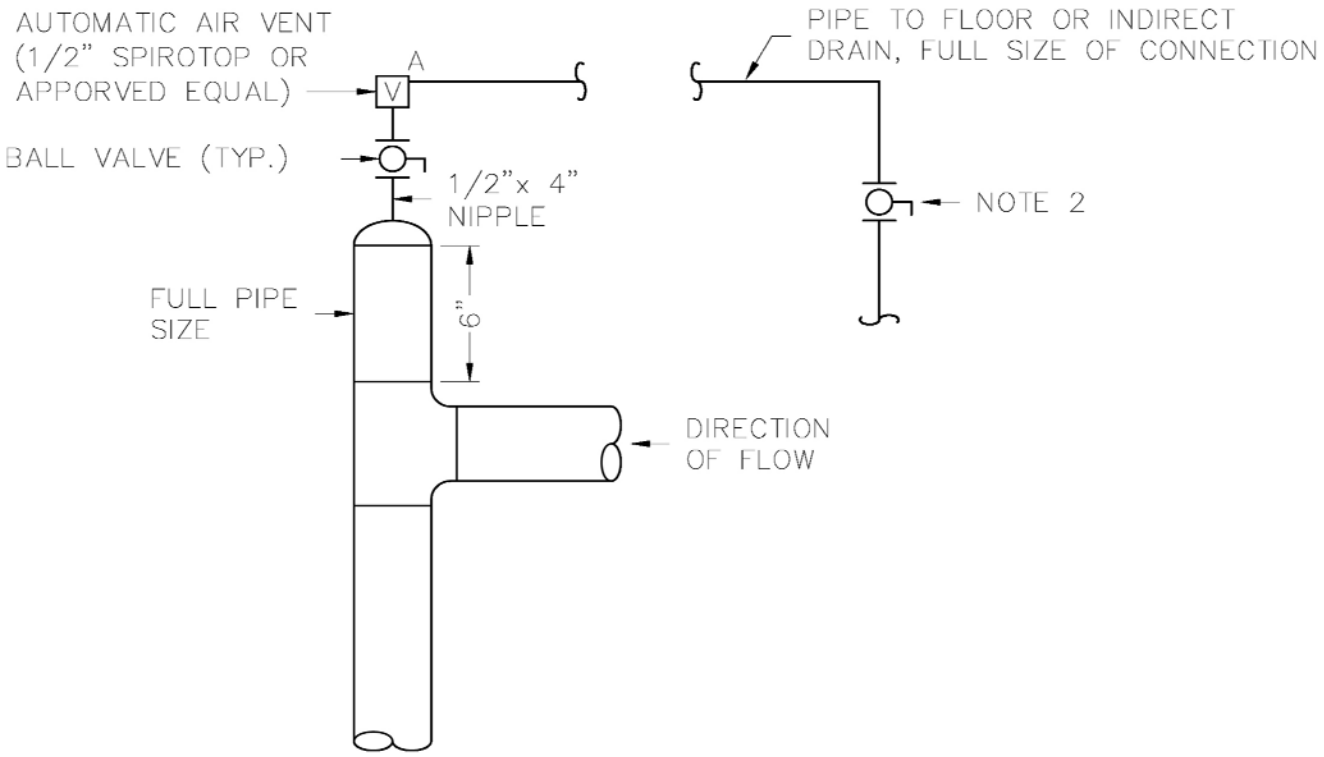
D. Thrust blocks, if required, shall be poured in place and inspected by UGA utility personnel prior to covering up.

E. The manufacturer of the pre-insulated pipe shall prepare field verified installation shop drawings prior to fabrication and installation; the manufacturer’s authorized representative shall field inspect installation and testing; the contractor shall provide exact as-installed record “as-built” including GIS location of pipe and depth of bury. The manufacturer’s representative shall check the leak detection wiring, for continuity, prior to back filling.

F. Flange bolts shall be torqued as recommended by the gasket manufacturer.

AUTOMATIC AIR VENT DETAIL

SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY

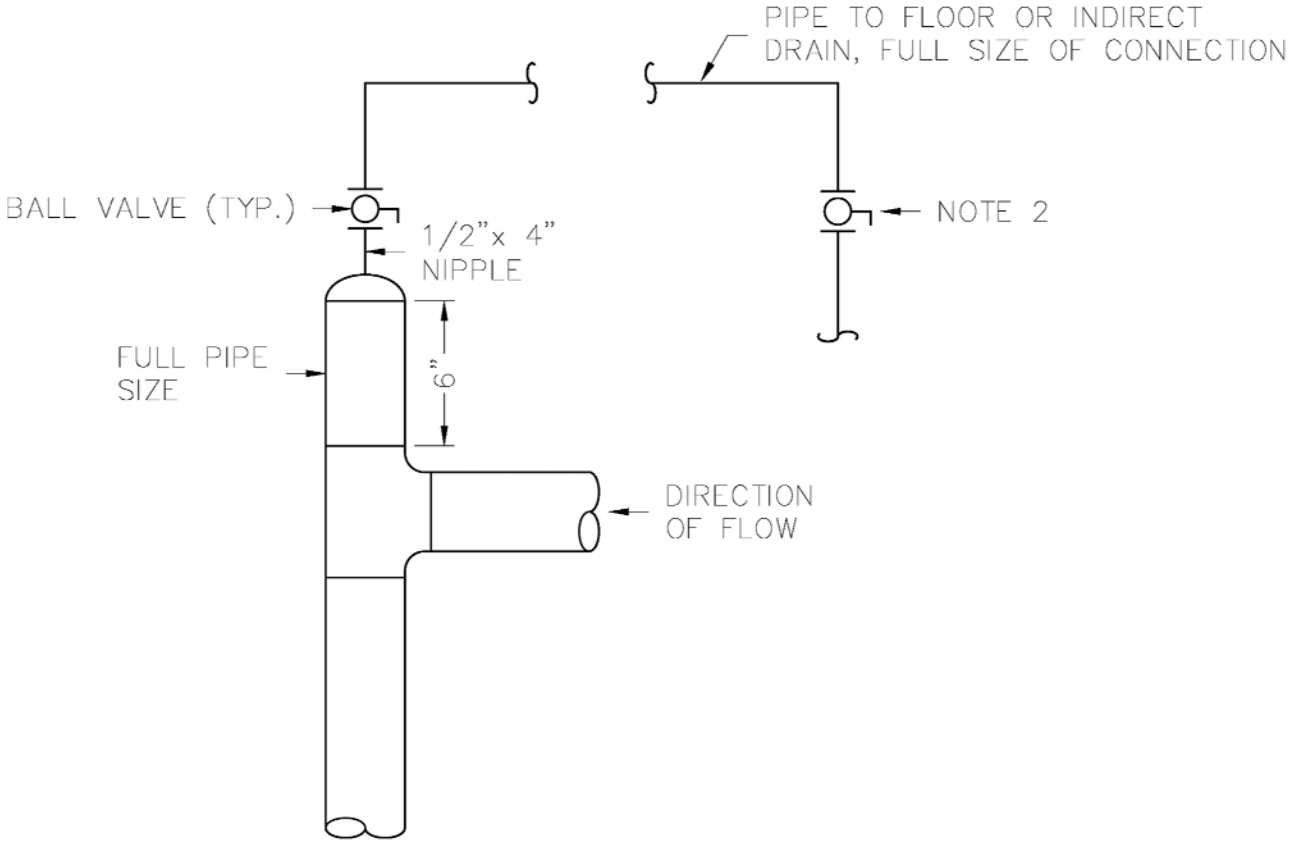


NOTES:

1. VENT ALL HIGH POINTS AS INDICATED ABOVE.
2. PROVIDE BALL VALVE IN ACCESSIBLE LOCATION WHERE DISCHARGE FROM TUBING CAN BE OBSERVED. PROVIDE AAV WHERE INDICATED. PROVIDE BALL VALVE AHEAD OF AAV.

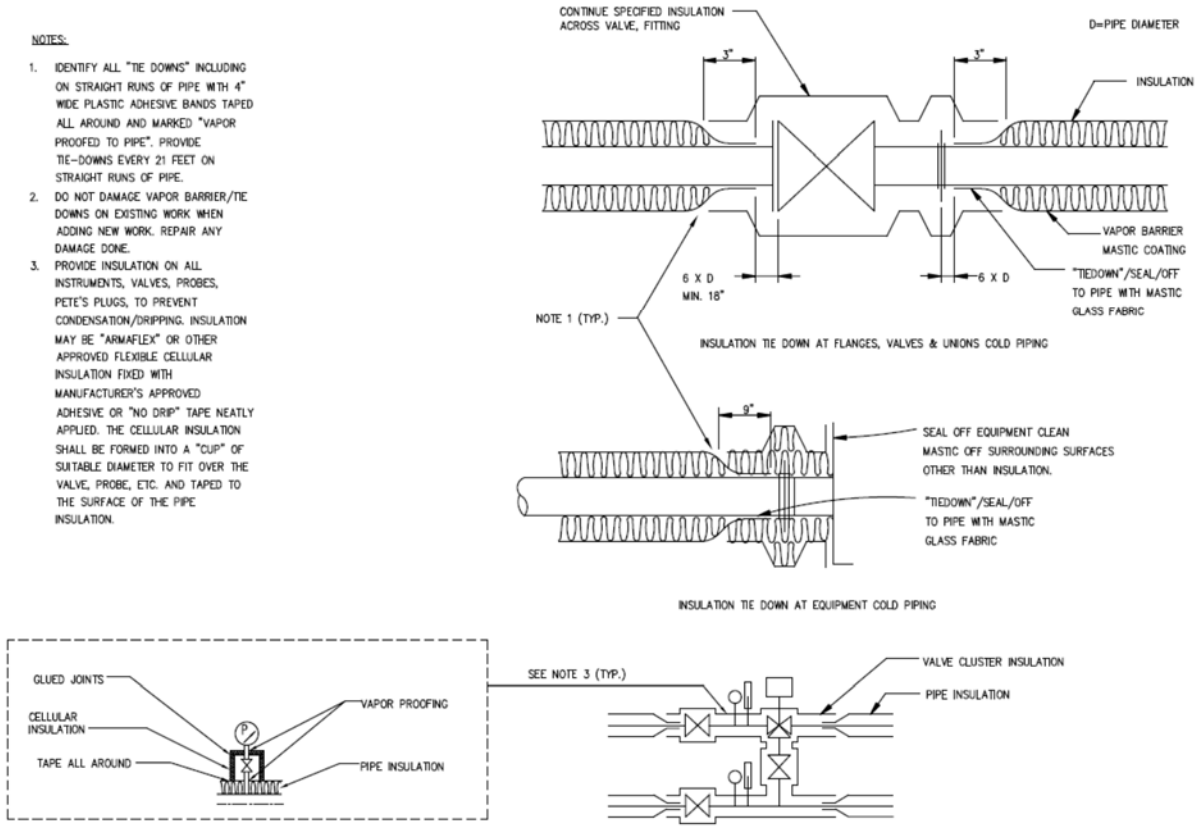
MANUAL AIR VENT DETAIL

SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



NOTES:
1. VENT ALL HIGH POINTS AS INDICATED ABOVE.
2. PROVIDE BALL VALVE IN ACCESSIBLE LOCATION WHERE DISCHARGE FROM TUBING CAN BE OBSERVED.

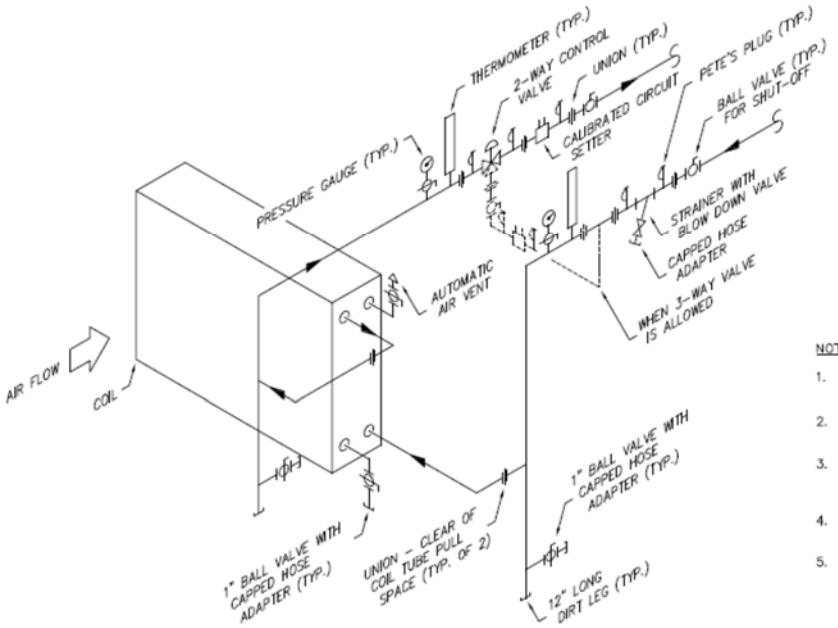
INSULATION TIE-DOWN DETAIL Reject – see 23 07 19 Piping Insulation
SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



INSULATION TIE DOWN/SEAL OFF POINTS FOR CHILLED WATER PIPE DETAIL
SCALE: NONE

AHU COIL PIPING DETAIL – SINGLE COIL Reject see 23 20 00

SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



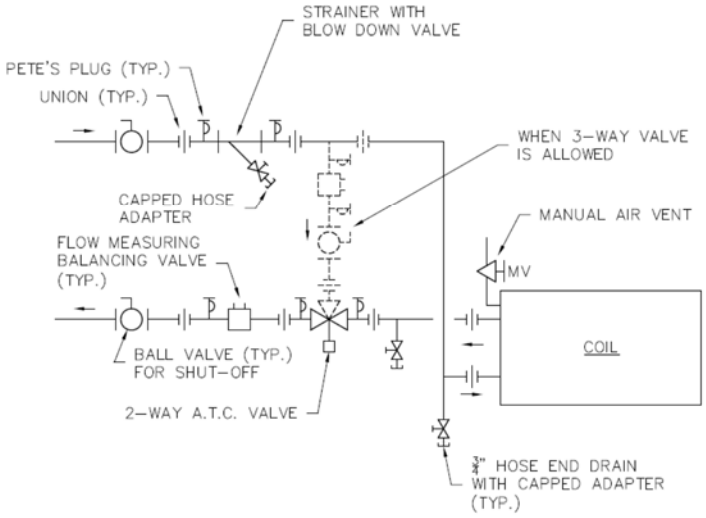
NOTES:

1. ALL SUPPLY AND RETURN HEADERS TO BE FULL SIZE FROM MAIN (SEE PLANS FOR PIPE SIZE).
2. ALL HORIZONTAL CONNECTIONS TO COILS FROM VERTICAL HEADERS TO BE SIZE OF COIL CONNECTIONS.
3. ALL COMPONENTS, INCLUDING DRAIN VALVE ADAPTER CAPS, TO BE RATED FOR FULL SYSTEM OPERATING PRESSURE.
4. CIRCUIT SETTER SHALL BE TOUR AND ANDERSON, MODEL STAD, OR APPROVED EQUAL.
5. INSTALL CONTROL VALVE PACKAGE IN HORIZONTAL PIPE RUN AS REQUIRED TO FACILITATE COIL REMOVAL.

A.H.U. COIL PIPING DETAIL – SINGLE COIL
SCHEMATIC ONLY

FAN COIL UNIT AND TERMINAL UNIT COIL PIPING DETAIL Reject see 23 20 00

SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



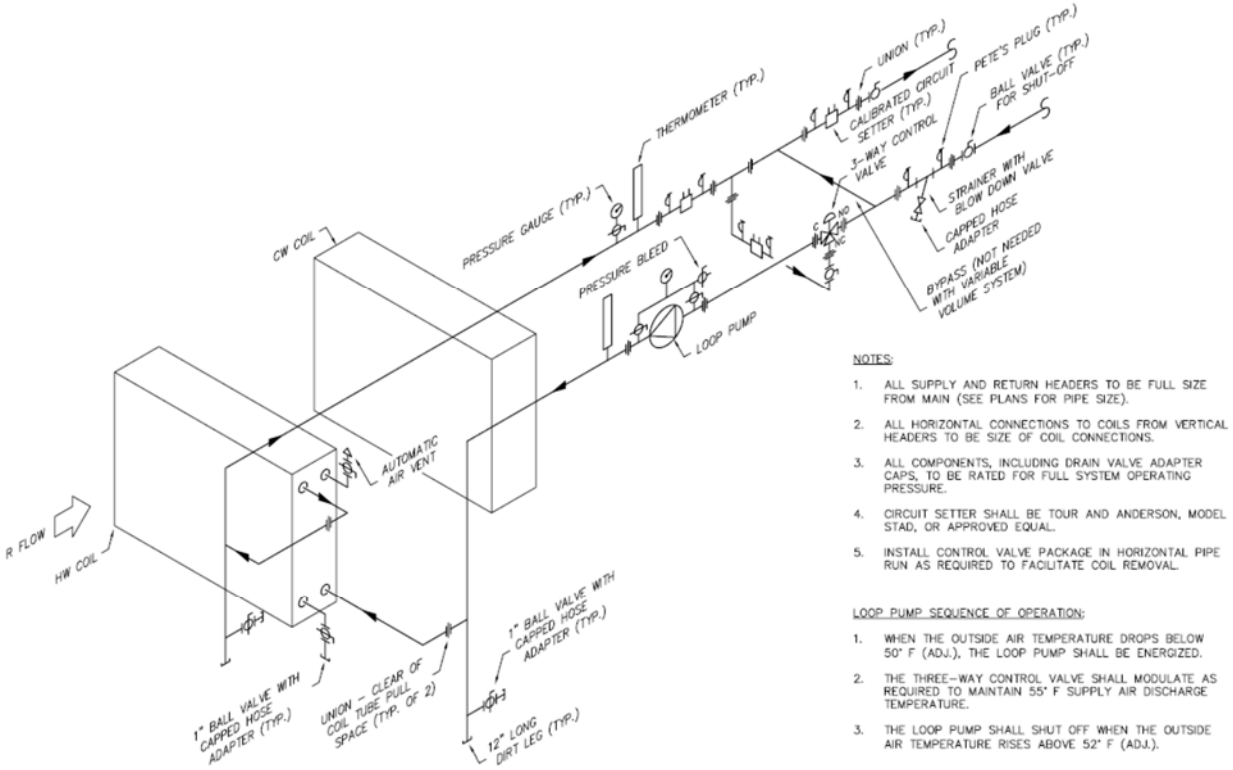
NOTES:

1. ARRANGE ALL PIPING TO ALLOW REMOVAL OF COIL.
2. PIPING SHOWN IS DIAGRAMMATIC.
3. ALL COMPONENTS, INCLUDING DRAIN VALVE ADAPTER CAPS, TO BE RATED FOR FULL SYSTEM OPERATING PRESSURE.
4. CIRCUIT SETTERS SHALL BE TOUR AND ANDERSON, MODEL STAD, OR APPROVED EQUAL.

FAN COIL UNIT & TERMINAL UNIT COIL PIPING DETAIL
(SCHEMATIC ONLY)

AHU COIL PIPING DETAIL – HOT WATER COIL WITH LOOP PUMP Reject see 23 20 00

SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



NOTES:

1. ALL SUPPLY AND RETURN HEADERS TO BE FULL SIZE FROM MAIN (SEE PLANS FOR PIPE SIZE).
2. ALL HORIZONTAL CONNECTIONS TO COILS FROM VERTICAL HEADERS TO BE SIZE OF COIL CONNECTIONS.
3. ALL COMPONENTS, INCLUDING DRAIN VALVE ADAPTER CAPS, TO BE RATED FOR FULL SYSTEM OPERATING PRESSURE.
4. CIRCUIT SETTER SHALL BE TOUR AND ANDERSON, MODEL STAD, OR APPROVED EQUAL.
5. INSTALL CONTROL VALVE PACKAGE IN HORIZONTAL PIPE RUN AS REQUIRED TO FACILITATE COIL REMOVAL.

LOOP PUMP SEQUENCE OF OPERATION:

1. WHEN THE OUTSIDE AIR TEMPERATURE DROPS BELOW 50° F (ADJ.), THE LOOP PUMP SHALL BE ENERGIZED.
2. THE THREE-WAY CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN 55° F SUPPLY AIR DISCHARGE TEMPERATURE.
3. THE LOOP PUMP SHALL SHUT OFF WHEN THE OUTSIDE AIR TEMPERATURE RISES ABOVE 52° F (ADJ.).

23 21 23
HYDRONIC PUMPS
(For chilled and condenser water)

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 21 13 – Hydronic Piping
      iii. 26 00 00 – General Electrical Requirements
2. **PRODUCTS**
   A. Basis of design shall be Patterson Pump Company.
   B. Shall have bronze wear rings, external seal flush line, silicon carbide seals and tungsten carbide seals on chilled and condenser water systems respectively.
3. **EXECUTION**
   A. Pipe connections shall be installed in such a manner as not to put stress on the seal.
   B. Provide all pumps with start-up strainer to be removed before handover.
   C. Pump base shall be properly grouted and pump and motor aligned per the manufacturer's instructions and recommendations.
   D. Pump impellers, on oversized pumps, shall be skimmed for peak flow of no more than 5% of maximum design flow the current project.
   E. The manufacturer or factory authorized representative shall inspect the installation and submit certification that the pumps installations are in accordance with installation instructions and good engineering practice.
   F. Install shaft grounding rings equal to Aegis SCR to all pumps requiring the use of VSDs.

23 22 13
STEAM AND CONDENSATE HEATING PIPING

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 22 16 – Steam and Condensate Heating Piping Specialties
      iii. 33 66 00 – Hydronic and Steam Energy Utilities
   B. Heating shall be steam; supply pressure to the building is 100 psig; reduce inside building at pipe entry; provide drip set immediately upstream of PRV station. PRV installation shall comply with manufacturer's installation instructions and recommendations. Provide pressure gauge downstream and P/T ports up and downstream of every PRV.
   C. UGA requires the use of expansion loops; expansion joints require variance approval.
   D. For underground steam piping the manufacturer of the pre-insulated pipe shall provide field verified installation shop drawings to the Contractor, Design Professional, and the Project Manager prior to fabrication and installation.
2. **PRODUCTS**
   A. Above Ground Steam Piping
      i. Steam piping shall be steel, ASTM A53, Schedule 40 seamless steel with welded joints for all piping larger than 2". Threaded steel pipe shall be allowed for 2" and smaller.
      ii. Steam condensate piping and pumped condensate shall be Schedule 80.
   B. Underground Steam Piping (NEED THIRD PRODUCT)
      i. High/Medium Pressure Steam Piping (greater than 50 psig)
         a. Basis of design is Thermacor Duo-Therm 505.
      ii. Steam Condensate
         a. Basis of design is Thermacor HT-406.
3. **EXECUTION**
   A. Steam Piping
      i. Above ground steam piping and condensate piping shall be installed to slope in the direction of flow.
      ii. All welding procedures, welder qualification, quality, and testing shall conform to the requirements of ANSI B31.1, Code for Pressure Piping; and to the ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications. The Contractor shall be responsible for the procedures, quality and visual testing of all welding performed by him and his employees.
      iii. The WPQs shall be performed under the witness of an independent agency. The witness shall be a representative of an independent testing agency, Authorized Inspector, or consultant, any of which must be approved by the National Certified Pipe Welding Bureau. The qualifying test segment must be a 2 inch nominal pipe size with wall thickness within range of the WPS. Tests position shall be "6G" per ASME Section IX.
      iv. All welding shall be done in accordance with ASME B31.1, Code for Power Piping.
      v. Welding procedures, and all welder qualifications (WPQs and Evidence of Continuity) shall be maintained on the jobsite.

vi. The Contractor shall pressure test the steam and condensate piping. A third party testing firm shall be hired by the owner to perform Ultrasonic testing of 100% of the underground full penetration welds and any above ground welds that the owner chooses. Fillet welds shall be tested using a dye penetrant. Contractor shall be responsible for all labor, material, and travel expenses involved in the re-inspection and retesting of any welds found to be unacceptable.

B. Underground Steam and Condensate Piping:
   i. The manufacturer's authorized representative shall field inspect installation and shall witness and report on all testing.
   ii. Fittings shall be factory insulated with pressure testable joint closure; leak detection wiring, connectors and monitoring panel.
   iii. The Contractor shall provide exact as-installed record "as-built" including GIS location of pipe and depth of bury. The Contractor shall employ a licensed surveyor to measure the elevation of the installed piping and include information in close out documents.
   iv. Underground piping shall contain leak detection wire wired to a monitoring panel. The manufacturer's representative shall check the leak detection wiring, for continuity, prior to back filling.
   v. Steam pipe in vaults shall be insulated with cellularglass and covered with stainless steel jacketing.
   vi. The Contractor shall provide an air pressure test of the outer conduit for all class A piping.
   vii. Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried utility at two levels above the buried pipe, at 12" below grade and at the top of the fill (approximately 12" above pipe).

23 22 16
STEAM & CONDENSATE HEATING PIPING SPECIALTIES

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 05 23 – General-Duty Valves for HVAC Piping
      iii. 23 22 13 – Steam and Condensate Heating and Piping
   B. The Contractor shall submit shop drawings for gasket materials on jointing which shall include manufacturer's installation instructions and recommendations.
   C. Provide steam powered sump pumps in all steam manholes as required to keep the manhole dry.
   D. In steam manholes, provide redundant steam traps at drip legs.
2. **PRODUCTS**
   A. Steam system components requiring access (PRVs, unions, valves, etc.) shall be insulated with removable customized jackets. Features shall include:
      i. High temperature insulation blanket capable of withstanding 1000 degrees F. If installed in below ground vaults, then the insulation blanket shall be aerogel.
      ii. PTFE jacketing.
      iii. Kevlar threads.
      iv. Double-row stitching with minimum 4-6 stiches per inch.
      v. The surface temperature shall not exceed 120 degrees F, for 100 psi steam.
      vi. Mating seams shall include 2" flap secured with hook and loop fastening material, and straps with buckles.
   B. Basis of Design shall be Thermaxx.
   C. Valves manufactured in China are prohibited.
   D. Ball Valves are not allowed for any steam, steam condensate, or pumped condensate systems.
   E. Ball Joints
      i. Equal to Hyspan Type N Style I
      ii. Equal to Advanced Thermal Systems (ATS) S Series Ball Joint
   F. Control Valves
      i. Equal to Armstrong International Inc. or Jordan Valve
   G. Expansion Joints
      i. Equal to Hyspan – Packed Type
      ii. Equal to ATS Thermal Pak TP2 Expansion Joint
   H. Gaskets
      i. For steam piping joints shall be equal to spiral-wound metallic - Flexitallic, Flexite Super metallic spiral wound type, 304 SS (minimum) with non-asbestos mineral filler ring-type gaskets in conformance with ANSI B16.20.
   I. Pilot Valves
      i. Equal to Spence Engineering Company, Inc. Type D Pressure Pilot
   J. Pressure Reducing Stations
      i. Equal to Spence Engineering Company, Inc. Type E Main
   K. Relief Valves
      i. Equal to Kunkle or Spence Engineering Company, Inc.
   L. Steam Traps

i. Equal to Armstrong 800PC Series Bucket Traps (for use in steam manholes and campus distribution)
ii. dProvide dual traps in steam vaults. All steam trap assemblies located in steam vaults shall be threaded (not welded) and shall consist of the following components: two bucket steam traps in parallel with individual strainers and check valves. A total of 6 isolation valves shall be provided.

M. Steam Powered Sump Pumps (for use in steam manholes):
i. Equal to Spirex Sarco (required 36”x36”x36” sump)
ii. Equal to Penberty (requires 18”x18”x18” sump)

N. Valves for steam and steam condensate:
i. 1/8”-2”:threaded gate valves equal to Nibco Inc. or Milwaukee Valve
ii. 2”-20” “
a. In steam manholes and campus steam distribution system, triple offset butterfly type, 150 lb. class, with face-to-face dimensions allowing interchangeability with gate valve. Valve shall be doube-flanged, bi-directional, zero leakage, with single-piece vlave and stem, and field replaceable seats. Valve shall be provided with manual operated hand wheel and gear operated shaft to allow for slow opening of valve. Acceptable manufacturers are:
1) Vanessa
2) Nibco
3) Adams Valves
4) Bray
5) ABZ
b. Within buildings, flanged gate valves shall be allowed.

3. **EXECUTION**

A. Steam and condensate and heating hot water lines shall be cycled through heat-up and cool-down and joints inspected for leaks and tightened as needed (at least twice, after 2 months and after 9 months during the warranty period).
B. Flange bolts shall be torqued strictly in accordance with the gasket manufacturer’s installation instructions and recommendations.

23 25 00
HVAC WATER TREATMENT

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 64 16.16 – Water-Cooled Water Chillers
      iii. 23 65 00 – Cooling Towers
   B. **For UGA Athens Campus Only** - HVAC water treatment company responsible for all water treatment on campus is:
      i. Chem Aqua
      ii. Contact person is John Mayfield, ph. (404) 558-9695
      E-mail: jmayfiel@nch.com.
      iii. Chem Aqua shall be employed by the Contractor on all new and renovated condenser water, chilled and heating hot water plant to review design, preparation, cleaning, flushing and start-up.
   C. Design Professionals are encouraged to explore design solutions that do not require and / or minimize any chemical water treatment requirements.
2. **PRODUCTS**
   A. Cooling Towers Treatment:
      i. Controllers: Chemical feed and conductivity controller shall be an L.M.I. (Liquid Metronics Inc.) Model DC-4500 or approved equal. This system shall be mounted and pre-piped to a hard synthetic backboard. Flow assembly should include a 4 station corrosion coupon rack (3 for steel and 1 for copper) and shall be piped in 1" schedule 80 pvc pipe. Ball valve cut off at inlet and outlet of board. The controllers shall be provided with a BACNET card and shall interface with the DDC.
      ii. Pumps: All chemical feed pumps shall be Pulsafeeder Model C+ or approved equal and shall include both speed and stroke adjustability and shall be a 12 GPD capacity. Pumps shall also be pre-mounted on hard synthetic backboard and plumbed to a 1" injection assembly. Injection assembly will be piped in 1" Sch.80 pvc pipe.
      iii. Flow Indicator: A Flow indicator shall be installed upstream of the chemical injection assembly. Flow indicator shall be of brass and or stainless steel construction and will have graduated markings. At a minimum flow indicator will read from 0-15 gpm.
      iv. Biocide:
         a. Primary Biocide shall be controlled via a biocide timer built into the L.M.I. controller. Controller will send 120 volts to the biocide pump at a pre-determined time and duration. Dosages will vary depending on system size and load etc.
         b. Secondary Biocide shall be tabulated bromine and shall be fed through a bromine feeder. Bromine feeder shall be a minimum 40 lb. capacity (equal to a Pentair Model HC 3340). This system shall be piped separately of the main chemical feed system with a separate supply and return to system. Ball valve cut off at inlet and outlet of bromine feeder.

Install a flow meter upstream of feeder. Install a drain line on feeder to floor drain.

v. Blow-Down Solenoid Valve: Provide a solenoid valve appropriately sized for the system blow-down and installed separately of the chemical feed system piping. 120 volt coil assembly shall be wired from solenoid to coil. Asco Red Hat Valve (Grainger Part # 3UK51 or approved equal) shall be a (1/2”). Model will depend on size of system and blow-down requirements.

vi. Shut off Valves: All shut off valves shall be ball valves.

vii. Water Meter: An appropriately sized make-up water meter shall be provided and installed in the cooling tower make-up water line. Meter shall have a 100 gal/contact pulse contactor that will send a dry-contact pulse signal to the DC-4500 which will actuate the inhibitor feed and will allow for feed proportionate to load. Provide Meter equal to Seametrics MJ series.

viii. Chemical Feed Tanks: Chemical Feed tanks shall be min. 15 gal. and maximum 30 gal. in capacity and should be sized according to the system size and requirements. Provide electronic level indicating wands.

ix. Secondary Containment: A pallet style spill control vessel shall be placed beneath chemical feed station to contain the inhibitor and biocide chemical containers. This containment vessel shall be a maximum of 8 inches tall and minimum of 24 inches in depth and a minimum of 48 inches in width.

B. Closed Loop Water Treatment:

i. Bypass Feeders should be a flat bottom style 5 gallon capacity. Shall have a ¼” turn locking lid with minimum 3.5 inch opening at the top for chemical addition. Install a ball valve on inlets and outlets of bypass feeder tank. Drain line shall be provided from feeder tanks to floor drains.

C. Provide 30” filter housing, Shelco model # F0C-908 in cast iron, or approved equal. Provide ball valve at inlets and outlets for isolation. Provide a PSI gauge installed on inlet and outlet of filter housing for open loop and closed loop systems.

D. Provide corrosion coupon test rack upstream to include three test stations for steel and one for copper for both closed loop and open loop systems.

E. Provide complete high efficiency sand filter system with integral BACnet compatible PLC control and pump that provides ½ micron filtration.

3. **EXECUTION**

A. Provide flushing and cleaning of all new systems as approved by the water treatment vendor.

B. Provide corrosion coupon test rack upstream of water treatment controller and blow-down solenoid. Test steel coupons after exposure for 30, 60, and 90 days and submit evaluation to Project Manager. Test steel and copper coupons prior to expiration of first year warranty and submit evaluation to Project Manager.

C. Mount bypass feeder on house-keeping pad or steel stand.

D. New and renovated condenser water system installations shall be visited quarterly during the warranty period by the water treatment company and evaluation report submitted.

23 31 13
METAL DUCTS

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 07 13 – Duct Insulation
   B. Duct distribution layout shall allow the total air flows on all air moving devices to be accurately measured air flow measuring devices and by pitot traverses (by TAB agency).
   C. All supply air, and exhaust systems after the fan, ductwork shall be sealed using UL 181 B listed duct sealant similar or equal to Foster 32-19 non-fibrated to SMACNA seal class "A". At the contractor's option longitudinal joints on supply air ductwork downstream of VAV terminals and return air do not need to be sealed however the leakage class specified shall be achieved. Connections at all duct branches, spin-ins, fire/smoke dampers, in-duct equipment, etc., shall be sealed.
   D. SMACNA Leakage Class shall be 6/3 upstream of VAV terminals; 12/6 downstream of VAV terminals; All supply air ducts upstream of VAV terminals shall be leak tested as well as all the return air ductwork located outside the building insulated vapor/water barrier envelope. The tests shall be witnessed by UGA-FMD personnel. Duct leakage tests shall be performed by the TAB agency and the TAB report shall clearly indicate the amount of leakage measured (difference between that measured at outlets and at duct traverse(s). Ductwork downstream of VAV terminals and return air ductwork located outside the building insulated vapor/water barrier envelope shall be tested at the discretion of the CxA and/or the Project Manager. All HVAC ductwork located in high humidity areas, where condensation could occur, shall be leak tested.
      i. FMD Projects only – Additional duct section(s) to be tested, if required, shall be selected by the Engineering Job Captain.
   E. Duct leakage tests shall be done with fire dampers, duct access doors, flexible duct connector run-outs, etc., installed.
   F. For renovation projects where the existing ductwork to be utilized in the new design, the ductwork shall be pressure tested to verify air leakage. If leakage is excessive, than remedial action shall be taken.
   G. Strap hangers or any other duct installation method utilizing screws or rivets through the ductwork shall not be used.
   H. Flexible ductwork shall be factory-fabricated Class-1 type rated for a minimum 10" positive and 2" negative operating pressure and 5000 fpm velocity. Flexible ductwork shall be insulated type, R = 6 minimum and shall be listed under UL181. Vapor barrier shall be metalized film with reinforcement, 0.05 perm per ASTM E96 Procedure A. Inner film shall be CPE or PE with corrosion-resistant helix. Flexible ductwork shall be equal to Flexmaster 1m, Thermaflex MKE (4-12" ID); MKC (14" and above). Flexible ducts downstream of terminal units shall be max 5 ft. long, installed free of kinks, and connected at terminations equal to Flexmaster "Quick Release – LS Series" stainless steel clamps.
   I. Internal duct liner anywhere downstream of filter banks, including inside equipment such as AHU's, FCU's, VAV terminals, etc. is prohibited.
   J. Hangers shall be installed completely outside the duct vapor barrier. Rigid, non-compressible (under the load), inserts shall be provided between duct and hanger in

such a manner that the insert is sealed to the butting insulation on either side and vapor proofed continuously through the hanger.

K. Each duct branch shall have a MVD; splitter dampers shall not be used; dampers at air registers shall not be used for primary balance.

L. In addition to spot-pins, adhere insulation to ducts with 100% coverage of fire retardant adhesive Foster 85-65. The use of staples on insulation will not be permitted.

M. Low-pressure spin-in fittings with dampers shall be furnished at round duct run-outs in diffusers, grilles, and registers where shown on the drawings. Fittings shall be spin-in type (stick-on type is NOT acceptable), complete with damper, 3/8" square one-piece damper shaft, nylon shaft bushings at exterior duct wall penetrations, 2" stand-off bracket, locking quadrant, and factory-sealed longitudinal seams. Barrel leakage to be less than 1 cfm at 4" sp. Basis of design is Flexmaster FLD-B03 with sealed seams, or equal.

DAMPERS
23 33 13

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 09 00 – Building Automation and Temperature Control System (BAS)
      iii. 23 31 13 – Metal Ducts
2. **PRODUCTS**
   A. Basis of design shall be TAMCO 1000 for typical indoor, non-corrosive applications.
   B. Dampers shall have aluminum frame with airfoil aluminum blades; shall be flanged with full face area matching the duct internal dimension where used for balancing, to reduce pressure loss.
   C. Linkage shall be concealed in frame outside air stream and accessible for inspection.
   D. Blade seals shall be silicon, EPDM or vinyl.
   E. Axle material shall be plated steel or aluminum.
   F. Jamb seals shall be silicon or flex stainless steel; shall be AMCA labeled AMCA leakage rated AMCA Class 1 (4cfm/sq-ft maximum with 1" pressure).
   G. Shall be 'no maintenance construction' and have a 5 year manufacturer warranty.
   H. Flow control dampers size shall be determined by the Design Professional and verified by the controls subcontractor and the damper manufacturer to ensure proper control damper authority.

23 36 01
VAV Terminal Units

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)

2. **PRODUCTS**
   A. Terminal units shall comply with ASHRAE Standards 130 and AHRI Standard 880.

   B. The Design Professional shall specify:
      i. The static or total pressure drop through terminal at design maximum primary fluid air flow with damper/valve full open under steady state control;
      ii. Design primary air-flow; external static pressure loss through the ductwork and other elements; including, coils, maximum allowable pressure on system, and operating system pressure system reference point when in operation.
      iii. Allowable pressure drop by specifying and scheduling the primary inlet pressure and the external static pressure associated with each air terminal unit. Air flow sensor shall provide accuracy within 5%, with a 90-degree elbow connected directly to the unit inlet.

   C. Air terminals shall be tested in accordance with current/latest ASHRAE Standard 130 methods of testing Air Terminal Units. NC levels shall be estimated, as outlined in AHRI Standard 880, latest edition at time of design. The manufacturer's air terminal unit data shall be certified as per ANSI/AHRI Standard 880 'Performance Rating of Air Terminals,' as governed by the Air Control and Distribution Devices (ACDD) section of AHRI. Design Professionals shall ensure to check the notes pertaining to NC calculations in printed catalog used for the project design. Cataloged NC values shall be based for attenuation for both radiated and discharge sound. Design Professionals shall specify sound power level with end reflection added into the discharge cataloged and certified data for sound power levels. Use of sound attenuators to achieve design sound goals shall be avoided.

   D. Control of air terminal units shall be pressure independent over the intended design flow range. The VAV Controller shall have an operating range of velocity pressure from . In w.g. to 1.0 in w.g. Designer shall consider the range of flow required to ensure that the air terminal units can be controlled to the lowest minimum flow (high amplification).

   E. Insulation, where needed to prevent condensation or achieve design noise levels, shall be 1"-thick, closed-cell foam insulation with a minimum of R=4. Insulation shall meet state and local code requirements applicable to air terminal unit insulation and shall meet the current edition of the following standards – ASTM C1071, UL 181, NFPA 90A, ASTM E81 (or UL 723 or NFPA 255). Raw edges shall be coated with an approved sealant.

   F. Leakage rate from terminal unit casing not to exceed 1 cfm with 1" inlet static pressure for terminals up to, and including, 12" and 2 cfm from terminals above 12."

G. Motors shall be ECM suitable for variable speed control of an analog output signal from a BACnet compatible controller.

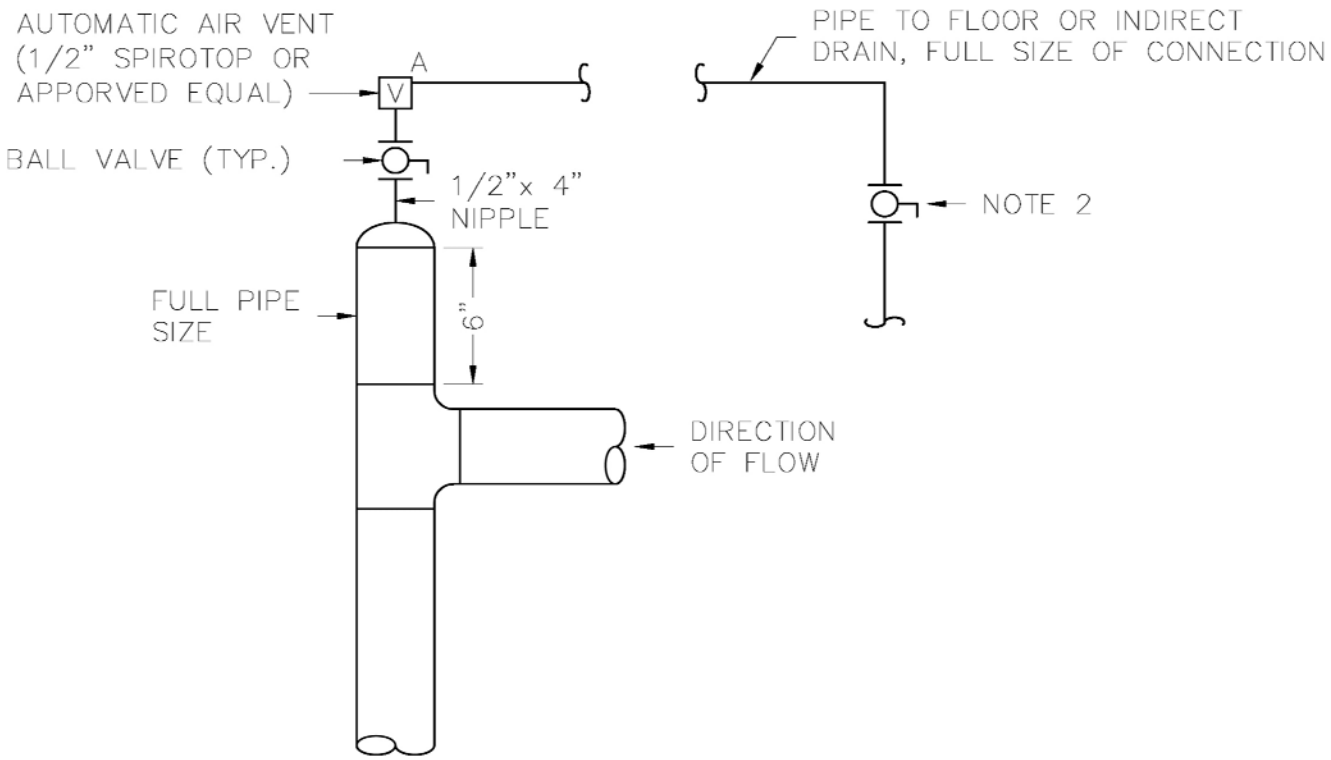
H. Design Professional shall include an airflow temperature sequence diagram for the air flow terminals showing; set-points, dead band, and max and min flows in cooling and heating modes. Graphic shall indicate fan speed 0 to 100%.

3. EXECUTION

A. Install in accordance with manufacturer's recommendations.

AUTOMATIC AIR VENT DETAIL

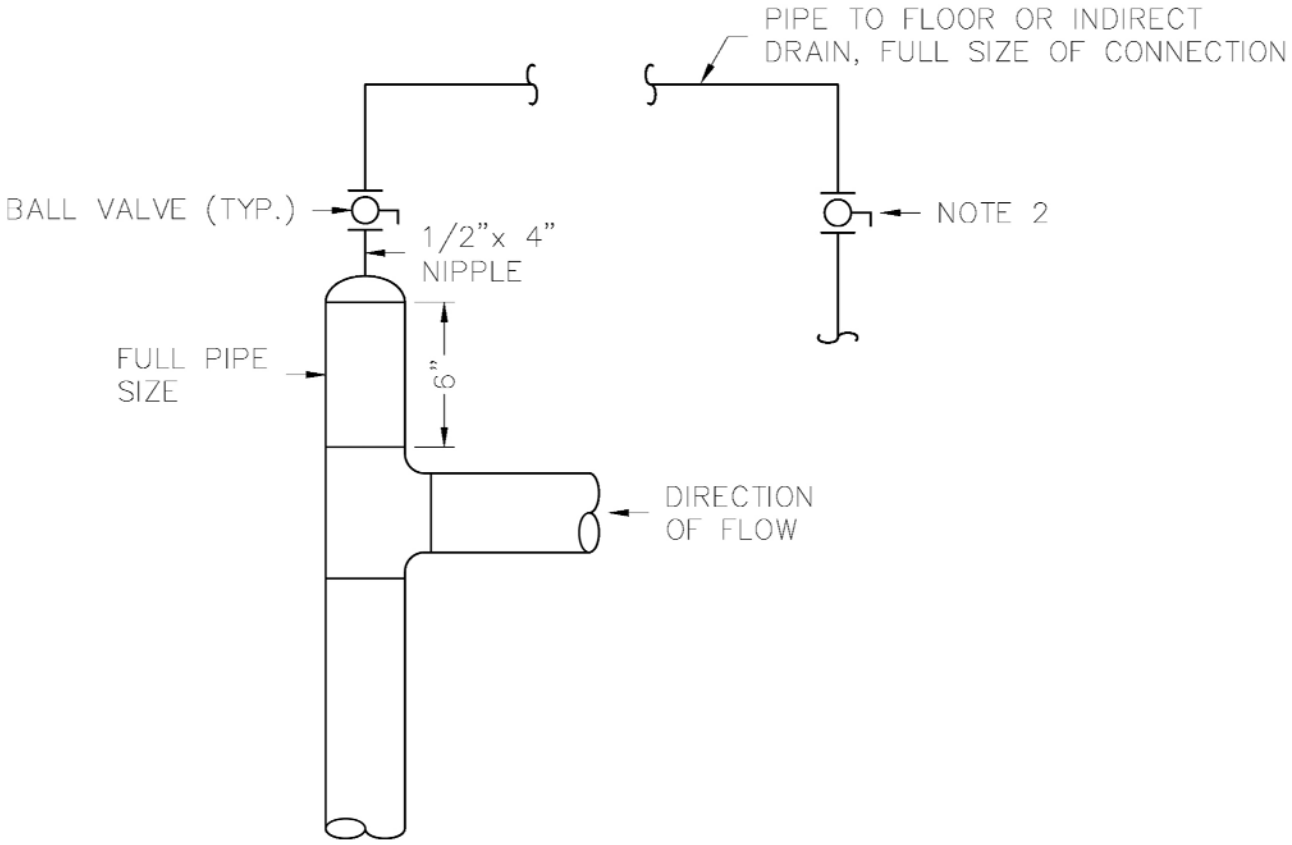
SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



NOTES:
1. VENT ALL HIGH POINTS AS INDICATED ABOVE.
2. PROVIDE BALL VALVE IN ACCESSIBLE LOCATION WHERE DISCHARGE FROM TUBING CAN BE OBSERVED. PROVIDE AAV WHERE INDICATED. PROVIDE BALL VALVE AHEAD OF AAV.

MANUAL AIR VENT DETAIL

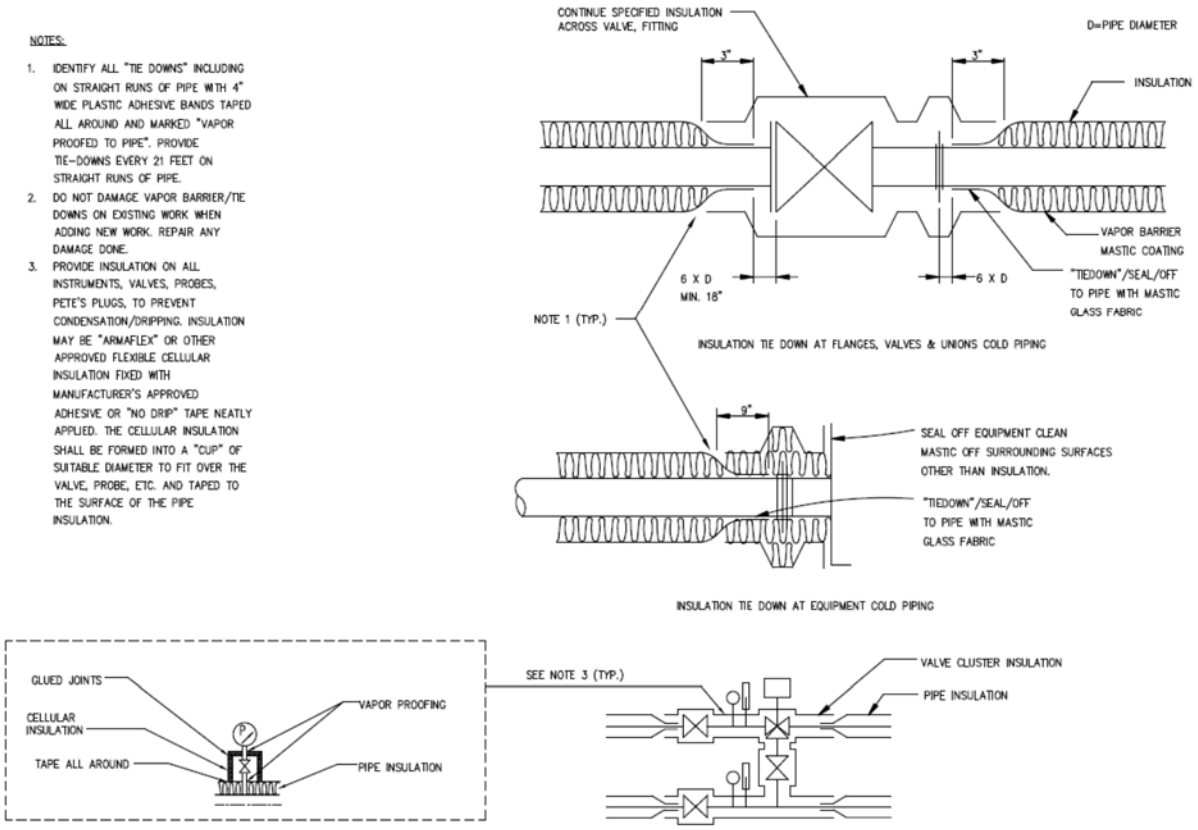
SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



NOTES:
1. VENT ALL HIGH POINTS AS INDICATED ABOVE.
2. PROVIDE BALL VALVE IN ACCESSIBLE LOCATION WHERE DISCHARGE FROM TUBING CAN BE OBSERVED.

INSULATION TIE-DOWN DETAIL Reject – see *23 07 19 Piping Insulation*

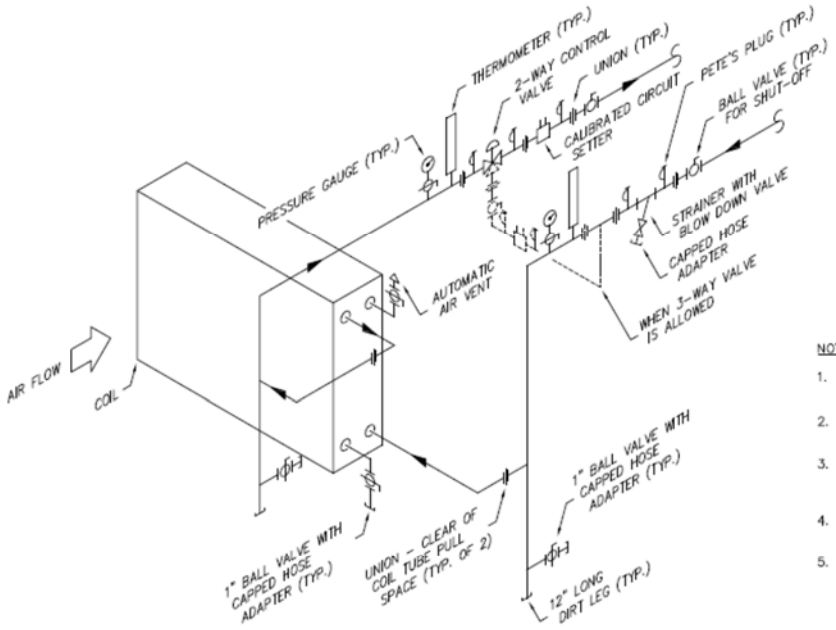
SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



INSULATION TIE DOWN/SEAL OFF POINTS FOR CHILLED WATER PIPE DETAIL
SCALE: NONE

AHU COIL PIPING DETAIL – SINGLE COIL Reject see 23 20 00

SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



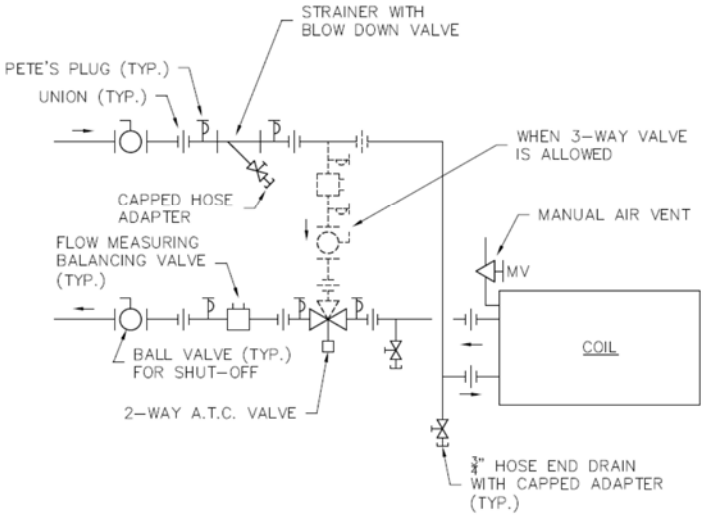
NOTES:

1. ALL SUPPLY AND RETURN HEADERS TO BE FULL SIZE FROM MAIN (SEE PLANS FOR PIPE SIZE).
2. ALL HORIZONTAL CONNECTIONS TO COILS FROM VERTICAL HEADERS TO BE SIZE OF COIL CONNECTIONS.
3. ALL COMPONENTS, INCLUDING DRAIN VALVE ADAPTER CAPS, TO BE RATED FOR FULL SYSTEM OPERATING PRESSURE.
4. CIRCUIT SETTER SHALL BE TOUR AND ANDERSON, MODEL STAD, OR APPROVED EQUAL.
5. INSTALL CONTROL VALVE PACKAGE IN HORIZONTAL PIPE RUN AS REQUIRED TO FACILITATE COIL REMOVAL.

A.H.U. COIL PIPING DETAIL – SINGLE COIL
SCHEMATIC ONLY

FAN COIL UNIT AND TERMINAL UNIT COIL PIPING DETAIL Reject see 23 20 00

SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



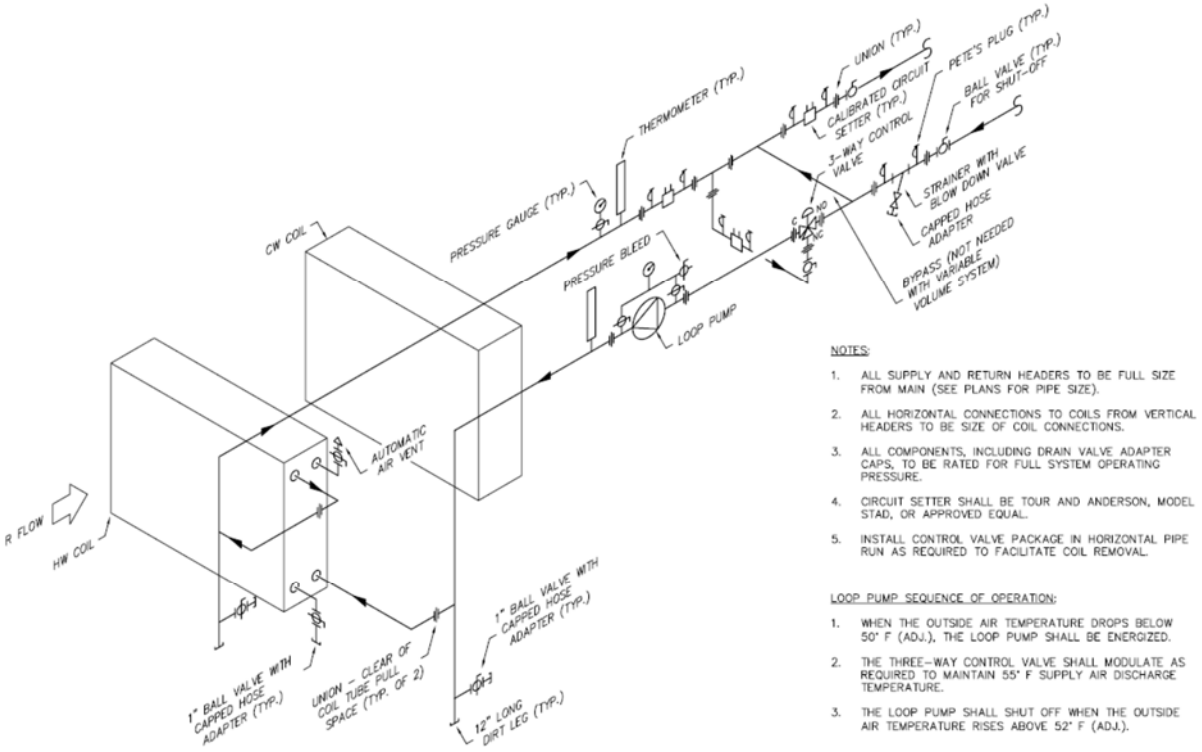
NOTES:

1. ARRANGE ALL PIPING TO ALLOW REMOVAL OF COIL.
2. PIPING SHOWN IS DIAGRAMMATIC.
3. ALL COMPONENTS, INCLUDING DRAIN VALVE ADAPTER CAPS, TO BE RATED FOR FULL SYSTEM OPERATING PRESSURE.
4. CIRCUIT SETTERS SHALL BE TOUR AND ANDERSON, MODEL STAD, OR APPROVED EQUAL.

FAN COIL UNIT & TERMINAL UNIT COIL PIPING DETAIL
(SCHEMATIC ONLY)

AHU COIL PIPING DETAIL – HOT WATER COIL WITH LOOP PUMP Reject see 23 20 00

SCHEMATIC DRAWINGS FOR GENERAL REFERENCE ONLY



NOTES:

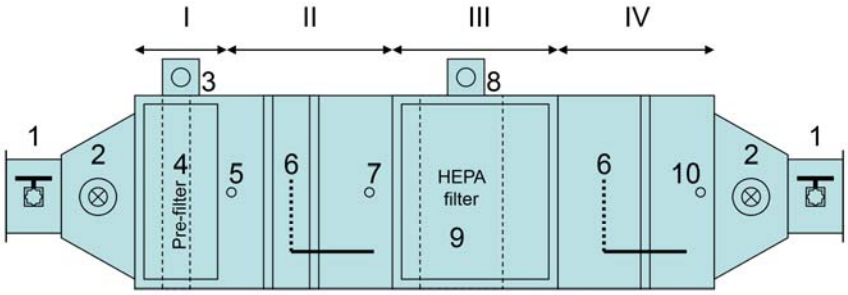
1. ALL SUPPLY AND RETURN HEADERS TO BE FULL SIZE FROM MAIN (SEE PLANS FOR PIPE SIZE).
2. ALL HORIZONTAL CONNECTIONS TO COILS FROM VERTICAL HEADERS TO BE SIZE OF COIL CONNECTIONS.
3. ALL COMPONENTS, INCLUDING DRAIN VALVE ADAPTER CAPS, TO BE RATED FOR FULL SYSTEM OPERATING PRESSURE.
4. CIRCUIT SETTER SHALL BE TOUR AND ANDERSON, MODEL STAD, OR APPROVED EQUAL.
5. INSTALL CONTROL VALVE PACKAGE IN HORIZONTAL PIPE RUN AS REQUIRED TO FACILITATE COIL REMOVAL.

LOOP PUMP SEQUENCE OF OPERATION:

1. WHEN THE OUTSIDE AIR TEMPERATURE DROPS BELOW 50° F (ADJ.), THE LOOP PUMP SHALL BE ENERGIZED.
2. THE THREE-WAY CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN 55° F SUPPLY AIR DISCHARGE TEMPERATURE.
3. THE LOOP PUMP SHALL SHUT OFF WHEN THE OUTSIDE AIR TEMPERATURE RISES ABOVE 52° F (ADJ.).

23 41 33
HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTRATION

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 09 23 – Building Automation & Temperature Control System (BAS)
   B. UGA Exhaust HEPA Design Criteria
      i. All BSL-3/ABSL-3 laboratories at UGA require HEPA filters to be placed on their exhaust. This section provides a reference diagram and detailed requirements for the HEPA filter sections, components, and housing for exhaust HEPA units used at UGA.
      ii. Reference diagram:



I. Pre-filter section
II. Upstream mixing section (w/ fold away diffuser plate)
III. HEPA section
IV. Downstream mixing section (w/ fold away diffuser plate)

(Weather caps to be used if installed without shelter)

1. Bubble-tight dampers
2. 3" Decontamination ports
3. Dwyer Magnehelic/Photohelic gauge (pre-filter)
4. Pre-filter
5. Certification injection port
6. Fold down diffuser plate
7. Certification reference port
8. Dwyer Magnehelic/Photohelic gauge (HEPA)
9. HEPA filter (99.97% efficiency tested in place)
10. Certification sample port

      iii. Sections: to provide for proper decontamination of exhaust HEPA units and annual certifications of the HEPA filter inside the unit, the HEPA unit shall be comprised of the following sections: pre-filter section, upstream test section (with fold away diffuser plate), HEPA section, downstream test section (with fold away diffuser plate)
         a. The pre-filter section will have frames that accommodate filters that are standard to campus use. There shall be no gaps in the housing filter frame and around the filter panel that allows air to by-pass the filter media. The placement of the pre-filter is application specific and the Design Professional shall ask the Project Manager to coordinate a meeting with Office of Biosaftey to discuss during the design phases. If deemed appropriate (because of the frequency of changing the pre-

filter), the pre-filter can, be located in the BSL3 lab itself; however, this requires variance approval as the Project Manager will need to coordinate with UGA Office of Biosafety to determine acceptability.

b. An upstream swing-away, fold away, or pivot test section (that achieves the effect of mixing certification challenge aerosol equivalent to injecting the challenge aerosol in a straight run of duct 10 duct diameters upstream of the dirty face of the HEPA) shall be provided between the upstream bubble-tight and the dirty face of the HEPA filter.
c. A HEPA section that secures a gasket-seal 99.97% tested-in-place efficient HEPA filter. The mechanism that secures the HEPA filter should be replaceable without having to replace the housing.
d. A downstream swing-away, fold away, or pivot test section (that achieves the effect of mixing certification challenge aerosol equivalent to the mixing of the challenge aerosol in a straight run of duct 10 duct diameters downstream of the clean face of the HEPA) shall be provided between the clean face of the HEPA and the downstream bubble tight damper. Alternatively, a sample port located 10 duct diameters downstream of the clean face of the HEPA can be provided downstream of the downstream bubble tight.

2. **PRODUCT**

A. Components

i. Bubble tight dampers on the dirty and clean side of the HEPA housing to facilitate room isolation and gas decontamination shall be provided. The dampers shall:

a. Be a positive seal, isolation type damper.
b. Cylindrical and constructed of 11 gauge T-304 stainless steel.
c. Have a blade that shall consist of two 3/16” thick stainless steel plates with a replaceable silicone gasket between them.
d. Be sealed when the gasket is in against the housing wall of the damper.
e. Be constructed under a quality assurance program that addresses the requirements of ANSI/ASME NQA-1, “Quality Assurance Program Requirements for Nuclear Facilities.”
f. Be an all weld design. Welded joins and seams shall be continuous if they are pressure retaining.
g. Be buffed or brushed to remove heat discoloration, burrs, and sharp edges.
h. Have damper parts (if part of a gasket setting surface) that are ground smooth and flush.
i. Be built buy welders, procedures and operators that are qualified in compliance with ACME Boiler and Pressure code, section IX.
j. Have a blade that is tested in the closed position at 10” water gage and be bubble tight per ANSI/ASME N509-1989 Paragraph 5.9.7.3.
k. Have a damper housing that is tested by the pressure decay method in accordance with ANSI/ASME N510-1989: “Testing of Nuclear Air Cleaning Systems” Paragraph 6 and 7 and have a maximum leak rate of 0/0005 CFM per cubic foot of housing volume at 10” water gage. Test duration shall be 5 minutes with readings taken at 1 minute intervals.

l. Have a ¼ turn worm-geared actuator with hand wheel. The actuator shall have an aluminum base and cover and be fully lubricated and self-locking.
m. The basis of design for the bubble type damper is the Flanders model DBTM-FB-304-12.

ii. 3" Decontamination ports will be provided between the bubble tight dampers and the HEPA filter housing on the transitions between the bubble tight dampers and the HEPA filter housing. The 3" decontamination port will be made of stainless steel, have a lockable butterfly valve, dust cap and be designed and constructed under the same standards as the HEPA housing.

iii. A Dwyer Photohelic gauge, or approved equal, with an appropriate range based on fan selection calculations, to accurately detect pressure differences across the pre-filter will be provided. The Photohelic gauge will be protected from contamination by inline HEPA filters suitable for the environment the HEPA unit is installed in. The inline HEPA filters will be located between (2) 2-way ball valves and have a decontamination port with a ball valve to allow decontamination of the inline filters. There will be one line with this set up on the upstream side of the pre-filter and one on the downstream side of the pre-filter. An analog signal from the Photohelic shall be input to the Building Automation System (BAS) to indicate filter condition and to alert remote operators and lab occupants when filter panel needs to be replaced.

iv. Pre-filters (if required by conditions of the facility environment) will be provided for HEPA filters and be located in the exhaust HEPA housing unit upstream of the upstream mixing section. Pre-filter sections will provide and continuous seal on all 4 sides of filter as to prevent contaminants from going around the pre-filter and getting into the HEPA. Pleats of pre-filters shall be in the vertical position when installed.

v. A certification injection port made of a 1" stainless steel half coupling with a stainless steel plug will be provided for injection of certification challenge aerosols between the pre-filter and the upstream fold down diffuser plate.

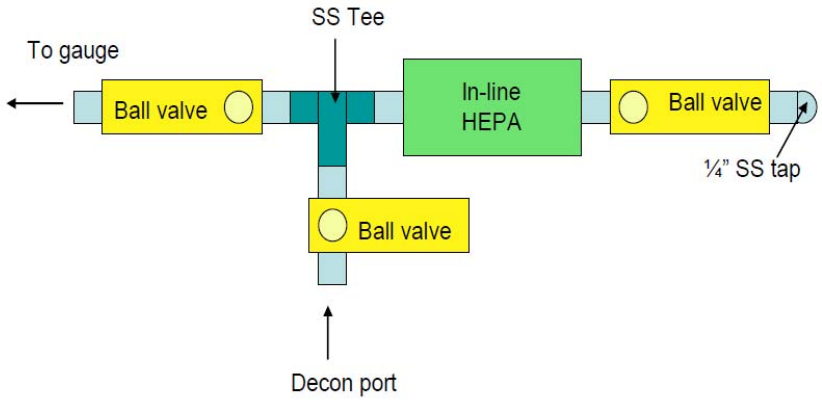
vi. A fold down diffuser plate (that creates mixing of certification challenge material as noted above) will be provided. The fold down diffuser plate will lock out of the way during normal HEPA unit use and will lock in the diffusion position during certification.

vii. A certification reference port made of a ½" stainless steel half coupling with stainless steel plug will be provided between the first fold down diffuser plate and the upstream side of the HEPA.

viii. A Dwyer Photohelic gauge, or approved equal, with an appropriately specified range based on fan selection calculations, to detect pressure drop across the HEPA filter will be provided and be connected between the gauge and the housing via ¼" SS tubing. The Photohelic gauge shall be protected from contamination by inline HEPA filters suitable for the environment the HEPA housing is installed in. The inline HEPA filters will be located between (2) 2-way ball valves and have a decontamination port with a ball valve to allow decontamination of the inline filters. There will be one line with this set up on the upstream side of the HEPA filter, and one on the downstream side of the HEPA filter. An analog signal from the Photohelic gauge shall be input to the BAS

to indicate filter condition and to alert remote operators and lab occupants when filter panel needs to be replaced.

Diagram of inline filter arrangement:



ix. HEPA filter (99.97% efficiency tested in place), gasket sealed. Pleats of HEPA filters shall be in the vertical position when installed. Basis of design is the Flanders KG series housing.

x. A certification sample port made of a ½" stainless steel half coupling with a stainless steel plug will be located between the downstream test section and the downstream bubble tight, or be located 10 duct diameters downstream of the clean side of the HEPA filter.

xi. If the HEPA housing is installed outside in an uncovered location it will be provided with a weather cap to shed water. The Photohelic gauges will be covered with weather caps too.

B. Housing

i. *HEPA unit housings will be made of T-304 stainless steel and will NOT have provisions for BAG-IN/BAG-OUT of the HEPA filter (Flanders model KG series is an example of an acceptable housing style).* The following information is taken from a Flanders/CSC® spec sheet.

ii. The filter housing shall be a side access housing and shall be manufactured from 14 Ga. & 11 Ga. T-304 stainless steel (unpainted). The housing shall be adequately reinforced to withstand a negative or positive pressure of 10" water gage. The housing shall be side access for filter installation and change-out. Housing design and filter arrangement shall allow air to enter and exit housing without changing direction. The housing shall accommodate gasket seal filters. Prior to leaving the factory, each filter sealing mechanism will be checked with an alignment gage to insure proper alignment of the sealing edge.

iii. All "pressure retaining" weld joints and seams shall be continuously welded; weld joints and seams requiring only intermittent welds by design shall not be continuously welded. As a minimum, all weld joints and seams shall be wire brushed and/or buffed to remove heat discoloration, all burrs, and sharp edges. All weld joints and seams that are a portion of any gasket setting surface (i.e., duct connecting flanges) shall be ground smooth and flush with adjacent base

metals. All welding procedures, welders, and welder operators shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, section IX. All production welds shall be subjected to a visual inspection which incorporates the workmanship acceptance criteria described in sections 5 & 6 of ANSI/AWS D9.1-1990, "Specification for Welding of Sheet Metal."

iv. All hardware on the housing and mechanical components of the filter sealing mechanism shall be 300 series stainless steel except for the access door knobs which are cast aluminum.

v. The filter sealing mechanism shall be replaceable and shall be operated by a locking handle. The sealing mechanism shall be designed to exert an equal force to the top and bottom edge of each filter when engaging and disengaging the filter on the sealing edge of the housing.

vi. The housing shall have a filter access port that is sealed by a removable, gasket sealed access door. The door gasket shall be silicone and shall be manually replaceable after the door has been removed from the housing.

vii. The filter housing shall be manufactured under a quality assurance program that addresses the requirements of ANSI/ASME NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities". The housing shall be tested for filter fit, operation of the filter clamping mechanism, sealing edge alignment, and leak tightness before leaving the factory. Both the filter sealing surface and the complete assembly pressure boundary shall be leak tested by the "pressure decay method", in accordance with ANSI/ASME N510-1989 (reaffirmed in 1995), "Testing of Nuclear Air-Cleaning Systems", paragraphs 6 & 7 and have a maximum leak rate of 0.0005 CFM per cubic foot of housing volume at 10" water gage. Test duration shall be 5 minutes with pressure readings recorded at 1 minute intervals.

viii. Fold away, Pivot, or Swing Aside Test Sections: The test sections shall be constructed the same as the filter housings. The test sections shall provide the ability to test the system per the intent of ANSI/ASME N510-1989 (reaffirmed in 1995), "Testing of Nuclear Air Cleaning Systems" (ANSI/ASME N510 was written for walk-in style filter plenums and contains some tests that cannot be performed on side-load style filter housings). All components of the test sections shall be constructed of 300 series stainless steel. The test sections shall have a maximum pressure drop in accordance with the air flow of the housing unit when the diffuser wall is in the open position. All test section ports shall be labeled with stainless steel (SS) labels. Injection ports shall be 1" SS half coupling with SS plugs and sample parts shall be 1/2" SS half couplings with SS plugs.

23 52 00
Heating Boilers

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
2. **PRODUCTS**
   A. Boiler Types:
      i. When lower temperature heating is applicable (below 130 degrees supply water), condensing boilers shall be specified.
      ii. The boilers shall be provided with a minimum of 4 to 1 capacity turn-down and shall be fully modulating.
   B. Controls:
      i. Boiler(s) shall be controlled by BAS. Manufacturer provided boiler controls shall not be allowed.
      ii. The boiler shall be provided with an integral BMS to ensure safe start-up, and shut-down in accordance with the governing codes.
      iii. The boiler manufacturer shall be required to review the boiler plant sequence of operation and provide approval before acceptance of the design.
      iv. Boilers shall be provided with a BACnet card to allow for remote visibility of the following minimum points:
         a. Modulation rate (%)
         b. Runtime (hours)
         c. Enable/disable
         d. Manual override
         e. Alarm
   C. Approved Manufacturers:
      i. Patterson Kelly
      ii. RBI
      iii. Aerco
3. **EXECUTION**
   A. Condensing boilers shall be provided with acid neutralization kits.
   B. The boiler shall be started by a factory authorized representative.
   C. Boilers shall be started by a factory authorized representative.
   D. The consultant shall verify that there is sufficient volume in the heating hot water system to avoid short-cycling. The consultant shall verify minimum required volume with all listed manufacturers.

23 64 16.13
AIR-COOLED WATER CHILLERS

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 25 00 – HVAC Water Treatment
   B. Chillers shall be provided with Bacnet communication and shall utilize R134a.
   C. Chillers shall generally be selected for 10F chilled water temperature drop.
   D. Design Professional shall specify noise levels and, if required to meet owners performance requirements, options for sound dampening.
   E. Chiller shall have capacity control down to 10%.
   F. Chiller available output data shall include operating and peak tonnage and amps, chilled water temperature difference, pressure drop across chiller, and accessible trend data for all associated points without need for additional software and programming.
   G. Shall have multiple independent refrigerant circuits.

2. **PRODUCT**
   A. Acceptable Manufacturers:
      i. Carrier
      ii. Trane
      iii. York
      iv. Daikin

23 64 16.16
WATER-COOLED WATER CHILLERS

1. **GENERAL**
   A. Related sections:
      i. 01 81 00 – Facility Performance Requirements
      ii. 23 00 00 – General Mechanical Requirements (HVAC)
      iii. 23 25 00 – HVAC Water Treatment
   B. Design Professionals must discuss chiller selection with Project Manager at project concept design stage to determine Owner's performance requirements. Chillers shall be selected at the concept design stage based on energy efficiency and maintainability in addition to first cost. For any water-cooled chiller above 300 tons, selection must be based upon life cycle costs analysis for at least 10 entering separate conditions accounting for varying entering condenser water temperatures and anticipated capacity operating points. The life cycle analysis shall account for anticipated maintenance costs, first cost, and energy costs over the life of the machine.
      i. Design Professional shall discuss sound level requirements for the specific project with the Project Manager and establish decibel limits and agreed noise levels shall be listed on chiller schedule.
      ii. Design Professional shall discuss with manufacturers and Contractors cost options to increase warranty length from 12 months after Material Completion (not start up) to 24 months and for 60 months.
   C. Chillers shall be provided with Bacnet communication.
   D. Chillers shall utilize R134a.
   E. Chillers shall generally be selected for 10F chilled water temperature drop. Discuss with Project Manager during concept design stage.
   F. Design Professional shall discuss piping design (preliminary, secondary, etc.) with Project Manager during concept design stage. Factory test as required to verify chiller performance may be required. Discuss with Project Manager early in the design.
   G. Chillers shall operate, in the installed location, free of any condensation under all operating conditions. Insulate accordingly.
   H. Chiller piping configuration shall match existing in renovated buildings.
   I. Factory-mounted refrigerant pump-down machine may be desired. Discuss with Project Manager early in the design.
2. **PRODUCT**
   A. Acceptable manufacturers:
      i. Carrier
      ii. Daiken
      iii. York
   B. All water-cooled Centrifugal chillers above 300 tons shall have VSD.
   C. Water cooled chillers shall include marine water-boxes with hinged covers.
   D. The chiller shall be provided with refrigerant leak detection system and associated exhaust as required to meet the International Mechanical Code.
   E. Provide hand-off-auto switch (HOA located on the BAS control panel itself and labeled "chiller command" for the purpose of isolating the chiller from the BAS).

F. Condenser water Cooled VFDs shall be provided with dual strainers installed in the cooling medium piping as required to ensure that the VFD heat exchanger does not clog up.

3. **EXECUTION**
   A. The chiller shall be installed to allow adequate clearance for compressor removal. Installation of hoists and rails should be considered where possible to accommodate compressor removal.
   B. The chiller shall be installed to allow for adequate clearance for rodding out both the condenser water and evaporator barrels.
   C. The chiller shall be started by an authorized factory representative.

23 65 00
COOLING TOWERS

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 23 25 00 – HVAC Water Treatment
      iii. 26 29 23 – Variable-Frequency Motor Controllers
   B. Design Professional shall discuss suitability of a cooling tower system that does not require chemical water treatment with the Project Manager.
2. **PRODUCTS**
   A. Cooling towers shall have fully welded stainless steel cold water/lower basins (no bolted sumps) and stainless steel hot/upper sumps
   B. Motors in air stream shall be Totally Enclosed, Air Over (TEAO).
   C. Vertical shaft bearings shall have rain seals.
   D. For new cooling towers, provide mechanical float valve(s) on make-up(s) at the tower. Float valve shall be brass. On retrofits to existing cooling towers, using electronic probes provide Magnetrol model T52-1E3a-BKP mechanical valve or approved equal mounted to the exterior of the tower and re-use existing wiring and solenoid valve(s).
   E. Concrete basins shall be sand blasted and pressure cleaned prior to applying bonding agent and coating under required temperature and humidity conditions. All coating processes must be observed by UGA or CxA.
   F. Fans drives shall be VSD and it is preferred for the VSD to be located inside the building.
   G. Condenser water/cooling tower shall have a sand filtration system.
   H. Cooling tower shall be provided with a 2” drain, minimum, located in the center of the basin well to allow for ease of basin cleaning.
   I. Cooling Tower Access:
      i. Cooling towers shall be provided with access platforms that allow for cleaning and maintaining of cooling tower.
      ii. Provide hand-rails on the top of the tower for safety and davits for removal of fan motors.
      iii. Access platform design shall be submitted to Project Manager for approval early in the design phase.
   J. Design Professional shall consider site location of cooling tower including dust, sound, and accessibility issues. If placed too close to a road there may be a maintenance issue due to dust.
   K. Below grade sumps shall not be allowed.
3. **EXECUTION**
   A. All drains shall be routed to sanitary sewer.
   B. Provide a factory-authorized service representative to perform start-up services.
   C. Provide adequate clearance (30” minimum) under the cooling tower to accommodate drain(s) and allow inspection and cleaning.
   D. Verify that existing devices to be re-used are working (see above).
   E. Remove all redundant existing devices and repair surrounding as required.
   F. Contractor shall insure that construction debris and dust does not enter condenser water system.
   G. Provide heat tracing for the make-up water piping.

23 73 00
INDOOR CENTRAL-STATION AIR-HANDLING UNITS

1. **GENERAL**
   A. Related sections:
      i. 23 00 00 – General Mechanical Requirements (HVAC)
      ii. 26 92 23 – Variable-Frequency Motor Controllers
   B. Design Professional shall discuss selection, location and model number of AHU(s) with UGA in the early stages of design.
   C. Select most efficient fan for the application by comparing life cycle costs of alternatives considered; submit details with shop drawings submittals; specify highest efficiency motor available (NEMA Premium); consider fan performance over full range of anticipated operation and submit curves at the design development stage.
      i. OUA Projects only – Fan wall systems are preferred. The Design Professional shall specify this as the basis of design and shall discuss options with the Project Manager during the design phase to determine most suitable (lowest life-cycle cost, including electrical service costs) system for specific project. If a fan wall system is selected itshall follow the Product requirements below.
      ii. **FMD Projects only** -- Fan wall systems are required. Refer to Product requirements below.
2. **PRODUCTS**
   A. AHUs over 3000 cfm
      i. Select cooling coils for 400 fpm max face velocity and entering water 1F above the design chilled water supply temperature.
      ii. AHUs shall be modular, double walled; operate without condensation forming on exterior surfaces under any and all anticipated operating conditions. Unit double wall internal insulation shall have a flame spread rating not over 25 and smoke developed rating no higher than 50 complying with NFPA 90A.
      iii. AHU shall have a leakage rate of 1% or less at 10” pressure.
      iv. Cooling coils:
         a. Coil tube diameter shall be 5/8” minimum, tube thickness of .020”, and minimum aluminum fin thickness of .008”.
         b. Cooling coils shall have a minimum of 6 row cooling coils and maximum of 8 row cooling coils.
         c. Fin spacing shall not exceed 10 fpi. Fin height on cooling coils shall be limited to 39” for all units that are 100% outside air.
         d. Provide multiple sections with drain pan where 39” has to be exceeded.
      v. Drain pans:
         a. 16 gauge stainless steel
         b. Multiple section cooling coils shall have intermediate drain pans.
         c. Drain pans to be sloped, IAQ type, to prevent standing water from accumulating in pans.
      vi. Filters:
         a. Filter efficiency shall suit the application and be MERV 11 minimum where application does not dictate higher efficiency.
         b. Specified sizes shall be limited to 24x24xD; 12x24xD; 20x20xD; 16x20xD; 16x25xD; 20x25xD. The depth ‘D’ will depend on the application

(Design professional to discuss with Project Manager). Face velocity shall be the same or less than 450 fpm.

c. On units 78" and less in height, use side access filter sections.
d. On units greater than 78" high, use upstream access filter sections.
e. Filters: Rating systems for air filters shall be ASHRAE Standard 52.2-2007 Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
f. The lifecycle cost of filters shall be carefully considered during the design and selection of the filters. Filters shall be scheduled on the drawings. Dust holding capacity shall be included in selection criteria.
g. Layout shall ensure adequate ease of access to space is provided.
h. Filter and holding frame combination shall ensure that air does not by-pass the filter media.

vii. AHUs with chilled water coils shall have pre-heat coils.
viii. Heating coils shall be heating hot water. Steam heating coils shall not be used without variance approval.
ix. Air blenders shall be provided on AHUs units that contain mixing boxes that are designed and configured to ensure proper mixing of outdoor and return air and to prevent "nuisance" freeze stat trips. If space does not allow for the use of air blenders, mix air in ductwork prior to entering the mixing plenum, or utilize baffles inside the mixing plenum to ensure proper air mixing.
x. Units shall have, minimum 24" wide, access doors on filter, coil (up-stream, down-stream and between coils), and fan.
xi. UV disinfection system:
    a. The device shall be classified by UL (Underwriters Laboratories) as an Air Duct Mounted Accessory and meet all applicable UL standards. Manufactures UL file number shall be permanently marked on the exterior of the product.
    b. Shall be of stainless steel and aluminum construction. Any exposed screws or fasteners shall be stainless steel.
    c. Approved UV lights shall be provided at all cooling coils.
    d. On units 78" and less in height, UV light racks shall be side accessible slide out type, to slide out of units for changing bulbs.
    e. On units greater than 78" high, utilize stationary UV racks.
    f. Every access door on the AHU that allows persons to see the UV lights shall have a lock-out-tag-out safety.
    g. The UV dosage shall be calculated for probable rating of URV-13, 99% air disinfection (S. marcescens) at air velocity and temperature and shall be adequate to deactivate microbial growth on all exposed surfaces.
    h. Lamps:
        1) Lamps shall be positioned for a 360-degree disinfection zone. Lamp supports shall be stainless steel. Exposed screws and fasteners shall be stainless steel.
        2) The lamp shall be generic, available on the open market and not product specific. Lamps shall be Philips, GE, Sylvania, Ushio or UGA preapproved equal.

i. UV disinfection system shall be warranted to be free of defects in workmanship and material for a period of 5 years from date of Material Completion.

xii. Face-and-by-pass damper control shall not be used without UGA-FMD approval. If IFB coils are permitted to be utilized, dampers shall shut off tight to prevent air leakage through damper assembly to coil.

xiii. All air handling units shall have a base rail for unit support and coil trapping. Base rail height shall be sized such that the cooling coil may be trapped without chipping or penetrating the floor. Base rails shall be 5" minimum and higher if 4" housekeeping pad cannot be provided.

xiv. Each section/module shall have an interior light. Lights shall be factory wired to a single light switch with GFI outlet located adjacent to the fan access door. Access doors shall have a view window.

xv. Fan array system: This shall consist of multiple, direct driven, arrangement 4 plenum fans with fan wheels that are rated and certified with tests and procedures in accordance with AMCA publication 211 and comply with the requirements of the AMCA Certified Ratings Program and constructed per the AMCA requirements for the duty specified, (Class III). The fan array shall be selected to operate at a system Total Static Pressure (TSP) that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed. Fan static efficiency shall be selected for 70% or higher.

a. Each fan cube shall be furnished with sound attenuation (internal to the air handling unit) and internal vibration isolation.
b. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed an equivalent Grade G.55, indicating a maximum of 0.022" per second peak, filter in (0.55mm per second peak, filter in) residual unbalance.
c. Each fan/motor "cube" will be provided with an individual backdraft damper. Manufacturer shall incorporate damper System Effect Pressure Loss when selecting fans. Damper system effect pressure loss shall be generated from test data of the dampers as installed on the inlet of the fan. Dampers shall be low leakage, max. 2 CFM/sq. ft. at 1" differential static pressure.
d. All motors shall be standard foot mounted type, TEAO or TEFC motors, premium efficiency. Motors shall meet the requirements of NEMA MG-1 Part 30 and 31, section 4.4.2. Motors for use in multiple fan arrays that operate at varying synchronous speeds shall be rated for use with Variable Frequency Drive(s) (VFDs). All motors shall include permanently sealed bearings and shaft grounding system, to protect the motor bearings from electrical discharge machining due to stray shaft currents. Motors sizes shall be limited to 7.5 Hp or smaller. All motors to be factory wired to an electrical panel or VFD mounted on the exterior of the air unit. Wiring of motors in the field by the contractor is not acceptable.
e. It is preferred that each fan shall be driven by an individual VFD, for maximum redundancy and individual motor protection. If a single VFD is

used to serve more than one fan, each fan motor shall be furnished with a means of manual disconnect and overload protection (circuit breaker).

f. Both local (indicator lights or panel) and interface for remote indication of fan operation (on-off) at BMS shall be provided.

23 74 00
PACKAGED OUTDOOR HVAC EQUIPMENT

1. **GENERAL**
   A. Related sections:
      i. 23 09 23 – Building Automation and Temperature Control System (BAS)
   B. All packaged equipment shall be provided with native BACnet interfaces to allow seamless interface with BAS.

23 81 29
VARIABLE REFRIGERANT FLOW (VRF) HVAC SYSTEMS

1. **GENERAL**
   - A. Related sections:
     - i. 01 75 00 – Starting & Adjusting
     - ii. 23 00 00 – General Mechanical Requirements (HVAC)
2. **PRODUCTS**
   - A. Basis of Design: Daikin
   - B. VRF System Type:
     - i. VRF systems may be water-cooled or air-cooled. Discuss with Project Manager.
     - ii. The Design Professional shall consider the requirements of ASHRAE Standard 15 to ensure that potential refrigerant release does not endanger occupants.
     - iii. Ducted systems shall be provided with manufacturer supplied filter rack.
     - iv. Refrigeration piping shall be brazed. Mechanical joints may be considered on a case-by-case basis.
   - C. Quality Control:
     - i. The Contractor shall provide proof that at least two of the installing technicians have received and completed training from the manufacturer. Provide proof of training with submittals. VRF Trained technicians/installers must be on site overseeing the duration of project.
     - ii. The Bidding mechanical subcontractor must give proof of adequate manufacturer VRF training. Three VRF successful installs of similar capacity and referrals with contacts shall be provided to the Project Manager.
   - D. System Flexibility:
     - i. Variable Refrigerant Flow Systems shall be designed to allow for maximum flexibility in the case of future renovations. All VRF projects shall be reviewed to accommodate future expansion or modifications. Discuss requirements with Project Manager.
     - ii. The number of selector boxes and the number of associated zones shall be discussed with Project Manager.
     - iii. Isolation valves shall be provided upstream of each branch selector box, allowing for zone isolation.
   - E. Controls:
     - i. The system shall be provided with a BACnet interface allowing for monitoring of all points through the BAS. In addition, the controls shall allow for remote set-point adjust of the VRF system.
3. **EXECUTION:**
   - A. A factory employee or factory designated individual shall be present at start-up.
   - B. Technicians working on VRF shall be certified and shall maintain current VRF installation certifications on site at all times. All refrigeration piping shall be hard drawn, type X, and shall be selected to handle the operation pressure.
   - C. The refrigeration piping shall be purged with nitrogen, vacuum tested and pressure tested in accordance with the manufacturer's recommendations. The system shall be pressured tested for a period no less than 24 hours.
   - D. A qualified owner's appointed representative shall witness purging, vacuum testing, and pressure testing.

E. The VRF system shall not be used to cool the building during construction. The contractor shall provide temporary cooling if necessary.
F. Brazing Qualifications:
    i. All brazing procedures, brazer qualification, quality, and testing shall conform to the requirements of ANSI B31.1; and to the ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications. The Contractor shall be responsible for the procedures, quality and visual testing of all brazing performed by him and his employees.
G. The BPQs shall be performed under the witness of an independent agency. The witness shall be a representative of an independent testing agency, Authorized Inspector, or consultant, any of which must be a Certified Welding Inspector (CWI) and/or approved by the National Certified Pipe Welding Bureau. The qualifying test segment must be a minimum 3-inch diameter pipe with the range of wall thicknesses and material types qualified as applicable for each project and within range of the BPS. Tests position shall be all positions defined in QB-120 to QB-124 of ASME Section IX.
H. All brazing shall be done in accordance with ASME B31.1.
I. Brazing procedures, and all brazer qualifications (BPQs and Evidence of Continuity) shall be maintained on the jobsite.
J. All technicians who will be performing brazing operations shall be certified in accordance with American Welding Society standards. All welding certifications and procedures shall be shall be maintained on site.