SECTION 23 00 00 – PLUMBING, HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

PART 1 - GENERAL

1.1 REFERENCES

A. Manual Part 3, Project Planning and Design Guidelines and Standards

B. Drawing and General Provisions of Contract, including General and Supplementary General Conditions and Division 1 section apply to work in Division 23.

C. Codes and Standards: Reference Architect’s agreement. Include referenced codes and standards in Contract specifications.

1.2 SYSTEM DESIGN REQUIREMENTS

A. The University Philosophy:
1. The university is extremely conscious of maintenance costs. Give special attention in the design process to provide for sufficient and safe access space for maintenance of mechanical systems. Clearly indicate locations of ceiling and wall access panels and other necessary access space. Provide easy access to rooftop equipment.
2. Exterior mechanical installations must not only be designed for proper functions, but must be considered in the aesthetics of building design. Locate large and unsightly installations hidden from public view and enclose appropriately.
3. Show mechanical installations on drawing elevations of structures including, installations projecting above parapet walls.
4. Design systems to provide flexibility in the future. Provide systems that are easily adaptable to new layouts or changes in use. Layout mechanical rooms with space for future equipment. Study the possibility of future needs, expansion, or new equipment at the time the basic design is being formulated.
5. The university is committed to sustainable, low energy use and environmentally friendly buildings. Apply LEED and High Performance Buildings into design and construction.

B. Certain operations require special HVAC systems consisting of filtration, humidity control, special exhaust systems, or different temperature settings than surrounding spaces. These areas may include, autoclaves, lab equipment, print shop equipment, machine shop equipment, carpentry shop equipment, metal working shops, and laboratories involved in higher level chemical, biological, and radioactive material experimentation. Work with the University Project Manager to identify these areas and determine appropriate design parameters.

C. Notify the University Project Manager of all modifications affecting supply and exhaust air in animal rooms, laboratories, environmental chambers, confined spaces, trailers, office spaces, darkrooms, and buildings or spaces being renovated or modified for special occupancies.

D. Obtain a complete list of the chemicals and gases to be used and stored in laboratories. Use this list to determine fume hood exhaust for flammability, toxicity, corrosiveness, and explosion hazards.

E. If perchloric acid is used, provide a specialized, dedicated hood constructed of stainless steel, porcelain coated, or non-plasticized PVC lined. Label hood “for perchloric acid use only”. Provide the hood with its own non-reactive duct and exhaust fan and built-in water wash-down system.

F. Provide galvanized steel, aluminum, PVC coated, or stainless steel ducts for ventilating bio safety cabinets, chemical fume hoods and flammable storage cabinets. Design and install systems to ensure that hoods and ducts are under negative pressure all the way out of the building.

G. If a hood is tied into an existing central exhaust system serving multiple fume hoods, then the air system will need to be evaluated to determine if it has sufficient capacity for the addition of other exhausted equipment.

H. Provide make-up air to compensate for the air being exhausted. The location and volume of make-up air is critical to assuring proper fume hood operation and worker protection.

I. Air Handling Devices

1. Base calculations on methods and data from the most recent issues of ASHRAE, Fundamentals Handbook.
2. AIHA/ANSI standards shall be utilized for projects with .laboratory or industrial ventilation requirements.
3. All AHUs and exhaust fans shall be AMCA certified for sound and air performance
4. Design air conditioning systems to conserve energy. Systems shall automatically adjust to actual space load conditions to reduce energy consumption at part loads. The use of fan powered terminals and fan coil units are discouraged, and any use of these products must be approved by Building Maintenance and Operations through the University Project Manager.
5. Use the following design temperatures for heating and air conditioning systems:
   a. Winter:
      1) Outside air temperature: -10 degree F. outside air temperature. For 100 percent outside air systems use -20 degree F.
      2) Inside air temperature: 72 degree F.
      3) Wind velocity: 15 mph.
   b. Summer:
      1) Outside air temperature: 100 degree F. dry bulb, 59 Degree F. wet bulb for systems with OSA economizers or 100% OSA Systems, otherwise 95/63.
      2) Inside air temperature: 72 degree F dry bulb, 63 degree F wet bulb.
      3) Air cooled condensers and dry coolers: 105 degree F.
      4) Wind velocity: 8 mph.
   c. Discuss laboratory, animal holding and other special room requirements with the University Project Manager.
6. Ventilation: Comply with ASHRAE 62 Ventilation Standards. Provide demand control ventilation in highly occupied spaces. Laboratory spaces to comply with ANSI Z9.5.
7. Pressurization: All specified pressure differentials are with respect to the adjacent corridor.

Ante Room (or lab without ante room)	Negative	0.01 (In. H2O)
Laboratory (BSL-2)	Negative	0.01 (In. H2O)
Laboratory (BSL-3)	Negative	0.05 (In. H20)
Office	Positive	0.01 (In. H2O)
Classroom	Positive	0.01 (In. H2O)

   Verify pressurization requirements with the university project manager
8. Engineer to indicate pressurization relationships, and specify individual CFM offsets for spaces on the drawings.
9. All research and academic laboratories should be designed with negative pressure, inward air flow. Any deviation from that standard would require a completion and approval by EH&S.
10. Locate the supply, return, and/or exhaust in a given space so flow of air will be toward the most contaminated area of that space.
11. Do not provide humidity control except when specifically required by the program plan. When humidity control is necessary use plant steam to generate clean steam through a clean steam generator.
12. Use outside air for cooling whenever economical. Where practical design systems with economizer cycles that automatically allow the quantity of outside air supplied to the building to be modulated.
13. Use transfer fans for cooling for electrical closets where possible except for large main electrical rooms. Do not provide fan coils in secondary electrical closets.
14. Filter loading design pressure drops:
   a. Pre-filters = 0.9 IN WC

b. Final-filters = 1.5 IN WC
c. HEPA filters = 1.5 IN WC

15. Locate air handling equipment inside buildings.
16. Discuss the needs for redundant (2N, where N = the number of devices required to meet the load,) and back up (N+1, where N = the number of devices required to meet the load) systems with the UC Project Manager. On mission critical applications, determine the system's single point of failure(s).

J. Design systems that require 24 hours/day operation separate from those that may require only 8 hours/day operation. Systems that require 8 hours/day of operation shall be zoned appropriately for unoccupied operation.

1. Equipment cooling with domestic water is prohibited. Cooling loads should be supplied chilled water from the campus district chilled water system. Requests for exemption shall be made to the University Project Manager.
2. Unless otherwise specified, isolate all rotating and reciprocating machines so that 90% of the disturbing frequency shall be eliminated.
3. The university utilizes a central Building Automation System (BAS) for control of HVAC functions. Coordinate HVAC tie-ins with the BAS.
4. Avoid small separate heating and cooling devices such as fan coil units and unit heaters except for energy conservation or to facilitate scheduling of air handlers. Where this equipment is used, it shall be controlled by the BAS.
5. Provide occupied-unoccupied programming of systems to initiate shut down of ventilation, exhaust, fan systems, and pumps wherever possible.
6. Use variable air volume supply and exhaust to compensate for diversities in loads and reduce equipment sizes.
7. Water-cooled or air cooled condensers are acceptable depending upon job requirements. Water-type cooling towers are preferred to conserve energy and should be considered on systems 80 tons and larger.
8. Specify electrical by-pass switch, external to the drive at critical locations, with appropriate safeties on variable speed controllers to allow use of the equipment if the variable speed controller fails.
9. Design systems utilizing campus district steam and chilled water.
10. Hydraulically decouple the building pumped systems from Utility Company and/or campus district systems. Reference Part 3 for Steam and Chilled Water Utility Connection standards.
11. Design hydronic systems with two-way valves.
12. Chilled Water Systems: Design chilled water systems with a 14 degree temperature difference. Design buildings with variable flow pumping systems
13. Thermostat Locations: Locate thermostats central to the load and where possible near the door. Mount thermostats 60 inches above finished floor except mount adjustable thermostats in accordance with ADA requirements.
14. For remodel projects, note for demolition of existing piping to the main riser. Demolition of an existing piping system will include removal of components which do not remain as part of the system, all associated abandoned hangers, valves, supports, and all associated equipment.
15. Verify the use of return air plenums with the University Project manager. Where plenums are allowed, all return air grills shall be provided with return air boots.

K. Laboratories - General:

1. Select exhaust fans in a common system to be capable of providing 30 percent extra capacity and pressure. The speed increase shall not exceed the safe recommended speed as specified by the manufacturer of the device.
2. Provide laboratory with 100% exhaust.
3. Where surrounding structures, building air intakes, public gathering places, or other areas may pocket or concentrate chemical exhaust contaminants from the exhaust systems, then the exhaust shall be treated to minimize point source air contamination by using a high plume dilution exhaust fan.

4. Locate laboratory supply air grilles to prevent unwanted cross drafts around specialty equipment such as chemical fume hoods, biosafety cabinets, and atomic absorption spectrophotometers. Airflow shall move from the entrance of the lab towards the lab hood.
5. Maintain lab and entry vestibule under negative pressure.
6. Maintain the lab more negative than the vestibule.
7. Equip hoods with audible and adjustable visual low-flow alarm set to alarm at face velocity as determined by the manufacturer and acceptable with EH&S..
8. Provide redundant/backup HVAC systems for air handlers and exhaust fans serving laboratories.
9. Fume hoods to be VAV.
10. Provide emergency backup power on hazardous exhaust systems and do not shut down upon activation of any alarm. Provide dedicated switches in the building fire alarm panel to allow capability for manual fan shutdown by the fire department.
11. Air change rates in laboratory spaces to turn down based on occupancy. Verify air change rate with the university project manager.
12. For flammable storage cabinets, do not exhaust. If exhaust is deemed necessary, confirm with EHS and AHJ and provide fire damper. Verify exhaust system can accommodate flammable airstream.
13. Provide heat recovery systems on laboratory systems when possible.
14. Coordinate minimum air change rates with the University Project Manager and EH&S.
15. Mount sash sensors outside fume hoods on corrosive chemical applications.
16. The need for a push-button timed over-ride on fume hood sash alarms shall be approved by the University Project Manager and EH&S
17. Ventilate Chemical Storage Rooms or Waste Storage Rooms.

L. Laboratory HVAC Control: The laboratory control system shall perform the following functions:
1. Hood face velocity
2. Laboratory pressurization
3. Laboratory temperature control
4. Proper air distribution
5. Pressurization (either positive or negative) shall be maintained by airflow based on the formula:
    a. Supply cfm: Exhaust cfm - offset cfm.
    b. Supply cfm: Air supplied to the space to maintain temperature and provide make-up.
    c. Exhaust cfm: Air leaving the space either through the hood's exhaust or through the general exhaust.
    d. Offset: Is an arbitrary amount set to provide pressurization.
6. The lab controller (programmable) shall receive inputs from all controlling devices and provide outputs to control the lab's environment.

M. Standard Laboratories - Biosafety Level 2:
1. Provide 30% reserve capacity in new HVAC systems design to accommodate future research needs and help retard system obsolescence and minimize overall capital outlay.
2. Laboratory air circulation shall comply with ASHRAE standards.
3. Maintain all laboratories under negative pressure.
4. Design laboratory exhaust air grilles with inflow air velocity rates ranging between 500 and 700 linear feet per minute.

N. Standard Laboratories - Biosafety Level 3 (BL3):
1. Design in accordance with the Campus standard "Biosafety Level (BL3) Construction Standards. Copies of this standard are available from the university EH&S.
2. All supply and exhaust from each holding room must be provided with bubble tight control dampers.

O. Photography Darkroom: The Kodak K-13 photo darkroom design standard shall be used as a guide. All photo darkroom designs shall be specified and/or approved by the university DEHS before any implementation. Minimum requirements to control photochemical vapors, fumes, and dusts are as follows:

1. All darkrooms shall have 100% outside air supply. Exhaust shall be discharged away from any building air intake. Provide a minimum of 8 air changes per hour. Maintain all darkrooms at a negative pressure to its surroundings (0.05 in wg.).
2. Desired and compatible temperature ranges for photo darkrooms shall be 69 to 75 degree F.
3. The university DEHS will participate in photo darkroom design, as there may be special requirements associated with numerous processes that generate hazardous gases and shall approve all plans before any construction takes place.

P. Environmental Chambers: These units are variable and shall be evaluated individually by the university DEHS before purchase and/or installation.

Q. Biosafety Cabinets (BSC):

1. Construction of new facilities in campus may require the installation of biosafety cabinets. Some BSCs of the Class II Type B 2 have 100% exhaust requirements. Design of space HVAC systems shall accommodate the exhaust requirements of the BSCs. In addition, filter pressure drops across HEPA filters must be monitored for proper system airflows.

R. Equip multiple hoods on the same fan system with a control damper at each hood

S. Animal Facility Design Conditions:

1. Heat and ventilate animal laboratory and animal facilities by an independent system.
2. Conform to the most current edition of the ILAR "Guide for Care and Use of Laboratory Animals", available from the University Project Manager and/or Institutional Veterinarian.
3. Additional guidelines and design criteria for animal holding areas may be applicable. The University Project Manager shall coordinate with the Institutional Veterinarian for additional guidelines.
4. Provide separate ventilation system for the animal facility and system redundancy and system monitoring. Redundant systems required for supply, exhaust, heating and cooling so minimum environmental conditions can be maintained in animal holding with one unit out of service. Discus requirements with Institutional Veterinarian and the University Project Manager.
5. Size strainers on floor drains to match the size of sewage material from the animal facilities. The University Project Manager shall coordinate with animal facility personnel.
6. All wall and ceiling penetrations (including fire sprinkler heads) to be sealed airtight for vermin control.
7. Provide dedicated exhaust system for the cage wash area due to saturated vapor content. Exhaust duct should be stainless steel.
8. Provide 100% outside air with MERV 15 filtration.
9. All ductwork in animal facilities must be welded stainless steel.
10. All supply and exhaust from each animal hold room must be provided with bubble tight control damper. These dampers are controlled individually thru the BAS for decontamination purposes. Coordinate decontamination requirements with the University Project Manager.
11. Temperature and Humidity criteria: Maintain temp set points +/- 2 deg between 64-84 deg F. Humidity must be maintained between 30-70% with +/- range of 10% RH (with the low not allowed to go below 30% or high above70%). Depending on species, there may be rooms that require temp and humidity levels outside of range. Discus requirements with Institutional Veterinarian and the University Project Manager
12. All facility systems should be on back-up generator
13. Locate distribution systems in full accessible interstitial space with a minimum of 6’ 8” clear height. All serviceable components should be accessible.
14. Mechanical systems should be soundproof to minimize disturbance to research animals. Systems should not be located directly above or adjacent to animal holding rooms.
15. Facility should have the following through a central distribution system:
    a. Medical O2 (NFPA 99 certified)
    b. CO2
    c. Vacuum.
16. Animal Watering System:

a. An automatic watering system to all animal housing rooms.
b. Water is RO with acidification.
c. Automatic watering system is flow thru or filtered recirculation system.
d. Stainless steel manifold distribution designed in a way to prevent “dead legs.”
e. System shall be equipped with a programmable flush system for each rack and be centrally monitored for pressure or leaks.
f. System should be designed to include treated storage tanks that are sized accordingly to provide minimum of 48hours of animal drinking water (when facility is at full capacity) in an emergency.
g. BAS shall monitor system
h. See 23 60 00.

T. Utilities:
1. In general, utilities will be included in Division 2 and work in this Division will only extend to 5 feet outside of Building or Structure excavation perimeter.
2. Specify the following where exceptions occur and Building Services extensions and connections are made to public utilities:
   a. Connection charges, membership fees, system development charges, and the like, that in principle allow the right to obtain a services from a Utility Company will be arranged and paid for by the university.
   b. In the event that the serving Utility Company installs their own taps, service, meters, etc., all costs imposed by this action shall be the responsibility of the Contractor.
3. The Campus is a continuously operating facility. Construction of new and maintenance of existing utility systems, equipment and distribution requires capability of isolation of equipment, systems, and branches of the distribution system. It is therefore imperative that the design and installation of new and modified utility systems include sufficient isolation capability. All work involving the central utility systems (i.e., steam, natural gas, condensate, chilled water, hot water, domestic water, medical gases, and/or vacuum systems), whether upgrade of the system or tie-in to the central system must include provisions for system isolation. Location of isolation devices shall comply with the directives in Section 01040. An isolation plan shall be submitted to the University Project Manager as part of the Schematic Design and Construction Document phases of the project. The University Project Manager will be responsible for approval of the plan and coordination with the Design Team.
4. The University Project Manager will furnish information regarding the preferred locations of incoming utility services to the building and waste outlets. This will generally be furnished in the form of a site plan and pertinent elevations will be given. Piping in the building must be generally arranged and oriented to conform to these. Layouts should not be started until this information has been furnished.
5. All incoming utilities shall be metered. Meter domestic water per Local standards and meter chilled water, electricity and steam per the university standards, which are available through the University Project Manager. Provide for isolation of meter, bypass around meter, and complete shutoff of meter and bypass.
6. All incoming utilities shall be provided with means of isolating the building from the utility distribution system inside the building at the point where the utility enters the building.
7. The University Project Manager will furnish the locations of all underground utilities prior to demolition and excavation.
8. Steam is distributed from the university Central Utility Plant via direct buried lines. Nominal distribution pressure is 125 psig saturated. All building mains shall be dripped and branches back-graded to the main.
9. Install steam service lines to each building with a minimum of 20 pipe diameters straight run for metering.
10. Provide main building shut off valves outside the building typically in the mechanical vault.
11. Insulate all steam and condensate lines. Insulate valves, strainers, and other equipment with removable preformed insulated casings or jackets.
12. Steam condensate is returned to the university Central Utility Plant via direct buried lines.

13. Condensate receivers with mechanical pumps are not permitted without approval by the university Facility Operations through the University Project Manager. If pumps are used, provide centrifugal duplex type with cast iron receiver. Provide float operated mechanical alternator for switching for alternate service. Size receiver capacity for 25% future capacity. Install flash tanks ahead of receivers.
14. Specify methods and locations of trapping.
15. Meter steam supply in each building. Steam and condensate meters must be approved by the university Facility Operations through the University Project Manager.

U. Steam and Condensate Distribution Systems:

1. Campus steam is provided by connecting to the piping headers located inside the designated mechanical utility vault. The utility vaults house the expansion joints and condensate trapping stations for the steam service. All penetrations into the utility vaults shall be constructed such that the watertight seal at the wall is maintained. These header connections are typically 12” Sch 40 steel pipe. Saturated steam at 110-125 psig will be provided for the building at the steam header.
2. Steam Distribution Piping:
   a. An isolation valve must be located in the utility vault downstream of the connection to the steam header. The service pipe from the utility vault to the building shall be according to the standard specification for preinsulated piping systems. The service pipe from the vault to the building shall be anchored in un-excavated soil within 5 feet outside of the vault wall and also outside the building wall in order to minimize the expansion directed into the vault and building. Provision for thermal expansion of the service line must be addressed. Additional expansion loops and anchors may be required depending on the distance and routing. Extreme care should be taken in the design of the high temperature piping systems to avoid excessive stress on the pipe, anchors, vault and building. The slope of the steam connection piping must lie so that the condensate is effectively drained to either the steam header located in the utility vault or to the building.
   b. After the building penetration, isolation flanges and gaskets should be provided to electrically isolate the distribution system from the building in order to prevent electrolytic corrosion on both systems (see REF DWG 1). Provisions to trap the condensate must be made directly after the isolation flanges and gaskets in the building. Downstream of the trapping station an isolation valve must be located inside the building. Directly downstream of the isolation valve and upstream of the building pressure reducing station, a vortex-shedding mass flow meter, pressure and temperature compensating, shall be installed (see specification). This meter will be installed in a length of straight pipe dictated by the particular piping configuration and model of steam meter in order to have accurate measurement. The meter shall be sized to accommodate both the maximum and the minimum flow rates anticipated. If the metering accuracy cannot be maintained at both the maximum and minimum flow values of the meter, a parallel dual meter installation will be needed. If necessary, the combination of two meters must be sufficient to measure low load conditions. The meter output shall report to the Building Automation System (BAS) and communicate with the campus network. Meters may need periodic calibration based on the manufacturer’s recommendation.
3. Steam Meter Specification: Please see section 23 09 00
4. Steam Condensate:
   a. Condensate return is done by connecting to the headers located inside the mechanical utility vault. These header connections are typically 4” Sch 80 steel pipe.
   b. An isolation valve must be located in the utility vault upstream of the condensate header and header isolation valve. The service pipe from the utility vault to the building shall be according to the standard specification for preinsulated piping systems. The service pipe must be anchored in un-excavated soil within 5 feet of the vault wall and also outside of the building wall in order to minimize the expansion directed into the vault and building. Thermal expansion of the service line must be provided for outside of the utility vault, between the anchors.
5. Draining Piping Low Points:

a. If it is necessary to trap and drain the connection line in-between the utility vault and the building, and no practical steam main drainage scheme exists, using only pipe slope (either to the building or to the utility vault), then these traps may be connected directly to the pumped condensate return line. Care must be taken in sizing the steam main from the vault to the building because if the building penetration is located higher than the utility vault connection, and it is desired to drain the condensate into the utility vault, over-sizing the steam main to accommodate counter flow conditions may be necessary.

b. Upstream of the building penetration, isolation flanges and gaskets should be provided to electrically isolate the distribution system from the building in order to prevent electrolytic corrosion on both systems. Upstream of the isolation flanges there is located a single trap discharge connection from the steam trap located upstream from the steam isolation valve located inside the building. A steam condensate isolation valve shall be located inside the building upstream of the trap discharge connection.

6. Liquid Mover:

a. The steam condensate return system is intended to operate in the future under pressure and have no working atmospheric vents after leaving the buildings. All condensate trapped inside the building must be collected in a non-vented receiver and pumped into the condensate return system using a steam motivated steam condensate pump (see REF DWG 1). Please note that the pressure reducing valves serving the steam condensate pumps are fed with the pressure of the main steam line (110-125 psig) upstream of any pressure reducing stations. This allows the motivation pressure of the steam-powered pumps to be adjusted over time to meet the changing system demands without concern regarding the pressure of the steam for use by the building loads.

b. It is anticipated that the condensate return line back-pressure will increase as more buildings are constructed and come on line. Building condensate return design should be based on the worst case of 35 psig back pressure, yet be adjustable for the low backpressure that will be seen during the first several years.

7. Condensate Return Temperature:

a. Minimum steam condensate return temperature from the building is assumed to be 180F. Maximum steam condensate return temperature from the building is assumed to be 200F. Under no circumstance is live steam (other than flash steam) to be introduced into the steam condensate return lines.

b. Damage may occur to the insulation and waterproof protective jacketing if excessive pipe surface temperatures are reached. This damage will lower the long-term efficiency and will shorten the service life of the piping system.

V. Chilled Water Distribution Systems

1. The Central Utility Plant (CUP) produces chilled water at 40F and through a variable flow primary distribution system, provides chilled water to the buildings for cooling. There is an assumed heat pickup during distribution of less than 1F.

2. CUP Chilled Water Re-set Schedule:

a. Building design should reflect an increased chilled water supply temperature during cold outside conditions. CUP provided chilled water supply temperature will increase during cold weather as shown in the schedule.

1) If OSA > 45 F, then building design at CHWS = 41F (standard condition)

2) If OSA < 45 F, then building design at CHWS = 46F (free cooling mode)

b. Chilled water should be returned to the CUP at 56F.

3. Chilled Water Connection Configuration:

a. The campus chilled water distribution system will operate in a de-coupled manner. A primary-secondary bridle connection and building circulation pumps should be used for building cooling. The CUP provision of chilled water uses variable-flow primary pumping to the building infrastructure connection.

b. Campus buildings use internal secondary loops with variable flow pumping to distribute chilled water to the HVAC (Heating, Ventilation, and Air-Conditioning) and process cooling loads (typically process loads are isolated in a tertiary pumping loop using a heat exchanger).

c. The primary-secondary pumping interface is an important consideration. Use of a 2-way modulating control valve installed on the return leg back to the CUP is used to maintain a chilled water return of 56F (see REF DWG 2).

4. Low Delta T Syndrome:
   a. The CUP is design to accept 56F chilled water return (CHWR) and maintaining this full temperature differential has energy utilization advantages.
   b. The energy cost associated with a low delta T can be avoided, but requires that building designers exercise care both in design and commissioning of their respective building projects.
   c. An important consideration is the ability of the building to maintain 56F chilled water return back to the CUP – especially at peak load, but also at part load. As the standard suggestions, using a 2-way control valve to hold building return chilled water at 56F, before allowing it to return back to the CUP, can cause building cooling problems. Building designers need to exercise great caution in considering the potential for chilled water mixing in the de-coupling bypass pipe. The commissioning process should be used to verify high CHWR temperatures leaving individual heat transfer devices within the building, in a dynamic setting, at both peak load, and at part load. Relaxing the requirement of CHWR = 56F will not be a solution to poorly controlled building loads. It is important to consider the matching of flows for building pumping with chilled water demand at the various building loads. Flow meters will be used on both the primary loop and the secondary loop to facilitate Building Automation System (BAS) control logic to approximate flow matching.
5. Special Consideration of CHWR < 56F:
   a. The university accepts, with respect to HVAC loads, that there are certain coil entering air conditions, depending on AHU (air handling unit) design, that will not allow chilled water leaving the coil to reach 56F.
   b. These special circumstances must be identified and approved on an individual building/project basis. Often this is discussed with reference to outside air conditions (OSA), though the range where the OSA temperature impacts specific designs, and consequently the requirement to hold CHWR = 56F, will differ based on the project. For the most part, this difficult operating range covers a small period of time.
   c. This standard is not intended to require a fixed unyielding conformance to the CHWR = 56F requirement without consideration for undesirable consequences. Unreasonable investment in buildings or wasteful energy practices should be avoided. These exceptions should be discussed, clarified, and approved during schematic design on an individual project basis. During this low coil load scenario, chilled water return to the CUP may be gradually relaxed, at the same time the AHU supply air discharge temperature is gradually raised through a controlled re-set schedule. Using creative instrument control sequences, it may be possible to increase CHWR to greater than 56F - this is acceptable and desirable (good design practice should strive to minimize all flow through the decoupled bypass/bridal connection – both to artificially cause CHWR = 56F to be a set maximum or set minimum).
6. 2-way Control Valve:
   a. Temperature control of the chilled water return back to the CUP must be maintained through a direct acting temperature control loop. The control valve and actuator assembly must be of industrial quality with a combined approximate 100:1 turn-down ratio.
   b. The control valve will need to be able to close against the possible 100 psi (230' W.C.) differential pressure from the central plant pumps and have 3-5 psid across the valve at full flow.
7. Process Cooling:
   a. Process cooling loads may require a special application during periods of low building load (cold outside air temperature conditions). Process cooling loads are assumed to be generally constant irrespective of outside weather conditions, 24 hours per day and 7 days per week (HVAC loads will be able to take advantage of outside air economizers). Process loads should have coils sized for warmer chilled water for those periods of time when the

CUP will have elevated supply temperatures as it operates in free cooling mode(it is likely that the heat exchanger could return water warmer than 56F).

b. Serving process loads during winter weather will often require the use of a smaller "minimum flow" chilled water pump for low load conditions as the main pump VFD control usually does not want to reduce flow to below 30% of schedule chilled water flow (end of main bypass with 3-way control valves should not be used).

8. High Static Head Problem:

a. CUP pumping operation at future build-out is based on a fixed maximum working pressure. During peak operation, dynamic pump head in combination with potential static head due to a high column of water, could exceed the CUP design basis if precaution is not considered. To that end, the highest point of the building chilled water piping system (including all connected equipment and piping) should not be higher than an elevation of 5,475 FT A.S.L. because of the static pressure induced on the campus system by the building piping system. In this case, use a flat plate heat exchanger(s) and building circulation pump(s) to isolate the building and campus chilled water systems (typically process loads are isolated in a tertiary pumping loop using a heat exchanger, in some cases the entire building will be served by a chilled water heat exchanger).

9. Flat Plate Heat Exchanger:

a. Use of a flat plate heat exchanger is required when the highest point of the building chilled water piping system exceeds the elevation of 5,475 FT A.S.L. because of high static head. Alternatively buildings may have both a direct de-coupled chilled water connection to the CUP and an indirect connection through the use of a heat exchanger. In many cases, in buildings with significant process cooling requirements, these cooling loads will all be served by a chilled water heat exchanger and a downstream tertiary pumping loop. In either case, the chilled water piping system downstream of the heat exchanger must be considered as an isolated system. This system must have provision to manage its own makeup water and chemical treatment. The piping system downstream of the heat exchanger must have provision for expansion capacity. The tertiary chilled water system should be designed to utilize warmer chilled water to account for both a 3 F approach or less and elevated CUP chilled water supply temperatures during winter operation (please see CUP free cooling mode chilled water supply reset).

b. If the entire building is served by a flat plate heat exchanger (ideally this should be avoided if AHU's can be kept below the approximately tenth story roof elevation) – when significant building chilled water equipment is above the specified elevation or if the process cooling heat exchanger is directly connected to CUP chilled water system, then the direct connection of the heat exchanger to the primary chilled water distribution network should be sized for a differential pressure of no more than 6.5 psid at the maximum flow (source side).

10. Central Utility Plant Water Treatment Management:

a. No makeup water or chemicals shall be introduced into the chilled water system at the building when directly connected to the CUP system. All chemical treatment will occur at the CUP. Piping system expansion capacity for each building project will be provided for at the CUP. The building mechanical systems designer must provide the campus Facilities Operations engineering staff with the calculated amount of expansion required for the building project from the point of connection with the campus system. All equipment and connections shall be specified for 150 psig ratings (flanges, gaskets, Victaulic connections, etc.). This is the rating of the campus distribution system chilled water piping.

11. Chilled Water Meter Specification: Please see section 23 09 00.

12. Reference Drawings:

a. The following diagrams are referenced in the above text and are for general use and design discussions. Valves are shown as a generic valve symbol and are not meant to depict a particular type of valve. It is important to emphasize again, that each particular installation is unique and may require a different approach to the installation.

1) REF DWG 1: Steam Connections Inside Buildings

2) REF DWG 2: Chilled Water Connections Inside Buildings

W. Energy Conservation:
1. The university is dedicated to the principle of conserving energy and will scrutinize proposed construction for means of reducing not only initial cost, but also long range operating and maintenance costs. Buildings will be designed making the most efficient use of building materials and energy sources available. Compliance with the standards in ASHRAE Standard 90 is a minimum requirement.
2. Give consideration to building utilization by planning for conservation between summer and winter and for periods of minimum occupancy. Design systems that require 24 hours/day operation separate from those that may require only 8 hours/day operation. Systems serving spaces with special year-round cooling loads e.g., computer rooms, data centers, equipment rooms, shall be designed separate from the building HVAC system.
3. Conservation of energy should be a significant factor in specifying or selecting equipment, system, controls, and sequence of operation. The alternatives shall be evaluated through life-cycle costing and presented to the campus energy engineer through the University Project Manager for approval.

X. Equipment Rooms:
1. Separate mechanical equipment rooms from electrical equipment rooms. Limit access to these rooms to authorized maintenance personnel only. House equipment requiring access by building or laboratory personnel separately.
2. Arrange access to equipment rooms so entry will not disturb the occupants or normal functions of the building. Outside access doors are preferable. Coordinate door sizes with the largest equipment size. Provide adequate heights for walking and moving equipment into and out of room.
3. Comply with ASHRAE standards and State of Colorado regulations for design and construction of mechanical refrigeration systems and related monitoring, ventilation, and storage of refrigerants.
4. Arrange and locate equipment rooms so that heat and sound will not be transmitted to other parts of the building. Insulation and ventilation are required where applicable per standard requirements. Where applicable size service elevators for equipment removal from basements and penthouses.
5. Locate equipment having parts which must be removed for maintenance (filter, coils, fan shafts, tube bundles, etc.) so that removal may be accomplished with adequate access and without interference with other functions of the building.
6. Surround the room with a 6 inch curb, a 2 inch cant, and waterproof the floor. Provide floor drains and slope floor to drains.
7. Provide high water detection alarms in all mechanical and equipment rooms at lowest point of floor. Provide a 3/4 inch conduit between high water alarm and the specified alarm panel for remote alarm.
8. Where possible lifting eyes should be permanently placed to aid in lifting and removal of mechanical equipment weighing over 100 pounds. Lifting eyes shall not be blocked by any device.

Y. Pipe and Duct Spaces in Chases:
1. Provide excess horizontal and vertical area in duct chases and pipe runs for future use where possible 25%, office buildings should have 10% excess.
2. Provide full size doors for access at each floor of chase with steel floor grating for service and maintenance. Provide additional reduced size access doors where full size doors will not work to maintain and service devices and/or components within the duct.

Z. Pipe and Duct Penetrations:
1. Specify and detail the manner in which pipes pass through roofs, walls, floors, and ceilings. Fire ratings must be maintained for all penetrations. The Contractor responsible for cutting or drilling holes and flashing, sealing, or otherwise furnishing them must be clearly designated in the project documents.
2. Design pipe, and duct penetrations so that minimum opening remains after installation. Seal openings to prevent passage of rodents, birds, bugs, fire and smoke. Materials used shall be sufficient to maintain fire rating of the wall, floor, ceiling and/or roofs.
3. Provide for continuous insulation for pipes and ducts passing through openings.

4. Provide tubing or pipe (not sheet metal) sleeves for all utility services passing through structural walls and slabs. All sleeves passing through slab floors shall project a minimum of 1 inch above the slab and be sealed water tight to the slab.
5. Provide toe boards and handrails when floor grating is more than 4 feet above the walking surface below.

AA. Provide concrete curbs in mechanical rooms to contain water spills.

BB. Access/Accessibility:
1. Any device, equipment and/or component having a moving part or that requires maintenance and/or service shall be easily accessible. If it is located above solid ceiling, in a chase or other concealed areas, an access door shall be provided so that parts can be exchanged and work be done as required. Minimum panel size to be 24 inches by 24 inches
2. Design and install utility distribution systems (i.e., conduit, piping, ductwork, etc.) in a layered configuration in the areas of renovation or new construction. Take into account the access to devices, equipment, and/or components.
3. Locate access to equipment and valves outside critical areas, clean rooms, and red zones. Obtain a list of specific areas from the University Project Manager.
4. Locate systems to provide access to devices and components that require access or maintenance. Design system hierarchy above ceilings as follows:
   a. Plumbing waste, vent piping and roof drain mains and leaders.
   b. Cable trays
   c. Supply, return, and exhaust ductwork
   d. Fire sprinkler mains and leaders.
   e. Electrical conduit and duct banks.
   f. Domestic hot and cold water, medical gas piping
   g. Fire sprinkler branch piping and sprinkler run-outs.
5. Submit a system layering plan including electrical components to the University Project Manager for review and approval as part of the Schematic design phase of each project.

CC. Acoustical Criteria:
1. Design systems to provide noise levels from equipment and ductwork not to exceed, ASHRAE NC-35 in class room, 40-45 in laboratories in all 8 octave bands.
2. Coordinate acoustical requirements for application specific areas.
3. Exceptions:
   a. Spaces within 15 foot radius from supply and return ducts from shafts: NC-40.
   b. Lobbies, Toilets, Commercial Areas: NC-45 – 50
   c. Kitchens: NC-45 to 50.
   d. Mechanical Rooms: NC-50 to 60.

DD. Temporary Facilities:
1. Do not use permanent building equipment without written permission from the University Project Manager. If equipment is used for temporary heating or cooling, maintain equipment per manufacturer's instructions and protect with filters, strainers, controls, reliefs, etc. Do not start the guarantee period until the equipment is turned over to the university for use.

EE. Painting:
1. All piping, conduit and equipment in unfinished areas shall be painted as required for preservation and identification.
2. All exposed work in finished areas shall be painted for appearance as directed by the Architect.
3. Painters will cover or mask off equipment tags, nameplates, etc., before painting and then remove masking in such a way that it does not destroy the information on the tag or nameplate.

FF. Process and Control Air:
1. Air supply for control of HVAC devices having electric or electronic components shall be dried through a refrigeration air dryer or desiccant dryer.

1.3 SUBMITTALS

A. Submittals shall be made in accordance with Section 01300 and as required by various Section of Divisions 21, 22, and 23 with the following provisions:
   1. Submittals will be reviewed by the Engineer to determine that the materials, equipment, and installation methods are in accordance with the project design concepts. The Contractor shall be responsible for space requirements, configurations, performance, bases, supports, structural members and openings in structure, and other apparatus that may be affected by the material, equipment, or installation.
   2. Include current, published catalog and specification sheets pertaining to proposed material and equipment.
   3. Identify each item with identification symbols identical to those used on the drawings and/or in the specifications.

B. Operation and Maintenance Manual: Furnish operation and maintenance manuals for equipment and systems installed under Divisions 21, 22, and 23 of the standards in accordance with Section 01730 and the following.
   1. Submit one copy of the manual to the Engineer for preliminary review prior to production of the final manuals.
   2. Following review of the preliminary manual by the Engineer prepare and submit final copies of the manual complying with the Engineer's comments noted on the preliminary manual.
   3. Include the following information:
      a. Alphabetical list of all system components with the name, address, and 24-hour phone number of the company responsible for servicing each item during the first year of operation.
      b. Manufacturer's data that are applicable to the installed equipment such as the following:
         1) Shop drawings (reviewed and accepted
         2) Product and performance data (reviewed and accepted)
         3) Installation instructions
         4) Lubrication instructions
         5) Wiring and temperature control diagrams (reviewed and accepted Shop Drawings)
         6) Parts lists
         7) Copies of warranties
         8) A compilation of the manufacture’s recommended maintenance schedule and routines for each piece of equipment
      c. A simplified description of the operation of each system including, the function of each piece of equipment within the system. Support descriptions with a schematic flow diagram when applicable.
      d. Emergency procedures for equipment operation during a fire or following the failure of major equipment. Describe procedures for normal starting, operating, shutdown, and long-term shutdown.
      e. Maintenance instruction including valves, valve tag, and other identified equipment lists, proper lubricants and lubricating instruction for each piece of equipment, and necessary cleaning, replacing, and adjusting schedules.
      f. Assembly, installation, alignment and adjustment instructions.
      g. System balancing report.
      h. Temperature controls, cut sheets and record drawings.
      i. Commissioning checklists and certification.

C. Record Documents: Furnish record documents for equipment and systems under Divisions 21, 22,and 23 of the Standards in accordance with Section 01720 and the following:
   1. Mark drawing prints to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers, and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control

devices located and numbered, concealed unions located. Note changes of ductwork or piping on the drawings if it has been relocated more than 1 foot from where shown on the drawings.
2. List all equipment parameters on the drawings in schedules whenever possible. Include room number where equipment is located.
3. At the completion of the project, mark all valve tag numbers on the drawings and turn these drawings over to the University Project Manager.
4. Provide standard long-form specifications.

D. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

1.4 QUALITY ASSURANCE

A. Installer Qualification:
1. Workmanship shall conform to the highest industry standard for each specific type of work.
2. Perform work in accordance with standard commercial practices.

B. Comply with Part 3 of this manual, state and federal codes, rules and regulations. As a minimum requirement, codes, rules and regulations take precedence over the drawings and specifications. Where the requirements of the drawings and specifications exceed those of applicable codes, rules and regulations, the drawings and specifications shall govern.

C. Chemical and physical properties, design, and performance characteristics of all material and equipment, and methods of construction shall be in accordance with the following applicable codes, regulations and standards. Current editions in effect 30 days prior to receipt of bids will apply.
1. Air Conditioning and Refrigeration Institute (ARI)
2. Air Movement and Control Association, Inc. (AMCA)
3. American Gas Association (AGA)
4. American National Standards Institute (ANSI)
5. (ASHRAE) American Society of Heating, Refrigerating and Air Conditioning Engineers
6. American Society of Mechanical Engineers (ASME)
7. American Standard Code for Pressure Piping (ASCPP)
8. American Society for Testing and Materials (ASTM)
9. American Water Works Association (AWWA)
10. Compressed Gas Association (CGA)
11. Environmental Protection Agency (EPA)

1.5 DELIVERY, STORAGE AND HANDLING

A. All mechanical equipment and materials shall be delivered, stored and handled in accordance with manufacturers instructions and the requirements of Section01 10 00.

1.6 WARRANTY

A. All mechanical equipment, materials and workmanship warranties shall be provided in accordance with the requirements of Section 01740 and the following:
1. Warranty all equipment, materials, workmanship, and proper operation of equipment and apparatus for a period of one year from date of final acceptance unless indicated otherwise in the individual sections. Extended warranty periods are identified in individual sections.
2. Compile and assemble the warranties specified in the individual sections into the operating and maintenance manuals.
3. Provide complete warranty information for each item to include date or beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. As specified in individual sections.

2.2 MATERIALS, GENERAL

A. Products:
1. Provide material and equipment new and free from defects.
2. Install all material and equipment in accordance with the manufacturer's current published recommendations.
3. Certain materials and equipment are specified by manufacturer and model or catalog number. Such specified items are the basis of design and establish a degree of quality, performance, and physical configuration.
4. Equipment and materials manufactured by any one of the manufacturers listed on the drawings or in the specifications will be acceptable.
5. Where no manufacturer is listed, provide a standard product meeting the requirements of the drawings and specifications, and manufactured by a firm regularly engaged in the manufacture of such products. All equipment, when possible, shall be:
a. Manufactured and purchased in Colorado
b. Manufactured and purchased in the USA.
6. Requests prior to bid for approval of equipment or material not specified shall be done in accordance with the requirements of Section 01 25 00.

PART 3 - EXECUTION

A. Additional charges will not be authorized due to the contractor's failure to become familiar with the existing conditions.

3.2 INSTALLATION, GENERAL

A. Permits and Inspections:
1. Secure all required permits, the university will pay for permit and inspection costs.
2. Pay all applicable royalties, inspection fees, taxes, and licenses.

B. Responsibility of Contractor:
1. The contractor is responsible for the complete installation and satisfactory operation of all work in accordance with requirements of the drawings and specifications.
2. The component parts of the installation shall function together as workable systems. Each system shall be left with all parts adjusted and in proper working order.

C. Coordination:
1. Coordinate project in accordance with Section 01040.

D. Scaffolding, Rigging, and Hoisting:
1. Provide all scaffolding, rigging, and hoisting necessary to safely accomplish the work following OSHA requirements.
a. Remove from premises when no longer needed.
2. Provide necessary services to deliver, erect, place, and install all equipment and apparatus furnished.

E. Damaged Surfaces:
1. At completion of the work, all mechanical material and equipment furnished shall be inspected for damage.
a. Repair damaged factory finishes to match adjacent, undamaged areas.

b. Replace deformed metal cabinets, jackets, and enclosures with new items. Finish shall match similar undamaged items.

3.3 TESTING, CLEANING AND CERTIFICATION

A. Cleanup:
1. At completion of the work, check and thoroughly clean all equipment.
a. Clean coils and plenums.
b. Clean under, in, and around equipment.
1) Clean exposed surfaces of piping, ducts, and hangers.
2) Clean equipment cabinets and enclosures.
3) Provide and install new filters for equipment.

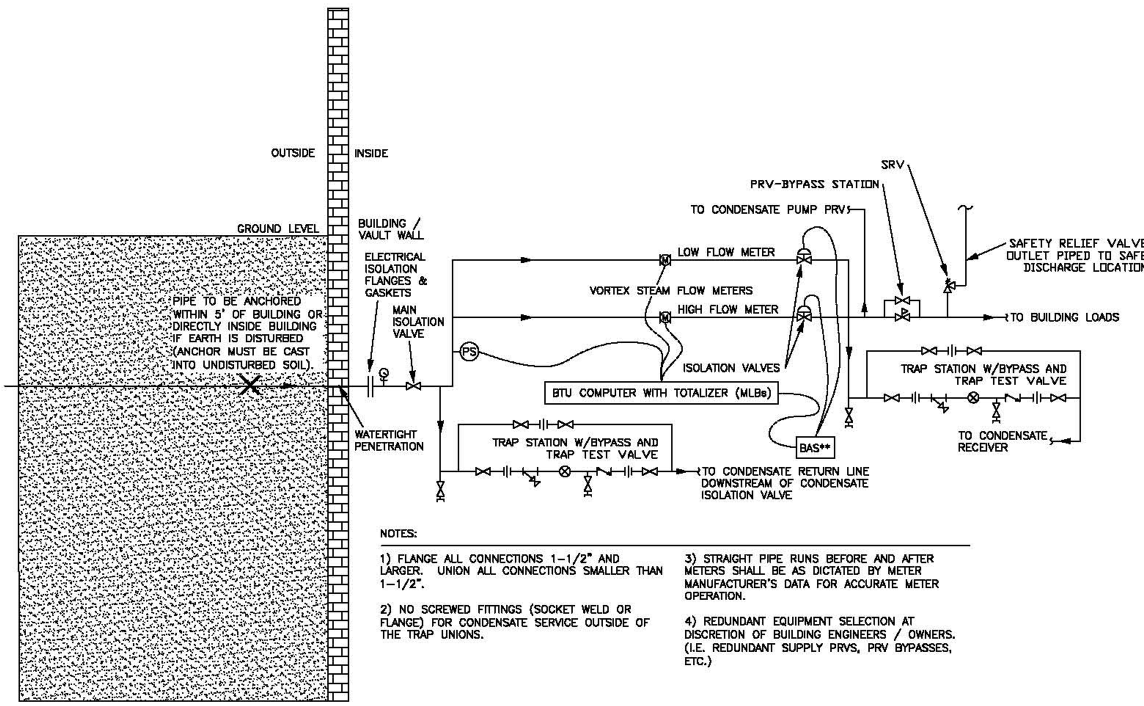
B. Project Closeout:
1. Verify that all work has been completed prior to requesting final walkthrough, including Contractor's preliminary review of mechanical systems start-up and acceptance checklists.

3.4 COMMISSIONING (DEMONSTRATION)

A. Training and Demonstration: Schedule instructional meetings for the university's Facilities Operations maintenance personnel on the proper operation and maintenance of mechanical systems. Provide the project manager a minimum of 5 days notice prior to any training, demonstration, or testing.

PART 4 - ILLUSTRATIONS

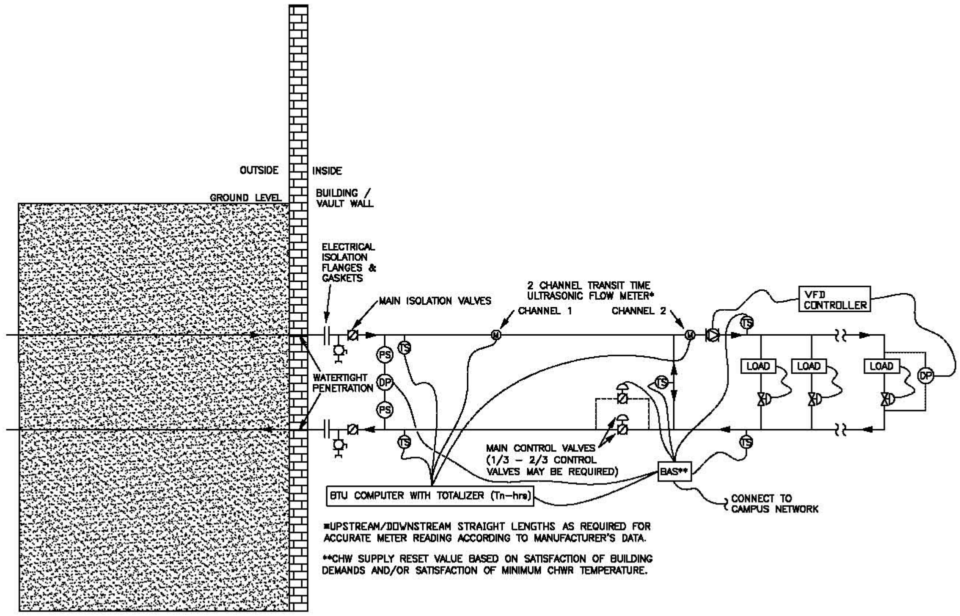
A. REF DWG 1: Steam Connections Inside Building



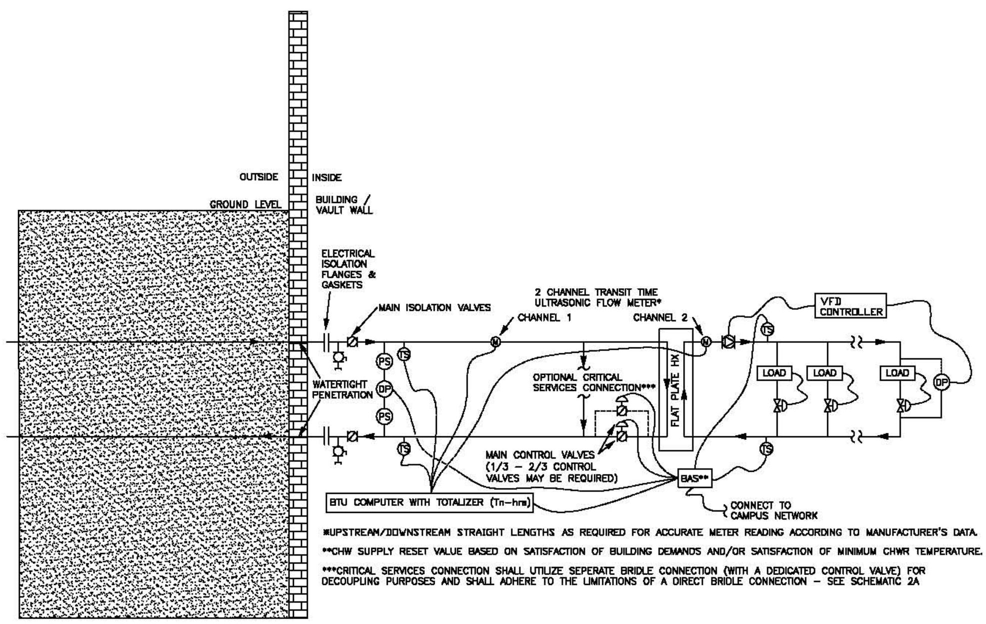
REF: SCHEMATIC 1 STEAM CONNECTION INSIDE BUILDING

B. REF DWG 2: Chilled Water Connections Inside Building

END OF SECTION 23 00 00



REF: SCHEMATIC 2A CHILLED WATER CONNECTIONS
INSIDE BUILDINGS WITH BRIDLE



REF: SCHEMATIC 2B CHILLED WATER CONNECTIONS
INSIDE BUILDINGS WITH HEAT EXCHANGER