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Mechanical

A. Design Criteria

Programming

1. Provide equipment access pathways large enough to allow for the removal of coils and other large pieces of equipment. Identify these areas on the design drawings.
2. Include an evaluation for building system renovation projects which describes the condition of the building systems, variances from present codes, and identifies spare system capacity or system deficiencies and opportunities for improving energy efficiency. The design team's mechanical, electrical, civil, structural, and architectural disciplines participate jointly in this evaluation.

Design Criteria

1. Provide the basis of design including design parameters and analyses for the following:
    a. Connection to existing utility distribution systems, including capacity and location,
    b. Temporary construction energy, water and sewer point of service,
    c. Distribution concepts including piping and ductwork,
    d. Load calculations for campus utilities,
    e. Seismic bracing for mechanical equipment, piping and ductwork,
    f. Special systems design (research and diagnostic equipment, and other equipment and designs not specifically covered by the FDS),
    g. Control systems and indoor environmental monitoring,
    h. Indoor dry bulb temperature,
    i. Indoor relative humidity,
    j. Outdoor dry bulb temperature,
    k. Outdoor wet bulb temperature,
    l. Occupancy, hours, and degree of activity,
    m. Ventilation – recirculation and outside air,
    n. Internal loads,
    o. Special loads,
    p. Insulating R-values for roof, wall, glass, etc.,
    q. Percentage of glass – fenestration,
    r. Type of glass, including coatings and solar coefficients,
    s. Building pressurization and infiltration,
    t. Code requirements and impact on criteria, such as:
        i. Energy code compliance path
        ii. Metering strategy
    u. Air quality design criteria, i.e. ASHRAE 62, current edition
    v. Noise criteria,

w. Building energy consumption and energy source,
x. Life cycle cost analysis for mechanical systems,
y. Sustainability,
z. Maintainability,
aa. Redundancy,
bb. Future Capacity,
cc. Standby Power,
dd. Fire and Life Safety.

2. Design systems and components with maximum reliability, maximum flexibility, and minimum operation and maintenance cost. Give full consideration for future system alterations with a minimum of system shutdowns. Accomplish preventive maintenance without a major building shutdown. Maintenance accessibility is very important. Meet current regulations for worker safety, including fall protection.
3. Since laboratory buildings need periodic renovation to keep up with changing technology, divide the building up into lab modules. These lab modules are a basis for HVAC and plumbing zoning.
4. Consider impact of summer heat waves when the outside air temperature exceeds design conditions set by the local energy code. Provide a control sequence that prioritizes cooling to more important spaces (e.g. classrooms over offices). Evaluate conditions that may create operational issues (e.g. reset chilled water temperature to chilled beams if elevated primary air temperature could cause condensation).
5. Consider the impacts of wildfire smoke events. Review impacts to natural ventilation, operable windows, mechanical air filtration, etc.
6. Develop a system redundancy plan that analyzes cost-effective means of providing equipment redundancy for reliable operations.
7. Provide isolation valves and devices for each utility serving each lab. Down feed all mechanical systems except the waste lines to minimize the number of floor penetrations.
8. Coordinate mechanical equipment located on the roof with the Architect. Minimize the number of roof penetrations.
9. Provide permanent guarded platforms as a means of accessing major equipment that needs to be maintained on a regular basis.
10. Provide access with platforms at each level for shafts that contain systems that require periodic maintenance, repair, or replacement (e.g. valves, dampers, and actuators), through access doors at a minimum size of 2’x4’.
11. Provide accessibility where space is required for future mechanical equipment.
12. Coordinate access method and platform requirements with Architect.
13. Mount equipment, e.g. fans and pumps, on a 4-inch thick concrete pad secured to structural slab. Size concrete pads larger than equipment. Extend the pad at least ten times the diameter of the mounting bolts past the equipment. Coordinate with Structural Engineer for final design.
14. See Architectural Finishes section for coating over entire mechanical room floor, including over housekeeping pads under air handling units, etc.
15. Provide floor drains in all mechanical and water entry rooms.

16. Provide galvanized schedule 40 pipe sleeves or manufactured through-penetration firestop devices for all piping penetrations through concrete and masonry. Coordinate with architectural and structural for location and installation.
17. Service elevator access is required for buildings with mechanical equipment on rooftops or in penthouses. Where no service elevator is provided, incorporate means so maintenance staff can safely transport materials to and from the roof or penthouse, such as a permanent crane, lifting mechanisms, overhead beams, or eye bolts. See also EH&S Safe Access and Maintainability Standards

Inter-discipline Coordination

1. Coordinate the mechanical work with other disciplines. Because of the space taken up by the mechanical equipment, coordinate the required infrastructure with all elements of the building to include architectural, structural and electrical. In many cases, the mechanical and electrical system space requirements necessitate changes to the floor plans, building sections, and exterior elevations, if not properly coordinated at the onset.
2. Align the mechanical shafts to minimize offsets.
3. Coordinate between the Mechanical Engineer and Electrical Engineer for equipment motors, motor starters, disconnect switches, thermal overload switches, variable frequency drives, and mechanical controls for all mechanical equipment including AHUs, exhaust fans, and pumps.
4. Avoid piping in electrical and IT (ex. MDF & IDF) rooms. See Electrical Design Standard for more detail.

Operational Constraints

1. Sustainability, operability, and maintainability are key elements in the evaluation of the Technical Program and Schematic Design. General use buildings are operated to match occupancy and are normally shut down during nights (10pm to 6am), weekends and holidays. Libraries usually have extended schedules. Laboratory buildings normally run continuously to maintain a safe working environment 24 hours per day. Evaluate on a building-by-building basis to allow a more efficient operation.
2. In remodel or renovation projects, shutdowns of existing utilities and services may be necessary. These shutdowns may have to occur after normal working hours to prevent interruption of critical operations. Temporary utilities may be necessary to maintain service to critical loads in laboratories and hospital health care areas and to refrigeration equipment.
3. Locate equipment, valves, and accessories above ceilings such that they can be readily accessed within arm's reach by a person standing no higher than the second highest step on a stepladder of a height that fits below the ceiling. Coordinate ladder placement to avoid interference from casework, lab benches, sinks, adjacent walls, or lab equipment. Give consideration to ceiling tiles immovable due to sprinkler heads, light fixtures, or other ceiling mounted devices.
4. The installation of equipment in challenging-to-access spaces (such as atria, high ceiling areas, or confined spaces) must have a "maintenance access plan" included in the design documents and details. The plan must be reviewed and approved by the maintenance and repair staff at ES and UW shops. The plan should note at minimum the following: potential hazards, hazardous areas and a plan to mitigate safety risks in these areas, tasks to be performed in these areas,

necessary equipment, and the responsible party for purchasing and storing equipment. A JHA template must be filled out before ordering equipment, with the Shop responsible for maintenance, and submitted with Closeout Documents. A link to access and download the JHA template can be found on this Job Hazard Analysis site. Additional JHA examples can be provided upon request.

Construction Requirements

1. Include a statement in the specifications that all components of the ventilation system (e.g. fan, duct, insulation, sound attenuators, terminal boxes, etc.) must be kept clean and dry as manufactured, delivered, stored and installed before operating the HVAC system. At the University of Washington Medical Center and specific animal care facilities, confirm if isopropyl alcohol wipe-down is required at all air handling equipment prior to installation.

Renovation and Demolition

1. The abandonment of existing equipment and material in place is not acceptable. Conserve space as much as possible.

B. Central Plant Utilities

Power Plant Central Utilities

Distributed utilities are generated at the Central Power Plant (CPP) and the West Campus Utility Plant (WCUP). Distributed mechanical utilities at the CPP include steam and steam condensate, chilled water, and compressed air. The WCUP generates chilled water only.

Steam and Steam Condensate

Steam is distributed from the Central Power Plant (CPP) to the campus buildings through the utility tunnel system. The primary use of steam is for campus building heat. Other uses are Power Plant boiler auxiliary equipment, building service water heating, kitchens, humidity control and sterilization at the UW Medical Center and campus laboratories.

Steam is generated at 425 psi at the Power Plant to operate the turbine generator. Steam is extracted from the Power Plant steam turbine and distributed to the campus at 185 psi. The Power Plant also generates steam at 185 psi to supplement the steam provided by the turbine. Exhaust steam from the steam turbine at 10 psi is distributed to the campus.

Each of the two steam pressure distribution systems is provided in a looped tunnel configuration as much as practical to provide service to the buildings. The loop configuration makes it possible to shutdown steam service from one side of the loop for maintenance or new construction connections while the other side of the loop remains in service to the buildings.

High temperature condensate is collected throughout the utility tunnel system where the 185 psi steam releases its energy and flashes. Low pressure steam generated from flashing is piped to the 10 psi steam system in the tunnel or in nearby buildings.

After the steam releases its energy and transitions into condensate, it is either pumped or returned by gravity to the Power Plant for steam generation.

Central Cooling Water (CCW)

Two utility plants supply CCW to the system:

The Central Power Plant (CPP) generates nominal 12,000-tons cooling capacity using five 2,000-ton centrifugal chillers, one 1,000-ton centrifugal chiller, and one 1,000-ton absorption chiller plus associated cooling towers and pumps. CCW-CPP operates seasonally from approximately April through October. CCW-CPP provides a source of higher temperature unconditioned condensing water during winter months when the chillers are off.

West Campus Utility Plant (WCUP) provides process cooling water with 3000-tons N+1 cooling capacity (with space for future build out up to 9000-tons N+1) using three 1,500-ton centrifugal chillers plus associated cooling towers and pumps. WCUP operates year-round.

Each plant delivers central cooling water to interconnected distribution piping with manual isolation valves for separating the plant’s service sections.

Compressed Air

Compressed air is generated at the Central Power Plant (CPP) by three oil-free air compressors with a total nominal capacity of 6000 ACFM. The compressed air is distributed as a central utility from the CPP to campus buildings primarily through the tunnel system. The distribution service nominal pressure is 100 psig. Before the compressed air leaves the Power Plant, it passes through a desiccant air dryer system lowering its dew point to approximately –15 °F. If drier air is required for use in the buildings, then an air drier should be provided in the building.

The primary use of compressed air on campus is for the building environmental control systems. There are many campus buildings with pneumatic controls that are still in operation. Many of the new and renovated buildings have been outfitted with Direct Digital Control (DDC) systems. These buildings with DDC systems still utilize compressed air for operating large pneumatic control valves and damper actuators. Other uses for compressed air on campus include fire protection dry pipe systems, fire smoke damper actuators, automatic door openers, and teaching and research laboratories.

Heating Ventilation and Air Conditioning

C. Air Handlers and Ventilation Fans

Design Criteria

1. Provide filtered and conditioned mechanical ventilation supply to all office, classroom, library, dining, patient care, laboratory, or housing occupancies and elsewhere where required by code or programmatic needs,
2. When feasible, specify fan speeds less than 1,000 rpm to reduce noise levels and increase equipment life.
3. Fan installation in penthouses or mechanical rooms is preferred. Provide weatherproof protection for outdoor fans.
4. Provide a permanent catwalk to access the upper portion of multi-level air handing units. Review with Engineering Services and the UW EH&S Safe Access team during the design phase of the project to ensure a clear understanding of the proposed solution.
5. Locate the fan as the last element of the exhaust system to assure that the ductwork throughout the building is under negative pressure.
6. Install fans to be readily accessible for maintenance and inspection without entering the plenum. If exhaust fans are located inside a penthouse, consider the ventilation needs of maintenance workers.
7. Discuss laboratory ventilation interlocks and standby power requirements with EH&S and Engineering Services.
8. Coordinate the mechanical design with fume hood selection and location to achieve design performance criteria listed in the EH&S Laboratory Ventilation Design Guide.
9. Where fume hood and general exhaust systems could be combined or separated, review design intent with EH&S and Engineering Services, including costs and benefits of the proposed solution.
10. Manifolded fume exhaust systems must have N+1 redundancy so they remain operational at design conditions during repair or unplanned outage.
11. Ventilate mechanical and electrical rooms for temperature control. The temperature setpoint to be a maximum of 85 ˚F unless there are specific equipment temperature requirements. Provide outside air to all mechanical and electrical rooms as part of the ventilation system.
12. Provide provisions for future ventilation for ductwork and piping systems for storage rooms that may eventually become offices. Storage rooms are not considered unoccupied areas.
13. To maintain optimal indoor air quality, locate air intakes to avoid contamination from streets, exhaust vents, loading docks, and other sources of contamination. Locate outside air intakes a minimum of ten feet above grade.
14. For air intake requirements of laboratories, see EH&S Laboratory Ventilation Design Guide.
15. To protect the air intake, locate all building exhausts as remotely as possible from the intake. All fume exhaust systems must be located on the roof and discharge vertically.

16. Avoid air intakes on southern elevations to minimize wind-driven rain and snow entrainment. Avoid using moisture eliminator in lieu of rain hood as it has high pressure loss and water collected on the louver is drawn into the system before reaching the drainage gutter.
17. Most building systems require large units, in the 20,000 to 75,000 CFM range. The use of multiple small package units is discouraged.
18. Separate ventilation systems or zones may be required for separate occupancy uses, such as libraries, auditoria, laboratories, etc. The occupancy schedule of these areas are not always the same. Make provisions to run these areas when the remainder of the building is not in operation.
19. Do not use operable doors or windows as part of a pressurization or smoke control system where it may compromise building security.
20. Do not use fan rooms and mechanical rooms as supply or relief/exhaust air plenums. Duct all outside air and relief/exhaust air ducts to outdoors.
21. Mechanical rooms to be equipped with continuous exhaust ventilation.
22. For fume exhaust, see Ductwork and Duct Accessories section and EH&S Laboratory Ventilation Design Guide.
23. Minimize return air plenums. Provide ducted return air system. Discuss with Engineering Services if plenum returns are proposed.
24. Obtain current airflow and hydronic reports for remodel projects or system retrofits, as the actual operating conditions are likely different from the original design data.
25. Provide blow through design roof mounted supply air systems to eliminate negative pressure plenums exposed to the weather.
26. Where designs incorporate fan arrays, provide current transducers to monitor the status of each fan motor through the DDC system. Select duct velocities to meet N.C. requirements of each occupied space. Identify NC level requirements in the Basis of Design narrative. Coordinate required NC levels with University Project Manager and users. Limit duct velocities to 1200 fpm for general supply and exhaust. Design fume hood exhaust duct velocities between 1200 and 1500 fpm.
27. A draw-through fan system is recommended. Typical arrangement of the components (in the direction of airflow) is heat recovery, heating water, and cooling coil.
28. Design buildings to be positively pressurized relative to the outside.
29. See EH&S Laboratory Ventilation Design Guide for the following systems:
    a. laboratory ventilation interlocks and standby power
    b. air intake
    c. airflow simulation study
    d. fume exhaust
    e. snorkel exhaust

Products, Materials and Equipment

Air Handlers

1. Include double-walled panels in air handlers with a minimum of 2 inches of fiberglass insulation, 16 gauge exterior galvanized steel; and 22 gauge internal galvanized steel perforated except downstream of cooling coils and in outside air intakes.
   a. Floor: non-skid floor that extends up the walls to prevent leakage in the event of water accumulation.
   b. For access doors, use the same metal gauges and insulation levels as are specified for the rest of unit.
   c. Downstream from cooling coils, double-walled internal duct insulation with a solid metal surface exposed to the air stream is required.
2. Provide galvanized angle iron bracing inside plenums.
3. Provide access doors to each area between the coils, filters and fan. The access between the coils, filters and fan must be a minimum of 18 inches (preferably 24 to 36 inches).
4. Fan array must include individual backdraft dampers at each fan.

Fume Hood Exhaust

1. Provide access for fan maintenance.
2. Mount the fan with vibration isolators.
3. Installing fans in a penthouse is preferred. Provide weather protection for fans installed outdoors.
4. Locate the fan as the last element of the system to assure that the ductwork throughout the building is under negative pressure.
5. Install fans to be readily accessible for maintenance and inspection without entering the plenum. If exhaust fans are located inside a penthouse, consider the ventilation needs of maintenance workers.
6. Discuss fire alarm interlocks to fume exhaust fans and standby power requirements with EH&S and Engineering Services.
7. Specify fume exhaust fans with minimum two belt sheaves.
8. Provide ball-type fan bearings (selected for extended life), lubricated with grease fittings extended through fan casing for easy access.
9. Provide each fan drive with an easily removable guard assembly protecting drive belts and shaft, with access for tachometer use.
10. Specify all belt guards to allow visual inspection.
11. In combined fume/general exhaust systems, provide means to safely replace filters and clean coils without exposing maintenance personnel or shutting down the fan system. Consider a bypass duct with low-leakage dampers around filters and heat recovery coils, or individual filters/coil on each redundant fan.
12. Add a warning label on all access doors where filters or coils are installed within fume exhaust systems or combined fume/general exhaust systems. Warning label to state:

"COMBINED LAB AND FUME HOOD EXHAUST AIR SYSTEM. DO NOT ENTER PLENUM WHILE AIRSTREAM IS ACTIVE."

Individual Fume Exhaust Fans

1. Provide fans with the following:
   a. Outboard "split" bearings,
   b. Shaft seal,
   c. An access door,
   d. Multiple 150 percent rated belt drive. In designing for explosion and fire control, provide fans with non-sparking construction and non-conductive V-belt drives.
2. Provide chemical resistant fan system.
3. Weld or permanently seal fan housing to avoid air leakage from the wheel shaft and discharge.
4. Fume exhaust fans to have arrangement 1 or 9, overhung wheel type with bearings outside air stream. Fans to have two bearings; split-case with split inner and outer races and cage.
5. Choose fan type as follows:
   a. Use straight-radial fans for systems handling moderate to heavy quantities of particulate matter in air.
   b. Use backward-inclined fans for systems handling relatively clean (low particulate) air.

Perchloric Acid Hood

1. Provide an induction type fan for perchloric acid hoods.
2. Provide perchloric acid systems, including duct fans and hood, with an internal wash-down system that meets the following requirements:
   a. Design the perchloric acid fume hood system to provide as complete a wash-down with all ductwork at 45 degrees or less from vertical to drain back to the fume hood.
   b. Provide fan casings and hood bottoms with continuous gravity drainage to the acid resistant waste.
   c. The wash down system to include a manual valve located adjacent to the fume hood.
   d. Prior to substantial completion, testing of the wash-down system to be witnessed and approved by Owner's witness and EH&S.

Installation, Fabrication and Construction

1. During storage, transport, and installation prior to start-up, cover the air handlers with plywood and/or plastic as necessary to keep them dry, clean, and protected from damage. Provide heaters and/or dehumidifiers if necessary to prevent condensation inside air handlers prior to start-up. Provide temperature/humidity data loggers in units in transit and during storage. Air handlers with insulation that has been wet are unacceptable.
2. Thoroughly clean equipment casings of debris and small particles of rubbish and dust before installing and making final duct connections.

3. Do not start the fans until the Owner has approved the level of cleanliness of the air distribution system. Provide full access to the system for the inspection of cleanliness prior to start-up.
4. The preferred fan design is single inlet, single width centrifugal type with backward inclined airfoil blades; however, utilization of airfoils, propellers, and duct axial flow fans is acceptable where appropriate.
5. Provide rigid structural steel base for both fan and motor with slide rails for drive adjustment. Hinged motor bases are not acceptable.
6. Avoid operating HVAC systems prior to the completion of construction except where flushing of the building is necessary to comply with LEED requirements.
7. After construction dirt has been removed from the building, provide new filters for permanent locations.
8. Indicate the required filter removal and equipment access space on the contract documents.

D. Building Chilled Water Systems

Building Chilled Water applies to one or more of the following systems:

- Central Cooling Water (CCW)
- Process Chilled Water
- Environmental Chilled Water

Programming

1. Provide mechanical cooling to all office, classroom, library, dining, patient care or laboratory occupancies and elsewhere where required by programmatic needs. Design cooling system based on indoor space temperature no warmer than 75 °F or as required by programmatic needs.
2. Discuss the intent of using Central Cooling Water with Engineering Services before design begins. Using the campus system is encouraged, but the CCW chillers and distribution piping may not have adequate capacity to serve new loads.
3. Some lab equipment may require a decoupled primary/secondary loop to accommodate high pressure drops and internal condensation.
4. Give special consideration to the location of cooling towers with respect to contamination of the building fresh air intake, intakes of nearby buildings and noise to the occupants and local residential areas.
5. If a building is connected to the Central Cooling Water (CCW) system, provide a heat exchanger and secondary pumping system to decouple from the CCW utility.
   a. Exception: CCW may directly serve air handling units located in mechanical rooms where the risk of a leak is contained. Cross-connections that can introduce foreign water into the CCW system, such as 6-way valves, are not allowed.
6. Size the chiller(s) with sufficient capacity to accommodate estimated future loads. Incorporate capacity control strategies to limit short-cycling and provide efficient operation during present and future loading.
7. Provide redundant capacity for the process chilled water system where a shutdown is not tolerable.

Design Criteria

1. Establish project design criteria for the following items:
   a. Chiller type,
   b. Chiller refrigerant type and quantity in pounds; refrigerant machinery room calculation; see Refrigeration section,
   c. Cooling tower type,
   d. Cooling tower air intake and discharge locations,
   e. Cooling tower chemical treatment system,
   f. Equipment location,
   g. Reliability of the system, i.e. quantity of equipment for maintenance and repair work,

h. Humidity requirements,
i. Future system expansion provisions,
j. Special equipment cooling requirements, e.g. lasers,
k. Chiller room alarm monitoring and ventilation,
l. Carbon footprint.

2. Provide equipment with weatherproof enclosures and screening if roof mounting is required.
3. Size the chilled water distribution piping for the ultimate load up to a maximum of 6 feet per second, or as required by Energy Code, whichever is stricter.
4. Calculate system differential pressure based on anticipated pressure drop for existing and future equipment. For process chilled water loops, base the system pressure on equipment differential not less than 30 psi. Locate the differential pressure controller two thirds of the distance to the most distant point of the system.
5. Depending on the level of reliability required for the system, cooling equipment may need to be on the emergency power for non-life safety systems. Coordinate with UW Project Manager. All additions to the emergency power for non-life safety systems must be discussed with Engineering Services.
6. Locate water-cooled chillers in the basement mechanical room for the best vibration isolation situation.
7. Provide lead-lag pumps for both the chilled water and condenser water systems.
8. Use inhibited propylene glycol to prevent freezing of condenser or chilled water coils exposed to outside air.
9. Provide an expansion tank fitted with automatic fill and drain for the chilled water system.
10. Provide controls that prevent the chiller from operating unless chilled water pump, condenser water pump, condenser fan, etc. are operating.
11. Provide access platforms as required for maintenance of rooftop-mounted cooling towers or chillers.
12. Provide make-up water and blowdown/drain meters for cooling towers. See Metering and Gauges section for information.
13. Where cooling tower basin heater is provided, control basin heater with a water level sensor that de-energizes the heater if not fully submerged.
14. Chemical treatment systems for cooling towers are preferred over non-chemical water treatment systems. Please discuss with Engineering Services if a non-chemical treatment system is being considered.
15. Provide secondary containment and an eyewash and safety shower for cooling tower chemical storage areas.
16. Provide a chemical pot feeder, coupon rack and make-up water meter on each building chilled water system not directly connected to campus CCW.
17. All equipment directly connected to the CCW system must be rated for 250 psig, including pipes, flanges, valves, heat exchangers, and coils.
18. Chilled water piping is not allowed in electrical and IT (ex. MDF & IDF) rooms. See Electrical Design Standard for more detail.

CCW-CPP Design Criteria

1. The Central Power Plant (CPP) CCW system is intended for environmental (comfort) cooling. The chillers operate only during the summer months.
2. Unconditioned CCW is circulated during the winter months and is used for condenser loads and heat recovery at some buildings.
3. The CCW-CPP System operates as a primary pumping system with pressure differential manually controlled at the CPP. Tertiary building pumps have largely been removed or abandoned.
4. The CCW-CPP System temperature and pressure varies during the operating season. Use the following for design conditions:

Season	Nominal Supply Temperature	Nominal Return Temperature
Summer (early-May through early-October)	44 °F	56 °F
Winter (early-October through early-May)	Unconditioned (typ ~60-70 °F)	Unconditioned (typ ~60-70 °F)

CCW-WCUP Design Criteria

1. The West Central Utility Plant (WCUP) CCW system was designed primarily to support critical lab and vivarium spaces. It operates year-round to provide cooling to process loads and comfort loads.
2. In the event of an emergency, the WCUP may shed environmental (comfort) cooling loads to maintain service to vivarium spaces.
3. The CCW-WCUP system operates as a primary pumping system with pressure differential automatically controlled based on a sensor near ARCF/Hitchcock. Additional controls located at the building control the building differential pressure.
4. The CCW-WCUP System temperature and pressure varies during the operating season. Use the following for design conditions:

Season	Nominal Supply Temperature	Nominal Return Temperature
All Seasons	42 °F @ 70 °F OAT reset linearly to 50 °F @ 40 °F OAT; waterside	Variable, 14 °F ΔT

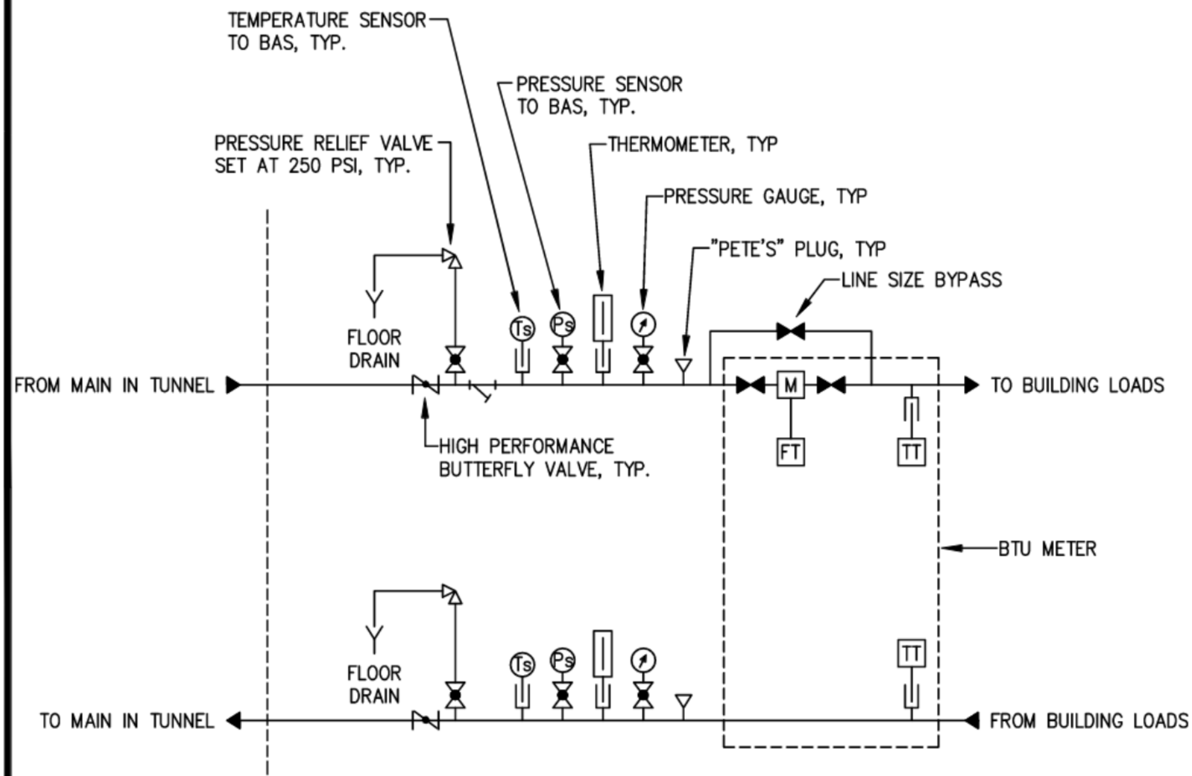
	economizer below 48 °F OAT	

CCW Header at Building

1. Locate the CCW header along a wall adjacent to the tunnel entrance at a convenient height for maintenance and repair access.
2. At each building CCW cooling coil or heat exchanger, provide a two way, pressure independent control valve, Delta P Valve as manufactured by Flow Control Industries, Inc., no substitutions.
3. A typical building header and coil connection is shown in the Central Cooling Water Building Header detail at the end of this section. Provide the appurtenances such as pressure gauges, thermometers and isolation valves shown on this detail.
4. Provide a pressure relief valve on the building-side of main CCW building isolation valves to allow for pressure relief when the main building isolation valves are closed. Pressure relief to be set at the 250 psi pressure rating of CCW components.
5. Monitor CCW supply and return pressures and temperatures in building DDC system.
6. Metering is required for all buildings that use Central Cooling Water and other campus utilities. See specifications on the Campus Utilities & Operations Standard website.

Installation, Fabrication and Construction

1. Locate the chilled water loop for each floor in the corridor, easily accessible to all spaces. Locate isolation valves for each space in the most accessible area (either in the corridor ceiling space or inside the room.)
2. Provide isolation valves at all air vents.
3. If two-way control valves are used, provide a 1-inch bypass line with globe valve for throttling at the most remote coil to allow continuous flow through the building piping.
4. All CCW and chilled water, piping and components, including control valves and heat exchangers, must be insulated. Condenser water pipes and components must be insulated if the system uses water-side economizer.



HEADER LOCATION:
LOCATE HEADER NEAR TUNNEL ENTRANCE IN MAIN MECHANICAL ROOM.

NOTE:
ALL COMPONENTS ON CCW SYSTEM SHALL BE RATED TO A MINIMUM OF 250 PSI WORKING PRESSURE.

UNIVERSITY of WASHINGTON	FACILITIES ENGINEERING SERVICES	STANDARDS DRAWING	DATE: 5/12/2023
		CENTRAL COOLING WATER BUILDING HEADER	REVISION: C
			SD–M–31

E. Building Steam and Condensate

Design Criteria

1. Steam is available from the Power Plant at 185 psig and/or 10 psig. Use 10 psig steam whenever possible because it benefits the operation of the Power Plant turbine generator. The 185 psig steam is reserved for use in buildings distant from the Power Plant (i.e., Campus Parkway and South Campus) and laboratory buildings that need the higher pressure steam for laboratory or process use. To meet varying load conditions in a building, provide local pressure reducing stations with parallel 1/3 and 2/3 full load valves per stage. Pressure reducing stations shall be complete in every detail to include gate valves for isolation, strainer, drip trap and strainer assembly, relief valves, and pressure gages.
2. Convert Power Plant steam to hot water at all buildings to meet all heating requirements. If the building already has a low-pressure steam line, the steam can be used for steam-to-heating water or steam-to-hot water system.

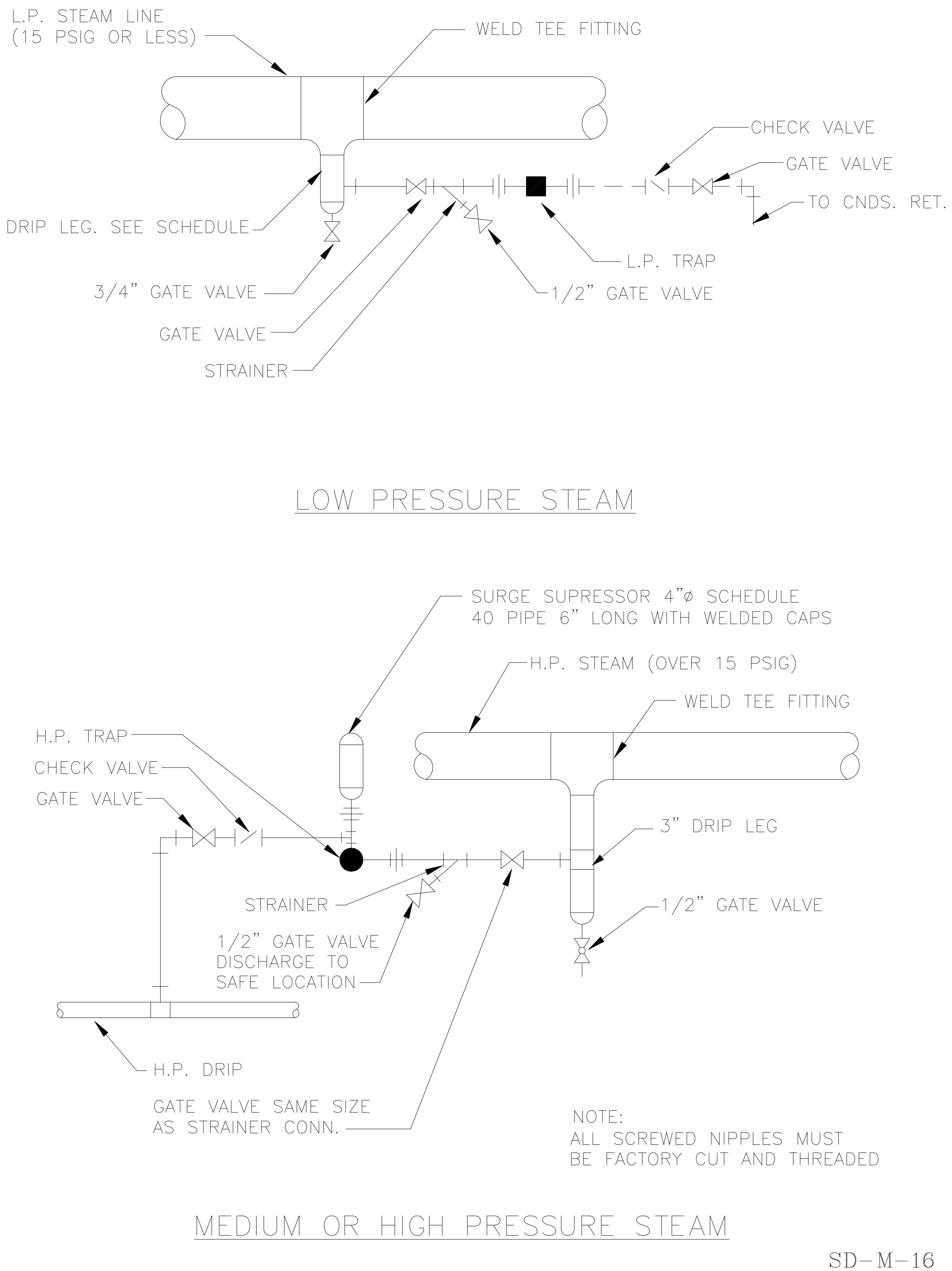
Products, Material and Equipment

1. Provide inverted bucket-type traps at the end of high pressure steam mains. Provide float and thermostatic type traps for low pressure steam mains.
2. Provide pneumatic rather than self-contained steam control valves on hot water converters.
3. Hand valves for radiators or convectors should be packed type suitable for servicing.
4. Converters must be ASME approved, stamped, and State Boiler Inspector's certificate forwarded to University. Use low pressure steam only (15 psig maximum) with capacity based on 7 psig steam to the control valve.
5. Provide slip-type pipe expansion joints. Bellows type pipe expansion joints are not acceptable.
6. Orient steam piping and install steam traps to avoid accumulating steam condensate above vertically oriented steam shutoff valves.
7. Where inverted bucket traps are used, avoid traps that lose their prime during low load conditions then need to be manually re-primed.
8. Preferably, avoid use of noise reduction orifice plates at steam PRVs.
9. See Steam Trap Assembly detail at the end of this section.

Installation, Fabrication, and Construction

1. Provide steam headers with valved branches to each specific load, hot water, storage heater, converter, heating coil, etc.
2. Flash high pressure steam (185 psig) condensate in a flash tank to the low pressure steam system.
3. Drip and trap all low and medium pressure steam (1 - 110 psig) supply main branches over 12 feet long.
4. Provide strainers ahead of all traps.
5. Provide adequate static head (minimum 12") above traps to insure proper operation.
6. Do not lift condensate by steam pressure.
7. Do not install steam or condensate piping below slabs on grade.

8. Discuss temporary heating with Engineering Services. Consider natural gas or electric-driven equipment in lieu of steam. If steam is used for temporary heat, dump condensate to sanitary sewer by tempering to below 140 °F.



Steam Trap Assembly

F. Coils and Filters

Coils

1. Provide detail drawings of cooling coil drain pan traps. For AHUs, assure that condensate trap has sufficient depth to overcome fan static pressure and the height of the drip pan connection is sufficient for the trap to clear the floor.
2. Use condensate drain pan dimensions sufficient to catch all condensate off coil. Provide pan under coil and extend downstream of coil far enough to catch all condensate.
3. Size cooling coils to meet both sensible load and latent load requirements.
4. Size cooling and heating hot water coils for maximum capacity allowed by the local energy code.
5. Size coils at no more than 550 feet per minute face velocity.
6. Discuss humidity control systems with Engineering Services. Consider effects of all operating conditions on dehumidification, such as fan system drawing in humid air when operating in economizer mode during rainy weather. Where space design requires humidification, equipment should be located within the central system air handling unit. Provide adequate water treatment to prevent mineral buildup.

Filters

1. Provide MERV 8 pre-filters and MERV 13 final filters.
2. Use 24 inch by 24 inch filters in air handling units.
3. Avoid custom filter sizes that are difficult to source.
4. Provide filters for specific applications (e.g. HEPA, grease).
5. Size filters at no more than 350 feet per minute face velocity.
6. In combined fume/general exhaust systems, provide means to safely replace filters and clean coils without exposing maintenance personnel or shutting down the fan system. Consider a bypass duct with low-leakage dampers around filters and heat recovery coils, or individual filters/coil on each redundant fan.
7. Include pressure gauges on Merv 13 filters for air intakes above 500 cfm

Products, Material and Equipment

1. For legacy systems only, provide non-freeze type steam coils with perforated inner distribution tubes with vertical tubes; each section should be individually trapped. Tube wall thickness must be 0.035 inches (minimum).
2. For systems that require freeze protection, provide inhibited propylene glycol. Provide glycol feed system for closed loops.
3. At the high points in the water systems provide automatic air vents with a cast iron body, copper ball float and needle, or ball-type air valve. Provide manual air vents on zone heating coils. Provide low point drains on hydronic systems.
4. Provide a maximum fin density for coils of 10 fins per inch and tube wall thickness of 0.035 inches (minimum).

5. Locate and arrange air conditioning equipment for reasonable motor, filter, and coil/tube removal.

Installation, Fabrication and Construction

1. Provide a hose end drain valve on each water coil.
2. Locate all air heating and cooling coils so that water jet or steam cleaning may be employed on each side of each coil. Provide ductwork access panels on each side of every coil.
3. Provide a balancing valve in the return piping from each individual coil.
4. Provide isolation valves with rising stems or quarter turn valves at the inlet and outlet of each AHU or supply fan coil, or other major component. Locate valves so that each unit, and its control valve, can be serviced without draining an entire system or riser.
5. Provide access panels in ceilings or partitions for servicing concealed coils.
6. Indicate the required coil equipment access and removal space on the contract documents.
7. Add a warning label on all access doors where filters or coils are installed within fume exhaust systems or combined fume/general exhaust systems. Warning label to state: "COMBINED LAB AND FUME HOOD EXHAUST AIR SYSTEM. DO NOT ENTER PLENUM WHILE AIRSTREAM IS ACTIVE."

G. Computer Server Rooms

Basis of Design

In support of the UW's efforts to meet its climate goals and objectives, no new server rooms or upgrades are to be designed into new or existing buildings on any of the campuses of the University of Washington. A server room is defined as a separate or shared space used to store, power, and operate computer servers and their associated components in support of business functions. Business functions are all of the activities that support the work of the University, whether academic, administrative, research, or clinical in nature.

This policy is effective immediately and applies to all University campuses, schools, colleges, and departments, including those in partnership with the University through affiliations, and third-party entities operating in University facilities. Campuses, schools, colleges, and departments are henceforth directed to work with the UW Information Technology (UW-IT) unit on solutions for meeting technology requirements.

University policies, standards, guidelines, and procedures institute controls that are used to protect and operate University assets and resources efficiently and effectively. While every exception to a policy or standard weakens the overall efficiency goals and intent of the policy, occasional exceptions may be necessary. See UW Administrative Policy Statement 17.1 which defines the process for the review, approval, and time limit of exceptions to this policy statement.

If the exception is granted, please contact Engineering Services to obtain the FDS section that outlines design criteria for computer server room design.

H. Refrigeration

Design Criteria

1. Provide design criteria and calculations for refrigeration system, including the following items:
   a. Refrigerant type
   b. Calculated refrigerant quantities of refrigerant machinery room, all rooms served by the refrigeration system, and all rooms with refrigerant piping routed through rooms
   c. Identify rooms with refrigerant that exceeds quantity threshold per code.
   d. Provide scheme for warning and exhaust systems to comply with code requirements.
2. Design air-cooled condensing units using an ambient temperature of 95 °F. Design to operate at a low ambient temperature of 0 °F.
3. Use of Variable Refrigerant Flow (VRF) system for space cooling is strongly discouraged.
   a. VRF systems are not allowed if they require a refrigerant leak detection system.
   b. Provide suitable isolation valves on each branch circuit.
4. Allow sufficient ventilation for air cooled condensing unit heat rejection. Do not install units in an enclosed space or areas (e.g.: parking garage) where particulate may foul heat exchangers.
5. Regulate condensing unit fan speed to control the condensing system operating pressure. For multiple fan units, regulate the fans on a "first on last off" basis.
6. Provide compressors located remotely from evaporators with oil separators. Design oil circulation piping to ensure adequate oil circulation.
7. Install refrigeration compressors, condensers, and condensing units in a mechanical room or in a weather-protected enclosure.
8. Provide evaporator condensation drains with a trap and route to funnel or floor drains. Provide condensate pan and piping with insulation.
9. Gravity drain all condensate pans, discuss with Engineering Services if a condensate pump is required.
10. Implement the "pump down" method to control compressors. Provide compressor controls with a low-pressure switch, primary control and a high-pressure limit with manual reset. Provide compressors designed with pressurized oil lubrication which have an oil pressure safety switch with timer and manual reset.
11. Provide a minimum of 400 cfm per ton for evaporator units.
12. Size Variable Refrigerant Flow (VRF) systems small enough to avoid classifying non-communicating spaces as refrigerant machinery rooms.
13. Where a refrigerant machinery room is required, design as follows:
    a. Refrigerant leak detection system must be per Preferred Manufacturer List
    b. Locate refrigerant leak detection panel inside the Refrigerant Machinery Room, with at least one remote panel connected to that system located outside the main entrance to the Refrigerant Machinery Room. If remote panel is located in an accessible common area, install panel in lockable cabinet. Consult with Engineering Services for key number to be used on lockable cabinet.

c. Refrigerant leak detection system must be compatible with the Fire Alarm System and the Building Automation System.
   i. The Fire Alarm System monitors status of the Leak Detection System for alarm and trouble (including loss of power) conditions.
   ii. During normal operation, the Leak Detection System commands the ventilation system to normal occupied airflow rate.
   iii. Upon an alarm signal at the Leak Detection System, the Leak Detection System commands the ventilation system to the emergency airflow rate. Transmit an alarm signal to Fire Alarm Panel and the Building Automation System. The audible and visual alarms are activated.
   iv. The Fire Alarm System and the Building Automation System monitor normal speed fan(s) status via current sensing relays. During failure of fan(s) to operate at normal speed in normal mode, generate a supervisory signal at both the Fire Alarm System and the Building Automation System. Fans shall default to the emergency airflow rate. The audible and visual alarms are activated.
   v. The Fire Alarm System and Building Automation System monitor emergency speed fan(s) status via current sensing relays. During failure of fan(s) to operate at emergency airflow rate in emergency mode, generate a supervisory signal at the Fire Alarm System. The audible and visual alarms are activated.
   vi. The Fire Alarm System monitors leak detection panel status via a trouble contact. During failure of leak detection panel, generate a trouble signal at the Fire Alarm System. Upon panel failure, fan(s) default to emergency airflow rate. The audible and visual alarms remain inactivated.

d. Legally required standby power must be supplied from UW Emergency Power System to refrigerant detection and ventilation systems serving refrigerant machinery rooms.
e. Leak detection system alarm level must be set to the refrigerant's Permissible Exposure Limit (PEL). Where calibration gas is not available at the PEL, set the alarm level for the lower calibration gas level. For example, adjust the set point to 900-ppm when the PEL is 1000-ppm, if 1000-ppm calibration gas is not available.
f. Locate refrigerant audible and visual alarm devices outside each refrigerant machinery room door and within the refrigerant machinery room as per ASHRAE 15/34 and NFPA 72. Audible alarm devices to have a continuous tone. Visual alarm devices to have blue acrylic light covers.
g. Provide all refrigerant audible and visual devices with signs permanently hung below the device(s). Signs must be three-layer etched plastic with white letters on a blue background. Letters must be a minimum of 1/2" high.

h. Signs within the refrigerant machinery room must read:

WHEN FLASHING
REFRIGERANT LEAK / NO FAN
EXIT SPACE

Signs outside each refrigerant machinery room entrance must read:

WHEN FLASHING REFRIGERANT LEAK / NO FAN DO NOT ENTER SPACE

i. Refrigerant machinery room systems must be commissioned, with a written functional test procedure reviewed by Engineering Services to ensure the system is calibrated and tested per design. The functional test will be witnessed by Engineering Services and Fire Alarm Shop.

Products, Materials and Equipment

1. Provide a minimum 3-year extended warranty beyond standard project warranty for compressors (parts and labor).

Installation, Fabrication and Construction

1. Braze all pipe joints under a nitrogen purge. No mechanical couplings allowed. No Flare connections.
2. All work must be performed by a contractor with a valid City of Seattle Refrigeration Mechanics license. A & B Refrigeration Handlers Certificate with a Universal Rating are also required where applicable.
3. Subject completed systems to the field test as stipulated in the latest edition of the Seattle Mechanical Code. The University's Representative must witness this test.
4. Complete Refrigeration Compliance Forms. The University can provide these forms.

I. Ductwork and Duct Pressure Testing

Design Criteria

1. Select duct velocities to meet N.C. requirements of each occupied space. NC level requirements to be identified in the Basis of Design narrative. Coordinate required NC levels with University Project Manager and users.

Supply, Return and Non Fume Exhaust Ductwork

1. Provide a 6-inch pressure rating for supply ductwork and plenums between the supply fan and the zone terminal boxes; for ductwork downstream of the terminal box, provide a 2-inch pressure rating.
2. Use the ASHRAE Handbook of Fundamentals chapter on duct design to determine the allowable leakage rate (cfm/100 sq. ft.) at the specified test pressure for each type of ductwork on the project other than fume exhaust ductwork. Specify for each type of ductwork the duct pressure rating, the pressure to apply during the duct leakage test, and the allowable cfm/100 sq. ft. leakage rate at the test pressure.
3. Minimize use of square elbows. Provide turning vanes in square elbows of supply ductwork. Do not use turning vanes in return or exhaust ductwork.
4. Do not use perforated plate ceiling diffusers in office or classroom applications. They cause drafts.
5. Specify laminar flow diffusers in laboratory applications when required.
6. Do not use nonmetal ductwork (i.e. fiberboard, fabric) without the approval of Engineering Services.
7. Design ductwork to and from the HVAC equipment so that stratified air is mixed properly before entering branch ducts or downstream equipment.
8. Limit flexible duct to no more than 6 feet and one elbow.
9. On renovation and remodel projects, provide a preliminary air balancing report with current and design airflows.
10. On renovation and remodel projects investigate the condition of existing duct liner, in particular at cooling coils. Test for mold and replace duct liner if warranted.

Dampers

1. To minimize noise, install manually operated, opposed blade or single blade, quadrant-type volume dampers on all branch main and branch duct takeoffs from the main duct to control the amount of air entering or leaving the branch. Locate those balancing dampers adjacent to the connection to the main branch.
2. Indicate balancing damper location for each outlet and each inlet.
3. Avoid register or diffuser-mounted dampers because they cannot reduce large volumes of air without causing objectionable air noise levels.
4. To minimize generated duct noise, locate volume dampers at least two duct diameters from a fitting and as far away as possible from the outlet or inlet.

5. Provide the necessary access space around components to allow the TAB technician to take proper readings. Allow adequate straight duct sections from fan outlets, elbows, or open duct ends to provide accurate duct traverse readings.
6. Provide "bubble tight" isolation dampers in combined lab/fume exhaust systems at each duct branch on each floor to allow for isolation of that floor for future connections without having to shut down the entire exhaust air system.

Pressure Relief Doors or Panels

1. Smoke/fire dampers have the potential to damage ductwork if they close by accident, or even if they close when the fan is shut off but wheeling down during a power outage, fire test, or fire. Risk of damage to the ductwork is particularly serious if a single smoke/fire damper can stop the full supply of air into or out of a large fan. Design the air distribution system so that the ducts won't be damaged if the fans are run with the smoke fire dampers closed.
2. The preferred means for protecting the ductwork against over-pressurization during smoke/fire damper closure is to select a duct pressure classification so the ducts can withstand sudden exposure to the maximum fan pressure. Provide accessible, well-sealed pressure relief doors or panels that can be closed after they open.
3. Use pressure relief doors rather than pressure relief backdraft dampers.

Mounting

1. For roof-mounted ductwork, fans and air handlers, see the architectural standard drawing titled Mechanical Equipment Mounting for minimum mounting height.

Renovation and Expansion Projects

1. When adding or removing ductwork on an existing air distribution system, show on the mechanical drawings all existing ductwork and flow rates required to be rebalanced after construction.
2. When removing existing fume hoods, review with Engineering Services and EH&S and provide a complete mechanical design to determine how it will impact associated mechanical systems and to ensure that another means of general exhaust will be provided to the project area.
3. Review manufacturer's fan data for existing fans to ensure these fans can operate at the new operating conditions. Review existing motor amperage and motor nameplate to determine if a new fan motor is required.
4. In the fan schedules, provide the existing and proposed fan airflows, fan static pressures, motor amperages and motor horsepower requirements for existing fans serving systems altered in renovation projects. The existing actual flows are needed for the design. Arrange with the University of Washington Project Manager for flow measurements as needed.
5. On floor plans, show any new balancing dampers required in the existing branch ductwork to facilitate balancing.
6. Require measurements, prior to demolition, of any unknown airflows or static pressures required to be reestablished as part of testing, adjusting and balancing.

7. If a small portion of an existing system is to be changed, avoid creating a new high pressure drop critical path to an existing system. Select larger components to avoid significant increases in the fan discharge pressure requirements.
8. Provide temporary means as necessary for dust control and lab safety while ductwork and fans are being removed and installed.

Fan-powered Zone Air Terminal Boxes

1. For VAV air terminal box fans, specify the method of speed adjustment (e.g., continuous or 3-speed fan control) to be used during testing, adjusting and balancing. In reviewing manufacturer's literature during design and during contractor equipment submittals, make sure the selected air terminal boxes operate at a speed range that doesn't create excess noise or motor problems. Specify "extra-quiet" fan-powered VAV boxes.
2. Specify maximum sound ratings for the air terminal boxes.
3. To control sound transmission out of the secondary (plenum) air intake, include a lined intake boot that has at least one 90 degree elbow.
4. On mechanical floor plans, indicate with dotted lines the horizontal access clearance requirements for maintenance of air terminal boxes.
5. Connect fan powered air terminal boxes to the ductwork with flex connections.
6. Connect fan powered air terminal boxes to structure with vibration isolators unless the fans are internally isolated.

Smoke/Fire Dampers

1. The smoke/fire dampers and their actuators are to be covered under the ductwork specialties section of the project specifications (not under controls or the fire alarm system). Exception: The position indication switch for smoke/fire damper pneumatic actuators is specified under the fire alarm system. Coordinate with electrical and refer to Environmental Health & Safety Design Guide – Fire Alarm System section.
2. The University strongly discourages use of engineered smoke control systems. Consult EH&S before designing one.
3. Work with the Architect and EH&S to minimize the number of smoke/fire dampers through (1) coordination of duct layout with suite configuration, and (2) close attention to code "exceptions" to standard smoke/fire damper placement requirements.
4. Dampers to be Class II, 250 °F, with a minimum closure time of 7 seconds and a maximum closure time of 15 seconds.
5. Fire damper actuating device to be rated at approximately 50 °F above normal operating temperature within duct system. Rate for 286 °F for smoke control systems.
6. All smoke/fire dampers must be self-resetting.
7. Provide damper blade position switch for position verification.
8. In new buildings or major renovations, the smoke/fire dampers to be monitored through the building fire alarm panel for both operational issues and periodic damper testing requirements.
9. Provide a schedule of all new or demolished smoke/fire dampers in the construction documents. Indicate unique device tag, manufacturer, model, dimensions, actuator type

(electric or pneumatic), actuator brand, electrical panel, electrical circuit and actuator torque rating within damper schedule.

Access Doors and Panels

1. Coordinate with Architect to ensure there are access doors through walls and hard ceilings wherever necessary to reach access doors in the HVAC equipment.
2. Provide a minimum of 24" x 24" size access doors and panels unless the duct is too small to accommodate a larger door or the necessary access can be handled easily with a smaller door.
3. Coordinate with Architect so that all access doors and panels in the ductwork are accessible in a manner that meets applicable safety standards. This includes access doors and panels located at the smoke/fire dampers.

Hospitals, Labs, and Animal Holding Facilities Pressure Relationships

1. On hospital, lab, and animal holding facilities projects, discuss with EH&S and Engineering Services whether there are any special requirements for documentation and review of room pressure relationships.
2. See EH&S Laboratory Ventilation Design Guide for additional information.

Construction Submittals

1. For smoke/fire damper submittals: Indicate device tag, manufacturer, model, dimensions, actuator type (electric or pneumatic), actuator brand, actuator voltage, electrical panel, electrical circuit, actuator torque rating. Include the number of damper actuators in each damper bank, and an equipment list showing the manufacturer, model number, and amperage draw for the actuators in each damper bank (whether composed of a single or multiple dampers).
2. Include manufacturer’s literature on the smoke/fire damper actuators.
3. For projects with electric smoke/fire dampers, provide shop drawings that show electrical and mechanical coordination of smoke/fire dampers.

Products, Material and Equipment

Accessories

1. Provide insulated drip pans for cooling coils.
2. Damper position switches that contain mercury are not acceptable. Use cam action, lever, or proximity type damper position switches.

Ductwork – Non Fume Exhaust

1. Provide an easily accessible lockable, handle for each balancing damper. Orient the handle parallel to the damper blade(s).
2. Use aluminum sheet metal with watertight joints for exhaust ductwork from high humidity areas such as shower rooms. Slope ductwork back toward inlet.

Fan-powered Zone Air Terminal Boxes

1. Internally isolate the fans in air terminal boxes.
2. Line the air terminal boxes with at least 1 inch of fiberglass batt insulation. Cover liner with aluminum foil at least 0.001 inch thick to prevent entrainment of fibers into the air stream.
3. Damper shafts to have at least one flat facet at the point of connection to the actuator.

Damper Shafts

1. Provide a grooved scribe running parallel to the blades on the end of each damper shaft to indicate damper position.

Fume Exhaust Ductwork

1. Fume hood ductwork to be 18 gauge minimum thickness, Type 316L stainless steel with continuously "butt" welded joints. A VanStone flange can be used in situations where the quality of the weld will be compromised because of inaccessibility to the work area.
2. See EH&S Laboratory Ventilation Design Guide for additional information.

Buried Fiberglass Reinforced Plastic (FRP) Ductwork

1. Submit design and calculations for buried FRP for review and approval.
2. Construct FRP per industry standards and manufacturer's recommendations.
3. Buried RFP thickness to withstand bearing loads from soil and structure above, in addition to any applicable ductwork suction pressure.
4. Provide counter weight and properly strap down buried FRP to resist buoyant force.
5. Compact soil to an unyielding state. Provide minimum 6" thick pea gravel underlayment and compact to an unyielding state prior to installing the FRP.
6. Ensure installing system free from unnecessary stresses.
7. Slope ductwork and provide drainage as needed.

Smoke/Fire Damper Actuators

1. If pneumatic actuators are used with smoke/fire dampers, then provide pneumatic lines made out of hard drawn copper tubing that meets copper tubing specifications under Environmental Control Systems.
2. Electric actuators to have an end-switch or clutch to reduce force on the damper when it is being held open. Do not use stall-motors on electric actuators.

Access Doors

1. Access doors to be hinged, latched, and gasketed. Where located in insulated ductwork, provide an access door that is double walled and insulated to same level as duct in which they are located.
2. Access panels need to open and close easily without damage to duct insulation, and reseal tightly on re-closure.

Installation, Fabrication and Construction

General

1. Expose no raw fiberglass fibers to the air distribution system air stream or to occupied space.
2. During storage, transport, and installation prior to start-up, cover the ductwork and air terminal boxes with plywood and/or plastic as necessary to keep them dry, clean, and protected from damage.
   a. Replace metal that is dented or has a damaged finish.
   b. Replace duct liner that is torn or wet.

Ductwork

1. Specify to cover the ends of ductwork while they are in storage and after installation prior to start-up, so they are protected from accumulation of dirt.
2. Thoroughly clean ductwork and plenums of debris and small particles of rubbish and dust before installing and making final duct connections.
3. Locate plenums at least 4 inches AFF to protect them from water in case of mechanical room flooding. Provide adequate support.
4. Provide each plenum area with a light. Include an "ON" pilot light on switch.

Fume Hood Ductwork

1. Slope all horizontal ductwork down towards the fume hood. Low points or “bellies” in the ductwork run are unacceptable.
2. Some retrofits may require to tie-into existing glazed ceramic ducts and vitrified clay tile ducts. Provide appropriate transition detail.
3. Decontaminate fume hood ducts being removed as part of the project.
4. Provide a flanged removable spool piece (minimum of 12 inches long) at each fume hood connection. Use spool sections for leak tests, inspection, and to facilitate removal of equipment. Install suitable gaskets at flanged joint connections.
5. Provide adequate space and easy access to facilitate inspection, repair, or replacement of exhaust ducts.
6. The target design velocity in each duct is in the range of 1200 to 1500 feet per minute (fpm) to prevent condensed fumes or particulates from adhering to the walls of the ducts, settling out onto horizontal surfaces, and to address acoustical issues. The actuated exhaust terminal unit needs to consider noise and prevention of product deposition in the ducts.

Fume Hood Exhaust Stacks

1. Terminate fume hood exhaust stacks at whichever is the greatest of the following: At least 10 feet above the roof for workers safety or stack height as determined by the air flow study.
2. Design discharge stack velocity to be at least 3000 fpm.

3. Do not provide exhaust stacks with weather caps or louvers, which require the air to change direction or cause turbulence upon discharge. Provide means to drain rainwater from exhaust stacks.

Zone Fan-Powered Air Terminal Boxes

1. Cover air inlet and discharge openings for air terminal boxes while they are in storage and after installation, prior to start-up to prevent accumulation of dirt.
2. Coordinate location of filters for easy access and replacement.
3. Orient secondary air inlets either down or sideways, not toward the ceiling.
4. Provide enough clearance between the secondary air inlet and the nearest surfaces to avoid restriction of air flow.

Access Doors

1. Provide hinged access doors on rectangular ductwork, air handlers and plenums. On round and oval ductwork provide removable access panels.
2. Provide access doors for all plenum areas. Provide latches operable from both inside and outside the plenum.
3. Provide access doors that open against pressure, and are self-closing due to the direction of airflow and by pressure differential. No exceptions.
4. Provide access panels upstream of all fire dampers, smoke/fire dampers, coils, and elsewhere where occasional access is required. Provide access panels to both sides of turning vanes.

Duct Pressure Tests

1. Pressure test 100% of all ductwork in shafts, all plenums, all fume exhaust ductwork, all snorkel exhaust ductwork and all hazardous exhaust ductwork. Additionally, all code required ductwork, two Owner selected supply ducts per floor, and one Owner selected exhaust or return duct per floor shall be tested.
2. Demonstrate to an Owner representative that the ductwork passes the following pressure tests before it is insulated or covered by walls or ceilings. Test ductwork after all associated smoke/fire dampers, fire dampers, pressure relief doors, and access doors have been installed.
3. Discuss test pressures applied to each system with Engineering Services.
4. Before testing, provide the Owner with the table or curve of pressure drop versus flow for the orifice being used to measure leakage. Provide data that is certified and an orifice that is clearly labeled so that a correlation between the orifice and table can be established.
5. Maintain a set of drawings for recording and sign-off of each tested section.
6. After each day of testing, submit to the Owner a copy of the paperwork recording the raw test data, calculating the duct areas, designating the duct category, and comparing the allowable and actual results.
7. Maintain pressure testing records on site. Provide a copy of current pressure test results if requested by an Owner Representative.

Supply, Return, Non-Fume Exhaust, and Outside Air Ductwork Test Procedure

1. Medium Pressure Ductwork:
   a. Test all ductwork systems at 4-inch or 6-inch, as applicable, static pressure, using a leak detection testing machine. All ductwork testing shall be conducted in accordance with latest published version of the SMACNA HVAC Air Duct Leakage Test Manual. Prior to testing verify that all medium pressure ductwork has been sealed to meet the SMACNA Seal Class A. for all joints, seams and at al duct wall penetrations.
   b. Medium pressure ductwork leakage shall be less than or meet the requirement of the following SMACNA Leakage Classes:
      i. Rectangular Metal – Class 6
      ii. Round or Flat Oval – Class 3
   c. Maximum allowable leakage is defined as Cubic Feet per Minute (CFM) air leakage per 100 square feet SURFACE AREA of duct section tested.
2. Low Pressure Ductwork:
   a. Test all ductwork systems at 2-inch static pressure, using a leak detection testing machine.
   b. All ductwork testing shall be conducted in accordance with latest published version of the SMACNA HVAC Air Duct Leakage Test Manual.
   c. Prior to testing verify that all low pressure ductwork has been sealed to meet the SMACNA Seal Class C. for all joints.
   d. Low pressure ductwork leakage shall be less than or meet the requirement of the following SMACNA Leakage Classes:
      i. Rectangular Metal – Class 24
      ii. Round or Flat Oval – Class 12
   e. Maximum allowable leakage is defined as CFM air leakage per 100 SF surface area of duct section tested.
3. Ductwork for Smoke Control Systems:
   a. Ducts shall be leak tested to 1.5 times the maximum design pressure.
   b. Leakage shall not exceed 5 percent of design flow.

Fume Exhaust Ductwork Test Procedure

1. Connect a blower to the duct specimen through a shutoff valve. Provide a magnehelic gage or inclined manometer with 0 inches to 10 inches w.g. range on the duct side of the shutoff valve.
2. Provide temporary seals at all open ends of the ductwork.
3. Average test pressure shall be 6 inches w.g. Initial pressure shall be 7 inches w.g.
4. Test all fume duct joints from the fume hood collar to the fan inlet flex connection, not inclusive.

5. To prevent over-pressurizing the ducts, start the blower with the variable inlet damper closed. Controlling pressure carefully, pressurize the duct section to the required level. When the pressure of the duct reaches 7 inches w.g., close the shutoff valve.
6. Using a stopwatch, measure the time elapsed from when the duct is at 7 inches w.g. to 5 inches w.g. Use the formula t = 6.23D to determine if the duct passes the test. ("D" is the nominal duct diameter, measured in inches; "t" is the MINIMUM allowable elapsed time, measured in seconds.)

Pressure Relief Doors or Panels

1. Demonstrate to an Owner's representative that the relief devices are functioning per the design intent and the ductwork is not damaged during a fire alarm test.

Smoke/Fire Damper Tests

1. As part of the test, the Contractor needs to demonstrate to an Owner's representative the full functionality of each smoke/fire damper by visual observation of the blades as it strokes "full open" and "full closed." All of the smoke/fire dampers need to pass the Owner-witnessed test before tests are witnessed by the Fire Department. To allow observation of the damper blades, Contractor to open access doors before the test begins.

Fire Damper Tests

1. The Contractor to demonstrate to an Owner's witness that the fire dampers drop from the "full open" to the "full closed" position by gravity when the fusible link is removed. Perform tests for the Fire Department only after fire dampers have passed the Owner-witnessed test. Open access doors to allow observation of the damper blades by the Contractor before the test begins.

J. Hydronic Heating

Programming

1. Establish laboratory and research space temperatures as part of the technical programming process. Design unoccupied spaces, including mechanical and electrical rooms, to be heated to a minimum of 40 °F for freeze protection.

Design Criteria

1. Design hydronic heating system with maximum capacity allowed by the local energy code.
2. Design new buildings and major renovations using low temperature hot water of 140 °F or less.
3. For buildings on Seattle campus, allocate space to accommodate connection to a future district hot water system, such as proposed space for heat exchangers, secondary pumps, and pipes from the building exterior to mechanical room.
4. Reset converter and radiation water temperatures by the outside air temperature. Historically in existing buildings, the normal reset schedule for a converter is to reset the water temperature from 180 °F to 140 °F as the outside air temperature changes from 20 °F to 70 °F respectively. The normal reset schedule for a radiation system is to reset the water temperature from 180 °F to 100 °F as the outside air temperature changes from 20 °F to 70 °F respectively.
5. Provide hot water heating radiation systems in areas where people are located adjacent to the outside wall. Examples of this type of occupancy are perimeter office areas and study carrels in libraries. Radiation systems are not required in lab areas, auditoria, or other areas where people are not seated along the exterior wall. Size radiation systems for 80% of transmission losses. Select finned pipe radiation to extend for the entire length of each glass area. If the perimeter heat loss does not exceed 250 BTUH/LF, radiation may be omitted.
6. Provide separate pumps and decoupled distribution systems for radiation systems and reheat coils. Discuss with Engineering Services if the systems are too small to justify separate systems. Stand-by pumps are required for critical systems. Please discuss standby requirements with Engineering Services and the Project Manager.
7. Night setback temperature control is required to protect the building and the equipment inside. Buildings with wood floors or equipment that would be affected by humidity (wood expands) are not allowed to drop below 55 °F. Temperatures below 55 °F have caused wood floors to buckle and pianos to go out of tune. For some buildings, a night setback temperature of 40 °F, for freeze protection only, is acceptable. Discuss with Engineering Services and the Project Manager.
8. For up-feed system, install control and isolation valves next to the apparatus on the same level.
9. Provide pipe test ports/wells to measure pressures and temperatures at each piece of equipment.
10. Provide a chemical pot feeder, coupon rack and make-up water meter on each hydronic heating system.
11. Any piping on the roof or exposed to freezing temperatures requires heat trace for freeze protection. Provide thermostatic control of heat trace wiring.

Products, Material and Equipment

1. For systems that require freeze protection, provide inhibited propylene glycol.
2. Provide a 0.001 waterside fouling factor for the hot water converter selection.
3. At the high points in the water systems provide automatic air vents with a cast iron body, copper ball float and needle, or ball-type air valve. Provide manual air vents on zone heating coils. Provide automatic air vents on pre-heat heating coils. Provide low point drains on hydronic systems.
4. Surface mounted convectors must have sloping top to prevent materials from being placed/stored on top of the enclosure and blocking airflow. Avoid custom enclosures.

Installation, Fabrication and Construction

1. Provide sectionalized down-fed hot water piping systems with isolating and drain valves to simplify servicing without draining large volumes of water during maintenance and repair.
2. Allow space for tube removal on each hot water converter.
3. Provide a hose end drain valve on each hot water coil.
4. Provide isolation valves at all air vents.
5. Install expansion tank per manufacturer’s installation instructions with pressure gauge, drain, air vent, and lockshield shut-off valve.
6. Provide control valves on convectors and radiation; dampers are not acceptable.
7. Provide isolation valves with rising stems at the inlet and outlet of each AHU or supply fan coil, or other major component. Locate valves so that each unit, and its control valve, can be serviced without draining an entire system or riser.

Plumbing

K. Compressed Air, Vacuum, Natural Gas & Nitrogen

Design Criteria

1. Provide minimum 30 psig compressed air to laboratories. Provide separate service for systems with different pressure requirements.
2. The dew point of the utility compressed air service is in the range of -15 °F.
3. If required, provide a separate valved branch to serve each of the environmental control air system and the fire protection system at the building service entrance.
4. Provide central building laboratory vacuum systems with an ASME receiver where practical. Duplex liquid ring pumps are the preferred type. Provide a liquid trap upstream of the receiver.
5. Vacuum pumps to be controlled by a pressure switch in the receiver set to operate between 22 and 25 inches of mercury vacuum.
6. Provide isolation valves at each floor and for each laboratory and equipment connection.
7. Size compressed air, vacuum and nitrogen pipes based on equipment specified demand or 0.5 scfm per outlet if none specified. Apply reasonable diversity factors based on user's input.

Installation, Fabrication and Construction

1. Pitch vacuum pipes in the direction of air flow.
2. Connect vacuum branch to the top of the main.
3. Natural gas or natural gas vent piping must never be installed in the campus utility tunnel system.
4. Natural gas service entrance piping must be protected from accidental damage by vehicles, foundation settlement, or vibration. Where practical, the natural gas service entrance pipe to be above grade and provided with a self-tightening swing joint prior to entering the building.
5. Natural gas meters must be installed outside the building to avoid leakage concerns.
6. Immediately prior to turnover to the Owner, contractor must ensure that odor is present at natural gas lab outlets and odor fade has not occurred.
7. See Metering Specification for natural gas meter requirement.

L. Potable and Nonpotable Water

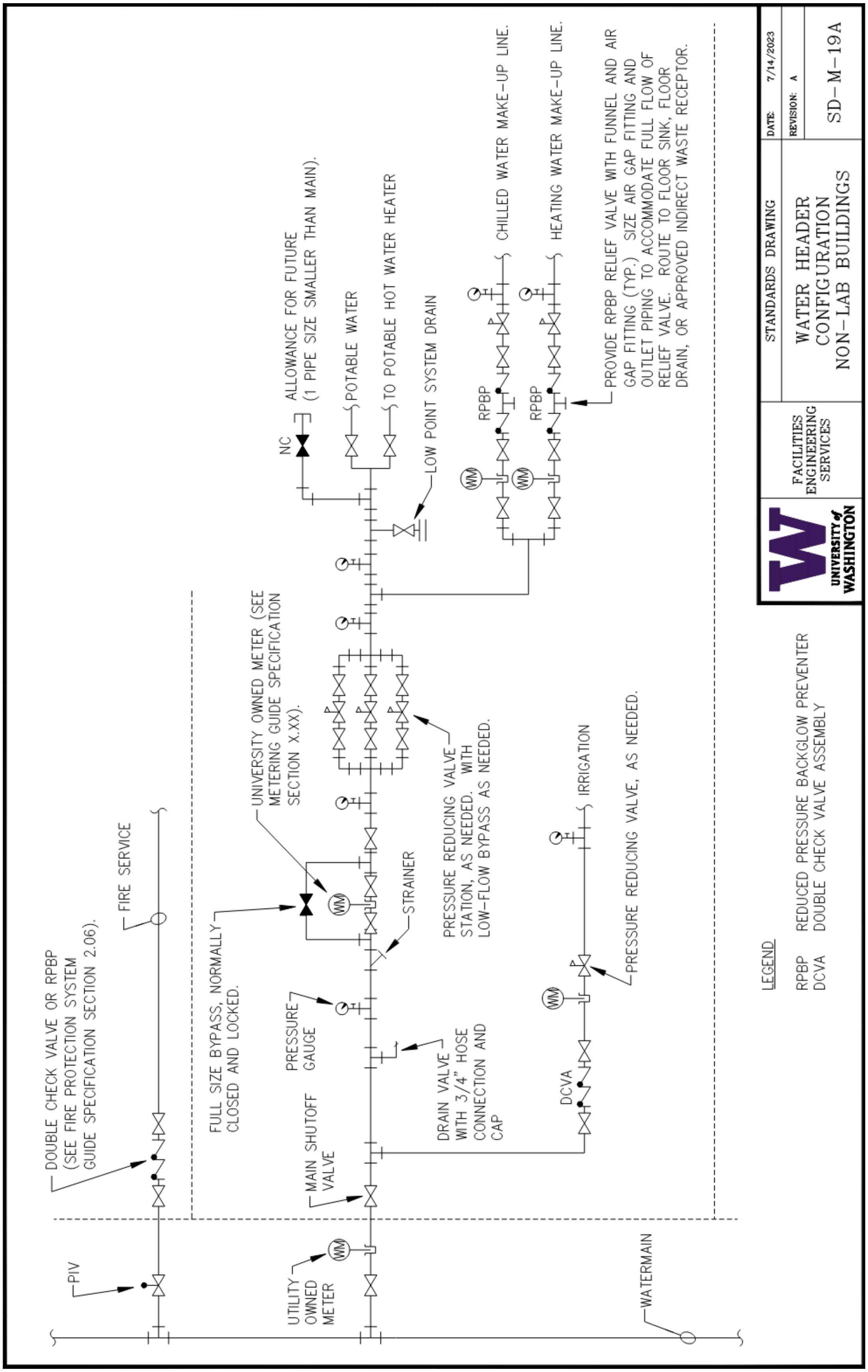
Design Criteria

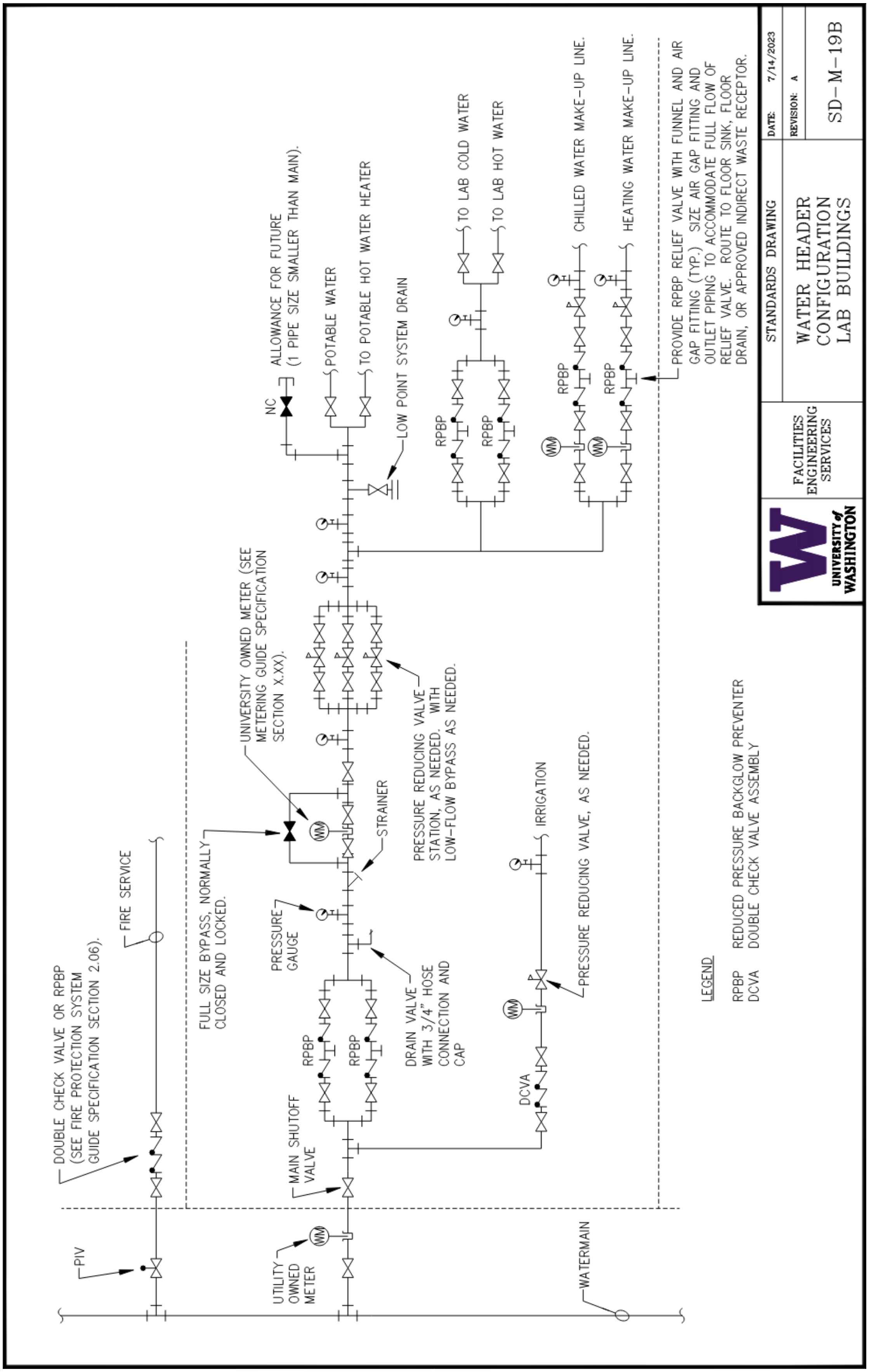
All work shall be performed in accordance with applicable codes and standards as adopted by the authorities having jurisdiction including amendments.

1. When incoming water pressure exceeds 80 psig, provide a pressure reducing station with two parallel PRVs (each sized at 2/3 of total flow, each valved to operate independently). Where the minimum rated flow of the primary PRV's is greater than 0, provide an additional low flow bypass PRV, sized to cover the range zero up to the minimum flow of the primary PRV.
    a. The assembly to include appropriate valves, strainers, gauges, drains, etc. and include a bypass.
    b. Where PRV's are required, irrigation branch shall be taken off upstream of the main domestic water PRV, and the pressure shall be controlled independently of the domestic water system.
    c. Design the system to provide a minimum pressure at the highest point of the building as needed for connected systems or at 25 psig, whichever is greater.
2. Provide a tee with a valved and capped connection for future growth in the domestic water header. The connection for future shall be sized to accommodate an additional 25% capacity beyond the current design capacity.
3. Provide the pressure backflow preventer devices in parallel, each sized at 2/3 of the total flow to prevent need for shutdown to test and repair.
4. Locate irrigation system backflow preventers inside the building mechanical room if possible. Otherwise, irrigation backflows are to be in non-public areas with adequate drainage and protection. Any irrigation connection will be provided upstream of the potable water system PRV assemblies and provided with a separate PRV where needed. Plumbing scope for irrigation systems will extend to the envelope of the building and will follow all standard plumbing specifications for valving, piping, etc.
5. Divide water system into smaller systems and provide isolation valves for each floor, each laboratory, each restroom, and each plumbing fixture.
6. Protect the water system by installing laboratory faucets with built-in and un-removable vacuum breakers.
7. Design plumbing systems for sports stadiums, classrooms, and auditoriums to handle load spikes.
8. Design hot water circulation piping with flow velocity not to exceed 4 feet per second.
9. Centralized water heaters are preferred. Distributed instantaneous water heaters are not acceptable in most cases.
10. Heat pump water heater systems shall be piped through a swing tank to ensure that heated water does not route from the water heater directly to the building without a thermal buffer.
11. Provide booster heaters for dishwashers and other equipment requiring hot water temperatures higher than building system design.

12. For semi-instantaneous steam water heaters, ensure control valve has sufficient turndown for low-load conditions.
13. Do not install water piping below slabs on grade except for trap priming lines. Protect copper pipes from contact with concrete.
14. Provide electronic sensor faucets for all lavatories. Do not use electronic sensor flushometers for toilets and urinals.
15. Provide wall mounted water closets.
16. Unless otherwise specified by code, provide the following flow rates:
    a. Water Closets, Dual Flush = 1.28/ 1.1 gpf
    b. Urinals = 0.125 gpf
    c. Public Lavatories = 0.5 gpm
    d. Residential Lavatories = 1.2 gpm
    e. Showers = 1.5 gpm
    f. Kitchen Faucet = 1.8 gpm
    g. Metering faucets = 0.25 gpc
17. Hard wire electronic fixtures from facility power source.
18. For emergency safety shower and eyewash stations, refer to EH&S Emergency Washing Equipment Requirements.
19. Waterless urinals not allowed.
20. Provide a full size domestic water bypass around rainwater harvesting systems with adequate capacity to support all connected loads.
21. Provide a full-size domestic water valved bypass around water pressure booster pumps.
22. Where a flood prevention valve is installed, provide a full-size valved bypass around flood prevention valve, or redundant flood prevention valves on building water supply.
23. Use diaphragm type flush valves for urinal and water closets using reclaimed water supply.
24. Provide frost-free, locking hose bibbs approximately every 100 feet along the exterior of the building at grade. Locations shall be verified with UW Facilities Outside Zone (Shop 10). Provide frost-free hose bibbs and/or roof hydrants to allow for cleaning each piece of mechanical equipment, one per roof amenity area, and one for green roof area.
25. Monitor domestic and lab hot water supply temperature in the DDC. Discuss alarming with Engineering Services.
26. Provide non-electronic thermostatic mixing valves. See Preferred Manufacturer List.
27. **See the two UW Standard Drawings below – Water Header Configurations for Non-Lab and Lab Buildings:**

Water Header Configurations for Lab and Non-Lab Buildings


PIV
UTILITY OWNED METER
WM
WATERMAIN
DOUBLE CHECK VALVE OR RPBP (SEE FIRE PROTECTION SYSTEM GUIDE SPECIFICATION SECTION 2.06).
FIRE SERVICE
MAIN SHUTOFF VALVE
FULL SIZE BYPASS, NORMALLY CLOSED AND LOCKED.
PRESSURE GAUGE
DRAIN VALVE WITH 3/4" HOSE CONNECTION AND CAP
DCVA
STRAINER
UNIVERSITY OWNED METER (SEE METERING GUIDE SPECIFICATION SECTION X.XX).
PRESSURE REDUCING VALVE STATION, AS NEEDED. WITH LOW-FLOW BYPASS AS NEEDED.
IRRIGATION
PRESSURE REDUCING VALVE, AS NEEDED.
NC
ALLOWANCE FOR FUTURE (1 PIPE SIZE SMALLER THAN MAIN).
POTABLE WATER
TO POTABLE HOT WATER HEATER
LOW POINT SYSTEM DRAIN
RPBP
CHILLED WATER MAKE-UP LINE.
RPBP
HEATING WATER MAKE-UP LINE.
PROVIDE RPBP RELIEF VALVE WITH FUNNEL AND AIR GAP FITTING (TYP.) SIZE AIR GAP FITTING AND OUTLET PIPING TO ACCOMMODATE FULL FLOW OF RELIEF VALVE. ROUTE TO FLOOR SINK, FLOOR DRAIN, OR APPROVED INDIRECT WASTE RECEPTOR.
LEGEND
RPBP REDUCED PRESSURE BACKGLOW PREVENTER
DCVA DOUBLE CHECK VALVE ASSEMBLY
UNIVERSITY of WASHINGTON
FACILITIES ENGINEERING SERVICES
STANDARDS DRAWING
WATER HEADER CONFIGURATION NON-LAB BUILDINGS
DATE: 7/14/2023
REVISION: A
SD-M-19A


WATERMAIN
PIV
UTILITY OWNED METER
FIRE SERVICE
DOUBLE CHECK VALVE OR RPBP (SEE FIRE PROTECTION SYSTEM GUIDE SPECIFICATION SECTION 2.06).
MAIN SHUTOFF VALVE
FULL SIZE BYPASS, NORMALLY CLOSED AND LOCKED.
RPBP
RPBP
PRESSURE GAUGE
DRAIN VALVE WITH 3/4" HOSE CONNECTION AND CAP
STRAINER
UNIVERSITY OWNED METER (SEE METERING GUIDE SPECIFICATION SECTION X.XX).
PRESSURE REDUCING VALVE STATION, AS NEEDED. WITH LOW-FLOW BYPASS AS NEEDED.
DCVA
PRESSURE REDUCING VALVE, AS NEEDED.
IRRIGATION
NC
ALLOWANCE FOR FUTURE (1 PIPE SIZE SMALLER THAN MAIN).
POTABLE WATER
TO POTABLE HOT WATER HEATER
LOW POINT SYSTEM DRAIN
TO LAB COLD WATER
TO LAB HOT WATER
CHILLED WATER MAKE-UP LINE.
HEATING WATER MAKE-UP LINE.
PROVIDE RPBP RELIEF VALVE WITH FUNNEL AND AIR GAP FITTING (TYP.) SIZE AIR GAP FITTING AND OUTLET PIPING TO ACCOMMODATE FULL FLOW OF RELIEF VALVE. ROUTE TO FLOOR SINK, FLOOR DRAIN, OR APPROVED INDIRECT WASTE RECEPTOR.
LEGEND
RPBP REDUCED PRESSURE BACKGLOW PREVENTER
DCVA DOUBLE CHECK VALVE ASSEMBLY
UNIVERSITY of WASHINGTON
FACILITIES ENGINEERING SERVICES
STANDARDS DRAWING
WATER HEADER CONFIGURATION LAB BUILDINGS
DATE: 7/14/2023
REVISION: A
SD-M-19B

M. Central Pure Water – Reverse Osmosis / Deionized (RO/DI)

Design Criteria

1. The minimum water purity standard for central RO/DI systems is the College of American Pathologists (CAP) Type II. Provide Point-of-Use polishing equipment if higher purity is required.
2. Typical central equipment to consist of flushable prefilters, multi-media filters, reverse osmosis unit(s), deionizers, carbon filters, ultraviolet lights, storage tank, and distribution loop pumps.
3. A water heater may be required upstream of the RO unit because they are most efficient when operated at an inlet water temperature of 77 °F.
4. Design system to circulate RO/DI water continuously in a closed series loop layout from the central equipment to lab outlets throughout the building. The distribution loop piping must be sized to circulate the water at a velocity in the range of 4 to 6 feet per second under no demand conditions.
5. Provide RO/DI system storage tank capacity for 24 hours of estimated usage.
6. Provide access for storage tank sanitization.
7. Install storage tank overflow pipe with a check valve or p-trap equipped with trap primer supplying suitable water quality.
8. Central RO/DI system controls shall be capable of restarting automatically following a power outage.
9. Discuss point-of-use equipment with client and Engineering Services.
10. Discuss opportunities for water reclaim from RO/DI reject water with Engineering Services.

Installation, Fabrication and Construction

1. Slope all horizontal piping to allow for free draining with a minimum slope of 1/8 inch per foot.
2. Minimize dead end pipe sections in the distribution system. Provide branch pipe drop to each outlet or piece of equipment. Dead ends to be no more than six pipe diameters from sealing point on branch to inside of main line.
3. Provide diaphragm valve for each pipe termination.

N. Waste and Drains

Design Criteria

1. Provide minimum 6-inch diameter side sewers.
2. Provide gravity waste drains. No waste pumping allowed without Engineering Services approval.
3. Investigate alternate side sewer designs to explore feasibility of eliminating backwater valve where otherwise required by code. When required, provide backwater valve of same material as sewer pipe.
4. When doing work in lab areas, please contact UW Facilities Engineering Services to ensure compliance with King County agreement dated 05-15-2022.
5. Do not install any type of chemical treatment system without first discussing with Engineering Services and the UW Environmental Health and Safety (EH&S) Department.
6. Connect all footing drains to the storm drainage system. If connection to the storm drainage system is not practical, the footing drain may be connected to the tunnel drainage system. Do not connect footing drains to an interior sump pump.
7. Connect garbage disposal waste piping to a major waste pipe with as few bends as possible. Provide accessible cleanouts in the waste pipe.
8. Locate centralized grease interceptors outside in an area accessible by service vehicle.
9. Provide a 6-inch diameter drain with 36-inch high standpipe for the discharge of fire sprinkler system test.
10. Due to the unstable nature of the soils East of Montlake Boulevard NE, it is recommended that all piping below slab on grade be hung from the slab rather than supported by the soil. Coordinate with the structural engineer for piping support from slab.
11. Coordinate cleanout locations with Architectural layouts.
12. Provide floor drains in all lavatories and connect to waste piping systems.

Installation, Fabrication and Construction

1. Do not install crosses into waste piping systems.
2. Connect to top of pipe and use a 1/8 bend located for branch connections to food service area waste piping.
3. Support waste and drainage piping crossing excavated areas on pre-cast concrete beams. Support concrete beams by the building structure and undisturbed earth.
4. Specify full size cleanouts for up to 4 inches. Use 4-inch cleanouts for all piping larger than 4 inches.
5. Floor drains: Slope floors to floor drains. Specify block-outs twice the size of the drain body and infill with non-shrink grout to prevent perimeter cracking at concrete. Provide electronic type trap primers for all floor drains.

O. Water Reclaim System

Water Reclaim and Rainwater Harvesting

1. Consider potential sources for water reclaim:
    a. Rainwater (Do not harvest rainwater from green roof),
    b. Rejection from RO/DI water,
    c. Cooling coil condensate recovery.
2. Given specialty equipment and maintenance requirements, include an equipment warranty period of 3 years at minimum.

Cistern

1. Slope floor to low point.
2. Route cistern vent to location where odors will not cause issues.
3. Valved bypass on incoming storm drain pipe is required if the location is a permit required confined space.

Piping and Pumping

1. Provide valved bypass around entire water reclaim system to ensure continuous domestic water supply.
2. Locate stormwater filter in mechanical room with drain.

Filtration and Water Treatment

1. Use UV for water sanitization in lieu of chemical treatment if feasible,
2. Use Calcite filter for pH control.

Reclaimed Water Usage

1. Provide a meter on all water usage from water reclaim systems and on the potable water make-up supply to these systems.
2. Consider use of reclaimed water for the following:
    a. Toilets/Urinals
    b. Irrigation
    c. Cooling Tower
3. All designs that include water reclamation must have prior approval by Engineering Services and Outside Maintenance Zone.

Specific Mechanical Systems

P. Commissioning

Background

1. New facilities have become much more complex, requiring that new methods of start-up and operation be employed to assure that each facility functions as intended.
2. There are many critical participants involved with a comprehensive building commissioning program. The participants are the Certified Commissioning Professional, Contractors, Consultants, and the Owner. The Certified Commissioning Professional is engaged directly by the Owner, and the Test Engineer is a member of the prime Contractor's team. The Certified Commissioning Professional and the Test Engineer have clearly defined responsibilities, and both become the essence of the final quality assurance program.

Design Criteria

1. Consultant to provide Owner's Project Requirements (OPR) document with input from Owner.
2. Depending on a project size and scope, the UW will typically hire a Certified Commissioning Professional directly. This is a firm skilled in commissioning facilities of the type represented by the specific project and is referred to as the Certified Commissioning Professional or Authority. The Certified Commissioning Professional is hired prior to construction to be available to work with the Design Team and Contractor. In some cases the Certified Commissioning Professional may be hired during design to contribute expert advice before the project is bid. Commissioning of the project's life safety systems need to be coordinated with and approved by UW Environmental Health and Safety.
3. The specific duties of the Certified Commissioning Professional are:
   a. Review the Contractor's systems start-up plans,
   b. Review the Contractor's equipment and component test procedures,
   c. Review the Contractor's systems and inter-systems functional performance test procedures,
   d. Witness, verify, and approve satisfactory completion of equipment and component tests and systems and inter-systems functional performance tests,
   e. Review and approve specified documentation,
   f. Coordinate the TAB firm's participation in the project,
   g. When commissioning has been successfully completed, recommend final acceptance to the Owner,
   h. Provide a project commissioning plan and functional performance test (FPT) procedures to be reviewed and approved by the project team,
   i. Generate and maintain an issue log throughout the commissioning process,
   j. Provide the final commissioning report in a timely manner.
4. Generally, the contract documents require the prime Contractor to engage a Test Engineer to organize, schedule, and conduct all equipment and apparatus tests, and prepare and perform all system functional performance tests. This organizing, scheduling, and testing is presented to

the Certified Commissioning Professional and UW Environmental Health and Safety for fire/life safety projects for review and approval.

5. The primary roles of the Test Engineer are to develop appropriate test procedures for all equipment/systems being tested, complying with the manufacturer's standards and procedures, and to ensure that all is successfully completed within the contract completion period.
6. The specific duties of the Test Engineer are as follows:
   a. Develop schedules for all testing; integrate testing into the master construction activity schedule; and coordinate all subcontractor testing.
   b. Perform system tests during both the winter and summer modes. Temperature tests can only be made on a design day. The Certified Commissioning Professional is responsible to return to the site on a design day to complete these tests.
   c. Coordinate directly with each subcontractor on the project specific to their responsibilities and contractual obligations.
   d. Observe the start-up and initial testing of equipment by the Contractor and subcontractors, and then all final tests of equipment and systems.
   e. Manage all cross system testing such as HVAC, building automation, fire alarm, emergency power, life safety, elevators, etc.
   f. Review operation and maintenance information and as-built drawings provided by the various subcontractors and vendors for verification, organization, and distribution.
7. The Certified Commissioning Professional may be hired prior to construction to be available to work with the Design Team and Contractor (Please consult with Engineering Services at early design phases). The Certified Commissioning Professional can contribute expert advice before the project is bid.
8. For projects with a MACC less than $3 million, it may not be necessary to require the prime Contractor to engage a Test Engineer. The scope of commissioning and the extent of commissioning requirements may be reduced as may be appropriate to the complexity and sophistication of the specific project. These decisions must be made by the Consultant and the University, via specific discussion of the commissioning program, and all related decisions and commitments made prior to the end of the design development phase.
9. Even though a Test Engineer may not be required on all projects, commissioning requirements for the project are still incorporated into the contract documents. The prime Contractor is required to designate, in writing, a member of the construction team to be responsible for the commissioning program.
10. For all projects, a critical requirement for the prime and subcontractors is development of the comprehensive test procedures for equipment and systems. This test is based on the operating criteria, test parameters, and acceptable results required. Many contractors have not had experience in this area. Therefore, someone who specializes (or has had experience) in development of test procedures is required.
11. Test procedures must be carefully reviewed and adapted to the unique characteristics and design conditions of the project.

Construction Submittals

1. Commissioning Plan submittal (for review by UW)

a. Commissioning plan
b. Basis of Design documentation
c. Sample installation audit forms
d. Draft startup plan
e. Draft commissioning schedule
f. Draft functional performance test procedures

2. Preliminary Commissioning Report submittal (for review by UW)

a. Commissioning plan
b. Basis of Design documentation
c. Installation audit forms
d. Startup plan and startup forms
e. Functional performance tests
f. Commissioning progress reports
g. Commissioning issues matrix
h. Commissioning meeting minutes
i. O&M preliminary review
j. Owner Training Plan

3. Final Commissioning Report submittal

a. Commissioning plan
b. Basis of Design documentation
c. Installation audit forms
d. Startup plan and startup forms
e. Functional performance tests
f. Commissioning progress reports
g. Commissioning issues matrix
h. Commissioning meeting minutes
i. O&M preliminary review
j. Owner Training Plan

Q. Environmental Control Systems

Environmental Control Systems Overview

1. Provide a building management system for operating the mechanical system and interfacing with the campus FacNet.

Approved Manufacturers and Installers (no substitutions):

1. Siemens Industry Building Technologies Issaquah Branch
2. Johnson Controls Bothell Branch
3. Alerton by ATS Automation

Secure DDC Controls Room

1. Secured DDC Room – Provide a dedicated, ventilated, well-lit and secure control room to house the environmental control system's main terminal, operating manuals, and mechanical drawings.

Hardware and Software

1. Operator Stations - Local Operator Station (LOS) Provide a PC station in a designated operations room with all required hardware and software. All components to be the latest version, capacity and speed available in the current high-end consumer market.
   a. Microsoft Windows base operating system,
   b. A complete software package with optimal architecture with pulldown menu and "one-click" approach,
   c. A video and audio card capable for dual monitor displays,
   d. Ports for connections with all peripheral components and network interface. Provide a minimum of two spare for each type of ports,
   e. Power surge protection.
2. Laptop - Portable Operator Station (POS): Provide one laptop with the same general functions and features as the LOS.
3. Controllers - Each controller to be stand-alone control upon communications failure. The controller to retain its programming during a power failure and resume operation without program reloading from another device.
4. Actuators – provide low voltage 24V actuators.
   a. Exception: Provide pneumatic actuators for all steam control valves.
5. Where compressed air is used for fire/smoke dampers or HVAC pneumatic controls, provide redundant pressure reducing valves so they can be replaced or serviced without disrupting building operation.

Graphic Display

1. Submit all graphic screens for approval prior to implementation. Display all controlled and monitored equipment within the graphics screens.
2. Display systems on a single graphic.
3. Provide floor plans with the approximate location of equipment, sensors and monitored points including:
    a. Thermostats
    b. Hydronic loop differential pressure sensors
    c. Duct static pressure sensors
    d. Outdoor air temperature / humidity sensors
4. Provide a summary page including setpoints, real time values, and valve and damper positions for each air handling unit system.
5. Provide sub-graphic for each major system including sequence of operation and setpoint values.
6. Provide dynamic graphics for fans, pumps, compressors, dampers that show a different color when operating (green). Indicate when a component is in alarm with flashing red.
7. Monitor CCW supply and return pressures and temperatures in building DDC system.
8. Provide control sequence to automatically circulate water in hydronic coils at least weekly to remove sediment and replenish water treatment. This is especially important for fan coil units and chilled beams.
9. Where a glycol feed pump is installed, incorporate a low liquid level alarm.
10. Monitor hydronic closed loop makeup water flow rate, and incorporate an alarm which indicates a system leak. See Preferred Manufacturer List for make-up water meter standard.
11. Provide a means to exclude any "rouge" zones from temperature / pressure reset calculations using the front-end graphics.

Interface

1. FacNet - The contractor shall provide all hardware, software, and licensing to provide secure communication, over the campus FacNet using TCP/IP, from the LOS or POS within the facility to the vendor's campus server for their system.
2. Connection Port Enclosure – Install the campus Ethernet connection port inside a 12x12x6 inch lockable enclosure. See UWIT drawing number CNT-C1-2.

Interfacing the DDC with Equipment Built-In Controls

1. For air handling units and cooling towers, packaged controllers are strongly discouraged. UW preference is for direct control through BAS.
2. When absolutely necessary, for equipment with packaged controllers, use built-in controls provided under other sections of the project specifications to handle staging and coordination of parts within each major piece of equipment. This provides a sole source of responsibility for the equipment's performance to avoid damage to the equipment, to increase safety, and to increase Contractor and manufacturer responsiveness during problem solving.
3. Indicate the relationship between the environmental control system and the dedicated (built-in) controls for specific HVAC equipment such as chillers, heat pumps, furnaces, and boilers.

4. The building's environmental control system may offer monitoring and enable the local controls for "on/off." Review with Engineering Services which parameters to be monitored by the environmental control system.
5. Operation of multiple supply terminal boxes in a single zone presents special problems. Discuss with Engineering Services.
6. Ensure adequate power and transformer sizing for devices starting and operating simultaneously (e.g. window actuators, damper actuators, blind operators, etc.)
7. Fan arrays must monitor the status of each motor and send an alarm to the Building Management System if any individual fan fails.

Interfacing the DDC with Fire Alarm

1. Control system to return to normal operation unmanned in stages after a power outage or fire alarm.
2. The fire alarm system must control life safety mechanical equipment such as those serving shaft pressurization systems, refrigerant machinery rooms, or smoke control systems. Where fans are shut down by the fire alarm system, shut down authority to be effective for all positions of the local hand-off-auto or VFD controls. The environmental control system does not control fans after shutdown by the fire alarm system until after reset of the fire alarm system and reset of fire/smoke dampers. Toilet and other non-recirculating exhaust fans to remain on unless this creates a problem of excessive pressure on exit doors. Fume hood fans to remain operating. Consult with EH&S for further information.

Interfacing the DDC with Emergency Power

1. In buildings where mechanical systems operate under DDC control in emergency power conditions, the environmental control system to monitor the fire alarm panel to determine when the building is under a fire alarm condition. The Environmental Control System to monitor the appropriate emergency power transfer switch to determine when there is loss of normal power and restoration of normal power.
2. Specify a restart schedule indicating equipment start-up priority.

Standby Power

1. Provide standby power for all FacNet Switches and control panels.
2. Provide a UPS (Un-interruptible Power Supply) having 5 year battery life and battery hot swappable capability for all cabinets containing controllers. Provide with fused duplex receptacle as the UPS power source. Monitor the UPS and provide an alarm point.

Renovation and remodel projects

1. Contact Engineering Services to decide what type of space and front-end equipment for the control shop will need to operate the system.
2. Pneumatic to DDC - The goal is to move from pneumatic to DDC controls. Consultant to evaluate this goal against limitations in project budget and schedule. Work with Engineering

Services on a project-by-project basis to determine how these goals are to be balanced on a given project.

3. New controls in existing buildings will match the existing approved manufacturers controls system in the building.

Metering & Monitoring

1. When a BTU meter is used for control, the temperature / flow values must be hard-wired outputs from the BTU panel to the DDC panel. Do not use network communication for control inputs.
2. Do not use airflow measurement stations for control. TAB contractor should determine appropriate fan speed or damper position.
3. Discuss with Engineering Services the use of water flow meters for control.

Sensors

1. Provide a tamperproof enclosure.
2. Hard-wire critical sensors to local controllers. This includes but is not limited to steam converters, high-limit pressure switches, low-limit freeze stats, fire alarm and smoke control tie-ins and other sensors related to equipment failure or life safety.
3. Provide a Pete's Plug test port at each piping sensor.
4. Wireless thermostats are not acceptable without prior approval from Engineering Services.
5. Freeze-stat and duct pressure safeties shall be manual reset (push button).
6. Freeze-stat shall be averaging type and installed upstream of the cooling coil.
7. Any fan safeties including but not limited to freeze-stat, duct pressure safeties, and duct smoke detector shut down signal shall be hard-wired to fan safety circuit.
8. Provide a Magnehelic gauge and a digital differential pressure transducer across each filter bank and monitor through the DDC.
9. Do not use CO_2 sensors for AHU level control. CO_2 sensors are acceptable at the zone level to comply with energy code requirements.
10. Thermostats should not be occupant adjustable.

Deliverables

1. Training - Specify provision for a minimum of 32 hours of classroom and on-site training in the operation and maintenance of the installed system. For the first training session, hold eight hours of this training prior to point to point testing.
2. Setpoint List - Provide a list of all the design setpoints and the final setpoints after commissioning is complete.
3. The final as-built control drawings should include a Bacnet network diagram including third party devices.

Wildfire Smoke Event Provisions

1. Include a “Wildfire Smoke Event” mode button in the BMS graphics to protect building occupants from smoke during wildfire events. An example of a Wildfire Smoke Event mode may include:
    a. Turning off air economizers
    b. Setting minimum damper positions that maintain the code-mandated outside air per person/square foot
    c. Continuously operating recirculating fans
2. In buildings without a BMS controlled HVAC system, provide instructions for manually implementing a “wildfire smoke event” mode.
3. In buildings that rely on natural ventilation, provide a wildfire smoke event plan approved by EH&S during the design phase.

R. Identification

Products, Material and Equipment

Control Wiring

1. Provide permanent, typed wire labels on individual control wires.

Piping

1. Piping labels: follow ANSI A13.1, or as required by safety codes or building code.
2. Asbestos-free labels: White lettering on a blue background label to read “asbestos free”.
3. Loop piping systems: indicate on the labels whether they are supply or return pipes.
4. Cooling water pipes connected to the campus utility system: state “Central Cooling Water” on the labels.
5. Chilled water pipes connected to a chiller within the building: state “Chilled Water” or “Process Chilled Water” on the labels.
6. Steam lines: Indicate steam pressure on labels
7. Gas lines (such as nitrogen, compressed air, etc.): Indicate gas pressure on labels.
8. Labels to be permanent weatherproof adhesive type.

Plumbing Fixtures

1. Label non-potable fixtures with black ½-inch lettering and yellow background on either plastic, or vinyl.

Valves

1. Valve tag: indicate valve size and service.
2. Provide 1” x 2½” bronze valve tags with stamped or engraved lettering 1/4” height minimum.

Equipment

1. Equipment label: Provide equipment name and I.D. as identified on the contract drawings.

Installation, Fabrication and Construction

Piping

1. Indicate direction of flow and service at least once in each space, at least once every 20 feet, and at all wall penetrations.
2. Attach piping labels at each end with adhesive arrow bands around the full circumference of the pipe and overlapping at the ends.
3. Orient adhesive labels parallel to the pipe, and locate labels where they can be read from the floor or the most likely approach for access.
4. Apply labels stating “asbestos free” at least once in each space, at least once every 20 feet, and within 6 inches of each point of connection with existing piping insulation. Mark the

circumference of the new insulation with a black marking pen at each point of connection with existing insulation and draw an arrow from the nearest "asbestos free" to the black line. On the arrow, write with the black marker "terminates here."

Plumbing Fixtures

1. Non-potable: Identify all fixtures dispensing non-potable water per Seattle Plumbing Code.

Valves

1. Tag each valve.

Equipment

1. Label each major piece of equipment.
2. Ceiling-mounted equipment identification to be readable from the floor.

S. Metering and Gauges

Meter Installation

1. Install and commission main meters and submeters as specified in UW Facilities Campus Energy, Utilities & Operations (CEUO) standards.
2. Provide all materials and cabling for a complete installation of each meter. Install meters per manufacturer's instructions. Test each metering system to meet data connection or transmission requirements.
3. Coordinate with UW Facilities CEUO and Engineering Services to involve them in all meter discussions during planning, design and construction. CEUO to provide steam condensate meter wiring connection diagrams for each project. Contractor to provide wiring diagrams for other meters for review and approval.

Gauge Installation

1. Provide thermometers and "Pete's Plugs" at all locations where fluid mixing or heat transfer occurs.
2. Provide pressure gages at all services entering the building, at pressure-reducing valve outlets, pump inlets and outlets, and on other equipment where required for confirming satisfactory operation.

Pipe and Fittings

1. Install thermometers where they can be read from the floor.
2. Mount pressure gages on ½-inch size pipe extensions with ½-inch shut off valves.

Pipe Accessories

1. Provide industrial quality analog thermometers with thermowell and 9-inch scale length. Provide a scale range of 30° to 240 °F in hot water piping, or 0° to 100 °F in central cooling water or chilled water piping.
2. Provide pressure gages with a 4-inch minimum size and a scale range approximately twice the operating pressure. Show units of measure on the face plate.

Duct Accessories

1. In fume exhaust ductwork, install two Pete's Plugs made of non-corrosive material in the exhaust duct at 90° to each other around the circumference, for the purpose of pitot tube insertion.
2. Provide dedicated adjustable inclined manometer or magnahelic gauge on each air filter installed to indicate filter pressure drop.

T. Motors and Variable Frequency Drives (VFDs)

Electric Motors

1. Provide “off-the-shelf” motors that are readily available.
2. Provide NEMA rated 1800 RPM motors with Class F or H insulation when appropriately matched to the driven equipment. Do not select motor speeds requiring V-belt drive reduction ratios greater than 6 to 1.
3. Identify the type of control for every motor within the scope of the project.
4. Provide factory lubricated bearings for motors less than 1/3-hp. Sleeve bearings are only permitted for fractional horsepower motors and where specifically recommended by the equipment manufacturer as the better type of bearing for the application.
5. Provide vertical shaft motors with suitable thrust bearings.
6. Shaded pole-type motors ≥ 1/8-hp are not acceptable.
7. Provide open drip-proof construction motors. Where conditions dictate, provide enclosed or explosion proof type motors.
8. Size motors to operate between 70% and 95% of full motor load when running at full 60 Hz speed. Overspeeding motors to normally operate above 60 Hz., such as in a fan array, is not acceptable. If a larger future load is anticipated, size the motor mounting pad to accommodate the larger anticipated motor frame size.
9. Provide shaft grounding ring for motors that are controlled by VFDs. See Preferred Manufacturer List.
10. Provide inductive absorber choke between VFD and motor. Ensure grounding path from vibration isolated equipment.

Variable Frequency Drives

1. Redundant VFD: Critical-need applications without redundancy require a dual VFD feature. Provide the dual VFD to be fully electrically isolated. Operate all safeties in dual VFD mode. Operate VFD by Manual Start Operation.
2. Provide soft start for motor 50-hp and greater.
3. On fan arrays in laboratory buildings or other critical applications, provide a separate VFD for each fan motor.
4. Amperage interrupt capacity: Requirements can vary depending on the electrical system design. The nominal requirement is often 65,000 RMS symmetrical ampere interrupting capacity. Coordinate the mechanical equipment ratings with the electrical designer and comply with the protective device study to determine the appropriate specification.
5. Radio frequency sensitive applications: A VFD may be installed in the vicinity of highly sensitive research or medical equipment. Radio microphones and sound reinforcement equipment may also be susceptible to RF generated by a VFD. An appropriate FCC rating may be necessary in these applications, and this requirement may result in the use of 6-step or 12-step technology VFDs. Review with Engineering Services if control and interface requirements in the standard specifications cannot be met.

6. Interface with Environmental Control System: The standard specifications require both hardwire and digital connection to the environmental control system.
7. Interface with the Fire/Life safety Systems: Ensure the Fire/Life Safety system operation sequence is met in Manual, Off, Auto, and Bypass Modes. Verify the correct speed is maintained in all Modes.
8. Sheaves and impellers: Use Motor Speed as the adjustment mechanism for balancing critical paths in air and water systems. After testing and balancing is complete, adjust sheaves, impellers and motor sizes as necessary so that the motor operates above 55 Hz and between 70% and 95% of full load amperage when the maximum desired system pressures and flows are produced. When the motor operates in VFD bypass at 60 Hz, verify that system pressures and flows do not cause problems and the motor current does not exceed full load amperage. It may be necessary to install pressure protection switches and/or duct blowout panels to protect variable air volume systems from over-pressure. Coordinate these requirements with the Testing and Balancing requirements.
9. Line reactance: Provide a minimum of 3% input line reactance. This may be provided in the form of separate line reactors at the input of the VFD, reactors included as part of the DC bus or a combination of the two totaling 3% to 5%.
10. Total Harmonic Distortion (THD): Specify in the documents that the THD at the point of common coupling for all VFDs connected, is less than 5% and to provide required filtering equipment in conjunction with line reactors.
11. Output rate of rise, peak output voltage and wire length: Purchase and install VFDs that do not damage typical premium efficiency motors. Implementing the following three requirements essentially eliminates motor insulation and bearing failures associated with VFD use.

    a. Use output filtering to keep the rate of rise, for each pulse in the output, below 1,000 volts/microsecond.
    b. Use output circuitry, which prevents the peak output voltage from reaching 1,000 volts to ground at the motor.
    c. Limit wire length to less than 50 feet between the motor and VFD. Demonstrate the 50 foot distance in the contract documents.

12. Provide damper control accessory.
13. Provide display and keypad for all drives, mounted either locally through enclosure door or remotely.

Installation, Fabrication and Construction

Electric Motors

1. Do not expose motors to the weather. Install motors within the building or in suitable enclosures. If motors are not housed within the building structure, specify totally enclosed type motors, even though a weatherproof enclosure is provided. Provide motor heaters in outdoor enclosures.

Variable Frequency Drives

1. Mount the VFD as close to the motor as feasible with no more than 50 feet separation. Coordinate with the electrical designer to ensure that this requirement is met. It is also necessary that the VFD be solidly mounted to structural members.
   a. Unistrut type structures can be used in most mounting circumstances.
   b. Do not mount VFDs directly to the flexible sides of air handling units, plenums or ductwork.
   c. Avoid mounting VFDs outdoors, inside plenums or air handling units, or adjacent to piping that could spray a leak onto the VFD housing. Discuss VFD location with Engineering Services.

U. Noise and Vibration Control

Design Criteria

1. Specify NC level requirement for each type of occupied space in the Basis of Design. NC levels to be approved by Engineering Services based on user's input.
2. Many campus buildings have vibration-sensitive equipment such as electron microscopes. Establish acceptable vibration criteria early in the technical program so that equipment, piping, and ductwork that require vibration isolation can be identified. Provide a table in the design documents which lists the vibration isolation requirements for piping, equipment, and ductwork.
3. Analyze mechanical system equipment sound levels to control noise transmission. Select all mechanical equipment to meet the noise criteria (NC) requirement of each occupied space. Identify NC level requirements in Contract Documents.
    a. Minimize the use of fiberglass liner inside ventilation ducts. Do not install liner between the supply fan cooling coil and the terminal unit. Do not install liner on outside air intake ductwork. Minimize liner in the return air duct.
    b. Reduce fan and air noise by the use of sound attenuators; round or oval ducts, where feasible, instead of rectangular duct, adequate transitions and sufficient upstream/downstream duct lengths at fans or terminal units, and design fans at low RPM.
    c. High density duct liner with foil face can be considered downstream of the terminal unit to mitigate cross-talk noise between rooms.
    d. Insulate fan powered boxes with fiberglass and a hard, cleanable surface exposed to the air stream.
    e. In renovation projects, existing HVAC systems with fiberglass liner in good condition may be left in place.
4. At University of Washington Medical Center projects, ductwork sound lining is not acceptable.
5. Provide acoustic treatment in mechanical room walls and ceilings if adjacent areas are affected by noises generated in the mechanical room. Coordinate interior finishes with Architect.
6. Avoid "Floating Slabs" i.e., slabs that are acoustically isolated from the structural slab with insulation between the two slabs. These slabs are usually constructed before the building is "closed in" or protected from rain. Consequentially they are exposed to rain which saturates the insulation, making the acoustical performance ineffective and providing a breeding place for mold and mildew.

Products, Material and Equipment

Vibration Control

1. Provide spring-type or rubber-in-shear vibration isolators for rotating equipment on grade.
2. Provide spring-type vibration isolators and inertia bases for rotating equipment in areas not on grade.

3. Provide springs that are large diameter, stable type which do not require guides or snubbers.

Noise Control/Acoustic Treatment

1. If sound attenuators are used, pack-less types are strongly recommended.
2. Fan powered boxes that have lining exposed to the air stream to have a cleanable surface.

Installation, Fabrication and Construction

Vibration Control

1. Do not make rigid connections between rotating equipment and the building structure that short-circuit vibration isolation systems.
2. Verify mounting systems are not resonant with supported equipment forcing frequencies.
3. Level vibration-isolated equipment while equipment is under full operational load.
4. Install piping sections in reasonable alignment. Use of vibration isolation components to correct misalignments is unacceptable.

V. Piping, Valves, Pressure Testing, and Accessories

Design Criteria

1. Design piping to allow for movement due to expansion and contraction.
2. Provide a service header for every service entering a building. Provide a shutoff valve in the service header piping immediately upon entry into the building. Install all meters, strainers, pressure reducing valves, backflow preventers, major branch connections, etc. at the service header. Provide bypass connections at the service header so that service to the building is continuous when maintenance is performed on the various components.
3. Provide isolation valves on each floor and major branches to facilitate work on pipe sections without shutting down the entire system.
4. Provide individual shutoff valve(s) to isolate each piece of equipment.
5. The following table lists typical piping systems with its corresponding symbol, and pipe codes to reference subsequent Products, Materials and Equipment tables.

Piping System	Symbol	Pipe Code	Pipe Test Method	Test Pressure, lb/in^2 gage
Acid Resistant Vent	ARV	P-3	Hydrostatic	(1)
Acid Resistant Waste	ARW	P-3	Hydrostatic	(1)
Carbon Dioxide	CO2	P-1	Pneumatic	1.5 x max. (2)
Central Cooling Water	CCW	P-4	Hydrostatic	250
Coil Condensate	CD	P-1	Hydrostatic	(1)
Compressed Air (Laboratory)	A	P-1	Pneumatic	150
Compressed Air (Pneumatic)	CA	P-1	Pneumatic	150
Condenser Water	CNDW	P-1	Hydrostatic	150
Fire Protection	F	P-10	(3)	(3)
Heating Hot Water	HHW	P-1	Hydrostatic	1.5 x max.
Helium Recovery	HR	P-1	Pneumatic	1.5 x max. (2)
Irrigation, Inside Building	I	P-1	Hydrostatic	150
Irrigation, Outside Building	I	P-9		

Laboratory Cold Water	LCW	P-1	Hydrostatic	150
Laboratory Hot Water	LHW	P-1	Hydrostatic	150
Laboratory Hot Water Circulation	LHWC	P-1	Hydrostatic	150
Laboratory Vacuum	LV	P-1	Pneumatic	100
Lake Water	LW	P-9	Hydrostatic	1.5 x max. (2)
Medical Gas	MG	P-8	Pneumatic (4)	(4)
Medical Vacuum	MV	P-8	Pneumatic (4)	(4)
Natural Gas	G	P-5	Pneumatic (4)	8
Nitrogen	N	P-1	Pneumatic	1.5 x max. (2)
Oxygen	O	P-8	Pneumatic (4)	(4)
Potable Cold Water	CW	P-1	Hydrostatic	150
Potable Hot Water	HW	P-1	Hydrostatic	150
Potable Hot Water Circulation	HWC	P-1	Hydrostatic	150
Process Chilled Water	CHW	P-1	Hydrostatic	1.5 x max.
Propane	P	P-5	Pneumatic	8
Refrigerant Liquid	RL	P-7	Pneumatic	350
Refrigerant Suction	RS	P-7	Pneumatic	125
Reverse Osmosis/De-ionized Water (High Purity)	DI	P-6	Hydrostatic	150
Roof Drain (Rain Leader)	RD	P-2	Hydrostatic	(1)
Sanitary Vent	V	P-2	Hydrostatic	(1)
Sanitary Sewer	SS	P-2	Hydrostatic	(1)
Sea Water	SW	P-9	Hydrostatic	1.5 x max. (2)
Steam (Low Pressure)	LPS	P-4	Hydrostatic	25
Steam (Medium Pressure)	MPS	P-4	Hydrostatic	90
Steam (High Pressure)	HPS	P-4	Hydrostatic	280

Steam Condensate	CNDS	P-4	Hydrostatic	1.5 x max.
Storm Drain	SD	P-2	Hydrostatic	(1)
Tempered Potable Water (Safety Shower/Eyewash)	TW	P-1	Hydrostatic	150
Trap Primer	TP	P-1	Hydrostatic	(1)
Well Water	WW	P-9	Hydrostatic	1.5 x max. (2)

Notes:

(1) In accordance with UPC – Min. 10 ft. head.
(2) 1.5 x Maximum Operating Pressure.
(3) Refer to NFPA and Environmental, Health & Safety - Fire Protection System section for information.
(4) Refer to NFPA for additional information.

Products, Material and Equipment

Pipe

1. Use industry standards for piping systems specified and comply with the following additional requirements:
2. The following tables list the typical service piping, standard operating pressures and temperatures, recommended testing pressures.

PIPE CODE P-1		
Service	Max Operating Pressure lb/in² gage	Max Operating Temp Deg F
Carbon Dioxide (CO)	Varies	-
Coil Condensate (CD)	40	60
Compressed Air – Laboratory (A)	100	100
Compressed Air – Pneumatic (CA)	100	100
Condenser Water (CNDW)	Varies	95

Heating Hot Water (HHW)	Varies	190
Helium Recovery (HR)	Varies	-
Irrigation, Inside Building (I)	100	70
Laboratory Cold Water (LCW)	100	70
Laboratory Hot Water (LHW)	100	160
Laboratory Hot Water Circulation (LHWC)	100	160
Laboratory Vacuum (LV)	-29 in-Hg	100
Nitrogen (N)	Varies	-
Potable Cold Water (CW)	100	70
Potable Hot Water (HW)	100	160
Potable Hot Water Circulation (HWC)	100	160
Process Chilled Water (CHW)	Varies	60
Tempered Potable Water (TW)	100	80
Trap Primer (TP)	100	70
Sizes	½-inch and larger	
Pipe	Above grade: Copper Type L or stainless steel; Below grade: Copper Type K or ductile iron; CNDW, CHW & HHW above grade: 2½ inch and larger, black steel. Schedule 40 Compressed air piping in the tunnels: Schedule 40, black steel, welded, for larger than 2 inch pipe size and schedule 80, black steel, threaded for 2 inch and smaller pipe size. Irrigation outside: See remarks. Nitrogen piping: Clean all fittings/joints for medical gas service per NFPA 99;	
Wall Thickness	Standard Weight	
Valves	Single piece, full flow ball style. Valves to have a packing nut independent of the handle.	

Remarks	Irrigation: Refer to Civil – Irrigation section. LV: Connect branch piping section outlet to top of main. Nitrogen piping system to be brazed under a nitrogen purge. Press fitting pipe joining systems okay on 2” and smaller CW, LCW, HW, LHW, CHW, CNDW piping Other mechanical joints okay only for 2½” and larger CW, LCW, CHW, HHW, CNDW and F piping. No mechanical fittings in shafts or other inaccessible locations.

PIPE CODE P-2		
Service	Max Operating Pressure lb/in² gage	Max Operating Temp Deg F
Roof Drain (RD) Sanitary Vent (V) Sanitary Sewer (SS) Storm Drain (SD)	N/A N/A N/A N/A	N/A N/A N/A N/A
Sizes	All	
Pipe	Above grade: Cast Iron CISPI 301, no hub; Below grade: Cast Iron CISPI 301, no hub with extra heavy coupling or hub & spigot. Roof drains: Cast iron.	
Wall Thickness	Standard Weight	
Remarks	Above grade force main & force main-vent same as pipe code P-4. Minimum test pressure: 125 lb/in². Below grade: Refer to Civil sections for utilities.	

PIPE CODE P-3		
Service	Max Operating Pressure lb/in² gage	Max Operating Temp Deg F
Acid Resistant Vent (ARV) Acid Resistant Waste (ARW)	N/A N/A	N/A N/A
Sizes	All	
Pipe	Above grade: Polypropylene; pigmented, flame retardant Below grade: Polypropylene; pigmented, non-flame retardant	
Wall Thickness	Schedule 40	
Remarks	Above grade: Fusion joints. Below grade: Fusion joints. Within laboratory casework (accessible): Mechanical joints allowed at the connection to the plumbing fixture.	

PIPE CODE P-4		
Service	Max Operating Pressure lb/in² gage	Max Operating Temp Deg F
Central Cooling Water (CCW) Steam (LPS) Steam (MPS) Steam (HPS) Steam Condensate (CNDS)	200 15 60 185 Varies	70 259 338 388 -
Sizes	All	
Pipe	Black steel	

Wall Thickness	LPS and CCW, larger than 12 inch Standard Weight; LPS, MPS, HPS and CCW, 2½ inch to 12 inch Schedule 40; LPS, MPS, HPS and CCW 2 inch and smaller Schedule 80; CNDS, Schedule 80.
Valves	Campus utility building isolation valves 2½ inch and larger for CCW, HPS, MPS and LPS service to be triple offset or quadruple offset high performance butterfly valves, see remarks. At CCW control valves, provide DeltaPValve by Flow Control Industries, no substitutions. Inside the building CCW 2½ inch and larger to be Class 150 or Class 300 butterfly valves. CCW 2 inch and smaller to be ball valves or rising stem gate valves suitable for 250-psig. HPS to be Class 300 rising steam gate valve. MPS, LPS and CNDS to be Class 150 rising stem gate valves.
Remarks	2-inch and smaller: Threaded forged fittings; 2½-inch and larger: Butt weld type forged fittings; All steam raised faced flanges, with spiral wound gasket. High performance butterfly valves to be Class 150 or Class 300, triple offset or quadruple offset, steel, lugged style, and gear operated by TYCO, Vanessa; WEIR, Tricentric; or QUADAX VALVES, Inc., no substitutions. Specify 300# or higher rated fittings where Schedule 80 piping is used.

PIPE CODE P-5		
Service	Max Operating Pressure lb/in² gage	Max Operating Temp Deg F
Natural Gas (G) Propane (P)	5 5	- -
Sizes	All	
Pipe	Black steel	
Wall Thickness	Schedule 40	
Remarks	Above grade: 2-inch and larger butt-welded fittings; 2-inch and smaller threaded fittings allowed. Below grade: Refer to Civil sections for utilities.	

PIPE CODE P-6		
Service	Max Operating Pressure lb/in² gage	Max Operating Temp Deg F
Reverse Osmosis/De-ionized Water (DI)	100	70
Sizes	All	
Pipe	Polypropylene – non-pigmented	
Wall Thickness	Schedule 40	
Valves	Union body, full port, ball style	
Remarks	Electrofusion joints for distribution piping. IR butt weld joints allowed at generation skids. Piping to be continuously supported.	

PIPE CODE P-7		
Service	Max Operating Pressure lb/in² gage	Max Operating Temp Deg F
Refrigerant Suction (RS) Refrigerant Liquid (RL)	High Side: 250 Low Side: 90	150 70
Sizes	½-inch and larger	
Pipe	Copper, ACR type	
Wall Thickness	Standard Weight	
Remarks	No flared connections and fittings. Braze piping under nitrogen purge.	

PIPE CODE P-8		
Service	Max Operating Pressure lb/in² gage	Max Operating Temp Deg F
Medical Gas (MG) Medical Vacuum (MV) Oxygen (O)	Varies Varies Varies	150 70 -
Sizes	½ inch and larger	
Pipe	Medical Gas and Oxygen: Copper, wall thickness per Code, Medical Vacuum: Copper Type L, Piping to be specially prepared and labeled for medical service, oxygen and vacuum.	
Wall Thickness	Standard Weight	
Remarks		

PIPE CODE P-9		
Service	Max Operating Pressure lb/in² gage	Max Operating Temp Deg F
Irrigation, Outside Building (I)	100	70
Lake Water (LW)	Varies	70
Sea Water (SW)	Varies	70
Well Water (WW)	Varies	70
Sizes	½-inch and larger	
Pipe	Polypropylene or CPVC or PVC if not exposed. Sea water, outside: HDPE	
Wall Thickness	Schedule 40	

PIPE CODE P-10		
Service	Max Operating Pressure lb/in² gage	Max Operating Temp Deg F
Fire Protection (F)	-	-
Sizes	See remarks.	
Pipe	See remarks.	
Wall Thickness	See remarks.	
Remarks	Refer to NFPA and Environmental Health & Safety Design Guide – Sprinkler Protection & Standpipes section.	

Pipe Insulation

1. Provide metal jackets for pipe insulation located in outside air intakes, outdoors, and in the tunnel system.

Valves

1. Provide valves with flanged, grooved or threaded ends. Valves may have solder ends for 2-inch and smaller copper piping.
2. Provide gate valves with rising stem and union bonnet for 2-inch and smaller.
3. Provide ball valves for 2-inch and smaller pipe and butterfly valves for 2½-inch and larger pipe.
4. Balancing valves to be globe type with ports and graduated scale. Do not use balancing valve as an isolation valve.
5. Balancing valves to be sized based on the appropriate Valve Flow Coefficient (Cv), not the service pipe size.
6. Plug valves larger than 2-inch size to be lubricated type.
7. Provide pressure reducing valve and check valve on each individual closed loop makeup water system.

Strainers

1. Provide wye type strainers in 2-inch and smaller piping.
2. Provide basket type strainers in piping larger than 2-inch, except for steam piping.
3. Provide wye type strainers in steam piping.
4. Match strainer body material with piping material.
5. Provide strainer screens with a free area not less than three times the free area of the pipe line. Perforations to be 1/16-inch size. Provide stainless steel screens in steam strainers. Provide brass screens in all other strainers.

Installation, Fabrication and Construction

Pipe and Fittings

1. Provide unions or flanged connections at equipment for maintenance and repair.
2. Provide insulating nipples or flanges between to connect piping with dissimilar metals.
3. Provide welding outlets where branch piping is smaller than the main. Provide welding tees for all other cases.
4. Where grooved mechanical joints are allowed, see standard specifications for requirements.

Pipe Sleeves

1. Provide sleeves large enough to allow insulated piping pass through without disrupting the insulation.
2. Provide elastomer wall penetration modular seals on all sleeves through exterior walls below grade.
3. Provide UL Listed fire-stopping material on all sleeves through fire rated floors and walls.

Valves

1. Install valves with the stem in vertical position is preferred. Do not install valves with stem below the horizontal plane.

2. Install isolation valves staggered where they come out from a pipe shaft so they are accessible.
3. Install valves with adequate room to permit removal of the bonnet, disk, and trim without removing the valve from the line.
4. Provide globe valves where throttling is required, except for balancing valves.
5. Provide balancing valves at all pumps, system coils, and equipment connections.
6. Triple Duty valves are not allowed.
7. Discuss the sizing of balancing valves for small coils (less than 1 gpm) with Engineering Services.

Strainers

1. Provide a ball valve and hose-end adapter for blow-down on all wye strainers, except use gate valve on steam and condensate strainers.
2. Provide strainers ahead of automatic control valves, steam traps, and in main service piping to buildings. Those steam traps provided for a device having an automatic control valve do not require strainers.

Headers

1. Space components apart by at least two pipe diameters between flanges.
2. Locate header assemblies approximately 4 feet above the floor.

Piping Pressure Tests

1. Pressure test all pipe systems to maintain constant pressure for a minimum of 2 hours.
2. Test piping after all associated fittings, and valves have been installed.
3. Demonstrate to an Owner representative for each pressure testing. Leave the pipe exposed and do not insulate until the associated pipe section has been signed off by an Owner representative.
4. Repair leaks discovered during pressure testing, and retest.
5. Maintain a set of drawings for recording and sign-off of each tested section.
6. After each day of testing, submit to the Owner a copy of the paperwork recording the raw test data, designating the piping system and Pipe Code, and comparing the allowable and actual results.

Pipe Testing Methods

1. Hydrostatic pressure testing: Use clean, fresh city water for test. On compressed gas piping remove water from piping systems after testing and dry by blowing dry, oil-free air or nitrogen through lines.
2. Pneumatic pressure testing: Perform testing with dry, oil-free air or nitrogen on piping systems.
3. See Design Criteria section for test method and test pressure.

W. Pumps

Basis of Design

This section applies to the selection and installation of pumps for hot and chilled water circulation, condenser water systems, sump and steam condensate return systems.

Design Criteria

1. Locate pumps in mechanical rooms whenever possible, provide easy service accessibility, and isolate them to prevent pumping or vibration source noise from disturbing the surrounding occupied areas.
2. Provide pumps that allow installation of a larger impeller to meet future requirements whenever possible.
3. Provide stand-by pumps when shutdowns cannot be tolerated for repairs and maintenance. For example, condensate pump stations, sewer lift stations, and primary pumping loops.
4. Provide pumps that operate at 1800 rpm.
5. Provide centrifugal-type pumps where the shutoff head is not more than 25% greater than the operating head.
6. Provide check valves in the pump discharge piping when pumps are operating in parallel, standby, or whenever a reverse flow may occur.
7. Provide "lead-lag" start controls for dual pumps. Provide the ability to manually alternate the pumps on a "lead" start.
8. Obtain discharge head information for condensate pumps from the UW Project Manager. There are locations on campus at an elevation lower than the Power Plant. Other locations are gravity return to the Power Plant hot well.
9. Provide duplex pumps with standby power for steam condensate pumps stations and sewer lift stations.
10. Ensure that a copy of each pump curve with design conditions plotted is included in the Operations and Maintenance manual.

Products, Material and Equipment

1. Provide a pump that is a complete, integrated unit consisting of pump, motor, shaft, coupling, frame, and base as manufactured at the factory.
2. Pumps: Centrifugal, end suction or horizontal split case type.
3. Provide close-coupled pumps up to 1-hp; otherwise provide a frame-mounted type.
4. In-line circulators may be used when they can be adequately supported and are easily accessible.
5. Provide frame-mounted, not close coupled, chilled water pumps, so that the entire casing and connections may be completely insulated.
6. Provide mechanical seals on all pumps, suitable for the intended service.
7. Provide certification from the pump manufacturer that the mechanical seals for pumps are suitable for the maximum expected temperature and chemical treatment used.
8. Provide all pumps with inlet strainers as part of the piping or pump inlet accessories.

9. Provide pressure gauges upstream and downstream of pump between pump and isolation valves.
10. Provide an air vent in the casing of 1-hp and larger pumps.
11. Provide vertical shaft-type sump pumps with the motor located above the sump.
12. Condensate pumps: Preferred floor mounted, cast iron casing type. Select pump and pump seals for 210 °F water without flashing for large condensate applications.

Installation, Fabrication and Construction

1. Specify each pump with separate balancing valves in the discharge piping so the design flow rate may be set.
2. Provide each pump with check valves, isolating valves and unions or flanges for easy service removal.
3. Grout pump base to the concrete equipment pad or inertia base for floor mounted pumps.
4. For floor mounted condensate pumps, provide a sight glass and vent. Terminate vent outdoors.
5. Provide isolation valves between condensate pumps and condensate receiver.
6. Minimize pipe/pump flexible connections.
7. Verify pump alignment and submit alignment data.

X. Testing, Adjusting, and Balancing

Design Criteria

1. Check with the UW Project Manager to see if the TAB services are to be provided by the Contractor as part of the construction contract or to be hired directly by the UW under a separate contract.
2. Give special consideration to the TAB process during the design so that a technician can test and analyze the particular installation and properly balance the system to obtain the greatest system efficiency and comfort level. It is important that balancing capability be designed into the system.
3. On systems with variable frequency drives (VFD) the fan and pump design performance needs to be accomplished with the VFD operating at 55 to 58 HZ as the standard VFD arrangement unless specifically directed otherwise by the contract documents. Provide the necessary sheave replacements and pump impeller trim to achieve this arrangement.
4. Specify that Testing, Adjusting, and Balancing is performed in accordance with current NEBB or AABC requirements. Balancers must be affiliated by qualification with NEBB or AABC.
5. Specify the scope of Testing, Adjusting, and Balancing in the project contract documents.

Construction Submittals

Balance Report submittals

<u>Preliminary submittal</u>

1. Draft report for review by the A/E, Certified Commissioning Professional, and UW Engineering Services that includes the following:
   a. A list of items that prevents the balancer from providing a full and complete balance or testing,
   b. Narratives that describe all problem areas that may require major construction or design changes,
   c. Narratives that describe the building systems and control systems to demonstrate comprehension of system operation, including system diversity,
   d. The balancing agenda which reiterates the scope of the balancing work and the intended order of activity,
   e. Sample balancing data sheets.

<u>Final submittal</u>

1. Certified Testing, Adjusting, and Balancing report that includes the following:
   a. Completed balancing data sheets,
   b. Drawings annotated to indicate inlet and outlet numbering that corresponds to the balancing data sheets,

c. Narratives that describe the building systems and control systems including system diversity,
d. Narrative description of those items not conforming to the contract requirements.

Y. Water Treatment and Flushing

Design Criteria

1. Coordinate water treatment requirements with Engineering Services and CEUO.
2. Provide cooling tower water treatment controller per Preferred Manufacturer List.
3. Provide volume calculations for all closed loop hydronic systems. Design documents to indicate calculated volume on drawings.
4. Provide catalog cut sheets including SDS data sheets for chemicals used. List the name and chemical content of all additives, the amount to be added to each piping system, the total volume of each system and schedule of chemical feed.
5. Submit a flushing and water treatment plan for each system. Include data sheets for equipment to be provided and parameters set for the procedure; such as media used for flushing, pressure, velocity, temperature, and duration.
6. Conduct and submit initial water quality analysis to ensure the onsite water supply is within reasonable expected conditions and as a basis for the overall chemical treatment program.
7. Provide inhibited propylene glycol for systems subject to freezing. Submit a report of the manufacturer and specific chemical contents of all additives, the amounts added, the total volume of the system, and the rated freezing temperature for the specified concentration.
8. Provide a schedule indicating total volume of each system and targeted tolerable range of test results.
9. Provide a list of piping systems requiring chemical treatment and specify treatment.
10. Chemical treatment report to include pipe volume for each hydronic system. In addition, the report is to include the total bacteria, corrosion rates, and meter readings.
11. Provide a chemical pot feeder, a coupon rack, and a make-up water meter for each hydronic system, (except chilled water system not decoupled from the CCW).

Installation, Fabrication and Construction

General

1. Submit a flushing and water treatment plan and integrate the tentative schedule in the construction outlook plan.
2. Maintain a set of drawings on-site for recording and sign-off of each flushed and/or treated section or system. All flushing/cleaning and treatment to be observed and documented with results approved by an Owner representative.
3. After each day of flushing/cleaning and treatment, submit to the Owner a copy of the paperwork recording the raw data, designating the piping system and Pipe Code, and comparing the allowable and actual results.
4. Where new Central Cooling Water is provided, chemically treat according to UW water treatment requirements provided by Engineering Services and CEUO.
5. Projects should hire the sole source contracted UW water treatment vendor (Chem-Aqua as of 2023); contact Engineering Services to verify water treatment vendor.

6. For closed-loop hydronic systems, label total water volume (in gallons) and glycol concentration (in %) near chemical pot feeder and O&M manual.

Flushing/Cleaning and Treatment Methods

1. Special procedures or temporary modifications may be required to ensure all parts of the system are flushed and receive chemical treatment. Pay particular attention to piping dead legs and back-up equipment (back-up chiller, back-up pumps, etc.). Return all systems to intended operating conditions after successful completion of the procedure.
2. Hydrostatic or water flush: Use clean, fresh city water. On gas piping, remove water from the entire system after flushing and use the following pneumatic cleaning method to dry the system.
3. Pneumatic cleaning: Blow clean, dry and oil-free air or nitrogen through the system.
4. Water flush: Flush piping with water at a velocity of 6 ft/s until effluent is clean and contains no visible particulate matter. Provide flow measurement in flushing water supply line to be used as basis for verification of flow velocities in piping system. Clean all strainers after flushing.
5. For CCW, perform the system pressure test and flushing in the presence of Engineering Services. CCW cannot be used for flushing. Provide temporary pumps, to flush the system with water at a velocity of 5 to 6 feet per second. Piping to be filled with clean water after flush and prior to opening valves. Notify Power Plant personnel to open the valves to the main CCW system after approval by Engineering Services
6. Extension of water treatment program: Continue the treatment program for a period of one year following the date when the system is put into intended normal operation. The extended program includes monthly water quality tests, reports, and scheduled chemical feed to maintain water quality within tolerable ranges.
7. The following table lists the typical piping system, pipe code, and corresponding recommended cleaning method:

Piping System	Cleaning Method
Acid Resistant Waste	-
Carbon Dioxide	Pneumatic
Central Cooling Water	Water Flush
Coil Condensate	Water Flush
Compressed Air (Laboratory)	Pneumatic
Compressed Air (Pneumatic)	Pneumatic
Condenser Water	Water Flush
Fire Protection	(1)

Piping System	Cleaning Method
Heating Hot Water	Water Flush
Helium Recovery	Pneumatic
Irrigation	Water Flush
Laboratory Cold Water	Water Flush (3)
Laboratory Hot Water	Water Flush (3)
Laboratory Hot Water Circulation	Water Flush (3)
Laboratory Vacuum	Pneumatic
Lake Water	Water Flush
Medical Gas	Pneumatic (2)
Medical Vacuum	Pneumatic (2)
Natural Gas	Pneumatic (2)
Nitrogen	Pneumatic
Oxygen	Pneumatic (2)
Potable Cold Water	Water Flush (3)
Potable Hot Water	Water Flush (3)
Potable Hot Water Circulation	Water Flush (3)
Process Chilled Water	Water Flush
Propane	Pneumatic
Refrigerant Liquid	Pneumatic
Refrigerant Suction	Pneumatic
Reverse Osmosis/De-ionized Water (High Purity)	Water Flush
Sea Water	Water Flush
Steam (Low Pressure)	Water Flush
Steam (Medium Pressure)	Water Flush
Steam (High Pressure)	Water Flush
Steam Condensate	Water Flush

Piping System	Cleaning Method
Tempered Water (Safety Shower/Eyewash)	Water Flush
Trap Primer	Water Flush
Well Water	Water Flush

(1) Refer to NFPA and Environmental, Health & Safety - Fire Protection System section for information.
(2) Refer to NFPA for additional information.
(3) Refer to City/County Department of Public Health for cleaning, disinfection, bacteriological testing, and additional information. Contact Owner prior to testing.