MIT
Design Standards

DIVISION 22 — Plumbing

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APPENDIX A: SCHEMATICS

A: Plumbing Waste Water

B. Plumbing Water Supply

1. M.I.T. PLUMBING SYSTEMS GOALS

It is our mission to provide safe, reliable and efficient plumbing systems that are designed to conserve water, energy and the environment. To achieve these goals, we commit ourselves to adhere to pertaining codes, regulations and industry standards. We will provide redundancy where necessary to achieve uninterrupted service and minimize downtime. We will provide sufficient design flexibility to allow for future expansion. As an institute of technology, we will keep an open mind to design proposals that incorporate new technology and innovative approaches to plumbing engineering.

1.1 Top Ten List of Common Plumbing Design Issues (not prioritized)

1. During renovations and for new construction, provide back water valves at grade level and basement level floor drains (sanitary) and area drains (storm) to prevent back-charging of water. Correct existing conditions as required. Do not treat as existing to remain or "grandfathered."
2. Provide in-line check valves on hot and cold supplies to all plumbing fixtures.
3. Existing lead-lined piping shall be replaced as it is discovered during renovations.
4. Drain valves at bottom of risers 2-1/2 inch and larger shall be 1-1/2 inch size with 1-1/2 inch threaded fire hose connection.
5. Potable and non-potable water heaters shall be medium pressure (60 psi) steam semi-instantaneous with double wall 90-10 cupro-nickel alloy jacket and bundle.
6. Condensate from air conditioning coils shall be collected as reclaim water or piped indirectly to storm.
7. Domestic water booster pumps shall be vertical, multi-stage with variable speed drives and all wetted parts shall be 304 stainless steel. Control panels are to display inlet pressure, discharge pressure, flow, totalized flow, and pump status. Pressure and flow shall be displayed through the Building Management System (BMS).
8. Valves in chases are to be installed to be accessible for repair and replacement with access panels installed if needed.
9. When possible, the first three to four floors of a building shall be fed potable water directly from street pressure. A pressurized express main shall feed upper floors.
10. Irrigation water is to be metered by independent city meters to facilitate sewer abatements, and must tap the main ahead of the domestic water meter. Irrigation (non-sewer) meter shall be installed per Cambridge Water Department standards.

2. DESIGN REVIEW CHECKLIST

The Design Consultant is responsible for filling out, signing, and submitting this checklist at each phase of design as a guide for review by M.I.T. Facilities.

2.1 Schematic Design (SD) Phase

MIT will use this submittal to develop comprehensive cost scoping for project budget development. In addition to information noted below, the documents shall include statements of conditions, known and unknown, that could affect project cost (i.e. This portion of the ceiling is extremely tight and may require relocation of some existing services, etc.)

It is the intent of MIT that these documents identify areas of cost implication that the contractor can use to identify scope and cost that can be tracked through future phases of development.

Provide the following information in the Schematic Design submittal:

1. Review of applicable code, regulations, and standards.
2. State applicable codes on the cover drawing
3. Identify major equipment.
4. Identify space requirements.
5. System descriptions (Basis of Design)
6. Alternative design concepts.
7. Outline specifications.
8. Equipment cut sheets
9. Statement of probable costs (vendor assistance may be required.)
10. Incorporation of pre-design contingencies, design charrettes, and owner's program requirements.
11. System descriptions (Basis of Design) which must include:
    a. Preliminary drawings (layout and riser diagrams).
    b. Equipment lists or schedules.

c. Full description of each system and the project requirements that are satisfied by these systems.

d. Include information that can form the basis of inspection and test acceptance criteria.

2.2 Design Development (DD) Phase

1. Risers diagram for all systems
2. Specification of water meters.
3. Meter remote registers coordinated with M.I.T. Facilities.
4. Piping and metering of irrigation water.
5. Design of split water distribution system, as applicable.
6. Variable speed drive domestic booster pumps, as applicable.
7. Calculations of water distribution pressure and flow.
8. Water heater selection.
9. Hot water storage temperature, as applicable.
10. Tempered water system design.
11. Chase wall sizes coordinated between plumbing and architectural.
12. Natural gas systems including:

    a. Natural gas load calculations.
    b. Natural gas loads filed with the gas company.
    c. Elevated gas pressure permit filed, as applicable.

13. Flushing water including:

    a. System design, as applicable.
    b. Flushing water variance application filed, as applicable.
    c. Flushing water load calculations.
    d. Flushing water pressure calculations. End fixture pressure not to be less than 40 psig and not greater than 80 psig. Provide pressure control valves as necessary to attain design pressure limits.

14. Controlled Flow roof drain design, as applicable.

    a. System design, as applicable.
    b. Include roof drain areas serving for each roof drain and indicated on the riser diagrams.

15. Location of emergency showers and eyewashes.

    a. Emergency shower and eyewash locations to be reviewed with M.I.T. EHS.

16. Location of sanitary vent terminals with respect to HVAC fresh air inlets. Provide minimum 25 feet away from any fresh air intakes.
17. Piping of HVAC condensate to storm drain system.
18. Trap primers shall be provided for all floor drains and are installed where required.
19. Coordination of plumbing with HVAC.
20. Coordination of plumbing with electrical.
21. Sprinkler drains and compressed air service supplied to fire protection systems.
22. Garage waste, sand, and oil interceptor design reviewed with plumbing inspector.
23. Grease interceptors design shall be reviewed with plumbing and sanitary inspectors.
24. Updated fixture and equipment cut sheets provided.
25. Reclaimed water systems application for variance filed with Cambridge and reviewed with Plumbing Inspector.
26. Coordinate with the Architect to provide moisture resistant gypsum board in plumbing chases and wet walls to the greatest extent possible.
27. Provide sleeves for all pipe penetrations in wet wall and laboratories.
28. Provide cleanout at the end of a ganged water closets sanitary header. Cleanout shall be higher than flood rim of water closets.

2.3 90% Construction Documents and Construction Documents (CD) Phase

1. List of design changes from the Design Development issue.
2. Updated fixture and equipment cut sheets.
3. Natural gas loads and permits approved by Gas Company or State Board.
4. Flushing water system approved by local Authority having jurisdiction.
5. HVAC condensate coordinated with storm water system.
6. Electrical loads coordinated with electrical drawings.
7. Variances approved by responsible authorities.
8. Review of specification sections.
9. Coordination with other trades (mechanical, electrical and fire protection)

2.4 Shop Drawing Phase

1. Ensure that the shop drawing submittals comply with all aspects of the contract documents; note in writing any deviations for discussion with M.I.T. or provide written certification that shop drawing submittals are compliant.

2.5 Record Drawing Phase

1. Review record drawings and final submittals for compliance. Provide a written report of compliance or deviations.
2. Record drawings shall include all isolation valves location, valve tags, equipment location and schedules.

3. PLUMBING SYSTEMS DESIGN CRITERIA

3.1 City Water Metering Requirements

Provide Cambridge Water Department preferred meters for city water metering including:

1. Refer to MIT Utilities Water Meter Section for meters specification.
2. Provide meters for irrigation water branch, cooling tower branch, building main feed, and cooling tower blowdown line.
3. Water meters for cooling tower makeup and blowdown shall be installed after (downstream of) the building main meter. These meters are used to facilitate sewer rebate tracking with the City.
4. Water meters for irrigation systems shall be installed before (upstream of) the main building meter. These meters are not sub-meters of the building's main service and shall be fed directly from the water service entry separate from the rest of the building.
5. Provide a full size valve up to 2-1/2 inch with threaded hose connection at the outlet side of the city water meter to use for meter calibration, temporary feed to the building, and system draining.
6. All city water meters shall read in cubic feet.
7. With the exception of irrigation and cooling tower make-up meters, The City of Cambridge Water Department will supply water meters for services 2 inch and smaller, typically Neptune meters, AWWA C700.
8. For water meter specifications see utilities section of the MIT Design Standard.

Provide an electrical outlet for all meters requiring remote reading.

All meters shall be provided with manufacturer's remote registration hardware including a wall-mounted accessory pad for communications.

Fire protection services are not to be metered.

Install dedicated water meters for cooling tower make-up, cooling tower blowdown and in-ground irrigation systems. Dedicated meters are not sub-meters to a main meter, and shall be fed directly from the water service entry, separate from the rest of the building, upstream of the domestic water meter. Dedicated meters are used to facilitate sewer rebate tracking with the city.

Meters inside the building shall be installed in accessible locations. Exterior meter pits or vaults are not allowed.

Wherever possible, remove existing meters in exterior pits and vaults and relocate inside the nearest building.

Water used at a construction site shall be metered by the contractor and billed to the respective construction project account.

3.2 Backflow Prevention

Refer to "Plumbing Products" table below for acceptable backflow device manufacturers.

All backflow devices, 4 inch and under, shall have ball valves for isolation. Ball valves 2 ½ inch to 4 inch and smaller shall be American Valve 3700V (series). 2 inch and smaller shall be lead free bronze body valves. Specify gate valves for sizes 6-inch and larger.

Project specifications shall include the following under Part 3 – Execution:

> "Flush water lines prior to backflow testing to clear piping of sediment. Test all backflow devices and provide written record of each test result to M.I.T. Facilities. A third-party certified tester shall perform all tests. Rectify all test discrepancies prior to M.I.T. acceptance. Provide one spare parts kit to M.I.T. for each size backflow device."

Backflow devices with flange or body material dissimilar to the connected piping shall be installed with a dielectric kit supplied by the backflow device manufacturer.

All backflow devices shall be supplied with a 20-mesh strainer at the inlet.

Unless a fire pump is installed, strainers are not required for double check valves in fire protection services.

Where fire pumps are installed, provide a 20-mesh strainer body and strainer for fire pump testing and certification. This strainer is required to prevent foreign matter frequently present in new services from fouling the fire pump. After certification, remove the strainer element from the strainer body.

For sizes 2-inch and smaller, provide Watts LF909 QT-S. For hot water, provide Watts LF909 HW-QT-S. (210^{o}F)

For 2-1/2-inch and larger, provide Watts LF909 QT-S.

Provide air gap and indirect waste. Run waste pipe to nearest floor drain.

All backflow preventer assemblies over 2-1/2-inch shall be epoxy coated cast iron.

Backflow preventers shall be approved by the Cambridge Water Department.

Provide one (1) set of repair kit.

2 inches and smaller shall have a soft seat check valve upstream and downstream of device.

Provide pressure gauges upstream and downstream of backflow preventers.

3.3 Booster Pumps

Water pressure on campus can vary significantly from day to night and from season to season. Pressure ranges from 40 psig to 60 psig.

Buildings with the highest occupied floor over 40 feet above grade or four stories or higher shall have a booster pump system to maintain pressure.

Motors driven by VFDs shall be equipped with motor shaft grounding rings at both ends.

Motors for VFD shall be VFD inverter duty rated.

Split Systems: The basement through fourth floor shall be fed off of street pressure when practical. An express main from the booster pumps will feed the upper floors. This is to conserve energy by avoiding pressurizing water above 80 psig only to subsequently reduce pressure through a pressure-reducing valve to feed lower floors.

All domestic water booster pumps shall be vertical, multi-stage with variable speed drives. Control panels are to display inlet pressure, discharge pressure, flow, totalized flow, and pump status. Pressure and flow should be displayed through the building's BMS and MIT PI System.

Provide 3/4-inch shutoff valve with threaded hose connection at upstream of hydrocumulator tank. Provide pressure gage at hydrocumulator tank with shutoff valve.

Provide a full size by-pass with shutoff valve.

Provide BACNET output for booster pump interface.

3.4 Water Heaters, Master Mixing Valves and Circulator Pumps

Water heaters in academic buildings shall be semi-instantaneous medium pressure (60 psi) steam fired whenever possible. Configuration shall be double-wall with 90-10 cupro-nickel alloy jacket and tube bundle. Design engineers should be aware that due to the superheat available in the campus distribution system the steam temperature at 60 psig will be well above saturated conditions and may be as high as 415 degrees F.

Instantaneous water heaters shall not be used on potable hot water systems:

1. Instantaneous water heaters are defined as heat exchangers where the water to be heated is in the coil and the steam is in the jacket.
2. Semi-instantaneous water heaters are defined as heat exchangers where the water to be heated is in the jacket and the steam is in the coil. With an internal thermostatic control, these heaters are far more accurate.

Where a reduced pressure zone backflow preventer is installed in the domestic water supply, an expansion tank shall be installed in the cold water feed to the potable water heaters.

When storage type water heaters are used, storage temperature shall be from 140 deg F to 150 deg F to inhibit bacterial growth. This requirement is especially important in dormitory buildings and buildings with shower facilities where occupants can be exposed to aerosolized hot water.

Hot water heater steam control valves should be pneumatically controlled. Pilot operated steam valves should be used only in situations where compressed air is not available.

Thermostatic mixing valves shall be used to convert to hot water storage temperature to distribution temperature. Hot water distribution temperature shall be between 110 deg F to 120 deg F for academic buildings and 120 deg F to 130 deg F for residencies. Thermostatic valves shall be listed as lead free and be certified ASSE 1017. Hot water temperature should be displayed on the building's BMS.

1. For peak flow ranges 30 gpm and lower, specify Leonard, Lawler or Watts approved equal ASSE 1017 valves with 0.5 gpm minimum flow.
2. For peak flows from 30 to 120 gpm, specify ASSE 1017 digital response thermostatic mixing valves, Powers Intellistation LFIS, Armstrong "The Brain" DRV or Leonard Nucleus with 0.5 gpm minimum flow.
3. For all valve types, follow manufacturer's written instructions for hot water recirculation piping configuration and balancing. Manufacturer instructions shall take precedence over Construction Document details which are typically generic and schematic.
4. Provide a full size tee at the discharge of hot water mixing valve to enable load for mixing valve setting.
5. Provide a hot water by-pass with an isolation valve to the mixing valve hot water discharge. Pipe size shall match the hot water distribution main.
6. Provide temperature gauges on hot water supply and hot water discharge.
7. Provide strainer with blowout port and isolation valve on cold and hot water supply to digital mixing valve.

Provide drain port for thermostatic mixing valve cleaning and inspection. Provide a ¾" ball valve with threaded hose connection between the valve outlet and main shut-off valve to assist in testing and temperature adjustment.

Hot water circulation pumps shall be in-line stainless steel centrifugal pumps with close-coupled variable speed drive motor and on-board temperature and flow instrumentation. Grundfos Alpha or Grundfos Magna 3. Connect temperature, flow and status points to the building BMS.

On large distribution systems such as in a laboratory or residence hall (i.e. for return flow rates about 5 gpm and higher), overnight or weekend shut-down of the circulation system is not allowed. Doing so will result in excessive time to restore temperature throughout the distribution. For smaller distribution systems, overnight shutdown provided by a timer is permitted.

Electric water heaters: Provide a solid 90/10 copper-nickel tank with 316 stainless steel Inconel heating element.

For water heaters which use campus medium temperature water as the heat source, provide 316L stainless steel double walled plate heat exchanger with brazed copper construction.

For water heaters or water storage tanks installed above any occupied space, provide a safe waste pan under the water heater or hot water storage tank. The pan shall be piped indirectly to a properly trapped and vented fixture. Alternatively provide a solenoid shut-off valve with flood sensor and alarm local audible alarm.

3.5 Hose Bibbs and Wall Hydrants

Interior hose bibbs shall be provided in each toilet room with more than one flushing fixture and in each mechanical room.

Hose bibbs in toilet rooms shall be polished chrome plated with threaded hose connection, integral vacuum breaker and removable tee handle. Equal to Chicago 952-1/2CP.

Hose bibbs in mechanical rooms and other unfinished spaces such as trash rooms, storage rooms, etc. shall be rough chrome plated with threaded hose connection, integral vacuum breaker and removable tee handle. Equal to Chicago 998-RCF.

Provide hose bibbs in trash rooms and loading docks.

Exterior hydrants shall be self-draining, non-freeze configuration with integral vacuum breaker. Wherever possible, specify hydrants with flush access door with removable tee handle. J.R. Smith 5509QT or equal.

Exterior hydrants shall be located 2 feet above finished grade.

Provide wall hydrants every 100 feet along the perimeter for residential buildings.

On roofs with mechanical equipment such as air handlers with heating/cooling coils and cooling towers or on vegetated roofs provide non-freeze roof mounted hydrant(s) with ASSE 1052 backflow device and threaded hose connection. Hydrant shall be capable of being mounted to the

roof deck with flashing and counter flashing. Provide a hydrant drain piped over to the closest acceptable receptor such as a janitor sink or trapped and vented floor drain.

3.6 Floor Drains, Roof Drains and Area Drains

Provide trap primers and trap guards for all floor drains, either automatic or mechanical. Automatic one shall work for 3 psi differential. Similar PPP orWade.

Provide floor drains in toilet rooms with more than one flushing fixture, in mechanical rooms and in trash rooms. Locate mechanical room floor drains as required to receive discharge and/or drain down by mechanical and plumbing equipment. All RPZ backflows shall be piped indirectly to a floor drain.

All floor drains not regularly receiving process water waste shall be provided with an automatic trap primer similar to Precision Plumbing Products (PPP) Model MP-500-115V (1 to 4 outlets with distributor) or PTS (series) manifold multi-outlet units.

Floor drains are required at ADA showers.

Mechanical room floor drains shall be specified with removable sediment buckets. Provide with water dam floor drains for clean water waste (condensate drain discharge).

Roof drains shall be ASME A112.6.4 (latest adopted edition) general duty cast iron body with flashing ring, gravel stop and polyethylene dome strainer. Specify under deck clamps, sump receiver and other accessories as needed to mount to roof deck system.

Secondary overflow drains shall have a perimeter water dam approximately the same diameter as the drain flashing ring. Interior standpipe drains are not permitted. Water dam height shall be 2 inches minimum but not more than permitted by the loading factor of the roof system.

Provide bronze or stainless steel overflow drain outlet with insects screen.

3.7 Pressure Gauges, Temperature Gauges and Related Instruments

Pressure gauges, switches and transmitters shall have 1/4 inch isolation valves (or size as required by the instrument's process connection size).

Provide pressure gauges at the inlet and outlet of each pump, backflow preventer and pressure-reducing valve.

Provide temperature gauges at the inlet and outlet of each water heater, thermostatic valve, and circulation pump. Provide temperature gauges with 304SS stem and 316SS thermowells.

Pressure gauges shall be liquid filled Trerice 450 series or equal.

3.8 Drinking Fountains

Recess drinking fountains in alcoves. Do not project into corridors. Coordinate with the Architect as required.

Provide dual height units as required to meet barrier-free accessibility requirements.

Units should be electric water cooled with bottle fillers.

3.9 Toilet Room Fixtures

Residence hall water closets, lavatories, public urinals, and public/private showerheads shall be EPA Watersense ® certified.

Wall hung lavatories are preferred for commercial (i.e. non-residence) toilet rooms. Avoid the use of countertops.

Where countertops are used, specify an under-mount bowl to eliminate any lip or dam at the sink edge.

Lavatory selection and design shall be easy to wipe clean and prevent trapped water outside the sink bowl. Provide with overflow drain and grid strainer for public use and pop-up drain for residential use.

Public lavatory faucets shall be 0.35 gpm electronic sensor faucets. Faucets shall be battery powered with recharging technology (e.g. solar or turbine regeneration). Public lavatory faucets shall be specified with ASSE 1070 thermostatic temperature limiting valves set at 110ºF outlet temperature. Provide one (1) single handle manual operated faucet on public bathrooms.

Residence hall lavatory faucets shall be 0.5 gpm with manual control. In residence hall units designated ADA, provide ASSE 1070 thermostatic temperature limiting valves set at 110ºF outlet temperature.

Public water closets shall be wall hung flush valve fixtures, 1.0 gallons per flush. Flush valves shall be sensor operated, battery powered with recharging technology (e.g. solar or turbine regeneration).

Urinals shall be wall hung flush valve fixtures, 0.128 gallons per flush. Flush valves shall be sensor operated, battery powered with recharging technology (e.g. solar or turbine regeneration).

Residence hall water closets shall be tank-type, floor mounted, 1.28 gallons per flush or dual flush with fewer gallons per flush.

Shower valves shall be single handle, ASSE 1016 pressure balance, thermostatic or combined anti-scald units. Shower heads shall be maximum 1.5 gpm.

Provide in-line checks on both hot and cold supplies.

Water closets and flush valves shall be the same manufacturer, do not mix and match.

Provide water closet carriers with a 4-inch coupling (3-inch is not acceptable) and 500 pound load rating.

3.10 Janitor Sinks

Janitor sinks shall be floor mounted mop receptors constructed of terrazzo with 304 stainless steel bumper guards and wall splash guards. Faucet shall be two handle, wall mounted with polished or rough chrome plated finish, integral check valves, integral vacuum breaker and pail hook with bracket.

Minimum drain and trap size shall be 3 inch.

Hot and cold water supplies feeding janitor sinks shall be protected by ASSE 1013 reduced pressure zone backflow prevention. Point of use backflows are not preferred due to the number of assemblies required to be registered, maintained and tested, therefore consolidation is encouraged. A central RPZ with separate electric storage water heater feeding only the janitor sinks is ideal where recirculation is required due to distance from the hot water source to the furthest outlet. Non-potable hot water shall not be recirculated back to the potable hot water system or heaters.

3.11 Natural Gas

Determine the current gas supply company. As of year 2020 contact Eversource.

Provide an MIT gas sub-meter for any new building natural gas service. New gas meter shall have provisions for data transmission. For gas meter specification, see utilities section.

File total connected load for new gas consumption with the gas company in writing. Review the preliminary gas system load with the gas provider early in the design process and update regularly thereafter.

The gas company will make the connections to the gas main and will provide the service branch to the building.

The gas company typically furnishes and installs the gas meter assembly.

Provide swing joints at buildings as required by code and standards to account for building settlement.

Refer to laboratory services sections of the M.I.T. Guidelines for laboratory gas requirements.

Install emergency shut-off valves outside the labs with tee handles and on to the path of egress. Provide signage “master gas shutoff valve”.

For pressure less than or equal to 0.5 psi (14 inch water column):

1. Pipe Sizes 2 inch and Smaller: Schedule 40 black steel pipe with malleable iron screwed fittings.
2. Pipe Sizes 2-1/2 inch and Larger: Schedule 40 black steel pipe with welded joints.
3. Gas pipe shall be painted yellow with labels.
4. Exterior gas piping and piping exposed to the elements including all piping in open parking structures shall be polymer coated and joints shall be painted yellow with epoxy paint.

Natural gas to commercial kitchen cooking equipment shall be provided with an automatic shut-off, manually reset solenoid valve in addition to the manual shut-off and hood fire suppression automatic shut-off valve. The solenoid valve shall be controlled by a carbon monoxide and natural gas (methane) monitor connected to two (2) carbon monoxide detectors and two (2) methane detectors located in the room. The detectors shall be mounted as recommended by the detector/controller manufacturer, generally 3 to 5 feet above the floor and greater than 10 feet away from the cooking equipment or hood. Twin detectors are intended to provide redundancy. If one detector activates, the system goes into "alarm" mode with local alarm notification. If a second detector activates, the system goes into "shut down" mode which closes the natural gas solenoid and initiates a remote alarm notification to the building fire alarm system. The solenoid valve may not be automatically reset. It shall require manual reset at the controller to re-open.

3.12 Sewage Ejectors and Sump Pumps

Refer to 248 CMR, Section 10.15 (10) Table 5 for determine the capacity of sewage ejectors.

Elevator Sump Pumps – Provide submersible sump pump with 300 series stainless steel shafts, bronze impellers with 50 feet of power cable. Two (2) mechanical type float switches shall be suspended from the discharge pipe. Each switch shall be furnished with 50 feet of cable. Provide a control panel with including an alarm horn with a silence switch and one (1) set of isolated contacts for remote alarming. The general alarm shall be interfaced with the building management system.

For non-hydraulic elevators (traction elevator) the pump discharge force main shall be piped through an oil interceptor, then indirectly to the storm system clear water waste receiver.

For hydraulic elevators the pump discharge force main shall be piped through an oil interceptor and then discharged to a sanitary waste receiver.

All sewage ejectors and sump pumps in basins deeper than 4 feet shall be specified with rail removal systems.

Provide duplex pumps with an automatic alternating control panel.

Provide air cooled (no oil lubricated) pumps.

All sewage ejector high alarms shall be connected to the building management system (BMS).

Provide alarm indicator light outside the Mechanical Room.

3.13 Emergency Showers and Eyewash Systems

ANSI Z358.1 (latest edition) and 527 CMR 10.02 shall be followed in all respects when installing emergency showers and eyewashes on campus. MIT requires the tempered water system to support minimum of two (2) safety showers (40 GPM) on new laboratories buildings and one (1) safety shower and one (1) safety eyewash on existing laboratory building renovations.

Supply water to emergency showers and eyewashes shall be tempered in a range between 70ºF and 90ºF with a preferred temperature of 85ºF with emergency thermostatic mixing valves.

Thermal Storage:

1. Whenever possible, tempered water shall be supplied through a semi-instantaneous steam-fired water heater(s). This heater may be the potable water heater for the building. The intent is to minimize thermal storage required for ANSI flushing water supply requirements.
2. When semi-instantaneous heaters are not possible, M.I.T. prefers the use of dedicated electric storage water heaters to meet 15 minute tempered water requirements of ANSI.
3. Storage water heaters shall have a minimum combined storage capacity of 220 gallons at a storage temperature of 150 deg F to meet one shower and one eye wash requirements.
4. Storage temperature requirements are intended to mitigate Legionella pneumophila proliferation in stagnant water supplies. Higher temperature also allows a higher specific enthalpy thereby reducing storage volume.

Emergency shower mixing valves to comply with ANSI Z358.1 to provide 20 gpm of tempered water with positive hot water shutoff and cold water bypass bronze body, dual independent elements, stainless steel piston and liner. Thermostatic mixing valves shall be set for 85ºF and designed to provide full cold-water bypass on failure of the hot water supply.

Thermal storage shall be sized for one emergency shower and one emergency eyewash flowing for 15 minutes for existing buildings; two showers for new construction. Minimum delivery temperature shall not be less than 70 deg F after fifteen minutes.

Flushing water supply pressure to emergency showers and eyewashes shall not be less than 20 psig and shall not exceed 30 psig. Where water supply pressure is inadequate to supply the 20 psig minimum residual at design flow include a booster pump in the tempered water system.

Pipe sizing shall be based on two emergency showers flowing simultaneously without regard to delivery temperature including:

1. Minimum main distribution shall be 2 inch diameter.
2. Branch distribution to a floor shall be not less than 1-1/2 inch diameter.
3. Feeds to individual equipment shall follow ANSI requirements.

Continuous flushing of tempered water line to prevent stagnation, as required by Mass Plumbing Code, should be done by tying to a bathroom fixture (preferred connected to the cold water feed of urinals or water closets) or other approved means. Comply with the "5 foot rule" for dead legs.

Emergency eyewash models should be dual stream and the swing arm type is preferred. Drench hose units mounted next to laboratory sinks are prohibited. If used as supplemental equipment, such drench hose units shall be located 6 feet or more away from laboratory sinks and fume hoods.

Safety showers shall be specified with the manufacturer's flow switch package for connection to the BMS. Refer to controls sections for addressable monitoring by room number. Only located in common areas.

Safety showers do not require floor drains. Free standing eyewash units do not require hard piped waste, trap or vent. However, specify and detail that recessed pull-down eyewash units have the drain piped to the provided "daylight" outlet. The plumbing contractor shall be directed to modify free-standing eyewash/safety shower units to locate the eyewash drain approximately 24 inches above the floor with a galvanized nipple and elbow. This allows the discharge to be collected in a bucket during testing.

See Appendix A for emergency shower and eyewash details. Exposed and recessed options are detailed.

Tempered water distribution piping is not required to be insulated per ASHRAE 90.1 and the IECC.

Provide lockable line size full port shutoff valve on hot and cold water feed to the emergency mixing valve. Service valves in the tempered water distribution shall be locked open or have the operating handle removed and zip-tied to the pipe for use as needed for maintenance shut-downs.

Provide tempered water flushing line with an automatic trap primer valve (discharge time set at 30 second/ 24 hours). Drain line discharge to the mop receptor.

Provide testing certification for all emergency equipment which include emergency shower/eyewash stations, emergency showers and emergency eyewash stations. Testing procedures for certification shall comply with ANSI ISEA Z358.1.

3.14 Lab Waste Neutralization

M.I.T. uses centralized pH neutralization for the campus. Buildings without stand alone systems collect their lab waste in the basement and transfer it to the nearest neutralization system for neutralization.

Neutralization by the use of limestone chip tanks is not permitted, even in cases of "temporary" provisions. All lab waste shall be treated by means of a fully automated pH adjustment system.

Pumped lab waste piping should be Schedule 80 high density polyethylene (HDPE) with butt fusion or socket joints use socket fusion joints only when field fabrication of a butt fusion joint is not practical. Equivalent Standard Dimension Ratio (SDR) pipe wall thickness rating is SDR 11. Piping color should be black.

Gravity lab waste piping should be flame-retardant polypropylene (PPFR) with fusion joints and mechanical joints in laboratory casework. Piping color should be blue, pale green or dark green.

Point of Use Lift Stations:

Provide point of use lab waste lift station at lab sinks if lab waste cannot flow by gravity to the lab waste system.

Lab waste lift station package system shall be a UL listed and Mass approved product.

Practical Applications Inc. is the MIT preferred vendor for lab waste lift stations.

In certain locations on campus, laboratory sinks may still have limestone chip tanks below sinks without automatic pH treatment downstream. If such chip tanks are present, new infrastructure for laboratory waste transfer or treatment must be provided to comply with City of Cambridge and MWRA regulations.

In some locations on campus, some laboratory sinks may have limestone chip tanks installed but downstream piping is laboratory waste materials and waste is either treated or transferred to an appropriate treatment system. If such chip tanks are present, they should be remove and replaced with a new polypropylene (PPFR) p-trap. Legally dispose of chip tanks, p-traps and piping as hazardous waste if heavy metals or other contaminants are discovered. Testing to be done/verified by MIT EHS.

Lab Waste Transfer Stations:

Welded seam polypropylene basin with reinforcing ribs. Basins shall include 1 ½ inch low point drain valve, access manway, and threaded or flanged nozzles as required for pumps, inlet, outlet, vent and level sensors. Basin shall be air tight to prevent odors.

RF Admittance technology continuous level sensors for level measurement and pump on/off control. Point level sensors for high-high alarm and pump start permissive level. Equal to AMETEK Drexelbrook Universal or Intellipoint.

Duplex stainless steel housing and impeller centrifugal, end-suction pumps with suction flexible connections. Preferred pump configuration is floor mounted exterior. Submersible pumps may be considered on a case-by-case basis due to space restraints. Goulds or equal.

Discharge electromagnetic flow sensor capable of displaying and transmitting instantaneous flow and totalized flow. ABB or equal.

pH probe located in basin capable of transmitting pH to control panel.

Install sample port at pump discharge for grab and composite sampling at an accessible height without the use of a ladder.

Control panel with local power disconnect and touchscreen operator interface. Controller shall be a programmable logic controller (PLC) capable of receiving operating inputs and providing display or control of the following parameters:

Pump status: On/off/auto (user selected)
Pump run indication
Basin Level
Alarm: high level, pump failure, etc.
Discharge pH
Discharge flow (gpm) and totalized flow (gallons)
The controller shall be connected to the BMS system for remote monitoring of the basin high-high alarm and one general alarm point. The controller shall be provided with a UPS power supply sized to allow the controller to continue to operate for 120 minutes during a loss of normal power.

Centralized pH Neutralization:

Welded seam polyethylene contact tanks with reinforcing ribs. Tanks shall include access manway, and threaded or flanged nozzles as required for chemical injection, mixers, inlet, outlet, vents and sensors.

Tank-mounted pH probes capable of transmitting signal back to the main controller.

Tank or shelf-mounted metering pumps with concentrated 50% sulfuric acid and 50% sodium hydroxide reagent tanks. Although proper mixing should provide adequate pH response during treatment, assess the need to provide Calcium Carbonate solution and metering pump where influent waste is predominantly deionized to buffer the pH response of the treated solution. Include reagent tank low level switches.

Tank-mounted marine style mixers capable of completing a full tank turn-over in one minute or less. For example, a 500 gallon contact tank shall be mixed at a rate of 500 gallons per minute.

Discharge p-trap with in-line final pH sensor and MWRA required sample port and two additional MIT sample ports for grab and composite sampling.

Discharge electromagnetic flow sensor capable of displaying and transmitting instantaneous flow and totalized flow. ABB or equal.

Circular chart recorder to continuously record for 7 days minimum the discharge pH.

Control panel with local power disconnect and touchscreen operator interface. Controller shall be a programmable logic controller (PLC) capable of receiving operating inputs and providing display or control of the following parameters:

Metering Pump status: On/off/auto (manual user selected)
Pump run indication
Alarm: pH level out of limits, reagent tank low, pump failure, etc.
Discharge pH
Discharge flow (gpm) and totalized flow (gallons)

The controller shall be connected to the BMS system for remote monitoring of the parameters above. The controller shall be provided with a UPS power supply sized to allow the controller to continue to operate for 120 minutes during a loss of normal power.

3.15 Minimum Insulation Requirements for Hot and Cold Water

Applies to both potable and non-potable water distribution systems. Insulation shall meet the requirements of ASHRAE 90.1 (latest adopted edition).

Cold Water: Minimum 1/2 inch insulation thickness.

Tempered Water (70ºF to 90ºF): Insulation not required.

Circulated Service Hot Water (100ºF to 140ºF):

1-1/2 inch and smaller: 1 inch minimum insulation thickness at maximum conductivity of 0.28 BTU/in x ft2 x ºF.

2 inch and larger: 1-1/2 inch minimum insulation thickness at a maximum conductivity of 0.28 BTU/in x ft2 x ºF.

Circulated Hot Water (141ºF and higher):

1-1/2 inch and smaller: 1-1/2 inch minimum insulation thickness at maximum conductivity of 0.29 BTU/in x ft2 x ºF.

2 inch and larger: 2 inch minimum insulation thickness at a maximum conductivity of 0.29 BTU/in x ft2 x ºF.

Non-Circulated Service Hot Water:

All Sizes: 1 inch minimum insulation thickness at a maximum conductivity of 0.27 BTU/in x ft2 x degrees F.

3.16 Interceptors, Separators, and Holding Tanks

Food Preparation/Service Areas

Comply with 248 CMR, Mass Plumbing code where such drains must be provided. As a minimum the following are recommended:

- Cafeterias;
- Dining areas where food is prepared and served;
- Commercial kitchens;
- Restaurants;
- Medical facilities; and
- Where substantial amounts of fats, oil, and grease have the potential to enter the buildings drainage system or cause obstructions in sewage lines.

Residential Areas

Grease traps and interceptors are not required for residential buildings, structures, dwellings, dwelling units, or any private residence. Floor drains are required at ADA showers.

Cafeterias or Commercial Cooking Areas

Grease traps and interceptors are required in buildings deemed "residential" (e.g. Dormitories, graduate student apartment buildings) that include cafeterias or commercial cooking areas (i.e., dining halls).

The fats, wax, oil, and grease contents of a grease trap or interceptor shall not be discharged to the sewer system.

Chemical, biological, or physical means shall not be used to release fats, wax, oil, or grease into the sewer, bypass the trap or interceptor, or otherwise make the trap or interceptor operate less effectively. Only MWRA approved chemical or biological agents can be used in a grease trap or interceptor may be added to a trap or interceptor to convert the fats, wax, oil, and grease in a trap or interceptor to a substance not regulated by 360 CMR 10.021 through 10.024 if the resulting discharge from the trap or interceptor will not cause or contribute to an obstruction or blockage in the sewer or otherwise violate 360 CMR 10.021 through 10.024.

Central and point of use grease interceptors shall be provided per 248 CMR, Section 10.09. Provide testing port for central grease interceptor located downstream of the discharge.

Vehicle Maintenance Areas

Ensure that the floor drain shall be equipped with an approved sediment and sand control basket, or the floor drain shall discharge through a sand interceptor. Discharge of multiple floor drains into one sand interceptor is acceptable.

4. PIPE, VALVE AND EQUIPMENT IDENTIFICATION

Provide color-coded pipe identification markers on all installed piping.

Pipe markers shall be plastic tape type protected by clear acrylic coating. Refer to "Plumbing Products" below for approved manufacturers.

Provide valve tags for all valves and locations shall be indicated on record drawings.

Provide pipe labels with direction of flow.

4.1 Labeling

Label mains as follows:

1. at all points of entrance and exit from mechanical rooms,
2. adjacent to each valve,
3. on each riser between each floor,
4. at each tee fitting,
5. at points of entrance and exit from building,
6. at least once each room,
7. at intervals no longer than 20 feet.

For pipe 4 inch and larger, legend shall be 2 inch high. For pipe 3 inch and smaller, use 1/2 inch high legend.

Install arrow markers with each identification marker to indicate direction of flow. If flow can be in either direction, use double-headed arrow marker.

Reclaimed water piping shall be painted along its entire length in yellow enamel paint prior to insulation. Pipe shall then be labeled "Toilet and Urinal Flushing Only." After insulation, provide pipe label as specified in the table below. This procedure is mandatory; deviation shall require special approval of the State Board of Examiners of Plumbers and Gas Fitters.

Markers shall have band colors and legend as indicated in the following table:

Service	Legend	Band Color	Legend Color
Cold Water	Potable Cold Water	Green	White
Hot Water	Potable Hot Water	Green	White
Hot Water Return	Potable Hot Water Return	Green	White
Non-Potable Cold Water	Non-Potable Cold Water	Green	White
Non-Potable Hot Water	Non-Potable Hot Water	Green	White
Non-Potable Hot Water Return	Non-Potable Hot Water Return	Green	White
Tempered Water	Tempered Water	Green	White
Purified Water	RODI	Green	White
Sanitary Drain	Sanitary Sewer	Green	White
Sanitary Vent	Sanitary Vent	Green	White
Rainwater	Storm Drain	Green	White
Natural Gas	Natural Gas	Yellow	Black
Garage Waste	Garage Waste	Green	White
Garage Vent	Garage Vent	Green	White
Reclaimed Water	Gray Water	Purple	White
Flushing Water	Flushing Water	Yellow	Black
Irrigation Water	Non-Potable Water Gray Water	Yellow Purple	Black White
Boiler/CHW Make-up	Non-potable Water	Yellow	Black
Pure Water Make-up	Non-potable Water	Yellow	Black
Laboratory Air	Compressed Air	Blue	White
Laboratory Vacuum	Laboratory Vacuum	Blue	White
Nitrogen	Nitrogen	Green	White
Oxygen	Oxygen	Yellow	Black
Carbon Dioxide	Carbon Dioxide	Blue	White
Argon	Argon	Blue	White
Helium	Helium	Blue	White
Hydrogen	Hydrogen	Yellow	Black

4.2 Valve Tags

Provide valve tags as described below for each entrance, riser, floor, suite, or local area isolation valve. Each isolation valve location shall be depicted on the as-built drawings provided by the plumbing contractor. Valve tag charts shall be coodinated with the as-built drawings and submitted to the engineer of record and the owner's representative for approval before being installed in mechanical room.

4.2.1 Valve Tag Design and Material:

Stamped, etched, or laser engraved markings. Brass. 1-1/2" diameter with smooth edges. 0.032-inch (0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware. Fasteners: Brass wire-link or beaded chain; or S-hook.

NOTE: Any alternatives to this material need the written approval from MIT Facilities Engineering.

4.2.2 Valve Tag Information and Nomenclature

Line 1: Building- Room Number

Line 2: Piping System Abbreviation (please refer to section 4.2.5)

Line 3: Five digit Project #- PRJ#: 20123, or if applicable the seven digit work order #- WO#: 5678910.

Line 4: Three digit ascending sequential number in larger font

Figure 1: Examples of Valve Tags

4.2.3 Valve Tag Installation

Install tags on valves and control devices in all piping systems, which includes distribution shutoff/isolation valves, HVAC terminal devices and similar roughing-in connections of end-use fixtures and units, and fire protection drain downs. Any valve that is required to be isolated so R&M can meet the MIT EHS Policy EHS-O&M-04, Equipment-specific Energy Control Procedure (ECP) must be tagged. List tagged valves in a valve schedule.

Items not requiring valve tags are; check valves; valves within factory-fabricated equipment units.

Figure 2 below is an Example of a valve tag installed on MITs campus.

Figure 2: Valve tag installation.

4.2.4 Valve Tag Schedule

For all piping systems create the valve tag schedule as follows: Location (Building Room #, Line 1 on tag), piping system abbreviation (Line 2 on tag), Project # or WO # (Line 3 on tag), valve tag # (line 4 on tag), service description, valve type, valve size, normal-operating position (open, closed, or modulating), and drawing number.

Valve tag schedule must be included at the time of project turnover or occupancy (whichever comes first). At the time of project turnover, or occupancy, the As-built drawings submitted must have Valve Tag # (Line 4 on tag) identified for each

corresponding valve on the As-built drawings, Flow and Riser Diagrams, and when applicable the Record Drawings. See Example As-built drawing in Figure 3.

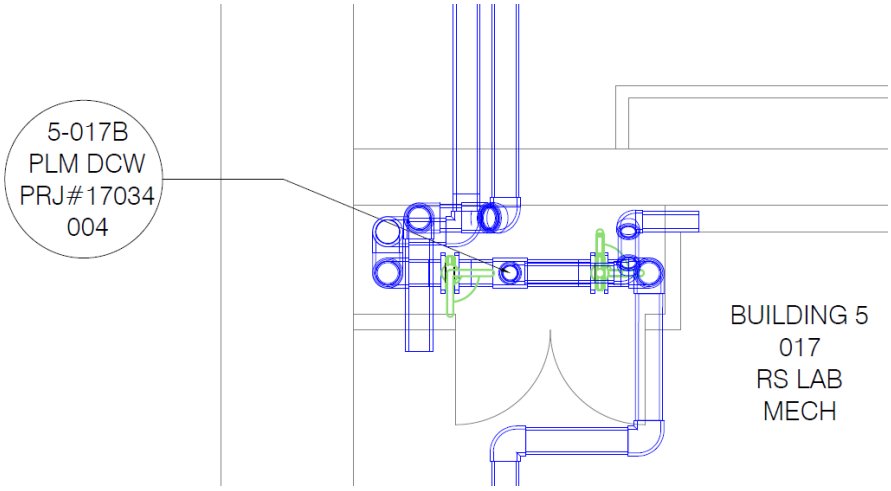


Figure 3: (Top) Valve tag sample with corresponding as-built. Building 5 – Plumbing – Domestic Cold Water – MIT Project# 17034 – Valve Tag # 004

The valve tag schedule for each corresponding system must be present on each Flow Diagram, Riser diagram, and As-built drawing. This includes the following systems Div 21-Fire Protection, Div 22- Plumbing, and Div- 23 HVAC.

At project turnover, the valve tag schedules must be provided as a deliverable electronically as a sorted EXCEL file and PDF document. Below is an example of a valve tag schedule in EXCEL form.

Table 1: Valve tag schedule example- for reference only.

Location Building- Room (Line 1)	Piping System Abbreviation (Line 2)	Project # / Work Order # (Line 3)	Valve Tag # (Line 4)	Service Description	Valve Type	Valve Size	Normal Position	Drawing No.
32-000CA	HVC CHW	20123	001	Chilled Water Upstream shutoff to Bldg	Butterfly	20"	Open	M2-0.1
32-100CA	HVC CHW	20123	002	Chilled Water Shutoff to FCU	Ball	1"	Closed	M2-1.1
32-200CA	HVC CHW	20123	003	Chilled Water Shutoff to Lab	Globe	3"	Open	M2-2.1

4.2.5 Valve Tag Piping with Abbreviations

Table 2: Piping Systems with Abbreviations

Piping System	*System Abbreviation (Line 2 on Tag)
HVAC CHILLED WATER	HVC CHW
HVAC PROCESS CHILLED WATER	HVC CHW PRO
HVAC HOT WATER	HVC HOT
HVAC HOT WATER RE-HEAT	HVC HOT RHT
STEAM CONDENSATE RETURN	STM CON
STEAM HUMIDIFICATION	STM HUM
STEAM LOW PRESSURE	STM LPR
STEAM MEDIUM PRESSURE	STM MPR
STEAM PROCESS	STM PRO
PLUMBING EMERGENCY WATER	PLM TW

PLUMBING GREY WATER	PLM GRY
PLUMBING NATURAL GAS	PLM NG
PLUMBING POTABLE COLD WATER	PLM DW
PLUMBING POTABLE HOT WATER	PLM DHW
PLUMBING POTABLE HOT WATER RETURN	PLM DHWR
PLUMBING NON-POTABLE (PROTECTED) COLD WATER	PLM PCW
PLUMBING NON-POTABLE (PROTECTED) HOT WATER	PLM PHW
PLUMBING NON-POTABLE (PROTECTED) HOT WATER RETURN	PLM PHWR
PLUMBING RO WATER SUPPLY	PLM ROS
PLUMBING RO WATER RETURN	PLM ROR
PLUMBING LAB COMPRESSED AIR	PLM LA
PLUMBING LAB VACUUM	PLM VAC
PLUMBING LAB WASTE	PLM LW
PLUMBING FORCE MAIN	PLM FM
FIRE PROTECTION SUPPRESSION	FP SUP

*If the system is not listed, then request a system abbreviation from MIT Facilities Engineering.

4.3 MEP Equipment Naming Standards

This section provides a methodology for achieving unique equipment names (Unit IDs) for Mechanical, Electrical and Plumbing (MEP) equipment identification. MIT Facilities Engineering Group (FE) shall approve alternatives and substitutions.

MIT Standard 26, Section 1.2 requires fed from labeling at all equipment with electrical feeds. The labeling for electrical panel schedules requires identification of exact equipment associated with each breaker. This drives the need for a unique equipment Unit ID for all MEP equipment with electrical feeds.

This section is applicable to all equipment with electrical feeds.

- Construction drawing schedules and plans shall include unique equipment Unit IDs.
- Labels applied to equipment shall match the Unit IDs provided in construction drawings and revisions.
- BMS Graphics shall match the unique Unit IDs provided in construction drawings and revisions.
- Electrical feeds and fed from labels shall match those unique Unit IDs provided in construction drawings and revisions.

The following is a list of abbreviations used to establish unique equipment Unit IDs in the construction drawings.

Table Symbols

** System or Skid ID is part of the Unit ID*

 # is a sequential number or 'letter'

RM is the space where the unit is located as shown on the MIT Space Accounting Floor Plans.

AS is the area served by the unit as shown on the MIT Space Accounting Floor Plans. AS is the exact room number, not the space type. AS is used for terminal units that typically serve only one space. If a terminal unit serves more than one space, then use the room number where the unit is located.

Table 1A: Plumbing System ID

System	Abbreviation
Compressed Air	CMP
Domestic Cold Water	DCW
Domestic Hot Water System	DHW
Irrigation	IR
Lab Waste	LW
Natural Gas	GAS
Non-Potable Cold Water	NPCW
Non-Potable Hot Water System	NPHW
Reverse Osmosis	ROS
Sanitary Waste	SAN
Storm Water	ST
Tempered Water	TW
Vacuum	VAC

Table 1B: Plumbing Unit ID

Equipment Description	Unit ID	Example
Air Compressor (Part of Skid)	* C-#	CMP-1 C-1A
Air Compressor Skid	CMP-#	CMP-2
Air Compressor Tank	* TNK-#	CMP-1 TNK-1

Air Dryer Refrigerator	* RAD-#	CMP-1 RAD-1
Air Dryer Regenerative Desiccant	* DAD-#	CMP-1 DAD-1
Domestic Hot Water Mixing Valve	* MV-RM-#	DHW MV-210-1
Domestic Water Booster Pump Skid	BP-#	BP-1
Drinking Fountain	DF-RM-#	DF-100CA-2
Exchanger/Water Heater/Boiler	* HX-#	NPHW HX-2B
Expansion Tank	* ET-#	NPHW ET-2
Gas Trap	TGAS-RM-#	TGAS-010-1
Grease Trap	TG-RM-#	TG-210-1
Kitchen Ejector Skid	KEP-#	KEP-1
Lab Waste Central Neutralization Station	CNS-#	CNS-1 (Serves multiple buildings)
Lab Waste Lift Station	LS-#	LS-1
Lab Waste Stand-Alone Neutralization Station	SANS-#	SANS-1 (Serves only one building)
Meter Gas	MG-RM-#	MG-210-1
Meter Water	MW-RM-#	MG-210-1
Pump	* P-#	DHW P-4
Reverse Osmosis System (Control Panel)	ROS-#	ROS-1
Sand Trap	TS-RM-#	TS-210-1
Sewage Ejector Skid	SEP-#	SEP-2
Storm Water Ejector Skid	SWE-#	SWE-1
Sump Pump Water	SP-RM-#	SP-001-2
Tempered Water Mixing Valve	* MV-RM-#	TW MV-210-1

Table 2A: Mechanical System ID

System	Abbreviation
Chilled Water System	CHW
Exhaust Air	EA
Fuel Oil	FO
Heating Hot Water	HHW
High Pressure System	HPS
Low Pressure System	LPS
Medium Pressure System	MPS
Process Chilled Cooling Water System	PCHW
Pumped Condensate	PC
Refrigerant	REF
Return Air	RA
Supply Air	SA

Table 2b: Mechanical Unit ID

Equipment Description	Unit ID	Example
AC/Evaporator	* AC-AS-#	ACCU-1 AC-305T-2
Air Conditioned Condensing Unit	ACCU-#	ACCU-1
Air Handling Unit	AHU-#	AHU-2
Biological Safety Cabinet (Part of Exhaust System)	* BSC-RM-#	EF-3 BSC-420-2 EAHU-3 BSC-420-2

Blower Coil Unit	BCU-AS-#	BCU-100CA-3
Boiler (Gas Fired Boiler)	BLR-#	BLR-2
Cabinet Unit Heater	CUH-RM-#	CUH-710-1
Chemical Pot Feeder	* CPF-#	HHW CPF-2
Chiller	CH-#	CH-2
Clean Steam Generator	CSG-#	CSG-1
Condensate Drain Pump	CP-RM-#	CP-305-2
Constant Air Volume Controller	CAV-AS-#	CAV-310-6
Constant Air Volume Controller (Exhaust)	ECAV-AS-#	ECAV-310-6
Constant Air Volume Controller (Return)	RCAV-AS-#	RCAV-310-6
Cooling Tower	CT-#	CT-1
Coupon Rack	* CR-#	HHW-CR-2
Dehumidifier	DH-AS-#	DH-205-1
Differential Pressure Sensor	* DPS-#	AHU-2 DPS-1
Electric ReHeat Coil	ERHC-AS-#	ERHC-210-2
Energy Recovery “Heat” Wheel	* HW-#	AHU-2 HW-2A
Energy Recovery Unit	ERU-#	ERU-4
Environmental Room	* ER-RM	ERCU-2 ER-310
Environmental Room Condensing Unit	ERCU-#	ERCU-2
Exhaust Air Handling Unit	EAHU-#	EAHU-5
Exhaust Air Valve	EAV-AS-#	EAV-310-6
Exhaust Fan - Part of Air Handling System	* EF-#	EAHU-1 EF-1C
Exhaust Fan - Stand Alone	EF-#	EF-2
Fan Coil Unit	FCU-AS-#	FCU-100CA-2

Fuel Oil Pump Skid	FOP-#	FOP-1
Fume Hood	* FH-RM-#	EF-3 FH-601-2 EAHU-3 FH-601-2
Glycol Feed Pump	* GFP-#	HHW GFP-2
Heat Exchanger or Converter	* HX-#	HHW HX-2B
Humidifier	H-AS-#	H-110-2
Kitchen Exhaust Fan	KEF-#	KEF-1
Kitchen Hood	* KH-RM-#	KEF-1 KH-110-6
Lab Hood	* LH-RM-#	EF-3 LH-601-3 EAHU-3 LH-601-3
Make-Up Air Handling Unit	MAHU-#	MAHU-6
Meter Steam	MSTM-RM-#	MSTM-020-1
Packaged Air Handling Unit	PAHU-#	PAHU-6
Process Chilled Water Filter	* F-#	PCHW F-1
Pump	* P-#	CHW P-6
Return Air Valve	RAV-AS-#	RAV-310-6
Return Fan - Part of Air Handling System	* RF-#	AHU-2 RF-2A
Return Fan - Stand Alone	RF-#	RF-2
Steam Condensate Return Pump Skid	CRP-#	CRP-4
Steam Pressure Reduction Station	PRV-#	PRV-1
Steam Trap	TSTM-AS-#	TSTM-001-6
Supply Air Valve	SAV-AS-#	SAV-310-6
Supply Fan - Part of Air Handling System	* SF-#	AHU-2 SF-2A
Supply Fan - Stand Alone	SF-#	SF-2
Tank Expansion	* ET-#	HHW ET-2

Toilet Exhaust Fan	TEF-#	TEF-2
Unit Heater	UH-AS-#	UH-110-3
UV Light	* UV-#	AHU-2 UV-2A
Vacuum Pump Skid	VP-#	VP-2
Variable Air Volume Controller (Exhaust)	EVAV-AS-#	EVAV-310-6
Variable Air Volume Controller (Return)	RVAV-AS-#	RVAV-310-6

Table 3: Electrical

ELECTRICAL

All electrical equipment names should also include the 'building information' then 'equipment information' in the string as follows:

BLDG NAME: **36**
BLDG ROOM: **029E**
BLDG SYSTEM: **'E' EMERGENCY, ' ' NORMAL, 'OS' OPTIONAL STANDBY, 'LR' LEGALLY REQUIRED**
BLDG EQUIPMENT: **'DP' DISTRIBUTION PANEL, 'P' PANEL, 'DS' DISCONNECT, 'XFMR' TRANSFORMER, ETC**
SYSTEM VOLTAGE: **'4' 480/277V, '2' 208/120V**
 # NUMBER IN SERIES: **1, 2, 3…**
'#' LETTER IN SERIES: **A,B,C… DO NOT USE *E, I O***

Example: A second 208V Distribution Panel, in Building 36, Rm 029E would be: '36-029E-DP23'

Table 3: Electrical Unit ID

Equipment Description	Unit ID	Example
Distribution Panel: Normal Power	BLDG-RM-DPV#	36-029E-DP23
Distribution Panel: Legally Required Power	BLDG-RM- LRDPV#	36-029E- LRDP42
Distribution Panel: Emergency Power	BLDG-RM-EDPV#	36-029E-EDP21
Electrical Power Transformer	BLDG-RM-XFMR-#	36-029E-XFMR-2
Electrical Switch (G&W Switches)	BLDG-RM-G&W'#'	36-029E-G&W-A, 36-

		029E-G&W-36-B, etc
Generator	BLDG-RM/ROOF-GENV	36-ROOF-GEN4
Heat Trace (Panel)	BLDG-RM-HT-V#	36-029E-HT-21
Meter Electric	BLDG-RM-ME-“EQUIPMENT NAME”	36-029E-ME-36-029E-DP23
Motor Control Center	BLDG-RM-MCCV#	36-029E-MCC4
Panelboard Branch Circuit	BLDG-RM-PV#	36-029E-P23
Substation	BLDG-RM-MSWGR‘V#’ or BLDG-RM-MSWBD‘V#’	36-029E-MSWGR4A Or 36-029E-MSWGR4A
Variable Frequency Drive	* BLDG-RM-VFD-EQUIP	36-029E-VFD-AHU-1

V= VOLTAGE IN NAMING: 4=480/277V, 2=208/120V
‘#’ INDICATES A LETTER SEQUENCE

5. PRODUCTS

5.1 General Requirements

All plumbing products shall be Massachusetts approved. Refer to contract requirements to verify if the “Buy American Act” applies.

Refer to 248 CMR, Section 10.15 (10) Table 5 for determine the capacity of sewage ejectors.

Provide stainless steel variable frequency drive hot water circulators.

5.2 Fixtures and Equipment

All plumbing products shall be Massachusetts approved. Refer to contract requirements to verify if the “Buy American Act” applies.

Refer to 248 CMR, Section 10.15 (10) Table 5 for determine the capacity of sewage ejectors.

Provide stainless steel variable frequency drive hot water circulators.

Provide piping and isolation shut-off valves with unions or flanges at all equipment connections arranged to allow removal of the equipment without dismantling piping.

Provide equipment clearance per manufacturer recommendations. Provide minimum 2 feet clearance all around equipment.

5.3 Preferred Manufacturers

Item	Preferred Manufacturers
TOILET ROOMS	
Lavatories	American Standard
Lavatory Faucets	TOTO Sloan Chicago Symmons (Commercial Grade for Housing) Delta (Commercial Grade for Housing)
Hose Bibs	Watts Chicago T & S Brass
Shower Units	Best Bath
Shower Valves	Symmons Safety Mix
Water Closets	TOTO Sloan
Urinals	TOTO Sloan
Flush Valves	TOTO EcoPower Sloan Solar Power
Supplies and Stops	McGuire Manufacturing
Shower and Toilet Room Floor Drains	J. R. Smith Zurn Watts
SINKS	
Janitor Sink Basins	Fiat Terrazzo
Janitor Sink Faucets	Chicago

Kitchen Sink	Just Elkay
Kitchen Sink Faucets	Chicago Symmons (Commercial Grade for Housing)
EQUIPMENT	
Drinking Fountains	Elkay Oasis Halsey Taylor
Floor Drains, Roof Drains, Area Drains, Planter Drains	J. R. Smith Watts Josam Zurn
Wall Hydrants	J. R. Smith Josam Zurn Watts
Grease Traps	Guardians Schier-Great Basin Zurn Rockford
Gas and Sand Interceptors	Rockford
Pipe Markers	Seton “Setmark”
Emergency Showers/Eyewashes	Guardian Speakman Haws Water Saver
Insulation	Owens Corning Manville Certain-Teed
Backflow Preventers	Watts
Pressure and Temperature Gauges	Ashcroft U.S. Gauge Trerice
Booster Pumps	Synchhroflo Grundfos VC System & Controls
Sewage Ejectors	Weil Zoeller
Sump Pumps	Weil

	Zoeller
WATER HEATERS	
Water Heater Steam	Patterson-Kelly Armstrong
Gas Water Heaters	Patterson-Kelly Aerco Lochinvar
Electric Water Heaters	A.O. Smith Hubbell Bosch (point of use)
VALVES	
Tempering Valves	Leonard Lawler Powers
Emergency Shower Valves	Leonard Lawler Powers
Ball Valves	Apollo (Conbraco) Watts
Gate, Butterfly and Check Valves	Nibco Stockham Milwaukee Victaulic
Thermostatic Mixing Valves	Lawler Leonard Powers Armstrong Watts
WATER METERS	
Services 2 inch or less	Refer to MIT Utilities Water Meter Specification
Services 2 inch or larger	Refer to MIT Utilities Water Meter Specification
Irrigation (non-sewer)	Refer to MIT Utilities Water Meter Specification

5.4 Pipe, Fittings and Valves

Soil, Waste, Vent and Storm Systems:

1. Buried piping:

    a. Epoxy coated service weight hub and spigot cast iron drainage piping in accordance with ASTM A75. Gasket in accordance with ASTM C564.
    b. Buried piping 10 feet or more below elevation of high water table: Ductile iron Class 56 with push-on joints.

2. Above-ground piping:

    a. Epoxy coated, hubless, cast iron drainage piping in compliance with ASTM A888, CISDI 301. Coating specification and testing in compliance with EN 877. Extra HD couplings in compliance with ASTM C1277 and ASTM C1540.
    b. Waste and vent piping 3 inches and smaller: Standard weight galvanized steel pipe with galvanized cast-iron drainage fittings or Hub-less cast-iron pipe and fittings or Type "L" copper with cast brass drainage fittings and solder joints.
    c. Vent Piping: Epoxy hub-less cast iron pipe and fittings or standard-weight galvanized steel pipe with galvanized cast-iron drainage fittings.

3. Hubless Piping Couplings:

    a. Heavy-Duty Couplings: ASTM C 1540 heavy-duty stainless steel hubless piping couplings equal to Anaco Husky Series 4000, Tyler Wide-Body, Mission Heavyweight C-series or Clamp-All.
    b. 1-1/2 inches to 4 inches in size: 4 bands.
    c. 5 inches and larger in size: 6 bands.
    d. Regular-Duty Couplings: CISPI couplings may be used on vent piping and 3-inch and smaller waste branches.

Garage Waste Piping:

1. Refer to waste and vent piping.

Pumped Waste Discharge, (Force Main): For storm or sanitary piping systems:

1. Above Grade: Standard weight galvanized steel pipe with threaded or mechanical couplings joints with galvanized cast iron drainage fittings.

2. Buried: Class 52 cement-lined ductile iron pipe and fittings with push-on joints.

Indirect Waste Piping:

1. Galvanized Schedule 40 ASTM A53 steel pipe with galvanized malleable iron fittings.

2. Type "L" copper with sweated connections.

3. Exposed -1/2 inches and smaller: chrome plated brass, threaded connections and fittings.

Under Slab and Foundation Drainage:

1. PVC Schedule 40 perforated piping with sealed joints.

Cooling Tower Waste:

1. From the drain receptor down to the point of connection to the sanitary stack. Standard weight galvanized steel pipe with threaded or mechanical couplings joints with galvanized cast iron drainage fittings.

Laboratory Waste and Vent Pipe and Fittings

1. Manufacturers:
   a. Enfield,
   b. Asahi,
   c. Orion,

2. Pipe: Fire retardant polypropylene, ASTM F 1412, Schedule 40.

3. Fittings: Identical to pipe material. Molded fittings per ASTM D 3311. Schedule 40. Heat fusion socket assembly. DWV pattern complying with ASTM D 3311.

4. Joint: Heat fusion method in accordance with ASTM-2657 and manufacturer's written instructions.

5. Flange: Fire retardant polypropylene, ASTM F-1412. ANSI/B16.5 Class 150 dimensions. Cast 316 Austinitic stainless steel backer ring. EPDM gasket.

6. Sink waste and trap fittings: Mechanical joints.

7. Do NOT use this pipe material or fittings for pressurized service (force mains).

Laboratory Waste Force Main

1. Pipe: High Density Polyethylene (HDPE) as defined in ASTM D 1248. ASTM F 714, ASTM D 3035 or ASTM D 2447. Thermoplastic extrusion. Cell Classification: 345464E per ASTM D 3350 or substantially similar. SDR 11 (Schedule 80). 3200 psi (24 MPa) yield-strength. Comply with ASTM D1598 using ASTM D 638 test methods. Pressure Rating: 160 psig at 73ºF. 100 psig at 125ºF. Marking: As described in ASTM D 3350.

2. Fittings: Identical to pipe material. Molded fittings per ASTM D 3261. SDR 11 (Schedule 80). Fittings may be field or shop fabricated following ASTM D 3261 procedures. 45 degree miter and 45 degree lateral only. Butt fusion end connections. Socket fusion end connections only for connections in field not possible with butt fusion equipment.

3. Joint: Butt fusion methods in accordance with ASTM D 3261. Threaded or solvent bonding of polyethylene materials is forbidden.

4. Flange: Fabricated or molded butt end flange adapter, SDR 11. Backer ring: ANSI/B16.5 Class 150 dimensions. Cast 316 Austinitic stainless steel. Gasket: EPDM, 0.06" thickness. Pressure Rating: Not less than 125 psig at 73ºF.

5. Flexible Couplings: Elastomer bellows with PTFE lining. Flanged connections. Pressure Rating: 225 psig, 26 inHg(vac) at 170ºF. Retaining Rods: All threaded rod, 316 stainless steel.

6. Ball Valves: For 3 inch and smaller. Polypropylene body, Viton seals, flanged or union end connections.

7. Butterfly Valves: 4 inch and larger: Wafer style. Polypropylene body and disc, Viton seals.

8. Check Valves: Wye-pattern for 3 inch and smaller. Swing check for 4 inch and larger. PVC body. Viton gaskets. Flanged end connections.

9. Piping shall be continuously supported in V-channel with V-channel clevis hangers every 5 feet on center.

Water Systems, Potable and Non-Potable:

1. Above ground piping, 2 inches and smaller:

   Polypropylene (PP-RCT) Requirements: Pipe shall be manufactured from a PP-RCT resin meeting the short term properties and long term strength requirements of ASTM F2389 and CSA B137.11. The pipe shall not contain reworked or recycled materials. All pipe is to be made in an extrusion process with longitudinal color stripes extruded on the exterior of the piping. The piping shall be extruded with a middle layer that has glass fiber content to restrict thermal expansion. All pipe shall comply with the rated pressure requirements of ASTM F2389 and CSA B137.11. Pipe and fittings shall be covered by a factory warranty for 30 years to be free of defects in materials or manufacturing. For hot water and hot water return systems provide SDR 7.3. For cold water systems provide SDR7.3 for pipe sizes 1/2 and 3/4 inch. Provide SDR 9.0 for pipe size 1 inch. Provide SDR 11.0 for pipe sizes 1-1/4 inch and larger.

   MIT is experiencing accelerated levels of corrosion in brass shut off valves and check valves that significantly shortens the life expectancy. The corrosion is caused by dezincification of high content zinc brass alloys.

   Dezincification typically occurs in alloys which contain more than 15% zinc. It is the selective removal of zinc from a brass alloy, leaving behind a porous copper-rich structure that has little mechanical strength. Accelerated degradation occurs with water high in chloride ions, water that is highly aerated with low rates of flow and relatively high water temperatures.

Dezincification leaves a white colored deposit on both the outside and the inside of the plumbing fitting and could ultimately lead to a failure of the fitting. As a result of this issue, brass valves are not approved for installation on the MIT campus.

Ball Valves: All bronze, lead-free, full port. Bronze valves must be specified and zinc content must not exceed 10% by weight.

Ball valves shall be Viega model 2971.3 ZL or 2970.3ZL
or:
Apollo 77CLF-A series with Viega model 2911ZL bronze transition piece (thread x press)
or:
Watts LFB6081 with Viega model 2911ZL bronze transition piece (thread x press)

Check Valves: Lead-free bronze body and clapper, solder ends, 200 WOG. Equal to Nibco S-413-Y-LF or Apollo 61Y.

Balancing Valves: Lead free bronze, PTFE seats, EPDM O-ring, solder end connections. 125 psig WOG. Equal to Nibco S-1810-LF, Circuit Solver, or Viega model 2981.3ZL with temperature port model 2934.8ZL and bimetallic thermometer model 2876.8US. Valve shall be insulated with Viega insulation shell model 2910.510.

Drain Valves: Lead free bronze, 2 piece, RPTFE seats, thread x solder end connections. 600 psig WOG. Hose thread adapter with cap and chain. Equal to Nibco 66-LF-HC.

2. Above ground piping, 2 -1/2 inches and larger:

Hard drawn ASTM B 88, Type L copper pipe with ASME B16.22 wrought copper fittings. ASTM B 32 solder filler material, 95-5 lead-free solder joints or:

Ductile iron coupling with copper alkyd enamel paint coating, ASTM A 536. Grade "EHP" EPDM elastomer gasket, ASTM D 2000. Equal to Victaulic Style 607 coupling. ASTM B 75, B 152 or B 16.22 copper alloy fittings. UNS C89836 or C92200 grooved end cast bronze fittings. Or:

Viega "Pro-Press."

Mechanical Joints: ANSI Class 150 flange adaptor equal to Victaulic Style 641 for connections to flanged equipment or valves. ANSI B16.1 dimensions.

Polypropylene (PP-RCT) Requirements: Pipe shall be manufactured from a PP-RCT resin meeting the short term properties and long term strength requirements of ASTM F2389 and CSA B137.11. The pipe shall not contain reworked or recycled materials. All pipe is to be made in an extrusion process with longitudinal color stripes extruded on the exterior of the piping. The piping shall be extruded with a middle layer that has glass fiber content to restrict thermal expansion. All pipe shall comply with the rated pressure requirements of ASTM F2389 and CSA B137.11. Pipe and fittings shall be covered by a factory warranty for 30 years to be free of defects in materials or manufacturing. For hot

water and hot water return systems provide SDR 7.3. For cold water systems provide SDR 11.0.

Ball Valves:

Brass ball valves are not approved for installation on the MIT campus.

Apollo 77CLF-A series with Viega model 2911ZL bronze transition piece (thread x press) - for 2-1/2 inch size only

or:

Watts LFB6081 with Viega model 2911ZL bronze transition piece (thread x press) - for 2 ½ inch size only

or:

Class 125, cast iron body, epoxy coated. Full port, flanged with stainless steel ball and stem and lead-free construction. ANSI B16.1 flange dimensions. Apollo Model 6PLF, American Valve Model 3700 and Watts Series G4000-FDA valves are acceptable products.

3. Buried piping, 3 inches and smaller:

   Type K annealed (soft) copper with wrought copper fittings and brazed connections.

4. Buried piping, sizes 4 inches and larger:

   Class 56 cement-lined ductile iron pipe and fittings with restrained mechanical joints.

5. Disinfection Chemicals: Hypochlorite: Fed. Spec. 0-C-114, or Fed. Spec. O-S-602, grade B.

6. Piping in inaccessible shafts and other concealed spaces:

   Shall be Pro-Press, welded or soldered joints. No bolted mechanical couplings are permitted.

Reclaim Water Piping

1. Pigmented ASTM F 2389 and CSA B137.11 polypropylene-random copolymer (PP-R) piping, SDR 11. NSF 14 certified. Equal to Aquatherm “Lilac” purple pipe or Niron purple with heat-fusion fittings.

Trap Primer Piping:

1. Buried: Type K, soft copper with wrought copper fittings and soldered joints with no buried joints. Install Armaflex closed cell neoprene insulation on buried copper tubing.
2. Above Grade: Type L, soft copper with wrought copper fittings and soldered joints

Natural Gas and Gas Train Vent

1. Pipe:

   2” and smaller: Schedule 40 black steel pipe with malleable iron screwed fittings.

   2.5” and larger: Schedule 40 black steel pipe with welded joints.

   Piping systems over 0.5 PSI: Schedule 40 black steel pipe with welded joints.

   Exterior exposed above grade including within parking garages: Polymer coated, schedule 40 black steel pipe and fittings with welded joints.

   Exterior buried: Polyethylene gas pipe and fittings in conformance with ASTM D2513 identified as “gas and ASTM D2513”. Provide electronically detectable yellow warning tape equal to Terra Tape identified as “Gas Piping Below” buried 12 inches to 15 inches above piping.

2. Nipples: ASTM A733, black steel, Schedule 40.

3. Fittings:

   2” and Smaller: Threaded. ANSI/ASME B16.3, Class 150. Malleable iron, standard pattern. ANSI/ASME B1.20.1 threads with approved pipe dope or Viega Megapress

   2-1/2” and Larger or Greater than 0.5 (14” w.c.) Pressure: Welded or flanged. ASTM A 234/A 234M for butt welding and socket welding. ANSI/ASME B16.9. AWS D10.12/D10.12M for welding materials.

4. Unions:

   2” and Smaller: Malleable iron. ASTM A182. Class 150.
   3” and Larger: Use flange.

5. Flanges:

   3” and Larger: ANSI/ASME B16.1, Class 150 flange. ANSI/ASME B16.20 gaskets.

6. Ball Valves:

   2” and Smaller: All bronze ASTM B 584, one piece, standard port, RPTFE seats, threaded end connections per ASME B1.20.1. Blowout proof stem design. Chrome plated ball. Steel tee handle. 600 psig CWP. WOG indicated on body. UL-listed for natural gas service. Fed Spec WW-V-35C, Type II, Composition BZ, Style 3. Apollo 70-100-07 series or approved equal.

   3” and Larger: Use Plug

7. Plug Valves:

2” and Smaller: All bronze ASTM B 584 or iron, bronze plug, threaded end connections per ASME B1.20.1. WOG indicated on body. UL-listed for natural gas service. A. Y. McDonald Mfg. Co. or approved equal.

3” and Larger: Cast iron ASTM A 126, Class B. Bronze plug, flanged end connections, WOG indicated on body. Square head or lug type, tamperproof. A. Y. McDonald Mfg. Co. or approved equal

8. Dielectric Fittings: Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials. 150 psig minimum operating pressure.

9. Coating, Exterior Piping: Shop applied pipe coating shall be adhesive-thermoplastic resin coating (Fed Spec L-C-530, Type I), thermosetting epoxy coating (Fed Spec L-C-530, Type II), or field applied for repairing damaged areas (Fed Spec L-T-1512, Type I), 10 mil nominal thickness for pipe joints and 20 mil nominal thickness for coating repairs.

10. Exterior buried: Polyethylene gas pipe and fittings in conformance with ASTM D 2513 identified as “Gas” and “ASTM D 2513”. Provide electronically detectable yellow warning tape equal to Terra Tape identified as “Gas Piping Below” buried 12 inches to 15 inches above piping.

Purified Water Piping System:

1. Pretreatment, from RPZ outlet to RO skid pump suction:

   Pipe: Chlorinated Polyvinylchloride (CPVC), Type I manufactured per ASTM D 1784. Schedule 80.

   Fittings: CPVC complying with ASTM F 439. Socket or threaded.

   Joints: ASTM D 2564 solvent cementing per ASTM D 2855 standard procedures. Use ASTM F 656 primers.

   Flange: ANSI B16.5, Class 150 pattern of identical pipe material.

   Ball Valves: CPVC, Type 1, ASTM D 1784 body and ball. PTFE seats and Viton O-rings. Standard ‘T” operating handle. Union or solvent cemented socket end connections. Blow-out proof stem. Equal to Georg Fischer Type 546.

   Check Valves: CPVC, Type 1, ASTM D 1784 body and check cone. PTFE seats and stainless steel spring. Body to be capable of being installed in any position. Union or solvent cemented socket end connections. Equal to Georg Fischer Type 562.

2. RO permeate through supply and return distribution:

Pipe: Type II copolymer, virgin and unpigmented polypropylene manufactured per ASTM D 4101, Schedule 40 for 2 inch and smaller. Schedule 80 for 3 inch and larger by IPEX/ENPURE high purity water systems. Products by Georg Fischer (+GF+) are not acceptable.

Fittings: Same material as pipe with bead and crevice free (BCF) fusion joints of the same manufacturer.

Joints: Heat fusion. Comply with ASTM D 2657 procedures and manufacturer's written instructions. Use fusion joining equipment supplied by the pipe and fitting manufacturer. Fusion inserts and prefabricated coil fittings are prohibited.

Flange: ANSI B16.5 Class 150 pattern of same material with stainless steel backer rings. For connection to flanged nozzles and equipment. EPDM elastomeric gasket equal to Garlok Style 370, FDA compliant ingredients.

Diaphragm Valves: Type II copolymer, virgin and unpigmented polypropylene body and bonnet manufactured per ASTM D 4101. PTFE diaphragm.

Pressure Reducing Valves: Type II copolymer, virgin and unpigmented polypropylene body manufactured per ASTM D 4101. PTFE diaphragm. Spigot end connections. Equal to Plast-O-Matic.

Pressure Reducing Valves: Type II copolymer, virgin and unpigmented polypropylene body manufactured per ASTM D 4101. PTFE diaphragm. Spigot end connections. Equal to Georg Fischer PROGEF Type V86.

Laboratory Gas Piping, Fittings and Valves

High Purity Copper Tube

Applies to concealed piping for general service laboratory gases requiring high chemical purity but not sensitive to small levels of particulates.. Representative gases include:

Laboratory Air
Laboratory Vacuum
Argon
Carbon Dioxide
Helium
Hydrogen
Nitrogen
Oxygen

1. Tube: Seamless copper tube, medical oxygen grade, drawn temper, Type L. ASTM B 819. Include standard color marking "OXY," "MED," or "OXY/MED" in blue for Type L tube. ACR tubing is not permitted.

2. Fittings:

1/8” to 1/2”: Copper Alloy barstock, treaded joints. ASTM B16, ASTM B453. Swagelok or equal.

1/2” and larger: Wrought copper, solder-joint. ASME B16.22.

3. Joints:

   1/8” to 1/2”: Threaded. ISO 7/1, DIN 2999, BSP TR, and JIS B0203 for tapered pipe threads.

   1/2” and larger: ANSI/AWS A5.8 brazing filler material, BCuP series. No flux.

4. Mechanical Joints:

   1/2” to 2”: Cast copper alloy unions, hexagonal stock with ball-and-socket joint, solder joint ends. ASME B16.18.

   3” and larger: ANSI Class 150 flange, ASME B16.24. ANSI B16.1 flange dimensions.

5. Snubbers: Brass body snubber fitting, 316 stainless steel sleeve. Porous sintered stainless steel element. Cajon or approved equal.

6. Needle Valve: For 1/8” to 1/2". Brass body, 316 SS packing gland, stem and seat, PFA packing. Phenoloc handle. Whitey 0, 1, or 18 series.

7. Ball Valves:

   1/8”: Nickel-copper alloy body, ball and stem, ASTM B164. Viton o-rings. Whitey 60 series or equal.

   3/8” and larger: All bronze, 3 piece, full port, PTFE seats, stainless steel ball, solder end connections. 600 psig WOG. Apollo 82-200-57, Watts B-6801.

8. Check Valves:

   1/8” to 1/2”: Brass body and poppet, BUNA-N elastomeric O-ring and PTFE-coated aluminum gasket. Stainless steel spring. Whitey 4C or equal.

   1/2” to 2”: Class 125, bronze body, bronze disc, solder end connections. Milwaukee 1509, Jenkins 4093, Stockham B-309.

   2 1/2” and larger: Class 125, cast iron body, bronze disc, flanged end connections. ANSI B16.1 flange dimensions. Milwaukee F-2974.

9. Purge Valves: Brass body with stainless steel poppet, ball and spring. Whitey P Series or equal.

10. Excess Flow: 316SS body, ASTM A479. Whitey XS series or equal.

11. Valves shall be by a single manufacturer. : Valves, fittings, components and each length of tube shall be factory cleaned and suitable for oxygen service in accordance with CGA Pamphlet G-4.1 and ASTM G93 Level C. They shall be permanently labeled and delivered plugged, capped, bagged or otherwise sealed. Plugs caps or other seals shall remain in place until final assembly. Plugs caps or other seals shall remain in place until final assembly.

12. Brazers shall be qualified in accordance with the requirements of NFPA 99. Joints and piping shall be continuously purged with a positive flow of Grade M, CGA Pamphlet G-10.1 oil-free, dry nitrogen per ANSI/AWS B2.2 and NFPA 99 procedures.

13. Valves and other lubricated components shall use non-hydrocarbon lubricants.

14. Line Pressure Regulator: Bronze body, bronze piston and cylinder. BUNA-N seat elastomer disc and stack. Cash Acme B Series with wheel handle.

15. Point of Use Regulator: Bronze body, stainless steel piston and cylinder. Equal to Concoa Series 400.

16. Source Quality Assurance: Valves shall be by a single manufacturer. Valves, fittings, components and each length of tube shall be factory cleaned per the applicable pipe standard. They shall be permanently labeled and delivered plugged, capped, bagged or otherwise sealed. Plugs caps or other seals shall remain in place until final assembly.

17. Joints and piping shall be continuously purged with a positive flow of Grade M, CGA Pamphlet G-10.1 oil-free, dry nitrogen per ANSI/AWS B2.2 procedures.

High Purity Stainless Steel Tube

Applies to high purity gases requiring very low to zero particulate content. Also used for exposed piping on walls or to ceiling mounted outlets/equipment. Also used for gas tubing down stream of local sub-micron filtration or locally/bench generated gases. Representative gases include:

Argon
Helium
Hydrogen
Nitrogen
Oxygen
Methane and other Flammables
Anhydrous Ammonia and other noxious/irritants
Pyrophorics

1. Tube: AISI 316L austenitic stainless steel, ASTM A 269. Comply with applicable requirements of ASTM A 450. UNS S31603 alloy. Welded seam by TIG weld process. Heat treated per ASTM A 269. Tube wall thickness as follows:
    a. 1/8 inch – 0.028 in (0.71 mm).
    b. 1/4 inch to 3/4 in - 0.065 in (1.65mm)
    c. 1 inch – 0.083 in (2.11 mm)
    d. -1/4 inch – 0.120 in (3.05 mm)
    e. 1-1/2 inch – 0.134 in (3.40 mm)
    f. 2 inch – 0.188 in (4.78 mm)

    ID Surface Finish: Mechanically polished to 240 grit (elecropolish to 20 Ra as required for higher purity applications as required by the User).
    OD Surface Finish: Bright annealed.
    Marking: Per ASTM A 450. Include "welded" and surface finish to marking.

2. Fittings: AISI 316L austenitic stainless steel, ASTM A 276 barstock equal to Swagelok tube fittings. ID and OD finished identical to tube. Stainless steel gaskets.

3. Weld: Tungsten inert gas (TIG) arc welding process with automatic orbital welding equipment. Comply with AWS procedures by certified personnel.

4. Ball Valve: AISI 316L stainless steel body, ASTM A 479. 240 grit mechanical polish wetted surface finish. Mill outer finish. 316L stainless steel bonnet and ball. Swagelok tube connector end connections or butt-welded with tube extensions. Equal to Whitey Series 80.

5. Check Valve: AISI 316L austenitic stainless steel body, ASTM A 479. 316L stainless steel PTFE coated gasket. 240 grit mechanical polish wetted surface finish. Mill outer finish. Swagelok tube connector end connections or butt-welded with tube extensions. Equal to Swagelok CA series.

6. Snubber: AISI 316L stainless steel body, ASTM A 479 with 316 stainless steel sleeve. Porous sintered stainless steel element. Equal to Cajon.

7. Filter: AISI 316L austenitic stainless steel housing with sintered nickel membrane. Wetted surface electropolished to 5 Ra. >=0.003 micron removal rating. Equal to Mykrolis (Millipore) Waferguard III NF-750 partical retention gas filter.

8. Manufacturer Cleaning and Passivation: Clean and descale tube and parts per ASTM A 380. Passivate tube and parts in citric acid solution and test for free iron per ASTM A 967. Rinse with 18 megOhm deionized water and dry with filtered, oil-free dry compressed air or nitrogen.

9. Manufacturer Packaging: Package in vacuum-sealed inner bags to protect the fitting from contamination caused by fitting movement and to prevent it from cutting the bag. Do not use lubricants on wetted components. Cover end connections of each assembled valve and tube to prevent contamination during shipment. Individually box each double bagged part.

10. Methane and other Flammables, Anhydrous Ammonia and other noxious/irritants, Pyrophorics shall be piped in coaxial stainless steel tubing with vacuum monitoring. Any service valves outside of cylinder cabinets shall be enclosed in ventilated valve cabinets.

5.5 Insulation

1. Manufacturers

   Johns Manville; Micro-Lok.
   Knauf Insulation.
   Manson Insulation Inc.
   Owens Corning; Fiberglas Pipe Insulation.
   Approved equal.

3. Mineral fiber, preformed pipe insulation. Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A with factory applied all-service jacket (ASJ-SSL) with white kraft paper with integral vapor barrier and self-sealing lap. Pre-cut fiberglass inserts with molded PVC covers secured with glass fabric tape. Maximum thermal conductivity of 0.29 BTU/in x ft^2 x ºF.

4. Fire Safety: Insulating materials as described above or approved equal materials shall meet Fire and Smoke Hazard Classification ratings on a COMPOSITE basis in accordance with NFPA 155 and UL 723. These products shall not exceed a flame spread and developed smoke rating minimum. Fitting covers shall not exceed maximum toxicity ratings.

5. Insulation Jacket, Exterior, Exposed

   Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

   a. Sheet and roll stock ready for shop or field sizing.
   b. Type 304, smooth 2B finish with Z-shaped locking seam. 0.024 inch (0.61 mm) thick.
   c. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
   d. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.

8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

5.6 Heat Tracing

1. Manufacturers:

   BH Thermal Corporation,
   Delta-Therm Corporation,
   Raychem,
   Tyco
   Approved equal.

2. Freeze Protection:

   Self-Regulating, Parallel-Resistance Heating Cables

   a. Heating Element: Pair of parallel No. 16 AWG, nickel-coated stranded copper bus wires embedded in cross-linked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled non-heating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

   b. Electrical Insulating Jacket: Flame-retardant polyolefin.

   c. Cable Cover: Tinned-copper braid, and polyolefin outer jacket with UV inhibitor.

   d. NEMA 4X connection kits for power, splice/tee and end seals.

   e. High temperature, glass filament tape for attachment of cable to piping. Cable ties are prohibited.

   f. Provide warning labels every 10 feet on exterior of insulation on opposite sides of the pipe.

3. Controller

   Single circuit logical digital controller with ground-fault protection. NEMA 4X enclosure of fiberglass reinforced plastic (FRP). 120 VAC supply voltage. Built-in self-test function. Alarm relay for connection to BMS to indicate temperature, ground-fault, current draw high, power loss.

4. Basis of Design: Raychem XL-Trace heating cable with RayClic connection kits and DigiTrace 910 (series) digital controller.

5. Temperature Maintenance, Service hot water.

   Not permitted. Provide mechanical circulation.

6. Provide label "Heat Trace" on insulation cover..

6. GREEN DESIGN

6.1 Reclaimed Water

Reclaimed water shall include:

1. Whenever practical and economical, consideration shall be given to collecting storm water for recycled use as irrigation water or toilet flushing.
2. Reverse osmosis (RO) reject water shall be reclaimed whenever possible to be used as irrigation, toilet flushing or non-potable water.
3. Reclaimed water systems shall not be employed in childcare facilities.
4. Reclaimed water systems shall comply with 248 CMR.

For new construction and substantial renovations, pipe water closets, urinals, process equipment and other non-potable water uses in reclaimed water piping (e.g. Aquatherm Lilac) whether or not reclaimed water is to be collected. The pre-separated system will allow for future reclaimed water system(s) to be installed without further disturbance to the building distribution.

6.2 Sustainable Design Strategies

Additional sustainable design strategies include:

1. Low flow consumption fixtures (i.e. EPA Watersense).
2. Controlled flow roof drainage.

7. OPERATIONS

Not issed.

8. ENVIRONMENTAL HEALTH AND SAFETY

Water Labeling: Refer to pipe identification above.

Emergency Shower and Eyewash Systems: Consult with M.I.T. Emergency Health and Safety (EHS) for the location of all emergency first aid equipment including emergency eyewashes and showers.

9. INSTITUTE SPACES

Not issued.

10. LABORATORY SERVICES

10.1 Water

Hot and cold water to laboratory sinks and equipment shall be supplied from central, duplexed reduced pressure backflow preventers after the containment backflow preventers at the water service entrance and distributed as a parallel (separated) piping system. In existing buildings where a separated water system is not provided, local RPZ's may be considered on a case-by-case basis or separation of the building will be required.

Laboratory hot water shall be generated by a dedicated set of water heaters supplied protected water from the backflow preventers.

Laboratory faucets shall be specified with integral spout vacuum breakers. Provide the appropriate level of backflow prevention at equipment connections.

10.2 Laboratory Water and Vent

Laboratory waste shall be collected by a dedicated waste and vent system. Pipe materials shall be as specified above.

Provide "V" channel between hangers to continuously support HDPE force main piping to prevent sagging.

Provide mechanical joints for laboratory sink waste and trap.

10.3 Laboratory Compressed Air

Laboratory compressed air systems shall not be used to serve utility equipment, such as pneumatic doors, HVAC controls, etc.

Design compressed air equipment and piping distribution to deliver 45 to 50 psig at the most remote outlet(s) with a distribution pressure drop not to exceed 5 psi. Add 25% to calculated peak flow to allow for future expansion. Use 1 scfm per laboratory outlet and apply the following diversity factors for sizing distribution piping. Note that the table below includes a 25% increase in load to accommodate future expansion.

Laboratory Air Diversity Factors

Number of Outlets	Diversity Factor
1-3	1.0
4-7	0.80
8-13	0.66
14-25	0.40
26-63	0.30
64 and up	0.20

Equipment shall be located with adequate access space for regular monitoring and servicing. Provide floor drain adjacent to equipment pads.

Compressed air quality delivered to laboratory users shall meet or exceed ISO 8573-1:2010 Class 2 for particulates, Class 2 for moisture (-40ºF dewpoint), and Class 1 for oil/hydrocarbon. Where central/plant compressed air is not available (either physically or in capacity), provide multi-plexed oil-free compressors. Whether plant air is used or local compressors are used, include an appropriately sized air receiver, auto-regenerative desiccant dryers, and final sub-micron particulate filters.

Locate air compressor system intake for breathing air systems outdoors above roof level. The air intake may extend through exterior wall and terminate below roof level when approved by MIT EHS. Air compressor system intake terminals shall be located at least 25 feet (may require more depending upon prevailing wind direction and velocity) from all exhausts, vents, vacuum system discharges or any anticipated source of odor or particulate matter. Air that is filtered for breathable ventilation system use may be considered an acceptable source of intake air when approved by MIT EHS. Combined air intakes must be sized for no restriction while flowing maximum intake possible, and shall be provided with an isolation valve at the header for each compressor served. Intake piping for air compressors shall be sized using the total SCFM for the system (both lead and lag pumps) and the total developed length of run. Coordinate with air compressor system technical representative and verify that proposed sizing of intake piping complies with manufacturer's recommendations.

Laboratory air compressors shall be multiplexed with receiver tanks and sized such that 100 percent of the design load is carried with the largest single unit out of service. Increase the calculated (SCFM) load by 25 percent to accommodate future system expansion.

Design air dryers, filters and pressure regulators for the laboratory air system in duplex, each sized for 100 percent of the load using duplex twin tower desiccant dryers. Include continuous line

dewpoint and carbon monoxide (as required) monitoring with sample connections on the discharge piping downstream of the filters and regulators. Locate monitors at, or integral with, the control panel.

10.4 Laboratory Vacuum

Design vacuum source equipment and piping distribution to deliver 19 inches Hg vacuum level at the most remote inlet(s) with a distribution pressure drop not to exceed 5 inches Hg. Add 25% to calculated peak flow to allow for future expansion. Use 1 scfm per laboratory inlet and apply the following diversity factors for sizing distribution piping. Note that the table below includes a 25% increase in load to accommodate future expansion.

Laboratory Vacuum Diversity Factors

Number of Outlets	Diversity Factor
1-3	1.0
4-7	0.80
8-13	0.66
14-25	0.35
26 and up	0.25

Equipment shall be located with adequate access space for regular monitoring and servicing. Provide floor drain adjacent to equipment pads. Floor drains serving vacuum pumps shall be provided with smooth, acid resistant interior coating. Provide a hose bib within the mechanical room.

Terminate laboratory vacuum exhaust discharge outdoors above roof level. Exhaust may extend through exterior wall and terminate below roof level when approved by MIT EHS. Laboratory vacuum exhaust shall terminate at least 25 feet horizontally (may be more depending upon prevailing wind direction and velocity) from all air intakes, doors, windows, louvers or any other building openings. Combine exhaust from each laboratory vacuum pump into one discharge pipe, sized for no restriction while flowing maximum discharge possible, and shall be provide with an isolation valve at the header for each pump served. Exhaust piping for vacuum pumps shall be sized using the total SCFM for the system (both lead and lag pumps) and the total developed length of run. Exhaust piping shall be sized and arranged to prevent moisture and back-pressure from entering pump. Provide valved drip-leg at base of exhaust stacks. Coordinate with vacuum pump system technical representative and verify that proposed sizing of exhaust piping complies with manufacturer's recommendations.

Laboratory vacuum pumps shall be multiplexed with receiver tanks and sized such that 100 percent of the design load is carried with the largest single unit out of service. Increase the calculated (SCFM) load by 25 percent to accommodate future system expansion.

10.5 Natural Gas

Natural gas pressure to laboratory outlets shall be not less than 4 inches w.c. and not more than 7 inches w.c. Size distribution piping in accordance with accepted practices. Indicate on plans or riser diagrams the total equivalent length of piping to the most remote outlet(s) and the gas load for each intermediate section of piping back to the gas meter or regulator. Use the appropriate tables from NFPA 54 to determine pipe sizes based on diversified connected loads.

Use 5 CFH (MBH) per laboratory gas outlet with the following use diversity factors. Note that the table below incorporates a 25% increase to peak flows to accommodate future expansion.

Laboratory Gas Diversity Factors

Number of Outlets	Diversity	Maximum Diversity
1-7	1.0	-
8-13	0.75	1.0
14-25	0.60	0.90
26-88	0.40	0.75
89-188	0.30	0.56
189 and up	0.20	0.50

Laboratory gas outlets in rooms with pressurized gas outlets (e.g. compressed air, nitrogen, argon, etc.) shall have integral check valves provided to prevent back pressurization of the natural gas system.

Provide master gas shutoff valve cabinet outside of the laboratory doors.

10.6 Gas Detection

For laboratories gas detection level, refer to MIT EHS Gas Detection Guidelines and recommendation.

Ensure that appropriate gas detection monitors, controllers and alarm devices are installed in rooms with gas storage and gas use for occupant safety.

For oxygen displacement gases such as nitrogen, argon, helium, carbon dioxide, etc. provide oxygen sensors to alarm if oxygen levels fall below 19.5%. For gases heavier than air, provide sensors 10 to 12 inches above the floor as well as at the breathing zone.

For rooms with oxygen storage, provide oxygen sensor(s) to alarm if oxygen levels go above 22%.

For flammable gases, provide appropriate lower explosive limit (LEL) sensors both low and high as required.

Provide gas detection within ventilated gas safety cabinets.

10.7 Laboratory Gases

Provide two-stage pressure regulating manifolds for laboratory gases as required by space programming provided by the lab planner or architect. For systems requiring continuous and uninterrupted service, provide automatic switch-over manifolds.

Provide sufficiently sized, properly ventilated and constructed room for laboratory gas cylinder storage and manifold systems in accordance with NFPA 99. Coordinate with the designated MIT representative to determine space required for storage of additional non-manifolded cylinders. Gas cylinder storage rooms shall be located at ground level with at least one exterior wall and be provided with a minimum 42 inch door opening to the outside. Localized gas cylinder storage rooms may be provided at other locations within the building when approved by MIT.

Acceptable manufacturers for gas manifolds are Beacon Medaes, Linde, Concoa, Swagelok or approved equal by MIT.

10.8 Purified Water

1) MIT Water Quality for a Standard High Purity Water System (written around ASTM Type III:
    1) Resistivity: 4-10 MΩ (adjustable).
    2) Bacteria: <10 CFU/100 ml at system.
    3) TOC: <200 PPB.
    4) Sodium: <10 PPB.
    5) Chlorides: <10 PPB.
    6) Total Silica: <500 PPB.
    7) Particles: <0.1µ absolute rated (integrity tested).
    8) pH: N/A.
    9) Endotoxin: <0.25 EU 90% of the time. *If endotoxin is important to end users, add ultra-filtration to the design.*

2) Small System Exemption:
    1) This specification is not intended for all systems on campus.

a) Small system exemptions would include point-of-use production and small or specialized treatment systems (in lieu of a central high purity water system).
b) Small water exemptions shall be defined by MIT based on total number of outlets, total daily volume, new or emerging technologies, and/or specialized application.

3) Proposed Treatment Process:
   1) Multi-media filtration or self-cleaning in line filter shall be used on systems with > 10 GPM make-up.
   2) Water softening.
   3) Carbon filtration.
   4) Sediment filtration.
   5) Single or 2-pass reverse osmosis.
   6) Re-pressurization pump (N+1).
   7) UV Sterilization (N+1).
   8) Final filtration (N+1).
   9) Mixed bed deionization or EDI (side stream on storage).
   10) UV for TOC reduction (side stream on storage).
   11) Controls and monitoring.

   Note: All new high purity water systems shall include a concentrate reclaim system or provide rationale for its exclusion.

4) Process Calculations & Component Sizing:
   1) Process calculations and component sizing rationale shall be included in the Vendor's proposal.

5) Control and Monitoring Provisions:
   1) The production and distribution systems shall include automatic instrumentation, equipment, alarms, and sampling ports to facilitate the monitoring of performance parameters and the system. Control for large systems (as defined by MIT) shall be either by local Programmable Logic Controller (PLC) with integrated controls or by a local central PLC with interconnection to local component PLCs. Set point changes shall be keyed by individual user or supervisory passcode, and program changes shall be made only by an administrator. The PLC controllers shall have a minimum of two permission levels.
   2) The preferred PLC will be Allen Bradley / Rockwell Micrologix Platform.
   3) Minimum 6" HMI, grayscale or color acceptable.
   4) The cabinet shall be a NEMA 4X enclosure and will contain a disconnect switch that will be interlocked with the panel door.
   5) At a minimum, the panel door shall include HMI, E-Stop, red alarm light, audible alarm, and resistivity meter.
   6) The panel shall be UL Listed.
   7) Electrical drawings for design purposes shall be provided once project is awarded.

8) Electrical drawings for As-Built shall be included in the turnover package.

6) Minimum Instrumentation:
   1) Pressure Gauges:
      a) All pressure gauges shall be:
         i) Liquid filled (fill fluids shall be inert or FDA approved)
         ii) 1/4" or 1/2" MNPT
         iii) 2-1/2" face
         iv) 0-100 PSI
      b) All gauges in the polishing loop shall be 316 SS or bronze.
   2) Resistivity Meter:
      a) The system shall include an in-line resistivity meter with sensors located on the supply and the return lines.
      b) The meter shall be calibratable.
      c) The preferred meter is Mettler Toledo, Model M300 or M800.
         i) Signet and Myron-L are acceptable but will require 3-point calibration at start-up.

   3) Storage Tank Level Sensors:
      a) The preferred level sensors will be pressure transmitters.
      b) Tank level sensors shall be testable and adjustable without draining the storage tank.
      c) Non-contact sensors (liquid level pulse, radar, ultrasonic) should be designed for high purity, low conductivity water.
   4) Flow Meters:
      a) Acceptable flow meters are roto-meters or in-line paddle type.
      b) Materials of construction for this design will be polypro, PVDF, Polysulfone, 316 SS, PTFE, Teflon, Hastelloy
         i) CPVC is acceptable on pretreatment
      c) Approved gasket materials will be Viton, EPDM, PTFE, Teflon, and Silicone.
   5) Distribution Pump Instrumentation:
      a) Distribution pumps shall be furnished with individual pump status monitoring, typically included with the VFD.
      b) Minimum status: UNDER VOLTAGE, OVER VOLTAGE, RUN-DRY PROTECTION
      c) Provide full size by-pass with isolation valve on distribution pumps.

7) Control Valves (Pre-treatment):
   1. In an effort to better understand setup, troubleshooting, and service, Fleck valves as the preferred manufacturer.
   2. Softener valves larger than 1.0 cu.ft. shall be meter-initiated regeneration.
   3. Softener valves larger than 1.0 cu.ft. shall be set up for counter-current regeneration.
   4. Twin alternating softeners will be used if counter-current regeneration is not available.
   5. Single tank set-ups for softening and carbon filters shall include pre-treat RO lockout or "no hardwater bypass" to protect RO membranes.

8) Media Pressure Vessels:
    1) Any pressurized vessel larger than 16" x 65" shall be ASME stamped.
        a) Any pressurized vessel 16" x 65" or smaller shall meet the following minimum criteria:
            i) Maximum operating pressure of 150 PSI at 120 degrees F, minimum burst pressure of 600 PSI.
            ii) Tanks that are FRP shall meet NSF Standard 61 & 372 and have a safety factor of 4:1.
            iii) Media Bed Backwash and Startup Provisions:
            iv) Each individual deep media/resin bed, softener, and carbon unit shall be arranged with individual bypass valving, flush ports, and piping arrangements to facilitate flushing of particle fines, required regenerations, soak procedures, and other startup requirements as appropriate for media replacement or service exchange without damaging or disrupting system operation or passing particles to downstream components. Designs shall include sufficient freeboard and adequately sized supply arrangement for effective backwashing and shall not allow chloramines to reach the RO membrane(s). Backwash provisions may be omitted for service exchange systems, but individual soak provisions (for carbon beds), startup, and fines flushing arrangements are still required. Carbon bed backwash capacity shall be at least 490 lpm/m^2 (12 gpm/ft^2) bed cross sectional area and drains shall be adequately sized for backwash (or surge tank discharge). The level of automation will be dependent on the size of the system.
9) Hoses:
    1. Hoses shall be sized to insure at least the required velocity under flow conditions.
    2. Hose length shall be minimized and supported to eliminate kinks at 0 PSIG.
    3. Acceptable connectors styles are camlock, compression, sanitary, flanges and threaded fittings.
    4. All connectors larger than 1" shall be stainless steel.
    5. Hoses shall be manufactured from FDA approved materials, suitable for deionized and potable water.
    6. Hoses shall be burst rated at a minimum of 125 PSI at 70 degrees F.
    7. Approved gasket materials will be Viton, EPDM, PTFE, Teflon, and Silicone.

10) Pipe, Fittings, and Valves:
1) Head Unit:
    a) Pretreatment:
        i) Schedule 80 PVC / CPVC (ASTM D 3915) or copper pipe, fittings, and true-union ball valves. Solvent cement socket, Propress, or solder joints are acceptable joining methods. Must use low VOC solvent cement, primers, cleaners, accessories with PVC/CPVC.
        ii) Valve types: Valves on the feedwater side of the RO production may be ball-type, diaphragm, or butterfly
    b) Purified Water:
        i) IPEX Enpure or Georg Fischer Sch 80 pigmented polypropylene. Socket fusion, butt fusion, or IR are acceptable joining methods. All piping shall be properly supported with V-channel, clips, and hangers, to prevent sagging or drooping. Piping that is installed will be level or intentionally pitched for drain ability.

ii) There shall be minimal threaded connections in the purified water side of the system.
iii) Where threaded connections must be used, female plastic adapters are not permitted unless the fittings are metal banded.

c) Supply and Return Manifolds:
i) Include a flow meter and flow control on the return.
ii) Backpressure relief valves if used, shall include a pressure gauge and will match the piping material.

2) The supply and return manifold will be plumbed in such a way that the system (head unit) can recirculate water onto itself so to prevent a full sanitization if there is distribution work performed.
3) In-line conductivity cell on the common return line is required.
4) Sample port shall be installed on the common return line.
5) Valve types:
a) Valves on the Purified Water side shall be diaphragm type or sanitary butterfly style.
b) Zero static valves shall be supplied where necessary to comply with dead leg requirements.
6) Distribution:
a) Distribution piping shall be Sch 80 polypropylene, pigmented is preferred.
b) Socket fusion, butt fusion, or IR are acceptable joining methods.
i) All piping shall be properly supported with V-channel, clips, and hangers, to prevent sagging or drooping. Piping that is installed will be level or intentionally pitched for drainability.
c) Approved vendors are +Georg Fisher+, Asahi, Enpure.
7) Distribution piping must be installed in accordance with Massachusetts Pluming and Fire Codes.
8) Valve Types:
i) Valves in the distribution shall be diaphragm type.
ii) Zero static valves shall be supplied where necessary to comply with deadleg requirements.
iii) Subloops will be engineered for proper hydraulic balancing and will the following, at a minimum:
(1) Supply line shall consist of pressure indicator and regulator
(2) Return line shall consist of flow control and indicator
(3) System shall be pressure tested at 150% of design operating pressure for 4 hours or at the maximum pressure rating of the system, whichever is less.

11) Sample Valves:
1) Sample valves shall be installed before and after all major components.
2) The design of the sample valves should match the parameters that are to be tested. For example, ball valves are fine for hardness, chlorine, and TDS, but are not acceptable for bacteria, endotoxin, and TOC.
3) In the polishing loop, sample valves shall be a sanitary type such as needle valves and diaphragm valves.
4) Test ports shall be installed to be fully drainable and avoid creating dead legs.
5) Approved gasket materials will be Viton, EPDM, PTFE, Teflon, and Silicone.

12) Future Tap Provision:
    1) All new systems shall be built anticipating future expansion.
    2) Include a valve for a future loop on the supply manifold.
    3) Include a diaphragm valve and flow meter for a future return.

13) Deadlegs:
    1) For this design, dead legs in the distribution are defined as anything greater than 6 times pipe diameter.
    2) The MIT High Purity Water System Standard will be a centrally distributed high purity water system that will supply water to select equipment, glasswashers, autoclaves, and point-of-use polishers. These connections are not considered part of the distribution, and may include deadlegs as defined above.
    3) If any of the post-installation points-of-use create dead legs that detrimental to the system as a whole, Facilities will identify and rectify.

14) Tags & Labeling:
    1) The water system is considered complete only after every valve, test port, and gauge is tagged, and matches the P&ID.
    2) Tags shall be installed to be clearly visible when a valve is in the normal operating position.
    3) The water system is considered complete only after every component is labeled and matches the P&ID.
    4) Labels shall be clearly visible on each major component.

15) Multi-Media Omission:
    1) The standard MIT design does not require multi-media filtration on any systems less than 10 gallon per minute make-up.
        a) Turbidity is the combination of colloidal and suspended materials. On campus in Cambridge, the turbidity ranges from 0.06 to 0.26. The turbidity on site was tested to be at 0.16 (11/12/21) which is in line with Cambridge's typical results. If a building, for some reason, tests > .75 NTU, then multi-media or other self-cleaning prefilters should be used.
        b) The multi-media on typical Cambridge water would serve little or no purpose, take up valuable real estate, and create unnecessary discharge which is frowned upon by the MWRA.
        c) The design and service program should include properly sized sediment filters requiring quarterly exchanges. These filters should be sized to last 6 months without a pressure drop of greater than 10 PSI.
        d) The typical SDI ranges from 1.5 to 2.5 on campus.

16) Water Softening

1) The system will include properly sized water softener(s) that will comply with the following:
   a) Resin must be premium grade, high capacity, gelular, sulphonated, polystyrene, cation resin supplied in the sodium form as moist, tough, uniform spherical beads.
   b) Minimum resin capacity of 24,000 grains
   c) Resin must comply with the FDA regulations for potable water applications, specifically 21 CFR 173.25.
   d) Uniform Spherical Beads: 95% of all beads shall be in the minus 6 to plus 40 mesh range.
   e) All softeners shall regenerate with pellet type salt intended for water softeners without any additives.
   f) Test ports shall be installed to enable sampling pre- and post-treatment.
   g) Pressure gauges shall be installed to enable readings pre- and post-treatment.

17) Carbon Filtration

1) Cambridge water supply contains chloramines. Both activated carbon and catalytic carbon are acceptable but shall be sized properly based on Empty Bed Contact Time (EBCT).
   a) GAC Media:
      i) The GAC carbon media shall be virgin, including service exchange systems.
      ii) The GAC carbon media shall be either bituminous coal or coconut shell, low ash, without silver or other chemical impregnation, and 12 x 30 or 12 x 40 mesh size.
      iii) The GAC media must meet ANSI/NSF 61 and AWWB604 certification.
   b) Catalytic carbon:
      i) The catalytic carbon must be manufactured without metal or alkali and have an iodine number greater than 825.
   c) All GAC & catalytic media must be pre-wetted for 24 hours prior to placing online.
2) EBCT for Chloramine Removal Standard Carbon is at least 10 minutes/cu.ft.
3) EBCT for Chloramine Removal Catalytic Carbon is at least 4 minutes/cu.ft.
   a) EBCT is equal to the volume of the empty bed divided by the flow rate. It is a measure of the time water is in contact with activated carbon, assuming all water passes through at same velocity.

   $$\text{Empty Bed Contact Time in Minutes (EBCT)} = \frac{\text{Bed Volume (sq.ft)} \times 7.48 \text{ Gallon/sq.ft.}}{\text{Flow Rate (GPM)}}$$

   16 x65 vessel will contain 4 cu.ft. (actual 4.05 cu.ft.) carbon media

   $$\text{(EBCT)} = \frac{4.05 \text{ (sq.ft.)} \times 7.48 \text{ Gallon/sq.ft}}{4 \text{ (GPM)}} = 7.57 \text{ min.}$$

4) Test ports shall be installed to enable sampling pre- and post-treatment.
5) Pressure gauges shall be installed to enable readings pre- and post-treatment.

18) Sediment Filtration:

1) Sediment filters prior to reverse osmosis shall be 5µ nominal rating.
2) Sediment filtration shall be sized for quarterly exchanges.
3) Single cartridge housings must meet NSF/ANSI Standard 42.
4) Single cartridge housings must be rated for 100 PSI at 100º F.
5) Multi-cartridge filter housings shall be stainless steel.
6) Multi-cartridge housings shall include vent ports.
7) All sediment filters shall be of N+1 design with isolation and bypass valves.
8) Filter elements shall at minimum be approved for use with potable water.
9) Test ports shall be installed to enable sampling pre- and post-treatment.
10) Pressure gauges shall be installed to enable readings pre- and post-treatment.

Note: Housing shall be non-proprietary to a single manufacturer's filter cartridges.

19) Reverse Osmosis:

1) The RO unit will include a UL Listed microprocessor (if not controlled by central PLC) to accurately measure water quality and control alarms and required flushes.
2) RO unit shall include the following features:
   a) Flow meters: permeate, concentrate, & recycle
   b) Pressure gauges: pump pressure, concentrate pressure, & inlet
   c) "Divert to Drain" feature on RO larger than 5 GPM makeup
   d) Auto flush
   e) Percent rejection readout
   f) Pre-treat lockout
   g) Low pressure protection
   h) General alarm
3) The RO frame shall be corrosion resistant such as powder coated.
4) The RO pump shall be stainless steel, multi-stage, centrifugal pump& motor.
5) Membrane housings shall be ASME code compliant (stamp not required) and meet NSF 61.
6) Minimum pressure vessel rating shall be 300 PSI.
7) Vessels shall be epoxy coated fiberglass or 316 L stainless steel. PVC vessels are not acceptable.
8) Split ring pressure vessel closures are unacceptable.
9) Housings shall not be proprietary to one manufacturer's membranes.
10) All piping on the high pressure side (pump discharge) shall be 316 stainless steel.
11) Concentrate valves shall be stainless steel.
12) Inlet solenoid shall be stainless steel or brass
13) The membranes shall be thin film composite and from a recognized industry leader such as Filmtec (Dow), Hydronautics, Fluid Systems, Koch, Suez, Toray.
14) Selected membranes shall be rated for at least 98% removal of ionic contaminants and organics of above 200 Daltons.
15) RO systems shall be designed to operate between 65% - 75% recovery.
16) RO equipment shall be sized without consideration of tempered water make-up. Sized based on winter ground water temperature, typically 40ºF

17) Vendor shall stock all components that make up the RO as standard inventory items.
18) Include in the design provisions to collect and re-use RO reject water either within the building or in other buildings. Keep in mind DEP does not want RO reject waste to go directly to storm without constant water analysis and MWRA does not want clear water waste going directly to sanitary.

Note: Built in CIP is not required. MIT would prefer all membrane cleaning to be performed off-site.

20) Storage Tank(s):
    1) Storage tank volume(s) should be sized to provide 24-hour capacity whenever possible.
        a) Multiple tanks are acceptable when real estate or access is a limiting factor.
        b) Multiple tanks will include interconnect piping at mid-tank and high level.
    2) Atmospheric storage tank(s) shall be free standing vertical closed top polyethylene (HDPE) /polypropylene/Nalgene, full bottom drain, meeting ASTM D-1998 standards. Resin specification from the tank manufacturer is required in the turnover package to insure that future welded fittings are compatible.
    3) Fittings shall be molded or welded, no bulkhead fittings.
    4) Fitting materials shall match the tank material.
    5) Acceptable fittings will include NPT, tri-clamp, flange joints
    6) Maximum temperature rating shall be 140º F.
    7) Vertical tank on a stand, spray ball for sanitation, cone-bottom, flanged or dished top, airtight manway. Stand must be plastic or painted (powder coated or epoxy painted) so as to be corrosion resistant.
    8) If the RO makeup enters the tank through a sidewall, an internal 90 must be installed to direct the flow inward to the bottom of the tank.
    9) Spray ball must be properly sized, material must be compatible with the plumbing material, and the pattern shall be 360º coverage.
    10) Minimum level controls will include:
        a) High level alarm (interlocked with actuated valve on water supply)
        b) RO off
        c) RO on
        d) Low level alarm
        e) Run-dry protection (interlocked with pumps)
        f) Vent Filter for Storage Tank:
    11) 0.2µ Hydrophobic filter cartridge(s), 222-style, with filter housing shall be provided.
    12) The RO will fill the storage tank. Since the conditions for temperature and pressure are standard, the air volume vented out of the tank to the atmosphere will equal the water volume flowing into the tank, i.e., at a fill rate of 5 GPM RO water to the tank, with a safety factor of 3 considered, 1.01 SCFM of air will be vented out through the filter.
    13) The Vendor shall provide vent filter calculations for sizing.
    14) The vent filter shall be located on the top of the tank and accessible for service.

21) Pressurization / Distribution Pump(s)

1) Multistage centrifugal pumps shall be arranged as N+1 and configured to provide operational redundancy, normally online and without stagnancy. Pumps shall be synchronized (running at the same time).
2) Controls shall be fully automatic, with individual VFDs provided for each pump.
3) In the event of pump failure, the remaining pump shall ramp up automatically to maintain normal system flow.
4) Pumps shall be sized to provide a minimum flow velocity of 3 ft./second throughout the distribution.
5) Distribution pumps shall be 316 SS, mill finish internals, multistage centrifugal pump, TEFC motor, packaged controls assembly, UL listed 508A.
6) Pumps shall be provided with silicon carbide seals and designed for use with low conductivity water.
7) Connections to the pump shall be sanitary or flanged.
8) Each pump will have its own dedicated circuit and power brought to each pump. Control panel will send RUN-STOP ALARM signals only.
9) The VFDs shall be set for auto-restart and include independent run-dry protection.
10) For this design, the acceptable manufacturers are Goulds and Grundfos.

22) UV Systems
1) All UV systems shall include:
   a) UV systems shall have a 316 SS chamber, less than or equal to 20 Ra.
   b) UV systems shall have a lamp-out indicator or status output
   c) UV systems shall be installed with stainless steel light traps
   d) UV systems shall have integrated thermal overload protection (auto-safety cut-off)
   e) Power to the UVs will be integrated with the pumps (no water, no power)
   f) The control panel shall include a UV fault
   g) The preferred vendors are Aquafine or Atlantic.
   h) Connections shall be flanged or sanitary
2) UV for Disinfection
   a) UV systems for disinfection shall be provided prior to the distribution in the recirculating loop, upstream of the final particulate filter.
   b) UV systems for disinfection shall be properly sized for a minimum fluence of no less than 30 milli-joule/cm^2
   c) UV systems for disinfection shall be rated at 254 nm
   3) UV for TOC Reduction
   a) UV systems for TOC reduction shall be provided for polishing and oxidation of organics where required
   b) UV systems for disinfection shall be properly sized for a minimum fluence of no less than 120 milli-joule/cm2
   c) UV systems for TOC reduction shall be rated at 185 nm

23) Mixed Bed Deionization / EDI
1) For this design, service exchange DI or EDI will be on a side stream located on the return at the tank.
2) When the resistivity falls below a desired setting, the return water is directed through the mixed bed or the EDI to restore the desired resistivity.

3) When the resistivity is within acceptable ranges, the side stream mixed bed will recirculate onto itself in a closed loop which will include treatment to maintain high quality DI water.
4) The DI will be sized for quick resistivity recovery and no more frequently than quarterly exchanges.
5) The EDI will be sized to maintain the desired resistivity.

24) Final Filtration
1) Final particle filters shall be installed prior to distribution and downstream of UV equipment.
2) The filter efficiency shall be greater than or equal to 90% at 0.1µm when tested at SEMI 5067A (polystyrene ball test) or per SEMI C079 validation standard.
3) Filter seal design shall be 222 or 226 style, with or without fins as required (code 2, 3, 7, or 8 as appropriate).
4) Flat gasket, crush-seal, and knife edge seal arrangements are unacceptable.
5) Final filters selected shall not require replacement more often than annually.
6) Housings shall be 316L stainless steel, with legs, electropolished or passivated, clamp or swing bolt acceptable, tri-clamp or flange connections, with approved gasket material.
7) Multi-cartridge housings shall include vent ports.
8) Final filters shall be of N+1 design with isolation and bypass valves.
9) Test ports shall be installed to enable sampling pre- and post-treatment.
10) Pressure gauges shall be installed to enable readings pre- and post-treatment.
11) The preferred housing manufacturer is Shelco. The preferred cartridge manufactures are Pall, Critical Process, Global Filter, or equal.

Note: Housing shall be non-proprietary to a single manufacturer's filter cartridges.

25) Minimum Start-up Procedures & Testing
1) Vendor shall include pressure testing (limited to the head unit), flushing procedures, and sanitization procedures.
2) System sanitization, water sampling, and associated laboratory analysis is required prior to system acceptance.
3) A detailed sanitization procedure shall be provided for approval prior to start-up.

26) Turnover Package (Deliverables):
1) At a minimum, the Turnover Package will include:
a) As Built P &ID Drawings
b) As Built Electrical Drawings (Control Panel Schematics)
c) As Built Drawings for Head Unit
d) PLC Program
e) Written Sequence of Operation
f) Pressure Testing Documentation (start-up)
g) Flushing and Sanitization Procedures (start-up)

h) Components Specifications (cut sheets)
i) Calibration Documentation for all Calibratable Equipment
j) Suggested Daily, Weekly, Monthly I&Ts (Inspection and Testing)
k) Suggested Service Plan

27) Planning and Equipment Arrangement:

1) Any proposal that does not include a general layout and P&ID of the system detailing equipment and components will not be considered.
    a. Layout drawings will be to scale and modeled in 3-D (AutoCAD, SolidWorks, Revit etc.)
    b. Layout drawings shall show water, drain, and electrical tie-ins.
    c. The P&ID shall include all equipment tags, pipe size, and materials of construction.
    d. Valve and sample tags shall comply with MIT Valve Tags Standard and can be assigned after the project is awarded and the design is finalized

28) Qualified Vendors:

    a. The qualified vendor must be established in the fabrication and installation of high purity water systems for a minimum of 10 years.
    b. The qualified vendor must carry minimum general liability insurance.
    c. All plumbing connections and on-site electrical work shall be by licensed mechanics and permitted.
    d. The qualified vendor must be capable of providing service for the designed system, including 24 hours emergency response program.
    e. The qualified vendor must have a separate service department and be located within 50 miles of campus. Minimum service staff of 5 local technicians.
    f. The qualified vendor shall warranty equipment for a period of one year from installation date.

11. EXECUTION

1. Provide hot water systems balancing, balancing shall be performed by the approved Balancing Agency.

2. Provide disinfection of water systems

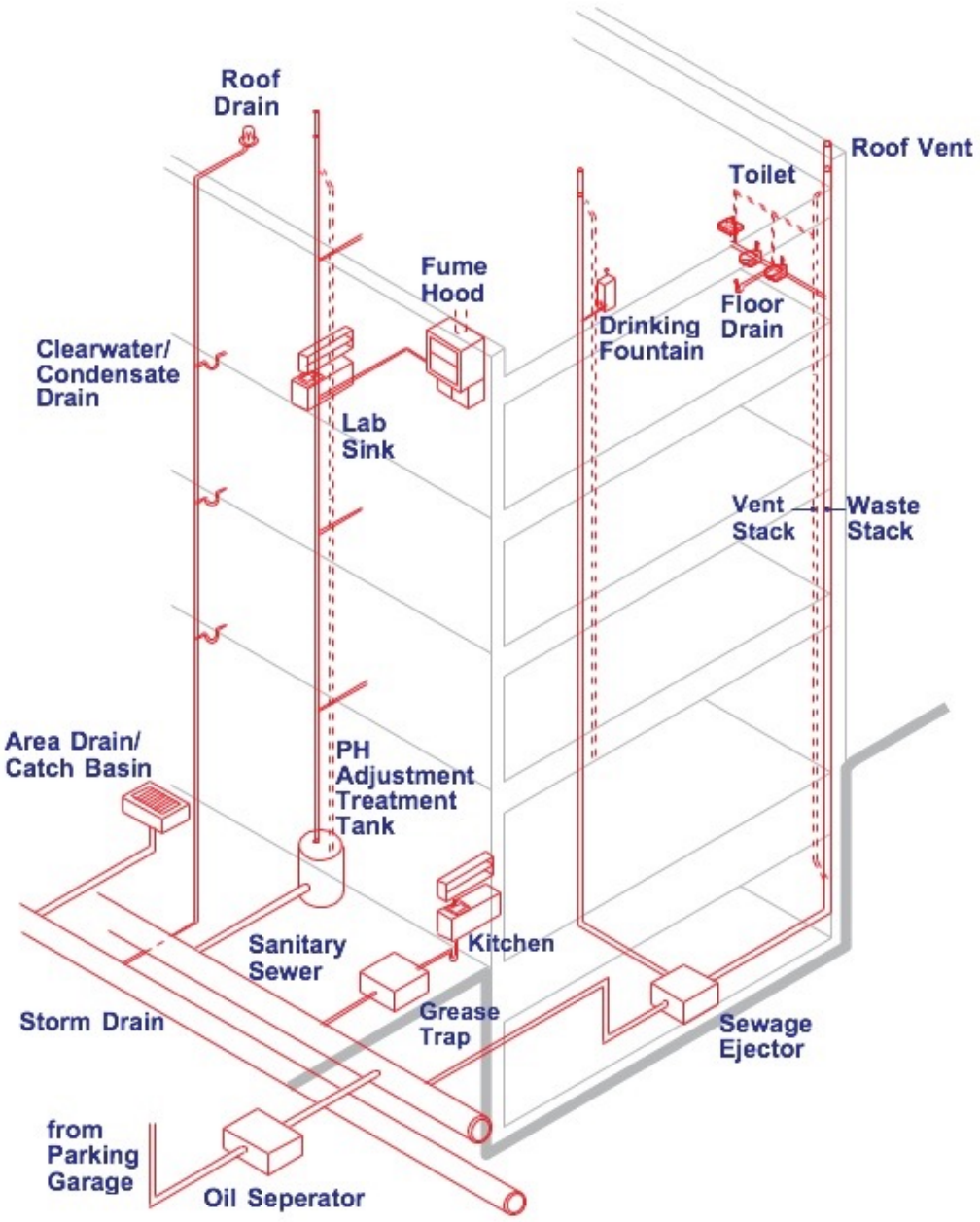
3. Provide disinfection and cleaning of purified water systems.

4. Provide 3rd party cross connection protection and approval.

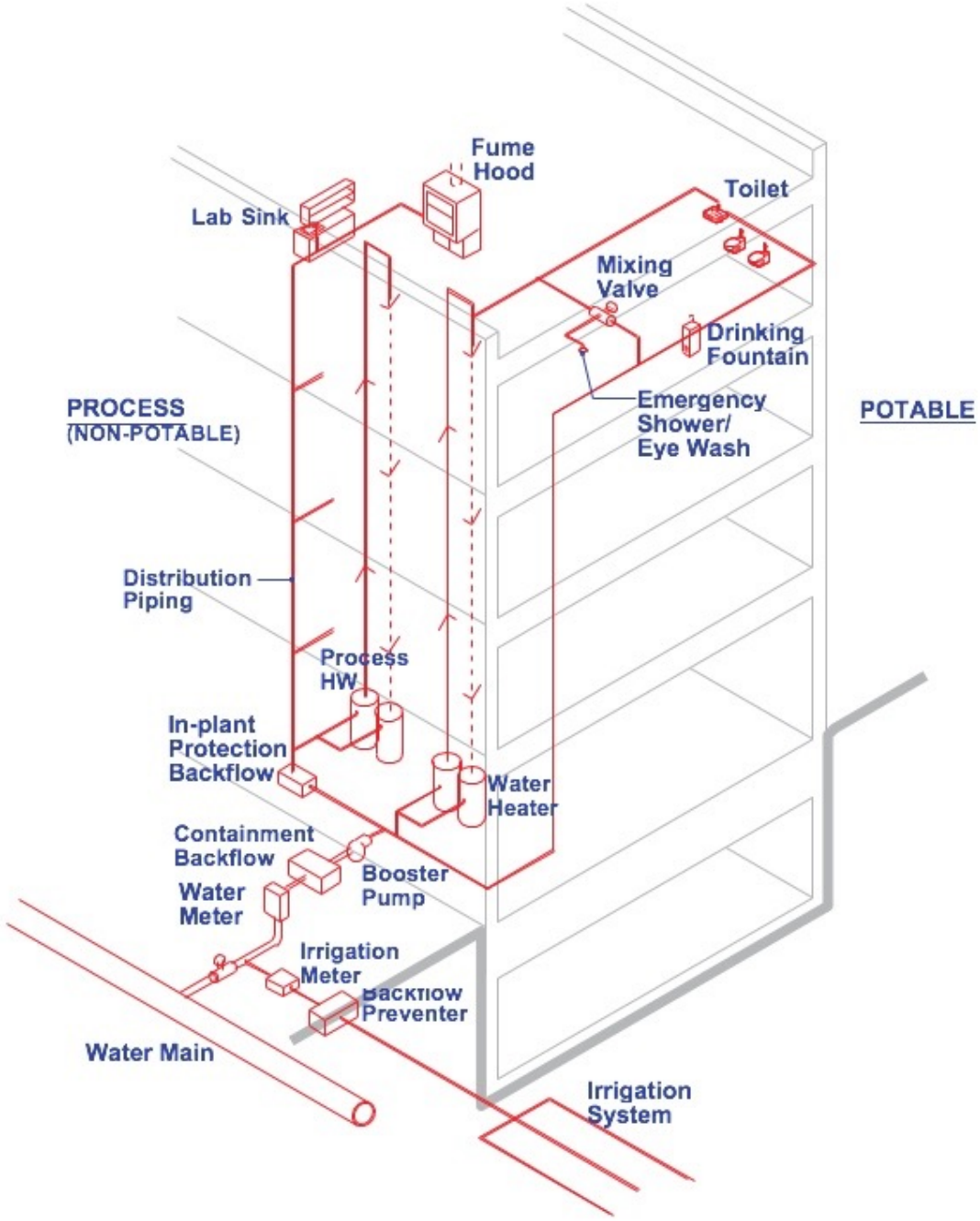
5. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be

molded and produced by the product manufacturer. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. A factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, verification of groove and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

APPENDIX A: SCHEMATICS



PLUMBING: WASTE WATER



PLUMBING: WATER SUPPLY

END OF DOCUMENT