
An Introduction to Hospital Domestic Water Systems

Course No: M03-039

Credit: 3 PDH

J. Paul Guyer, P.E., R.A., Fellow ASCE, Fellow AEI



Continuing Education and Development, Inc.
22 Stonewall Court
Woodcliff Lake, NJ 07677

P: (877) 322-5800
info@cedengineering.com

An Introduction to Hospital Domestic Water Systems



J. Paul Guyer, P.E., R.A.
Editor

Paul Guyer is a registered civil engineer, mechanical engineer, fire protection engineer and architect with 35 years of experience designing buildings and related infrastructure. For an additional 9 years he was a principal staff advisor to the California Legislature on capital outlay and infrastructure issues. He is a graduate of Stanford University and has held numerous national, state and local offices with the American Society of Civil Engineers, Architectural Engineering Institute and National Society of Professional Engineers. He is a Fellow of ASCE and AEI.

CONTENTS

- 1. GENERAL**
- 2. DOMESTIC HOT WATER SYSTEMS**
- 3. DEVICE CALIBRATION**
- 4. GENERAL PIPING DESIGN GUIDELINES**
- 5. INSPECTIONS AND WITNESS OF TESTS**
- 6. WATER DISTRIBUTION SYSTEMS**
- 7. WALL HYDRANTS**
- 8. COORDINATION**
- 9. BACKFLOW PREVENTERS**
- 10. PRESSURE REDUCING VALVES**
- 11. DOMESTIC WATER BOOSTER SYSTEMS**
- 12. SOLAR DOMESTIC WATER HEATING**

(This publication is adapted from the Unified Facilities Criteria of the United States which are in the public domain, have been authorized for unlimited distribution, and are not copyrighted.)

1. GENERAL. Patient care buildings shall have a minimum of two separate service entrances each designed for full demand (serving potable, process, and fire protection systems). These services shall enter the building at separate locations from a piped loop around the building. The purpose of this provision is to provide an uninterrupted water supply to facilitate maintenance and repair functions. Patient care buildings are buildings in which one or more of the following medical care functions take place and include:

- Acute Care
- Ambulatory Care
- Community-Based Outpatient Clinic (CBOC)
- Domiciliary
- Drug/Alcohol Rehabilitation
- Hospital
- Community Living Center (Long-Term Care)
- Medical Research
- Mental Health – Inpatient
- Outpatient Clinic
- Psychiatric Care Facility
- Rehabilitation Medicine
- Rehabilitation/Prosthetics

2. DOMESTIC HOT WATER SYSTEMS. Instantaneous and tank type water heaters are the domestic water heater systems most commonly used. Instantaneous water heaters are best suited for a service conditions requiring a steady and continuous supply of hot water. In these systems, hot water is heated as it flows through the tubes of a shell and tube system. These systems require thermostatic mixing valves to maintain a uniform temperature because the ratio heating capacity to hot water volume is relatively small. Semi-instantaneous water heaters are very similar to instantaneous ones but have a limited storage capacity that helps the system meet momentary surges in hot water demand. Alternatively, storage water heaters are best used for service conditions where hot-water requirements are not constant and a large volume of heated water is held in storage for periods of peak demand. The amount of storage required is calculated on the demand profile and the water heater recovery capacity. *Legionella* is always a concern when water is stagnant. To avoid stagnant storage conditions, designers should consider semi-instantaneous and instantaneous hot water heater systems when feasible. Tank systems can be considered if they are life-cycle-cost effective, but they shall be designed for continuous flow to limit stagnation, with adequate tank size for the application and not oversized, and with the ability to maintain a minimum water temperature of 54.4 deg C [140 deg F] necessary to kill bacteria. Plate heat exchangers are a type of instantaneous hot water heater that uses metal plates to transfer heat as opposed to the more traditional shell and tube design. Plate heat exchangers transfer the heat between two fluids (i.e. water or steam). The advantage of plate type exchangers is that they are more efficient and smaller in size than the shell and tube heaters. The disadvantages are they can be more expensive and create a higher pressure drop. A good hot-water heating system design is achieved by sizing the system properly to meet peak demand, optimizes system efficiency and is life-cycle cost effective. Oversized piping or long pipe runs can result in delivery delay of hot water to the end users and waste both energy and water resources. Designers and plumbing contractors shall coordinate with the architect for the best routing of hot water piping systems. Double walled heat exchangers shall be used in accordance with the IPC requirements for water supply and distribution.

Design analysis of economic criteria, peak demand requirements, daily variations, minimum flow, space restrictions, and energy sources available shall be used to determine the type of water heater system provided. Designers shall take into consideration the project requirements for backup energy sources for critical utilities including domestic water.

2.1 WATER HEATER EFFICIENCY. Domestic water heater efficiency shall meet or exceed the ASHRAE 90.1-2010 minimum efficiency for service water heaters. Gas water heaters up to 530 liters [140 gallons] are covered under the Federal Energy Management Program (FEMP) and the ENERGY STAR program. Federal laws and Executive Orders mandate the purchase of gas water heaters that meet or exceed the ENERGY STAR listed minimum efficiency. Gas-fired water heaters are more efficient in source energy use than electrical resistance water heaters. Avoid use of electric water heaters unless they are shown through calculation to be life-cycle cost effective or gas service is not available.

2.2 WATER HEATERS FOR PATIENT CARE AND RESEARCH BUILDINGS. Water heater systems for patient care and research buildings shall be designed for redundancy of the peak load such that the building hot water demand can be met with the largest unit offline. Preference shall be given to indirect heating sources of steam or hot water from a central energy plant. However, fuel-fired heaters may be used for special applications or if an indirect source is not readily available. Fuel-fired heating sources must be life-cycle cost effective and approval of the project manager is required. Alternate sources of energy for continuous operation are required. Electric water heater should only be used if an indirect source or other source fuels (e.g. natural gas) are not available. Hot water systems shall not use seals, gaskets or other components constructed of natural rubber which can support the build-up of biofilms. Hot-water recirculation and return piping shall be used and sized appropriately.

2.2.1 INSTANTANEOUS AND SEMI-INSTANTANEOUS WATER HEATERS. Provide redundant shell and tube instantaneous or semi-instantaneous central water heaters such

that the building hot water demand can be met with the largest unit offline. Heating system shall be capable of supplying the peak flow demand at a minimum discharge temperature of 54.4 deg C [130 deg F]. System must have a high turndown ratio to account for periods of minimum flow. Provisions shall be made for the water heaters to provide 77 to 82 deg C [170 deg F to 180 deg F] water at reduced flow for thermal eradication purposes. Provide a high temperature alarm device to detect mixing valve failure. Alarm shall sound when water temperature exceeds ± 5 degrees from the setpoint of 54.4 deg C [130 deg F]. The use of plate and frame heat exchangers shall be considered by the medical center. Include a hot water re-circulating loop system and design for water discharge at a minimum of 54.4 deg C [130 deg F] or higher as necessary to maintain minimal hot-water recirculating of 51.1 deg C [124 deg F] to limit the scald risk and to prevent the growth of bacteria (*Legionella*).

2.2.2 TANK-TYPE WATER HEATERS. Provide redundant tank type central water heaters such that the building hot water demand can be met with the largest unit offline. Tank-type water heaters shall be designed to maintain a minimum water temperature of 60 deg C [140 deg F]. Tank-type water heaters shall be capable of raising the discharge temperature to 77 to 82 deg C [170 to 180 deg F] for thermal eradication purposes. Circulating tank water heaters shall be considered to limit temperature stratification within the tank to limit the growth of *Legionella*. Heaters shall be capable of withstanding thermal and/or chemical eradication procedures to control bacteria. Provide with access for cleaning and disinfection. Include a hot water re-circulating loop system and design for water discharge at a minimum of 54.5 deg C [130 deg F] such that circulating water is no lower than 51 deg C [124 deg F].

2.2.3 DIETETIC EQUIPMENT. Provide duplex shell and steam coil booster heaters to generate the flow demand at 82 - 90 deg C [180 - 195 deg F] with each heater sized to supply 50% of demand. The use of plate and frame heat exchangers shall be considered by the medical center. Provide a hot water re-circulating system. Design sanitary drain systems using chemical sanitation agents in accordance with Federal, state and local requirements.

2.2.4 BOOSTER HEATERS. Provide simplex shell and tube booster heaters capable of 60 - 71 deg C [140 - 160 deg F] at point of use for areas needing higher water temperatures for sanitary reasons including cage washers, cart washers and sterilizers. The use of plate and frame heat exchangers will be considered by the medical center.

2.3 WATER HEATERS FOR NON-PATIENT CARE BUILDINGS. Water heaters serving non-patient care areas can be sized for 100% of peak demand in a simplex arrangement. Water heaters shall be designed with a minimum discharge temperature of 54.4 deg C [130 deg F]. System must have a high turndown ratio to account for periods of minimum flow. Tank-type water heaters shall be designed to maintain a minimum water temperature of 60 deg C [140 deg F]. Water heaters shall be capable of raising the discharge temperature to 77 to 82 deg C [170 to 180 deg F] for thermal eradication purposes. The use of plate and frame heat exchangers shall be considered when hot water heating systems are available. For buildings of less than 4500 sq. m [15,000 sq. ft.] with no shower facilities, provide fuel fired instantaneous or tank type water heaters instead of shell and tube central heaters. Electric water heaters may be considered with VA Authorities approval.

2.4 INSTANTANEOUS TANKLESS WATER HEATERS (POINT OF USE). Instantaneous tankless point of use (electric or gas) water heaters are not permitted as a primary source of hot water. Instantaneous tankless point of use water heaters are permitted for incidental use, sporadic equipment demands, or remote individual fixtures (e.g., lavatory, sink, shower, service sink) in non-patient areas with written justification. Point of use instantaneous water heaters are permitted for use at emergency fixtures to supply ANSI standard “tepid water” immediately at the emergency fixture or group of emergency fixtures.

2.5 SIZING OF WATER HEATERS. Size instantaneous and semi-instantaneous water heaters using the water supply fixture unit (WSFU) method contained in the ASHRAE Handbook, Applications, Service Water Heating. When a facility has a large number of patient bathrooms (greater than 100) the “Bathroom Group” fixture unit number may be

substituted for the individual component WSFU. A bathroom group consists of a toilet, lavatory, and shower or bathtub. See IPC for details. Special equipment demands such as dishwashers, sterilizers, and laboratory glass washers must be added to the water heater load at 100% diversity.

- Storage tank type heaters shall be sized using the gallon per hour method for fixtures contained in the
- ASHRAE Handbook, Applications, *Service Water Heating*. The ASHRAE Handbook includes fixture rates for a number of end uses and demand factors for several building types including hospitals and office buildings. For fixtures and building types not listed, designers shall determine the demand based on experience and standard practice. For clinics use a demand factor of 0.4 and a storage capacity factor of 1.0.
- The supply of water from the utility provider varies in temperature by season and location. Designers shall obtain the seasonal cold water service temperature from the water provider for the past three years (minimum). The lowest seasonal temperature recorded shall be used to calculate the water heating energy requirements.

2.6 THERMOSTATIC MIXING VALVES. Master Thermostatic Water Mixing Valves (MTMV) are used to temper water distribution from the hot water source. These valves shall conform to the requirements of ASSE 1017. Designer must consider the use of hilow type master TMV for applications requiring a wide range of flow. Provide a lockable bypass with normally closed valve for thermal eradication situations. Provide check stops and unions on hot and cold water supply inlets, adjustable temperature setting in accordance with ASSE 1017. The use of tempering valves, on all plumbing fixtures where people access water from the potable hot water distribution system is required in order to prevent scald injury. The water temperature delivered from the outlet must not exceed 43.3 deg C [110 deg F]. Provide ASSE 1070 tempering valves at individual point-of-use fixtures such as sinks and lavatories. Provide ASSE 1016 valves for shower and tub-shower applications that are thermostatic and pressure balancing (combination) type. In public restrooms, ASSE 1070 or ASSE 1069 tempering device may, if properly sized,

serve multiple fixtures in accordance with manufacturer's requirements. Provide ASSE 1071 valves to temper water at emergency eye-wash and showers locations. Install tempering devices as close to the fixture as possible to minimize the volume of tempered and stagnant water in high risk patient areas. Additional circulation connections may be necessary to avoid dead ends. All point of use tempering valves shall:

- Meet ASSE requirements for water temperature control for intended use
- Be "Lead Free" complying with NSF 372 (ASSE 1071 types excluded)
- Have cast bronze bodies with corrosion resistant internal parts preventing scale and biofilm build-up
- Have Internal parts able to withstand disinfecting operations of chemical and thermal treatment of water temperatures up to 82 deg C [180 deg F]
- Allow easy temperature adjustments to allow hot water circulation
- Have integral check valves with screens and stop

2.7 HOT-WATER RECIRCULATION LOOPS AND RETURN PIPING. Recirculating water systems is a means of controlling heat loss and final delivery temperatures. Hot-water recirculation is required for all patient care buildings. Hot-water recirculation in non-patient care buildings shall be in accordance with IPC. Hot-water recirculation systems shall be designed to meet the following requirements:

- Shall be located as close to the end-use fixture as practical. Domestic hot water must be available at each hot water outlet within 15 seconds of the time of operation. Design hot water velocity of 122-152 cm/sec. [4 - 5 feet per second (fps)]. Due to constant circulation and elevated water temperatures, particular attention should be paid to water velocities in circulating hot water systems. Both the supply and return piping should be sized so that the maximum velocity does not exceed the above recommendations. Care should be taken to ensure that the circulating pump is not oversized, and that the return piping is not undersized; both are common occurrences in installed piping systems.
- Size the hot water return lines by the heat loss method as outlined in the ASHRAE Applications Handbook, Service Water Heating; or ASPE Data Book Volume 2, Plumbing Systems, Domestic Water Heating Systems. The system heat loss shall

not exceed 3.3 deg C [6 deg F].

- Insulation thickness shall be governed by ASHRAE 90.1-2010. Insulation thickness and re-circulating pump size shall also be selected in order to limit the domestic hot water system temperature loss to exceed 3.3 deg C [6 deg F].
- Patient care and Research Buildings require redundant re-circulating pumps to allow for maintenance and repair without a system shutdown. Sequence of operations shall not allow for both pumps to run simultaneously. Pumps running in parallel with double the flow rate and result in excessive water velocity and pipe erosion.
- For high rise buildings, domestic hot water return loops of substantially varying pressures, as a result of pressure zoning or static head differences cannot successfully be joined to a single pressure zone water heater. Locate individual pressure zone water heaters within the pressure zones, where return pressures would vary substantially, causing deadhead on the lower pressure return circuits.
- Include provisions for isolating and balancing the system.
- The use of heat tracing shall not be used in lieu of hot water recirculation systems.

2.8 SHUT-OFF AND BALANCING VALVES. The purpose of balancing is to ensure a ready supply of hot water within reach of each fixture. The pump provides the circulation, but balancing is required to ensure that each riser (or branch) receives its proportional share of hot water. This is accomplished by making the pressure drop in each supply branch or riser equal so that the corresponding circulated water flow is equal. Provide separate check, isolation and balancing valves in the hot water return circulating lines at the point of connections of the domestic hot water supply line (main, branch or riser) with the hot water recirculation loop. Provide notes in the contract documents for the balance agency to set flow rate to the gpm as calculated by the system designer. The Designer shall use the circulation rates for all parts of the circulating piping and the total circulation rate required. Circulation rates are based on the heat losses in the piping system based on an allowable temperature drop of 3.3 deg C [6 deg F]. See ASHRAE Handbook, Applications, Service Water Heating, for details on hot-water recirculation loops and return piping. The balancing valve shall be the type specified in VA Master Specification

22 05 23. Lastly, velocities in hot water return piping shall be checked to ensure a maximum of 5 feet per second (fps).

2.9 HEAT TRAPS. Install heat traps (either valve type or loops) on the cold water makeup inlet and outlet connections of all hot water storage tanks for energy savings. Loop type heat traps tend to be less problematic and are preferred. Loops should be a minimum of 46 cm [18 in.].

3. DEVICE CALIBRATION. Provide Pete's plugs for access at all temperature and pressure indicating devices, where analog (gauges and thermometers) and digital (sensors for the EMCS system) devices are to be used.

4. GENERAL PIPING DESIGN GUIDELINES. The following design practices for the design of domestic water piping system shall be followed:

4.1 DEFINITIONS.

- Dead End - A length of pipe with one end open to the system and the other end terminating at a cap, blind flange or closed valve.
- Fixture Runout - A length of pipe with one end connected to the system (branch, riser or main) and the other end connecting to a supply stop for a piece of equipment or plumbing fixture.
- Oxidant Level - The amount of an oxidizing substance, such as chlorine, that is used for disinfection of the water supply.

4.2 REQUIREMENTS FOR PIPING SYSTEMS.

4.2.1 DEAD ENDS. The following design requirements shall be followed for dead-ends:

- The maximum length of dead ends shall be no greater than two pipe diameters from the branch, riser or main that it is connected to. Ideally the existing tee or fitting should be removed if the piping has no future use.
- Dead ends that terminate with a valve and a cap, plug, or flange shall be gate valves. A means to eliminate trapped fluid between the valve and the cap, plug, or flange shall be provided.

4.2.2 FIXTURE RUN-OUT. The following requirements shall be followed for water supply piping to fixtures:

4.2.3 HOT OR TEMPERED WATER SUPPLY. Pipe length shall be as short as possible to supply the fixture or equipment. The maximum allowable fixture run-out length of the pipe shall be determined based on the maximum allowable pipe volume method

described in Chapter 7 of the International Green Construction Code, latest edition with the following exceptions. Each fixture in the bathroom group shall be evaluated to ensure turnover of hot or tempered water even if separate feed lines are required. For public lavatories and low flow lavatory fixtures (.5 gpm), the hot water run-outs lengths shall be limited to a total maximum volume of 0.35 L [12 oz.]. For lavatory faucets other than public lavatory faucets (including hand washing sinks in patient and exam rooms), the maximum volume shall be 0.7 L [24 oz.] whether the source of hot water is from a hot-water recirculation loop or directly from a heater or boiler.

4.2.4 COLD WATER SUPPLY. Pipe length shall be as short as possible to supply the fixture or equipment. In patient care buildings, the maximum allowable fixture run-out length of the pipe shall be determined based on the maximum allowable pipe volume method. Maximum fixture run-out lengths for cold water piping to sinks, lavatories and showers shall be limited to a 0.95 L [24 oz.] total volume. The maximum allowable volume for water closets is 4.85 L [164 oz.] (1 water closet flush of 1.28 gpf). The maximum volume for urinals is 1.9 L [64 oz.] (1 urinal flush of .5 gpf). Each fixture shall be evaluated to ensure turnover of cold water even if separate feed lines are required.

4.2.5 BATHROOM GROUPS. A bathroom group is a group of fixtures located in a private bath consisting of a water closet, lavatory, bathtub or shower, including or excluding a bidet. The maximum allowable pipe volume for cold water in bathroom groups is 4.85 L [164 oz.] (1 water closet flush of 1.28 gpf) when water closets are flushed a minimum of 1 time per day. In this configuration, the cold water supply to all the fixtures of the bathroom group shall be in series with the water closet connected as the final fixture. The water closet flushing will provide for cold water turnover within the bathroom group. Designers shall discuss expected water closet usage with the medical staff prior to completing the design. Designer shall specify the use of automatic flushing valves with timers to ensure daily flushing of cold water line from the final element. Alternatively, water closets shall be piped separately from the sink and shower.

4.2.6 ICE MACHINES. Pipe length shall be as short as possible to supply the equipment.

The maximum allowable fixture run-out length of the pipe shall be determined based on the maximum allowable pipe volume method. Maximum run-out lengths for ice machines shall be limited to a 12 oz. total volume. If the maximum fixture run-out length is exceeded, water must be recirculated as close to the fixture or device as possible using the chase or wall cavity. A water return line with balancing valve (or similar device) shall be used to provide continual water flow near fixture. The domestic water supply mains and branches may run directly over the lavatories, showers, and other plumbing fixtures requiring hot water. Minimum size of fixture water supply pipes shall be in accordance with the IPC.

4.2.7 PROVIDE PROPER SPACE/MAINTENANCE access for the selected supplemental water disinfecting treatment system that is to be employed or may be employed in the future. Provide access to clean the interior of all water storage tanks. See section below for tank construction. Provide a means to flush all lines through outlets.

4.2.8 PROVIDE MEANS TO EASILY remove and disinfect all outlet devices, such as showerheads. Aerators are prohibited. Utilize self-draining showerheads, constructed from metal. Plastic showerhead components shall not be allowed.

4.2.9 WHENEVER PRACTICAL, PLASTIC HOSES and equipment containing natural rubbers shall NOT be used for any purpose in domestic cold, hot and hot water return lines. Copper or chrome plated brass tubing or pipe shall be used to connect to fixtures.

4.2.10 INSTALL THERMOSTATIC MIXING VALVES (TMV) with internal check valves as close to the fixtures as possible to minimize the volume of tempered water sitting in pipe or tubing.

4.3 LEGIONELLA MITIGATION

4.3.1 PURPOSE. The following design features shall be included:

4.3.1.1 THE EFFICACY OF BIOCIDES on suppressing or killing waterborne pathogens is dependent on multiple factors such as water quality, organic and inorganic contaminants, pH levels, disinfectant concentrations, and contact time. Water entering the building shall be continuously monitored for the following by means of gauges, sensors, and a grab sample port:

- Temperature
- Oxidant level (water disinfectant)
- pH
- Pressure

4.3.1.2 WATER SYSTEMS WITHIN THE BUILDING shall be monitored as follows in the table below. Temperature and oxidant levels are the two primary engineering controls to limit bacterial growth. Oxidant levels shall be measured continuously as water enters the building and through grab samples taken from building plumbing fixtures. Temperature shall be measured throughout the domestic water system (hot and cold). In addition to being a primary control measure, temperature can be a secondary indicator of flow since temperature of stagnant water will lower for hot water and rise for cold water.

WATER MONITORING DEVICES		
Location	Hot Water	Cold Water
Tanks *	T	T
Mains/Risers	T (most remote location**)	T (most remote location)
Branch (zone)	T (most remote fixture)	T (most remote fixture)
Recirculation	T – at end of return system and prior to mixing	T – at end of return system and prior to mixing
Recirculation Pump	Flow	Flow
Service Entrance		Oxidant Residual Level

T = temperature monitoring

* Bacterial growth is most prominent in stagnant areas such as storage tanks. Use of tanks in cold water systems (where temperature is not controlled) is discouraged.

** Location at longest distance from source for all mains or risers

4.3.2 BACKGROUND. *Legionella* is a bacterium that causes respiratory diseases collectively referred to as *Legionellosis* that includes *Legionella pneumoniae*. *Legionella pneumoniae* is also known as *Legionnaires Disease* (LD). *Legionella* bacteria are found naturally in water and have been associated with disease from building water distribution systems. LD occurs after inhalation or aspiration of contaminated water. *Legionella* bacteria are not transmitted from person to person. The elderly and persons with immune compromised systems are most at risk. *Legionella* bacteria growth increases in tepid water in a range from 20 deg C [68 deg F] to 50 deg C [123 deg F]. Given the various factors and complexities associated with LD, 100% prevention of LD is likely not possible. However, prevention and control practices can be implemented to reduce the risk of exposing people to *Legionella* in building water distribution systems. The following are

engineering controls that will suppress *Legionella* growth. More than one control may be necessary for successful inhibition of *Legionella* growth.

4.3.2.1 TEMPERATURE

- Maintenance of appropriate water temperatures is required. Water above 51.1 deg. C [124 deg. F] inhibits growth of *Legionella* in hot water systems. Precautions for the prevention of scalding shall be included in the hot water distribution system.
- Cold water temperatures below 19.4 deg. C [67 deg. F] inhibit the growth of *Legionella*.

4.3.2.2 FLOW

- Recirculation of water distribution systems is a means of limiting *Legionella* growth due to low flow or non-use periods. Recirculation aids in maintaining required water temperatures. Hot and cold water distribution systems shall be continuously circulated and piping insulated.
- Maintenance of water distributions systems (e.g. mixing valves) and plumbing fixtures such as shower heads is necessary to limit the build-up of biofilms and other deposits (e.g. corrosion) that can harbor the bacteria and make it difficult to eradicate.
- In order to reduce areas of stagnant water, distribution systems shall be designed to eliminate dead ends and minimize fixture run-outs.

4.3.2.3 OXIDANT (DISINFECTANT)

- Maintenance of disinfectant at a sufficient level to control *Legionella* growth may be required. The minimum level required to suppress bacterial growth will vary from building to building and by the type of oxidant (disinfectant) used. Monitoring of levels is required.

4.3.3 PIPING DESIGN GUIDELINES FOR LEGIONELLA MITIGATION. The following design requirements shall be included:

- The need to chill or cool the domestic cold water supply shall be evaluated at the

schematic phase. *Legionella* can propagate in temperatures exceeding 20 deg C [67 deg F]. The domestic cold water distribution system shall have a recirculation system. For cold water systems, although circulation back to the source location for the building is ideal, for renovation efforts, recirculation within the department (or floor) area of renovation would be acceptable.

- Ice maker water supply lines shall be copper and insulated. Avoid routing water lines near source of heat such as the compressor system of the ice maker.
- Cold and hot water piping systems shall be insulated in accordance with the latest version of ASHRAE 90.1.
- To enable thermal eradication and emergency shock chlorination, consider providing taps for connection of temporary booster heaters. Provide adequate electrical connections.
- PVC pipe shall not be used for sanitary and vent lines because of the high temperature water during thermal eradication. Cast iron shall be used.
- Aerators are prohibited in order to reduce exposure to *Legionella* contaminated water.
- Piping and components must be cleaned and protected from accumulation of debris and contamination prior to and during installation.
- Ensure that newly installed piping and components are flushed of debris and disinfected prior to being placed into service.

4.3.4 SUPPLEMENTAL WATER DISINFECTION METHODS. In addition to maintaining the appropriate water temperatures, minimum concentrations of various biocides (e.g. oxidizing agents such as chlorine) can inhibit the growth of *Legionella* in building potable water distribution systems. When considering the use of supplemental water disinfection methods for the prevention of *Legionella*, plumbing designers and the VA project manager (in collaboration with other facility stakeholders such as infectious diseases and infection prevention and control) shall review the merits of the many types of supplemental systems available prior to making a final selection. Environmental Protection Agency (EPA) approved oxidants (chlorine, monochloramine, and chlorine dioxide) are acceptable disinfectants for use in potable water distribution systems. Use of an alternative biocide

is permitted if the medical facility obtains a waiver. Information on the different systems and techniques is available on the EPA's website and through other sources including ASHRAE. Designers shall select the necessary equipment, piping and controls and provide adequate space for the maintenance and operations. The EPA regulates contaminant levels and disinfectant treatment for use under the Safe Drinking Water Act. Usually, the EPA delegates primacy to States for the regulation and enforcement of the Act within individual State boundaries. Systems must be specifically approved or recognized for the intended use by the State regulatory water authority. Federal and state safety regulations and permitting shall be followed. Designers shall coordinate permitting requirements with the local authority having jurisdiction. The facility must consult with the State (or its delegated local water authority) for regulating drinking water for guidance on system selection, achieving an appropriate biocide residual level at building outlets for *Legionella* growth suppression, system design, system operation, and ensuring compliance with regulations regarding water treatment system(s) and safety. Once a type of system is selected, either the State (or its delegated local water authority) or the manufacturer of the system must provide the minimum and maximum outlet biocide levels in writing for both hot and cold water. Design parameters to evaluate for supplemental water disinfection include:

- Potential impact of supplemental disinfectant on special use water systems
- Need for emergency power.
- System may need to be duplex for redundancy and maintenance.
- Spare parts may need to be purchased and stored locally.
- Federal and state safety regulations and permitting must be observed.
- Interaction of supplemental disinfection if shock chlorination is used as an emergency remediation method.
- Ensure enough maintenance access is provided around equipment.
- Provide sample points throughout the system to monitor effectiveness. Some critical points should be provided with automated data collection and alarm.
- Operational and maintenance requirements must be maintained to ensure system effectiveness.
- System must be equipped with automated features to ease of use and proper

maintenance and operation.

- Requirements for off gassing associated with the specific chemicals (for example Sodium hypochlorite).
- Chemical spill containment systems must be provided as per chemical storage requirements.

4.3.5 EMERGENCY WATER DISINFECTION METHODS. Emergency disinfection is the process of implementing immediate, temporary actions to reduce the amount of Legionella in a water distribution system.

4.3.5.1 THERMAL ERADICATION. Requires potable water in the system to be raised to 71 - 77 deg C [160 - 170 deg F] and flushed through every fixture for 30 minutes. Some design considerations are as follows:

- Central water heating equipment must be capable of raising water temperature to 82 deg C [180 deg F].
- Master thermostatic mixing valve located in the hot water distribution system may have to be bypassed to allow hot water to circulate in the distribution system.
- Select point-of-use thermostatic mixing valves that are amenable to thermal eradication procedures. See VA Master Specification 22 05 23 for required mixing valves.
- Consider providing taps for connection of temporary booster heaters to facilitate thermal eradication
- Provide adequate electrical connections for temporary booster heaters. Coordinate with electrical engineer.
- All equipment and appurtenances in the system will need to be reviewed for operation at elevated temperature (e.g. ensure water supply stops can withstand required temperatures).
- Means of tempering discharge will need to be considered to accommodate code requirements on discharge to sanitary sewer (max temp of 60 deg C [140 deg F]). Ensure discharge is compliant with the local requirements.

4.3.5.2 SHOCK CHLORINATION. Installation of a chlorinator is required. Shock chlorination involves the addition of chlorine to the water system in one of the forms listed above. Some design considerations are as follows:

- Provide taps for connection of temporary equipment
- All equipment and appurtenances in the system will need to be reviewed for operation at elevated oxidant levels.

4.3.6 SPECIAL USE WATER SYSTEMS (E.G., HEMODIALYSIS, LABORATORY, PHARMACY COMPOUNDING). It is important to consider the implications of Legionella mitigation strategies on special use water systems within the building. Special use water systems include: Hemodialysis, Laboratory Service, Pharmacy Compounding, and Supply Process Service (SPS). Water treatment strategies and chemical disinfectants may result in the introduction of products into, or the formation of disinfection byproducts in, the building water supply at concentrations that may be toxic to patients on hemodialysis. Accordingly, the impact of mitigation strategies must account for potential toxicity, methods for removal of the chemical agent and byproducts from the special use water system, and availability of assay methods to measure the chemical agent and byproducts for assuring patient safety. VA authorities responsible for the oversight of special use water systems are to be consulted during design development of the project and prior to any final decisions regarding water treatment strategies for Legionella.

5. INSPECTIONS AND WITNESS OF TESTS. The inspection plan needs the approval of the project technical representative. Frequency and requirements for inspections and testing must be added to the construction documents. Regarding inspections and test witnessing, the plumbing drawings and specifications shall coordinate with the project's commissioning specifications. Ensure that newly installed piping and distribution system components are flushed of debris and disinfected prior to being placed into service. Piping and components must be cleaned and protected from accumulation of debris and contamination prior to and during installation. Documentation of flushing and disinfection must be maintained. Disinfection for new installations or maintenance of piping, equipment, and components shall be conducted in accordance with the requirements of the IPC, American Water Works Association (AWWA C651-05).

6. WATER DISTRIBUTION SYSTEMS

- Where practical size incoming water service for future expansion. Provide sufficient length of pipe prior to backflow preventer for new branch connection
- Water Storage Tanks: Provide adequate space for maintenance access to clean the interior of all water storage tanks. Tanks shall be provided with a man way access to allow for inspection, maintenance and cleaning. Tanks shall be constructed to minimize stagnation and thermal gradients. Mechanical cooling may be needed to maintain water temperature.

6.1 METERING FOR USE

- All buildings greater than five thousand square feet shall install building-level advanced utility meters for electricity, natural gas, and/or steam, if used. In addition, install advanced utility meters for steam condensate, chilled water, hot water, domestic water, and/or non-potable water, if used.
- Install sub-meters for cooling tower makeup water and boiler makeup water.
- Energy or water intensive operations (i.e. laundry facilities, kitchen operations and data centers), regardless of size, must be similarly metered.
- Advanced meters or metering devices and supporting systems (e.g. transmitters, web connections) must provide data at least once every 15 minutes.
- In addition to providing data to building operators, building-level meters must transmit meter data directly to the existing data aggregation device in use at the facility.
- Projects involving metering or installation of a data aggregation device must follow the specifications.
- The designer shall investigate whether credit can be obtained from the public utility company for water consumed, but not discharged into the sanitary sewerage system. If credit is available and adequate water pressure is available, provide meters connected to the building energy management and control system for these water consumers. Examples of users are the irrigation system, cooling tower and boiler make-up, and possibly vacuum pumps.

- Install advanced water meters on all water wells installed on VA-owned property for agency use.

6.2 MEASURING AND INDICATING DEVICES. Analog gauge and electronic sensors/devices shall be used in tandem as much as is practicable. The gauge device will provide a local or immediate indicator of current conditions for troubleshooting and verification purposes. The electronic sensor/device will be used for continuous monitoring of water conditions and shall be connected to the building automation system. All electrical devices shall be on emergency power. All measuring devices shall be calibrated in accordance with the manufacturer's recommendations.

6.3 WATER HAMMER ARRESTORS. Size the piping for the hot and cold water systems not to exceed the maximum velocity allowed by the IPC, latest edition. Provide necessary water hammer arresters in accordance with the American Society of Sanitary Engineers (ASSE) Standard 1010, Water Hammer Arresters. Size and locate arresters per Plumbing Drainage Institute (PDI) Standard PDI-WH 201, Water Hammer Arresters, latest edition, requirements. Show quantity and type of water hammer arresters on plans and riser diagrams. Water hammer arresters shall be installed with inlet isolation valves to allow for maintenance. Provide access (including access doors where applicable) for each arrester. Coordinate locations with all applicable drawings.

6.4 TRAP PRIMERS. All floor drains and floor sinks shall have a single or manifold electronic trap primer supply. The trap primer control box shall be recessed. Traps primer control box shall be located a maximum of 6 m [20 ft.] from the traps(s) being served unless shown otherwise on the construction documents. Pressure type trap primers may also be considered. Trap primers shall be ASSE 1018 or 1044 approved. Designers shall minimize the run out length of piping for the trap primer and ensure water is flushed through to minimize the potential impact bacterial growth in stagnant water. Trap guards and rubber mechanical devices that do not use water for seal shall not be used.

7. WALL HYDRANTS. Provide wall hydrants a maximum of 60 m [200 ft.] apart at loading docks and at building entrances, with a minimum of one wall hydrant on each exterior wall. Where freeze conditions exist wall hydrants will be nonfreeze type.

8. COORDINATION. Designers shall coordinate electrical supply to including but not limited to, pumps, electronic faucets, electronic flush valves, electronic trap primers, and electronic water coolers.

9. BACKFLOW PREVENTERS. The domestic water supply must be protected from contamination due to non-potable liquids, solids, and gases being introduced into the potable water supply through backsiphonage and backpressure. Water supply to all equipment, fixtures, and pure water systems shall be evaluated as to the potential contamination hazard level. All backflow preventers shall comply with ASSE requirements. Buildings with a single service entrance shall be provided with dual parallel piped reduced pressure backflow preventers to allow for maintenance without a water shutdown. Patient care buildings shall have two separate service entrances that will allow for servicing without an outage. Provide a backflow preventer device as listed in IPC Chapter 6, Water Supply and Distribution and the following:

9.1 REDUCED PRESSURE BACKFLOW PREVENTERS. Reduced pressure backflow preventers conforming to ASSE 1013 shall be installed for the following equipment applications and systems.

- Deionizers
- Sterilizers
- Stills
- Dialysis, Deionized or Reverse Osmosis Water Systems
- Water make up to heating systems, cooling tower, chilled water system, generators, and similar equipment consuming water
- Water service entrance from loop system
- Dental equipment
- Power washer
- Cart washer
- All laboratory and industrial water systems

9.2 ATMOSPHERIC VACUUM BREAKERS. Atmospheric vacuum breakers conforming to ASSE 1001 shall be installed for the following equipment applications and systems.

- Hose bibs and sinks with threaded outlets
- Disposers

- Showers (handheld type)
- Hydrotherapy units
- Autopsy, on each hot and cold water outlet at each table or sink
- All kitchen equipment, if not protected by air gap
- Ventilating hoods with wash down system
- Film processor
- Detergent system
- Fume hoods
- Glassware washers

9.3 HOSE CONNECTION VACUUM BREAKERS.

Hose connection vacuum breakers conforming to ASSE 1011 shall be installed in the following locations for equipment and fixtures requiring non-continuous pressure:

- Hose bibbs and wall hydrants.
- Faucets with threaded outlets:
 - Service Sinks
 - Laundry Tubs

Provide cold water connection and/or treated water with a backflow preventer to the controlled temperature room humidification system.

9.4 FIRE SPRINKLER SYSTEMS AND STANDPIPES. Fire sprinkler systems and standpipes shall be protected against backflow by a double check prevention assembly meeting the requirements of the IPC. Fire sprinkler systems connected to nonpotable sources or systems that contain additives or antifreeze the potable water system shall be protected against backflow by a reduced pressure principle backflow prevention device conforming to ASSE 1013.

10. PRESSURE-REDUCING VALVES

Minimize the use of pressure-reducing valves by providing separate domestic hot water heating systems for each pressure zone in multi-story buildings.

11. DOMESTIC WATER BOOSTER SYSTEMS

11.1 MINIMUM PRESSURE. Maintain a minimum pressure of 240 kPa [35 psi] at the most remote plumbing fixtures or the minimum pressure requirements of connected equipment, whichever is higher. Obtain a flow test indicating static and residual pressures and flow volume to use in calculating minimum water pressure required. In minimum pressure calculations, use residual pressure at design flow. Investigate for daily pressure fluctuations experienced by the building water supply and modify starting pressures accordingly. Provide a pressure gauge on the top floor branch adjacent to the riser.

11.2 PATIENT CARE BUILDINGS.

- Use a three-pump system. System shall be configured so that at least two pumps will be in service if any one pump is taken out of service.
- Size one pump for approximately one-third of the total water demand.
- Each of the other pumps shall be sized for approximately two-thirds of the total demand.
- The smaller pumps shall operate until water demand exceeds the pump's capacity, at which point that pump shall stop and one of the other larger pumps shall start.
- When the demand exceeds the capacity of the larger pump, the smaller pump shall restart and both pumps shall operate together to provide 100% of the total demand.
- The other large pump shall be a standby and alternate with the first large pump to balance the run time of each pump.
- Install a hydro-pneumatic tank on the booster system discharge and "NO-FLOW" shutdown controls.
- The domestic water booster pump package including VFD, controls, and controlling devices shall be on emergency power.
- Discharge pressure shall be controlled using Pulse Width Modulated-Based (PWM) variable frequency drives through a packaged booster pump controller.
- Use spring-loaded swing check valves on pump discharge.
- Pumps discharge pressure, temperature, and alarms shall be monitored by the Building Automation System (BAS).

11.3 NON-PATIENT CARE BUILDINGS. Use a two pump system. Size each pump for 75% of the total water demand. Pumps shall alternate. When the demand exceeds the capacity of one pump, both pumps shall operate. Provide a pneumatic tank and "NOFLOW" shutdown controls.

12. SOLAR DOMESTIC WATER HEATING. The Energy Independence and Security Act (EISA) 2007 SEC. 523 requires that “if lifecycle cost-effective, as compared to other reasonably available technologies, not less than 30% of the hot water demand for each new Federal building or Federal building undergoing a major renovation be met through the installation and use of solar hot water heaters.” Refer to the VA Sustainability and Energy Reduction Manual. In the United States, different types of solar water heating systems are available. Different design guidelines are available from the National Renewable Energy Laboratory (NREL) and American Society of Heating, Refrigeration, and AirConditioning Engineers (ASHRAE) for small size systems, and the US Army Corps of Engineers Central Solar Hot Water Systems Design Guide.

12.1 BASIC SOLAR SYSTEM DESIGN. The main components added to a conventional heating system when solar thermal energy is used are:

- Collector field with collector field piping and support structure
- Heat transfer fluid (water glycol mixture)
- A storage tank system
- Pump for solar loop and pumps for other loops
- Heat exchanger(s) to transfer heat from one loop to another shall be double walled with an air gap open to the atmosphere between the two walls.
- Expansion and safety devices for each closed loop
- A controller with temperature sensors in collector field and storage tank that turns the pump on and off

Since the solar thermal system will provide only a percentage of the main water heating source, an auxiliary (back-up) water heater is necessary to provide 100% of the hot water demand load in the event of high demand or periods of too little solar radiation. All potable water storage tanks shall maintain a minimum water temperature of 54.4 deg C [140 deg F] necessary to kill bacteria. Systems shall be designed to prevent contamination from non-potable liquids, solids or gases being introduced into the potable water supply through cross-connections or any other piping connections to the system. Solar hot water

equipment shall conform to the specifications. Selecting the right solar water heating system will depend on three key factors: climate, budget, and water usage needs. There are a number of technologies available to heat water efficiently. Solar water heating systems may be used throughout the United States on any building with a south-facing roof or unshaded grounds for installation of a collector. System sizing estimates based on climate:

- Sunbelt - use 0.09 sq. m [1 sq. ft.] of collector per 7.61 L [2 gal] of tank capacity (daily usage).
- Southeast and Mountain states - use 0.09 sq. m [1 sq. ft.] of collector per 5.71 L [1.5 gal] of tank capacity.
- Midwest and Atlantic states - use 0.09 sq. m [1 sq. ft.] of collector per 3.79 L [1.0 gal] of tank capacity.
- New England and the Northwest - use 0.09 sq. m [1 sq. ft.] of collector per 2.81 L [0.75 gal] of tank capacity.

Estimates will be affected by water temperature, consumption amount, and the solar resource available at the site.

12.2 SIMPLE SYSTEM CALCULATION. A simple evaluation procedure can help to determine if solar water heating is appropriate. Traditional solar hot water heating systems are most cost effective in facilities with the following:

- Constant water heating load throughout the week and year; housing units and dining facilities are examples.
- High fuel costs to heat water; this is area specific.
- Sunny climates; this is area specific.

The economic viability of a solar system depends on the following aspects, including but not limited to:

- Amount of annual sunshine.
- Heating energy requirements throughout the year.
- Cost of the solar system.

- Price of conventional fuels.
- Temperature of hot water that is required.
- Annual operation and maintenance costs.