MANUAL OF RECOMMENDED PRACTICE

Construction Practices for Potable Building Water Systems

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The International Association of Plumbing and Mechanical Officials

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Foreword

This manual provides education and guidance to help plumbers and other personnel responsible for the installation and commissioning of a potable building water system (BWS) to reduce the likelihood of contaminating plumbing systems during construction activities. If unmanaged, construction activities uniquely contribute to the growth and spread of waterborne pathogens in a potable BWS which in turn contribute to public health disease cases, injury, or death. Since 1965**,** construction activities have been linked to *Legionella* and other waterborne pathogen outbreaks in community and healthcare settings. Most disease cases and deaths from construction activities are associated with a lack of implementing an effective water management process during the construction phase of work. According to the CDC from 2000–2014, when Legionnaires' outbreaks were categorized as resulting from an unmanaged external change, 75% of those outbreak events were associated with hazardous conditions during construction activities. This manual describes activities to be practiced during installation and commissioning of a potable BWS to assure water quality and safety prior to building occupancy. Recommended practices are intended to align with the process and procedures established when implementing a building water management program (WMP) that governs on-going operations and monitoring building water systems which are frequently required for specific building types such as healthcare facilities.

Purpose

Our purpose is to establish a process of water management during construction for new buildings, additions, and renovation of existing buildings. A process for water management during construction is necessary to control the unique hazardous conditions associated with the construction phase of work. Even if a building has been properly designed to reduce the risk of waterborne pathogen (e.g., *Legionella*) growth and spread, the construction phase can derail the water quality and safety of the BWS. Over the past decade numerous guidance documents about reducing the risk of *Legionella* and other waterborne pathogens in premise plumbing have been published. However, the primary focus of other guidance documents has been for the building owner to responsibly implement a WMP for on-going building operations. Current plumbing engineering and construction industry practices allow the construction team to assemble the BWS focusing on the plumbing system performance criteria (e.g, hot water circulation and avoiding pipe leakages) with minimal regard for water quality and safety practices. Gaps exist between the construction phase of work, commissioning for safe building occupancy, and on-going operations. The IAPMO Manual of Recommended Practice: Construction for Potable Building Water Systems is intended to address these gaps and increase plumbing engineer and contractor engagement for improved water quality and safety practices prior to building occupancy. This manual outlines a process for developing guidance for contractors and subcontractors installing and managing a potable BWS during construction. Additionally, this manual may be useful to allied professionals involved with implementing WMPs for building owners and responsible for building occupant safety in and around construction activities.

Audience

Architects
Building Owners and Operators
Certified Industrial Hygienists or Safety Officers
Commissioning Agents
Construction or Project Managers
Design Engineers
Facility Engineers
General Contractors and Subcontractors
Infection Prevention & Control Practitioners
Plumbers and Pipefitters
Plumbing Inspectors and Other Construction Officials
Public Health Professionals

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Manual of Recommended Practice
Construction Practices for Potable Building Water Systems

101 General

101.0 Scope

The IAPMO Manual of Recommended Construction Practices for Potable Building Water Systems, provides guidance on risk management practices specific to potable water supply and distribution systems, during new building construction, expansion, renovation, and replacement projects.

101.1 Applicability

This Manual is applicable to the building water system in the various stages of construction. Within this guidance, the potable building water system includes, but is not limited to:

- The incoming water supply or supplies (from municipal system or self-supplied water sources)
- Water processing steps (e.g., supplemental disinfection, softening, filtration)
- Domestic cold water distribution, chilling, and storage
- Domestic hot water distribution, heating, and storage
- Specialty systems or uses (food service, laboratory, medical equipment, dialysis, high purity water

101.2 Building Types

This Manual shall be applicable to the following building types:

- Commercial and Institutional
    - K-12 Education
    - Higher Education
    - Hospitality
    - Healthcare
    - Long Term Care
- Residential
    - Multiunit residential with central water heater

Note: Although the best practices presented in this guidance are applicable to all buildings, the manner and detail in which information is applied may differ by building type, intended functional purpose, and health characteristics of the building occupants. For example, it may be necessary to understand building occupants considered as susceptible persons, groups, or populations with underlying health conditions (e.g., diabetes, or chronic lung disease) or are immunocompromised (see Section 103.0 Definition of Terms: Susceptible Person)

101.3 Regional and Local Concerns

101.3.1 Regional Concerns

Local weather (e.g. hot and cold temperatures) or regional climate conditions (e.g., temperature, heavy rains, flooding) can impact water quality parameters such as temperature, disinfectant residual concentrations, and microbial growth. Weather and climate conditions should be considered when applying the recommendations of this practice Manual

101.3.2 Local Concerns

When multiple sources of water supply are purveyed, documenting all of the conditions for each source shall be included as part of the construction WMP. Changes in municipal disinfectants or water quality parameters per source shall be noted and taken into consideration. Changes in the water supply due to local emergency or disaster conditions impacting water quality parameters shall also be taken into consideration.

101.4 Terminology.

(1) "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy to comply with the manual.
(2) "should" is used to express a recommendation, but not a requirement.
(3) "may" is used to express an option or something permissible within the scope of the manual; and
(4) "can" is used to express a possibility or a capability.

Note: Accompanying sections of the Standard do not specify requirements or alternative requirements; their purpose is to separate explanatory or informative material from the text. Notes to tables and figures are considered part of the table or figure and can be written as requirements.

101.5 Units of Measurement.

Inch/pound units are the primary units of record in global commerce. In this Manual, the inch/pound units are shown in parentheses. The values stated in each measurement system are equivalent in application, but each unit system is to be used independently. All references to gallons are stated in U.S. gallons. For temperature US Fahrenheit (F°) are stated first with Celsius (C°) listed second.

101.6 Use of the Manual

This manual is intended to be used as information to control hazardous conditions of building water systems that are unique to the phase of building construction or during construction activities. Although this manual can be used during the engineering design phases of work to anticipate potential water quality and safety challenges, it is not a substitution for building codes or other required design criteria. The manual's authors have assumed that an engineer-of-record has appropriately performed plumbing engineer design and has obtained a legal permit for a specific building project in the state or federal jurisdiction of the building site on behalf of a specific building owner and for a designated occupancy type. For further plumbing design criteria and information related to design impacts to building water systems associated with growth and spread of waterborne pathogens, please review the regulations, codes, agency standards, and guidance documents listed in Section 102.0.

101.7 Disclaimer

This document is provided as a service to the industry. The information provided and the application of such requires each organization, group, or person to review the contents for appropriateness and application to the building type and the building owner's water management program. Every building water system has unique attributes which can directly influence water quality and safety parameters. The application of this information must be evaluated by the responsible party(ies) acting on behalf of the building owner and its associated building occupants. Modifications will be necessary for local, state, or federal regulatory requirements. The user(s) of the manual and their related organizations assume the sole risk and full responsibility for implementation of such practices during construction and the consequences of implementation for on-going operations in building environments. IAPMO and its task group members make no representations or warranties about the suitability, completeness, reliability, legality, accuracy, or appropriateness of the information provided to reduce the likelihood of waterborne pathogens present in any building water system, or the disease cases, injury, or deaths that may emerge from such building water systems.

101.8 Reference Publications

This Manual refers to the following publications and, where such reference is made, it shall be to the current edition of those publications, including all amendments published thereto.

101.8.1 Regulations, Codes, Agency Standards, and Guidance Documents

American Water Works Association (AWWA) Responding to Water Stagnation in Buildings with Reduced or No Water Use

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): ANSI/ASHRAE 188 Legionellosis: Risk Management for Building Water Systems

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): ANSI/ASHRAE Guideline 12-2023 Minimizing the Risk of Legionellosis Associated with Building Water Systems

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): ANSI/ASH RAE Standard 514-2023 – Risk Management for Building Water Systems: Physical, Chemical, and Microbial Hazards (ANSI approved)

International Association of Plumbing and Mechanical Officials (IAPMO): IAPMO/ANSI UPC-1 Uniform Plumbing Code

American Society of Plumbing Engineers (ASPE): Engineering Methodologies to Reduce the Risk of *Legionella* in Premise plumbing Systems

AWWA-EPA Document: Disinfecting Building Potable Water Plumbing in New or Repaired Systems November 2024.

Centers for Disease Control and Prevention (CDC): Developing a Water Management Program to Reduce *Legionella* Growth & Spread in Buildings

Centers for Disease Control and Prevention (CDC): Water Infection Control Risk Assessment (WICRA) for Healthcare Settings

Centers for Disease Control and Prevention (CDC): Routine Testing for *Legionella* (https://www.cdc.gov//egione//a/wmp/control-toolkit/routine-testing.html)

Centers for Disease Control and Prevention (CDC): Toolkit: Controlling *Legionella* in Common Sources of Exposure (https://www.cdc.gov/control-legionella/php/toolkit/control-toolkit.html)

International Organization for Standardization (ISO): Water Quality – Enumeration of *Legionella* Website https://www.iso.org/standard/61782.html

National Academies of Sciences Engineering Medicine (NASEM): Management of *Legionella* in Water Systems (https://nap.nationalacademies.org/catalog/25474/management-of-legionella-in-water-systems)

Veterans Health Administration (VHA): Directive 1061(4) Amended Oct 2024: Prevention of health care-associated *Legionella* disease and scald injury from water systems

United States Environmental Protection Agency (EPA) Safe Drinking Water Act, Drinking Water Regulations and Contaminants (https://www.epa.gov/sdwa/drinking-water-regulations-and-contaminant)

United States Environmental Protection Agency (EPA) Distribution System Water Quality Protecting Water Quality with HPC Monitoring (https://www.epa.gov/system/files/documents/2023-08/DS%20Toolbox%20Fact%20Sheets_HPC_508ed.pdf#:~:text=%E2%80%A2%20For%20regulatory%20purposes%2C%20a%20drinking%20water,matrix%2C%20including%20indicator%20organisms%20(e.g.%2C%20coliform%20bacteria).

101.9 Definition of Terms.

The definitions of terms are arranged alphabetically according to the first word of the term. Terms with abbreviations are listed after such terms in parentheses (e.g. AHJ, CDC, WMP) and will appear throughout the guidance document text.

-A-

Authority Having Jurisdiction (AHJ). The organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, installations, or procedures. The Authority Having Jurisdiction shall be a federal, state, local, or other regional department or an individual such as a plumbing official, mechanical official, labor department official, health department official, building official, or others having statutory authority. In the absence of statutory authority, the Authority Having Jurisdiction may be some other responsible party. This definition shall include the Authority Having Jurisdiction's duly authorized representative.

Aerators. A device typically installed at the end of a sink faucet with a small mesh screen to break water flow into multiple water streams adding air into the water flow.

Analytical Laboratory. Laboratory offering services that classify, assay and/or analyze chemical, material, biological, or environmental samples. To process water samples for pathogens such as *Legionella* special certifications are necessary.

-B-

Backflow. The flow of water or other liquids, mixtures, or substances into the distributing pipes of a potable supply of water from sources other than its intended source.

Backflow Preventer. A backflow prevention device, an assembly, or another method to prevent backflow into the potable water system.

Beneficial Occupancy. A stage of construction when all or part of a building is legal to occupy (i.e., approved for occupancy by an AHJ) for the intended functional purpose the building was constructed, whether before or after total completion of the construction project schedule.

Building Occupancy. Occupancy is the actual or intended use of a building type or classification for shelter for people, animals, or property as defined by building codes to further apply potential fire or life safety controls regarding known hazards to the building occupant.
Building as Vacant or Partially-Occupied. The state of a building water system when the building is closed and not in use (vacant) or major portions of the building water system is not in use, or the typical use is significantly reduced (i.e., partially-occupied). This includes the *off* hours of operation and buildings that are shut down for long periods of time (e.g., weeks, months, or years). This could include the construction period before initial opening.
Building Supply. A pipe carrying potable water from the water meter at the street invert or another source of water supply to the building's point-of-entry or other point-of-connection, or distribution on the site.
Building Water System (BWS). A system of plumbing components to deliver potable hot and cold water within a building or site for human consumption, hygiene, or other uses. The BWS extends from the point-of-entry through piping distribution (e.g. mains, risers, or branching) and extends to all distal or terminal fixtures (e.g., sinks, showers, water fountains, or other) as the point-of-use. For the purposes of this manual, the BWS does not include devices, processes, and appurtenances separated from the main BWS by backflow prevention devices, air gaps, or other means to separate the device. Also, *Cooling towers are explicitly excluded and must be managed during and after construction according to relevant AJH requirements*. Note that the AHJ for cooling towers often differs from the AHJ with authority over the potable water system.

-C-

Commissioning. A systematic process that provides documented confirmation that specific and interconnected fire and life safety systems (i.e., in this context the building water system) function according to the intended design criteria set forth in the project documents and satisfy the owner's operational needs, including compliance requirements of any applicable laws, regulations, codes, and standards requiring fire and life safety systems.
Construction Activities. The set of actions that is taken to ready a building, renovated portion of a building, or building addition for an initial occupancy.
Construction Documents. Plans, specifications, written, graphic, and pictorial documents prepared or assembled for describing the design, location, and physical characteristics of the elements of a project necessary for obtaining a permit.
Construction Project Water Steward. (See definition for Responsible Party)**.**
Consumer Confidence Reports. The US Environmental Protection Agency requires community water systems to provide a Consumer Confidence Report, also known as an annual drinking water quality report, to all customers (i.e., businesses, building owners, and residents). These reports provide citizens with information about their local drinking water quality and are typically available on the local water authority's web site. (see Annex A for further information).
Cross-Connection. A connection or arrangement, physical or otherwise, between a potable water supply system and a plumbing fixture or a tank, receptor, equipment, or device, through which it may be possible for non-potable, used, unclean, polluted, and contaminated water, or other substances to enter into a part of such potable water system under any condition.

-D-

Dead Leg. A section of potable water pipe which contains water that has no flow or does not circulate.
Decorative Water Feature. A device or system used to display water for an aesthetic function and is not for the purposes of drinking water. Examples include ornamental fountains, fish tanks, ponds, or other displays of water.
Disinfectant. Chemical agent or physical treatment used to kill or inactivate pathogens.
Disinfectant Residual. The net amount (concentration) of a chemical disinfectant remaining in treated water after chemical demand exerted by the water is satisfied. The units for disinfectant residual are expressed in parts per million (ppm)
Disinfection. The process of killing or inactivating pathogens. Disinfection may be by chemical exposures (free chlorine, monochloramine, chlorine dioxide, hydrogen peroxide and other disinfectants), thermal (high temperature), or UV.
Distal Sites. The plumbing fixture outlets providing cold water and are downstream from the water service entrance. Those plumbing fixture outlets providing hot water that are downstream from the domestic water heating equipment.
Drinking Fountain. A plumbing fixture connected to the potable water distribution system and sanitary drainage system that provides drinking water in a flowing stream so that the user can consume water directly from the fixture without the use of accessories. Drinking fountains should also incorporate a bottle filling station and can incorporate a water filter and a cooling system for chilling the drinking water.

-F-

Filtration. Water filtration is a process of removing or reducing concentrations of undesirable biological or chemical contaminants or aesthetic debris from water to increase water safety and improve water quality. Water filtration devices may occur at the building point-of-entry, mid-stream or in-line piping, or at the point-of-use (e.g., installed on a fixture).
Fixture Branch. A water supply pipe between the fixture supply pipe and the water distribution pipe.

Fixture Supply. A water supply pipe is connecting the fixture with the fixture branch.
Flushing. The action of moving water through the plumbing system to improve water quality. The purpose is to distribute fresh water throughout the building water supply system with water of a quality similar to what is supplied at the building's point-of-entry inlet. This action moves fresh water from the city water supply through the building and moves hot water from the water heater or boiler to the point-of-use.
Flushing Protocol. The procedure of when to move water through the plumbing system during the construction phase of work including frequency (i.e., define specific days of the week for a designated flushing) and a duration of each flush per fixture and valve of the fixture (e.g., time in minutes per flush per fixture per valve – hot and cold) in order to turn water over for maintaining temperature and residual disinfectant.
Full Flush. The one-time flushing event intended to replace at least 100% of the volume of the water stored in the system (complete system turnover) with fresh water from the water supplier to reduce the presence and/or risk of exposure to contaminants.
Flushing, Remedial. The action of replacing or replenishing the water in the plumbing network with a one-time intervention to end a stagnation period.
Flushing, Routine. The action of moving water through the plumbing that is implemented to improve or maintain water quality in the building on a regular basis.

-H-

Hazard. a physical, chemical, or microbial agent associated with a building water system that, in the absence of control, has the potential to cause harm to human health or system integrity.
Hazardous Condition. A condition that contributes to the potential for harmful human exposure to pathogens, chemicals, or physical hazards associated with a building water system**.**
Heterotrophic Plate Count (HPC). Heterotrophs are any microorganism using organic carbon as a food source. The number of heterotrophs in a given water volume (usually reported in Colony Forming Units [CFU] per mL of water) is considered an indirect measure of water quality and effectiveness of a water management program to control microbial growth. HPC is a test to assess heterotrophic counts. Alternative test methods for gross biological water quality may be acceptable based on local Authority Having Jurisdiction.
Hot Water. Water at a temperature exceeding or equal to 120°F (49°C).
Hot Water System. Water heating equipment and all connected downstream pipe fitting and components.
Hot Water Circulation System. A system of potable hot water supply and return piping with shutoff valves, balancing valves, circulating pumps, and a method of controlling the circulating system.

-I-

initial/Remedial/Full Flush/Turnover-Approach. Initial/Remedial/Full/Turnover-Approach flushing is a one- time event intended to replace all the water in the system (complete system turnover) with fresh water from the water supplier to reduce the presence and/or risk of exposure to contaminants. The water needs to flow at a rate to scour the pipes. Spend as few hours as possible completing this task.
Interruption of Normal Operations (System Shut Down Process). The set of actions that should be taken to ready a building for an extended period of no or limited operations or reduced occupancy.

-L-

***Legionella* spp..** A genus of bacteria that can cause a form of pneumonia called Legionnaires' disease or a flu- like illness called Pontiac fever when inhaled, aspirated or directly introduced into the lungs of susceptible individuals. Not all *Legionella* species are equally likely to cause infection and *L. pneumophila* is the species connected to most infections. Legionella spp. are a common environmental bacterium (that is, they can grow outside animal hosts) and are found in water in the natural and built environment, soils, and other ecological niches.
Legionellosis. The term used to describe Legionnaires' disease, Pontiac fever, and any illness caused by exposure to *Legionella* bacteria.

-M-

Monitoring. Conducting a planned sequence of observations or measurements of the physical and chemical characteristics of control measures. Control measures are actions taken towards maintaining a physical or chemical parameter within a pre-established range.

-N-

Nephelometric Turbidity Unit (NTU): A unit of measure indicating the number of suspended particles/solids in water creating an opaque condition. The higher the concentration of suspended solids, the higher the turbidity.
Normal Operations The state of a building water system when the building is open and being used as intended. This includes the normal hours of operation and the number of people that occupy the building.

-O-

Opportunistic Premise Plumbing Pathogen (OPPP): Refers to a group of microorganisms that can exist in building water systems that do not usually infect healthy hosts but may produce infections in immunosuppressed persons, those with underlying diseases, and those with advanced age. *Legionella* is one such pathogen of interest along with others such as *Pseudomonas aeruginosa*, *Acinobacter, Burkholderia, Stentrophomonas*, pathogenic *Mycobacteria* species and some fungi. These pathogens are associated with infection in the bloodstream, brain, spinal cord, lungs, heart, bones, and other regions of the body. These can be serious and even life-threatening infections.

-P-

Point of connection (POC). A new water piping connection for potable water at the building's point of entry, or a connection at an existing water supply pipe within the building (e.g., riser or branch pipe for renovation or expansion of a building).
Point of entry (POE). Where the water from the supply (either a regulated municipal supply or self-supplied water) enters a building. Some buildings may have more than one point of entry (e.g. healthcare facilities may have redundant systems with two points of entry).
Point of use (POU). The location where water is used for human consumption in the building (e.g., faucet or shower).
Potable Water. Water intended for human consumption for drinking or food preparation, or hygiene for bathing, showering, handwashing, or other domestic purposes. The potable water shall meet the requirements of the AHJs for Water and/or Health agencies.
pH Value. A measure of acidic versus base value of water using a range of 0 to 14 with 7 being neutral. Values < 7 indicate acidity, whereas values > 7 indicate base.
Plumbing Fixture. An approved type installed receptacle, device or appliance that is supplied with water or that receives liquid or liquid-borne wastes and discharges such wastes into the drainage system to which it may be directly or indirectly connected. Industrial or commercial tanks, vats, and similar processing equipment are not plumbing fixtures, but may be connected to or discharged into approved traps or plumbing fixtures where and as otherwise provided for elsewhere in this manual.
Plumbing System. Includes all potable water, alternate water sources, building supply, and distribution pipes; all plumbing fixtures and traps; all drainage and vent pipes; and all building drains and building sewers, including their respective joints and connections, devices, receptors, and appurtenances within the property lines of the premises and shall include potable water piping, potable water treating or using equipment, medical gas and medical vacuum systems, liquid and fuel gas piping, and water heaters and vents for same.
Point-of-entry. A location where the building water service line (i.e., supply) enters the building edge.
Point-of-use. A location where water is distributed for final use by a person (e.g., drinking fountain, sink fixture, or shower head).
Process flow diagram. A step-by-step drawing of a building water system that includes the location of all water processing steps including, but not limited to, conditioning, storing, heating, cooling, recirculation, distribution, and waste that are part of the building water system.
Program Team. The group or individual designated by the building owner or designee to be responsible for developing, implementing, and maintaining the water management program.
Property Invert. (See Water Service Connection).
Public Water System. A system for the provision to the public of water for human consumption through pipes or other constructed conveyances if such system has at least fifteen service connections or regularly serves an average of twenty-five individuals daily for at least 60 days per year.

-R-

Remote Outlet. Where used for sizing water piping, it is the furthest outlet dimension, measuring from the meter, either the developed length of the cold-water piping or through the water heater to the furthest outlet on the hot-water piping.
Responsible Party. The people and/or members of the water management program team (e.g. building owner, building owner representatives, tenant, management company, engineer of record, contractor/operator, or others) who will conduct work and are accountable for the safety of the building water system during construction, commissioning, and temporary operations prior to beneficial occupancy.

Riser. A water supply pipe that extends vertically one full story or more to convey water to branches or fixtures.
Risk. The potential for harm to humans resulting from exposure to a hazard such as physical (e.g., scalding, sediment), chemical (e.g., lead or copper), or microbial (e.g., *Legionella*).
Risk management. Systematic activities to reduce risk.
Roughing-In. The installation of all parts of the plumbing system that can be completed prior to the installation of fixtures. This includes drainage, water supply, gas piping, vent piping, and the necessary fixture supports.

-S-

Safe Drinking Water Act (SDWA). A US law established to protect the quality of drinking water focusing on all waters actually or potentially designed for drinking use, whether from surface water or groundwater sources.
Sediment. Debris within building water systems from soil entrainment/ingress, construction debris, corrosive metals, or other particulate matter impacting water quality and safety.
Service Line and Supply Line. Water service lines and building supply lines connect water purveyor water mains to buildings potable water systems and sometimes to supply fire protection systems. In some cases, the service lines is the property and responsibility of the water purveyor whereas the supply line is the property and respon-sibility of the building owner.
Spas. A tub, container, or small pool containing water for recreational or therapeutic use such as whirlpools, saunas, hydrotherapy pools, or other. If not maintained, these water features are known sources of harboring OPPPS.
Substantial Completion. (See definition for Beneficial Occupancy).
Susceptible person or population. An individual or group with characteristics that increase the likelihood of infections from OPPPs including but not limited to: children, persons > 50 years of age, smokers, person with an underlying health condition (e.g., diabetes, cancer, lung disease, transplants), or a person with a suppressed immune system, or taking drugs related to weakening the immune system.
Supplemental Disinfection. An onsite application of a method to disinfect water that flows within the building water system.
Stagnant Water. When water in the BWS (e.g. domestic water), remains unused, or moves very slowly through the system, causing water quality parameters to deteriorate. This may occur due to seasonal occupancy within the building, vacated areas during construction, or due to other conditions where water does not move routinely through the piping system. (see definition for Water Age)
System Reopening. The set of actions that should be taken to ready a building for normal operations after an extended period of no or limited operations.

-T-

Tepid Water. Lukewarm or ambient water temperatures typically in the range of 69^{O}F to 104^{O}F (20^{O}C to 40^{O}C) that supports the growth and spread of OPPPs.
Thermostatic (Temperature Control) Valve. A mixing valve that senses outlet temperature and compensates for fluctuations in incoming hot or cold-water temperatures.
Toilet Facility. A room or space containing not less than one lavatory and one water closet.
Turbidity. Cloudy condition of water due to the presence of particulate materials in suspension. A gross assessment of turbidity can be made via visual assessment of water. More accurate and sensitive measurement of turbidity is made via nephelometer and reported in units of NTU/L or FTU/L.

-W-

Water Age. The residence time water remains in one or more locations within the building water system. High water age negatively impacts water temperature (i.e., creates tepid water conditions) and residual disinfectant (i.e., promotes low disinfectant levels).
Water Distribution Pipe. In a building or premises, a pipe that conveys potable water from the building supply pipe to the plumbing fixtures and other water outlets.
Water Main (Street Main). A potable water supply pipe running underground for public or community water service connection.
Water Reservoir. Any device or piece of equipment that contains water within the mechanism which can become stagnant allowing for the growth or spread of OPPPs into the environment when the device is put into use.
Water Service Connection. The point of connection to the public water supply to a water service line at the boundary or edge of the building's site or lot.
Water Service Line. See **Service Line and Supply Line**.
Water/Wastewater Utility. A public or private entity which may treat, deliver or do both functions to reclaimed (recycled) water, potable water, or both to wholesale or retail customers.

Water Management During Construction (WMC). A risk management plan to help building managers identify risks to water quality and water safety prior to occupancy of any building (e.g., newly constructed, renovated, unoccupied and re-opened, change of use or occupancy and building acquisition). This plan includes clear procedures for managing these risks at various points in the building lifecycle, including start-up, normal operation, reduced occupancy, water system shut-down, and water system restart. A WMP can be used to manage any health risk associated with loss of chemical or microbiological water quality or with physical water safety (scalding).

Water Management Program (WMP). The implementation of a risk management plan for building water systems that includes the seven steps of developing a water management program (e.g., program team, water system descriptions and process flow diagrams, analysis of building water systems, control measures, monitoring /corrective actions, confirmation including verification and validation, and documentation) per ANSI/ASHRAE Standards 188 and 514. A WMP also includes risk management during construction activities and commissioning prior to on-going building operations and maintenance.

Water-Using Mechanical Systems. Includes building HVAC systems with chillers, compressors, blowers, boilers, pumps, and cooling towers.

Wetted Plumbing Systems. potable water systems that are filled with water.

Water Safety Plan (WSP). (See Water Management Program)

Water Supply System. The building supply pipe, the water distribution pipes, and the necessary connecting pipes, fittings, control valves, backflow prevention devices, and all appurtenances carrying or supplying potable water in or adjacent to the building or premises.

102 Pre-Construction Activities

Successful water management during construction and installation of water systems requires planning and activities before construction begins. Pre-construction activities may be the responsibility of design engineers, general contractors, or plumbers/plumbing contractors. Critical pre-construction activities include

- Identifying responsible parties
- Developing a project timeline, inclusive of water management activities,
- Assessing the building's water supply water quality,
- Ensuring that system components that are used during construction/installation (e.g., flushing ports and drainage, sample collection ports, temporary connections for water supply for construction activities) are included in design specifications and are scheduled for installation prior to their intended use, and
- Review of relevant guidance and standards.

102.0 Identify Responsible Parties.

Prior to installation of the BWS, the entity with overall responsibility for the construction project shall designate a responsible party to oversee and coordinate water management over the course of construction project. The responsible party shall designate individuals or organizations responsible for the activities outlined in this guidance that are appropriate for the building type and intended use. If a construction water management team is required per an AHJ (see section 102.4), or established voluntarily, the installer shall coordinate construction activities with the building owner's existing water management program and team requirements. If no water management program nor water management team is provided, then installer becomes Responsible Party for the entire construction period.

102.1 Develop a project timeline for water management activities.

The responsible party or a designee shall develop a project timeline showing specific plumbing system and water-related activities. A description of project scoping, scheduling and testing is presented in Section 103. Key milestones to include in the timeline include the anticipated dates or durations of (i) system installation, (ii) connection to the water supply (service), (iii) system filling and initial system flush, (iv) a schedule of sample collection and analysis, (v) a schedule of water turn-over (flushing) during the finishing construction and pre-occupancy water management period, (vi) commissioning (including final disinfection), and (vii) transfer of the system to the owner/operator for beneficial occupancy. If a project is conducted in stages, the schedule/timeline should cover all stages. The project timeline shall be maintained in project documentation and available for review and reference.

Prior to developing the schedule/timeline, the responsible party and water management team shall review building and occupant information and characterize the building in regard to its risk requirements (described below). Reviewing this information helps the team assess the complexity of the project and identify any components or processes requiring specific attention for risk management. Information that should be obtained and reviewed includes, but is not limited to,

- Architectural composite floor plans with plumbing fixture locations
- If the system is partially installed, as-built drawings,
- Specifications for treatment (e.g., water softener(s), filtration, supplemental disinfection, etc.) and water heating equipment
- Commissioning requirements
- Building Owner's Safety or Infection Control Risk Assessment during Construction Activities

Building intended use and anticipated occupancy are related to the level of water quality management required during both construction and building operations. Broad categories of buildings with different risk levels (public health risk to future occupants) and different water management requirements are presented in Table 102-1. All buildings of categories C and D should be disinfected per governing code and their designs must include disinfectant injection ports and sample ports for drawing water samples for measuring disinfectant concentration. Disinfectant injection points should be designed into the building water system without creating dead legs when not in use. Disinfection injection points can also be used during beneficial occupancy if the system design includes supplemental disinfection post-occupancy. Long-term supplemental disinfection often triggers extensive environmental regulatory requirements under the Safe Drinking Water Act and should be fully considered before it is added to a system.

TABLE 102-1
BUILDING WATER SYSTEM RISK CATEGORIES

CATEGORY	DESCRIPTION
A	Buildings with low likelihood of human exposure to aerosols such as: Single-family residences, duplexes, town homes and other small residential buildings
B	Buildings with *low/moderate* likelihood of human exposure to aerosols such as: • Commercial buildings without showering facilities • Retail buildings • Warehouses, server farms and other low occupancy buildings with low incidence of occupant exposure to aerosolized potable water
C	Buildings with *moderate* likelihood of human exposure to aerosols with sensitive occupants/users (excludes healthcare) such as: • Institutions, schools, and childcare facilities • Hotels and resorts • Gyms and Recreational facilities • Large office buildings • Medical office buildings • High-rise residential
D	Buildings with *high* likelihood of human exposure to aerosols including healthcare facilities with sensitive occupants/users such as: • Hospitals, critical access hospitals, and skilled nursing facilities (i.e., over 24-hour stay) • Senior facilities (e.g., assisted living) • Nursing and rehabilitation facilities • All other health care facilities including outpatient surgical centers and other outpatient care

Note: Buildings in *categories C and D* have specific water quality management requirements that must be considered in building water system design.

102.2 Water Supply Information Collection.

The Responsible Party shall obtain the building water supply information outlined in Table 102-2. Contractors and plumbers will use the information outlined in Table 102-2 for assessing results from water quality tests during construction, determining the suitability of the water supply for filling the BWS, and troubleshooting water quality problems encountered during construction. Information about the BWS supply should be recorded, maintained within construction water management documentation, and provided to the building owner after completion of construction and at the onset of beneficial occupancy.

Samples for field measurement of disinfectant residual concentration should be collected as near as possible to the service connection (if the connection does not exist when pre-construction water quality assessment is done) or from a sample port as close to the connection with the water supply as possible (if a service is already in place). Water quality can change significantly in service lines and samples collected downstream of service lines may not reflect water quality in the supply accurately.

TABLE 102-2
REQUIRED WATER SUPPLY INFORMATION

INFORMATION	INFORMATION SOURCES	USES OF THE INFORMATION
General water quality information	Water supplier Consumer Confidence Report (CCR), if the water supply is a public water system; water quality testing data for systems with self-supplied water.	• pH and temperature data are generally related to the potential for water quality change/degradation. CCR pH data can be compared against field measurements for building water samples. • Hardness and alkalinity contribute to precipitate formation in water heating, scale formation, and performance of treatment units

INFORMATION	INFORMATION SOURCES	USES OF THE INFORMATION
Type and level of disinfectant used	The water supplier AND field measurements conducted or overseen by the responsible party. In some cases the disinfectant type (free chlorine, chloramine, or undisinfected) is provided on the supplier's CCR. If not, the water supplier should be contacted to obtain this information. The water supplier can also be contacted for information on the typical disinfectant concentration at or near the new service connection.	• Selecting the appropriate measurement techniques and equipment for disinfectant residual • Disinfectant concentration from samples collected in the building are compared against disinfectant concentration in the supply • Determining whether the supply water is of suitable quality for filling the BWS
Corrosion control chemicals added to the water	Water supplier Consumer Confidence Report (CCR), if the water supply is a public water system	• Contextual information used if excessive corrosion is observed during construction/installation
Distribution system maintenance, main breaks, or other significant disruptions of the supplier distribution system near the building service connection(s) during the prior 3 months	Outreach to the water supplier	If the supplier reports distribution system disturbance near the service connection, • the responsible party may contact the supplier to determine whether flushing the supply distribution system is feasible and advised, • Prior to filling the building water system, additional water quality testing of the building supply should be conducted. At a minimum, turbidity and/or suspended solids should be tested. Additional testing could include HPC and *Legionella* or *L. pneumophila,* and • When filling the building, the responsible party should ensure the service connection is flushed until the water is clear and a steady disinfectant concentration is achieved.

102.3 Design Coordination.

The Responsible Party shall coordinate with the engineer-of-record to

- Ensure that designs include flushing ports and drains/drainage systems for use during construction and/or during occupancy.
- Design and install sample ports (i.e., water testing locations for non-fixture locations – risers, branches, etc.) in the piping design to comply with the Responsible Party requirements or with the WMP team. Building supply sample port(s) must be installed near the building POE(s) to allow collection of samples with water representative of the building's supply.
- Design and install temporary connections and distribution for water used for construction or during the construction process
- Design and install temporary or permanent ports for injecting disinfectant during building commissioning.

Before construction begins, the general contractor, building owner representatives, plumbing subcontractor, and the design engineer-of-record should review a schematic building section diagram (see example Figure 103-1). This diagram should illustrate the base BWS design, identifying existing components and highlighting areas that require additional coordination—such as flushing valves, sampling ports, or water treatment injection ports. The components requiring additional coordination may be temporary or, more commonly, permanent additions to the infrastructure. Their purpose is to support water management activities throughout both the construction phase and post-occupancy building operations.

Note: Although these supplemental water management components typically go beyond minimum code requirements, adequate water management during construction (as described in this manual) is impossible if they are not included in the system design and installation. When installed, they must not interfere with any applicable codes, standards, or AHJ compliance policies.

Traditional construction methods for BWS often pose challenges for effective water management. For example, piping risers, branches, or drops filled with stagnant water—awaiting fixture installation—can result in high water age and increased risk of water quality degradation. To mitigate such risks, a Construction Water Management Plan and Schedule should be developed (See

Sections 103 and 104 for more information). This plan and diagram should be used to identify key components and related activities, including but not limited to:

- Review transition points where the municipal water service line enters the building property. Identify above-ground flush points to address stagnant water or construction debris (soil/sediments) in underground service lines.
- Evaluate dry system start-up options and delay full or partial water system activation to the extent possible to reduce stagnation.
- Plan and implement flushing protocols, including identification of effective flushing points.
- Eliminate or avoid creating dead-end piping through design or field modifications.
- Designate temperature monitoring locations for both hot and cold water lines.
- Identify residual disinfectant sampling points, including risers and floor branch locations.

The building section diagram should serve as a critical communication tool to ensure all responsible parties share a clear understanding of the goals and requirements of the water management strategy. A construction water management plan can be effectively integrated into traditional construction methods without significant burden to the project. With modest time investment, clear communication, and practical implementation, the benefits to building safety and water quality are significant.

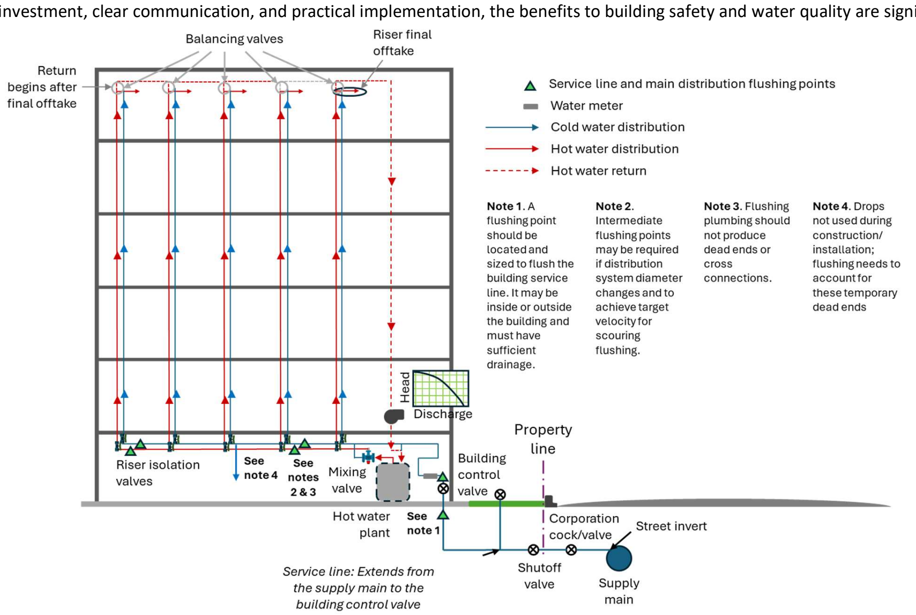

FIGURE 102-1
SERVICE LINE AND MAIN DISTRIBUTION FLUSHING POINTS

102.4 Review of Relevant Standards and Guidance Documents

The party responsible and members of the water management team shall review any standards and guidance documents relevant to water management in domestic water systems. Key documents include

- This manual,
- ASHRAE Guideline 12 (Managing the Risk of Legionellosis Associated with Building Water Systems)
- ANSI/ASHRAE Standard 188 (Legionellosis: Risk Management for Building Water Systems)
- ANSI/ASHRAE Standard 514 (Risk Management for Building Water Systems: Physical, Chemical, and Microbial Hazards), and

- ASPE's "Engineering Methodologies to Reduce the Risk of *Legionella* in Plumbing Premise Systems"
- Local, regional, state or national plumbing code
- Local, regional, state or national health code

Additional standards and guidance documents may be required for review for health care facilities, senior residential facilities, and other facilities with water management program requirements or that will ultimately be used by building occupants with increased susceptibility to waterborne pathogens.

NOTE: cross connection code requirements as it pertains to local ordinances

103 Water Management during Construction Activities

103.0 Construction Timeline, Activities, Hazardous Conditions, Key Events, and Milestones

103.0.1 Construction Timeline

By following the requirements described in Section 107, the building owner should be able to demonstrate acceptable potable water quality for beneficial occupancy reducing the likelihood of unintended consequences from construction-related activities. The facility should develop and maintain a construction project schedule to identify the risk management activities and key milestones that impact water quality. The construction schedule should also include any analytical laboratory testing events that are necessary to monitor water quality and water safety up until the first date of building operations. All phases of a construction or renovation project should be addressed in the schedule with the determination of risk (e.g. determine extent of project scope or renovation, identify susceptible population exposure, determine mitigation strategies). A simplified timeline for construction-related potable BWS activities is shown in Figure 103-1**.** For complex installations, the five phases shown in Figure 103-1 frequently overlap (e.g., when a system is commissioned in stages) and require the coordination of multiple parties such as building owner representatives, design engineers, prime contractors, plumbing professionals, and subcontractors such as commissioning agents and pre-occupancy disinfection specialists. Since protecting the potable water system is multidisciplinary responsibility, potable water system construction and commissioning should be implemented by a construction WMP team and with responsibilities of all parties clearly delineated.

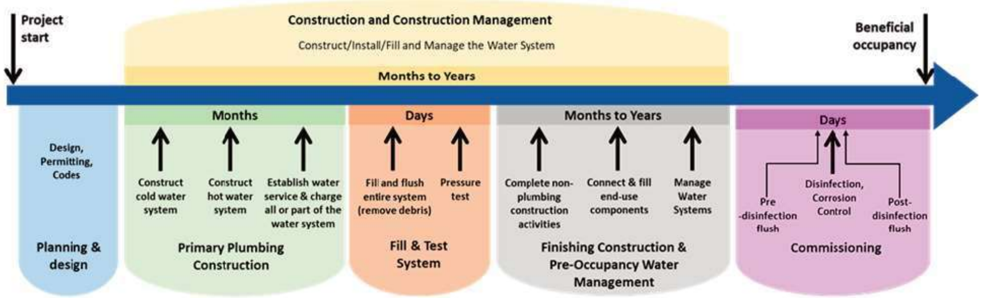

FIGURE 103-1
CONSTRUCTION ACTIVITIES TIMELINE

103.0.2 Construction Activities and Hazardous Conditions

Each of the phases shown in Figure 103-1 can be designed and executed to protect the potable BWS from contamination and reduce the likelihood premature growth and spread of OPPPs. Construction potable water system management is similar to water management under normal building operations with additional hazards or hazardous conditions that are present during construction primarily due to the building being unoccupied. Construction potable water system activities that can contribute to water quality control both during construction and after beneficial occupancy are listed in Table 0-1.

A fundamental aspect of this manual is that all of these activities are a part of water management during construction. At present, there is a misplaced conception that disinfection alone is sufficient for ensuring a potable water system is ready for beneficial occupancy. The reality is that many potable water systems that were designed and installed by conscientious professionals and disinfected according to requirements in place at the time have entered their service life contaminated, resulting in avoidable disease cases and expenses to the building owner. Although implementing a WMC during all phases of the potable BWS construction does not guarantee that all water systems will be contamination free at beneficial occupancy, it does represent a standard of care implemented during construction to reduce the likelihood of BWS contamination and subsequent exposure to building occupants.

TABLE 0-1.
LIST OF CONSTRUCTION ACTIVITIES AND HAZARDOUS CONDITIONS

POTABLE WATER SYSTEM CONSTRUCTION ACTIVITY	GENERAL DESCRIPTION
Pre-construction supply water assessment and design for maintaining water quality	The water quality of the future potable water system supply is tested and results are used to determine controls required during construction. System design includes features related to water quality management such as dedicated flushing points and associated drainage. Certified plumbing materials and designs are chosen to be compatible with the water supply characteristics.
Construction activities (hazardous conditions) within the overall construction project schedule known to increase risk	Demolition, excavation (e.g. soil, debris, or sediment invasion), underground utility connections, construction equipment with reservoirs, vibration activities (e.g., loosening biofilms from pile driving, jack hammering, and saw cutting), water main breaks, and re-pressurization of the BWS.
Construction water uses	Construction water uses that impact the potable water system are documented and designed to ensure non-potable water does not enter the potable water system and that construction water components do not present a residual risk when construction is completed, and construction water plumbing is disconnected.
Transport, storage and handling of plumbing equipment	Plumbing materials are transported, stored, and handled to minimize the risk that contaminants are present. Contaminants present in the system can be hazardous, can reduce the effectiveness of disinfectants in the water and can present conditions for biofilm growth and water quality degradation.
Charging (filling) the potable water system	Only potable water is used to charge the system. Practices are in place to ensure a sanitary connection to the water supply. If the water quality of the supply does not meet specifications, supplemental treatment may be required. Pressure testing is conducted to minimize the likelihood that contaminants are introduced. After connection, flushing is conducted to eliminate debris and contaminants present in the system prior to installation and debris and contaminants introduced during installation. See Annex C for details on initial system flush.
Staging	Construction of the water system is staged to reduce the possibility of contamination between filling and disinfection, to the extent feasible. For example, downstream system components are not connected to active parts of the system until necessary.
Preventing non-potable water from entering the potable water system	Backflow prevention and cross connection control activities are in place, monitored and documented.
Potable water system management between filling and disinfection or beneficial occupancy	Potable water system management between filling and disinfection (similar to a WMP during normal building operations) is governed by a WMP that requires a system assessment, implementation of water quality controls, regular turn-over of water throughout the connected BWS and monitoring of both the controls and the biological water quality.
Pre-occupancy disinfection and commissioning	The potable water system is disinfected according to standards. Disinfection requires pre- and post-disinfection flushing, maintaining a target disinfectant residual throughout the BWS for a specified duration and monitoring to ensure that the target disinfectant concentration and contact duration are met. Additionally, BWS commissioning efforts must include water efficiency systems and fixtures to assure adequate hot and cold temperature ranges, minimal water age (stagnation), and adequate disinfectant residual are present. See Annex C for details on system flushing.

103.0.3 Construction Key Tasks and Milestones

Key tasks and milestones within an overall construction project schedule are intended to increase communication and coordination for achieving interim progress toward the overall WMC goal of opening the new building or renovated areas with safe building water. For creating a base project schedule, Table 0-1 lists a minimal number of potable building water system key tasks and milestones representative of a typical building water system progress during construction. The building owner's specific project maybe more complex and require more detailed key tasks or milestones beyond those mentioned here for items such as off-site construction or utility connections; central utility plant/systems upgrades; phased construction or phased occupancy of the project; or specialty equipment installation (e.g., spas or saunas, decorative water features, misters, dialysis treatment, central sterile processing), among others.

TABLE 0-1
EXAMPLE(S) OF BWS PROJECT SCHEDULE KEY EVENTS AND MILESTONES

KEY EVENT OR MILESTONE	DETAILS AND REQUIREMENTS
Service connection to water supply	(1) Water provider to determine schedule for connections in coordination with the construction project schedule and shall ensure adequate flushing in accordance with the Authority Having Jurisdiction. (2) Document the following dates: Taps and connections, shutdowns and lockouts, flushing events prior to connection or any service interruptions.
Construction start date	(1) Document temporary water connection requirements and or permits in WMP (e.g., hydrant connections, or temporary water lines for removal later). (2) Document permanent water connection requirements and or permits in the WMP.
Cold water activation start date	(1) Document first time the BWS is filled or charged (a) Partial system activation dates (2) Document adequate flushing (a) Partial system flushing dates (3) Document cross connection device testing reports (4) Environmental Testing
Hot water system activation start date	(1) Document permanent start date (activation) (2) Document temporary start date (activation) (3) Document temperature and ranges (4) Equipment maintenance schedules
Piping system installation (cold, hot, sanitary, storm)	(1) Determine methods to minimize contractor or building occupant exposures (2) Drainage scheduling for flushing availability (3) Insulation (4) Punch List (5) AHJ inspections
Equipment installation (ice machines, etc.)	(1) All equipment start-up documentation (e.g., medical equipment, equipment with filters) (2) Procedures for health and safety
System purging (sediment and debris)	(1) Dry Nitrogen (2) Strainers/equip
Flushing protocols (start and duration)	See Annex C for details on system flushing
Installation testing	(1) Pressure testing
Water quality monitoring and testing	(1) Flushing protocols (2) Water quality monitoring (e.g., temperature, residual disinfectant, water age) (3) Analytical water testing (e.g., HPC, *Legionella*, or other pathogens) (a) Dates (b) Level/results
BWS Disinfection	(1) Procedure/method and testing results documented
Beneficial occupancy (substantial completion)	(1) AHJ final inspections/certificate of occupancy (2) Building owner's staff is the primary building occupant prior to first day of public operations (3) Determine hand-off of building water system from contractor to building owner
Building owner transition to on-going operations	(1) Utilities on and commissioned (2) Transfer of WMC from construction/commissioning to WMP for on-going operations
First day of business operations to public	(1) Public occupancy of the building for designated use (2) Healthcare providers have obtained a license to operate and admit patients for treatment

103.1 Equipment Requirements

103.1.1 Personal Protective Equipment (PPE).

Personnel that perform flushing shall utilize appropriate personal protective equipment (PPE) based on a task specific risk assessment and any OSHA requirements.

103.1.2 Other Equipment Requirements.

The following equipment shall be required for monitoring water quality parameters or testing:

(1) Appropriate sampling bottles/supplies for laboratory samples. Sample bottles for microbial parameters (HPC, *Legionella* and others) must be sterile and contain a disinfectant quenching agent.
(2) A digital colorimeter (chlorine meter) test kit with calibration to an accuracy of+/- 3 percent.
(3) Reagents for measuring specific residual disinfectant (e.g., chlorine or monochloramine)
(4) A digital thermometer for measuring water temperature. Thermometers should be calibrated for accuracy to within +/- 2^0F (+/- 1^0C)
(5) Tools for removing aerators and supply stop covers (check with the appropriate manufacturers)

Note: Additional equipment recommendations can include a digital camera, record book (for documentation), stopwatch, graduated measuring device (which, in combination with the stopwatch, can be used to estimate flowrates and calculate flush volumes), turbidimeter, and pH probe.

104 Construction Means and Methods

104.0 Construction Means and Methods

The Responsible Party shall utilize one of the construction means and methods described below (e.g., dry vs. wet system) for start-up procedures to fill, circulate, and operate the building water distribution system prior to beneficial occupancy:

104.1 Pressure Testing

Pressure testing can be conducted with water, air, or dry nitrogen purging. Air and nitrogen testing allow delay in filling the system and have water quality and water con-servation benefits. When pressure testing is conducted with water, the system must be filled with potable water; water for pressure testing must be from a regulated water supplier or a regulated and tested community water system (if self-supplied). Tests to ensure water quality is fit for purpose include visual inspection of water clarity, confirmation that there is no unusual odor to the water (beyond the smell of disinfectant), disinfectant concentration, and pH. Other tests that should be considered are total coliforms (an indicator of sewage contamination) and HPC (if high, an indication of poorly controlled biological water quality). Total coliform and HPC tests must be conducted by a certified laboratory and may require more than 24 hours to produce a result. Water should be considered unsuitable for human consumption if water quality samples are positive for total coliforms or if water samples have HPC > 500 /ml. Pressure testing with water should be conducted according to manufacturer testing considerations and methods.

104.1.1 Temporary Water Connections

When leaving the BWS dry, a temporary water supply connection that is separate from the permanent BWS may be supplied to serve water for construction activities (e.g., contractor restrooms or mixing aggregate materials). See also section 104.5.

104.1.2 Dry System Procedures

System filling can be delayed by employing dry system procedures. Dry system testing shall be conducted as specified in UPC section 609.4 (see text box). When dry system procedures are used for testing, the BWS shall be filled no later than two weeks prior to occupancy and with sufficient time to accomplish procedures as described 104.2.3 (Initial System Flush) and 104.9 (Pre-Occupancy Disinfection and Building Opening). Once the system is filled, the system shall be maintained as indicated as in Section 104.3 (Routine Flushing).

> **609.4. Testing.** Upon completion of a section or of the entire hot and cold supply system, the system shall be tested with water or air. The potable water test pressure shall be greater than or equal to the working pressure under which the system is to be used. The air pressure shall be a minimum of 50 psi (345 kPa). Plastic pipe shall not be tested with air. The piping system shall withstand the test pressure without showing evidence of leakage for a period of not less than 15 minutes.
> **Exception:** PEX, PP or PE-RT tube shall be permitted to be tested with air where permitted by the manufacturers' instructions.

104.1.3 Filling the System in Stages (Hybrid-Fill)

When only a portion of new construction or renovated BWS is filled with water, that portion of the system shall be flushed and tested in accordance with Section 104.1.4. Dry portions of the system shall comply with Section 104.1.12.

104.1.4 Wet System Procedures.

When Section 104.1.1 Dry System Procedures are not possible for the whole or part of a building, all or a portion of the water system shall be filled as described in section 104.2 (Filling the Building Water System) and procedures including routine flushing (section 104.3) and routine water quality monitoring (section 104.4) shall be followed for all filled sections of the building until building opening, when those procedures become the responsibility of the building owner/operator.

104.2 Filling the Building Water System.

104.2.1 Pre-system Fill Checklist.

Prior to filling the system, the Responsible Party shall

1) Communicate with the water purveyor to coordinate the connection and to verify that BWDS water quality meets target goals and specifications as indicated in Section 104.2.2 Filling the System.
2) Develop a plan to ensure only potable water from a suitable supply is used for filling the system.
3) Draw samples and test the water just upstream of building POE to meet the following potable water requirements:
   a) Sample is clear via visual inspection with no sediment OR turbidity of less than 1.0 NTU
   b) Sample is free of color via visual inspection
   c) Sample disinfectant residual meets water purveyor regulatory requirement.
4) If water sample does not meet potable water requirements above, Responsible Party shall coordinate with water purveyor to address further hazard controls.

104.2.2 Filling the System.

Once the pre-system fill checklist is complete, the Responsible Party or a designee shall flush the water system within 10 pipe diameters of the new connection until the supply water is visibly clear. If a water main break or other significant disruptive events occurred in the vicinity of the new connection over the past year, then additional flushing of at least 100% of the underground pipe volume greater than or equal to 2.5 feet per second from the service connection to the POE for the building prior to system fill shall be completed. Once clear water is visible, the supply shall be connected to the BWDS and both the cold and hot water distribution systems shall be filled with cold water. Sufficient drainage shall be available at the point of connection to ensure water does not pool and there is no opportunity for flushed water to enter the newly connected building water system, or as otherwise required by the AHJ. **Exception:** As outlined in Section 104.1.3 Filling the System in Stages (Hybrid-Fill) from the Point of Connection.

104.2.3 Initial System Flush.

The Responsible Party shall document the date of water activation for a newly constructed BWS and begin flushing activities. After initial system fill, the water system shall be flushed immediately to remove sediments, debris, loose deposits, and other residuals from the system installation process. The initial flush shall achieve the target velocity of no less than 2.5 feet per second; aerators, showerheads, and other flow regulating fixtures shall be removed prior to flushing. To the extent possible, valves shall be opened quickly for removal of biofilm. At least five pipe volumes should be flushed to account for nonideal flow and mixing in pipes. Water heaters with storage shall be flushed through the equipment's drainage port. Water heaters shall remain off (non-heating) during the flush. Other plumbing equipment with storage (e.g., water softeners) shall be flushed according to manufacturer instructions. Flushing should be conducted starting from the building POE service line and then conducted sequentially toward the BWS distal system segments; this type of progressive flushing prevents entrainment of contaminants deeper into the system. See Annex C for detailed guidance on system flushing.

104.2.4 Initial System Baseline Monitoring

After flushing, disinfectant residual and temperature shall be measured at representative fixtures and flushing points and recorded to serve as baseline values as outlined in Table 104-1, or as required by the AHJ.

104.3 Routine Flushing

After initial fill but prior to BWS disinfection, Responsible Party or a designee shall flush 100% of the volume in the cold and hot water system by developing a flushing protocol:

(1) Flush all fixtures in the building at least twice per week, 3-4 days apart (e.g., flushing schedule on Monday and Thursday or Tuesday and Friday).

(2) Flushing shall be conducted with aerators, flow restrictors and shower heads removed. Taps/valves/fixtures used for flushing shall be opened as quickly as possible (not gradually) to promote rapid changes in shear at interior pipe walls to promote removal of biofilm that accumulates during water stagnation.

(3) For each flushing occurrence

- **a.** Flush hot water first and then cold water;
- **b.** For hot water flushing after water heater and recirculation pump activation:
  - **i.** flush a minimum of three (3) times the total volume of water upstream of each fixture to the nearest branch or main. Include the volume of hot water storage to the fixtures nearest the water heater. Flush sequentially from the building POE to the furthest fixtures. Finally, flushing the return line downstream of each hot water return flow control valve and at the recirculation pump.
  - ii. continue flushing until temperature is stable to within ±5°F for hot water for 10% of randomly selected sinks, lavatories, and showers. For showers with diverter valves, flush both the fixed shower heads and shower hoses;
  - **iii.** once temperature is stable, at the same previously selected sinks/lavatories, measure residual disinfectant level. If residual disinfectant is greater than or equal to 0.2 ppm, (measured as total chlorine if the building supply has monochloramine disinfectant or measured as free chlorine if the building supply has free chlorine disinfectant) flushing can stop, otherwise continue flushing until residual target is met or as required by the AHJ.
- **c.** For Cold Water Flushing:
  - **i.** flush a minimum of three (3) times the total volume of water upstream of each fixture to the nearest branch or main. Flush sequentially from the building POE to the furthest distal fixtures.
  - ii. continue flushing until temperature is stable to within ±2°F for cold water and for 10% of randomly selected sinks, lavatories, and showers. For showers with diverter valves, flush both the fixed shower heads and shower hoses;

iii. once temperature is stable, at the same previously selected sinks/lavatories, measure residual disinfectant level. If residual disinfectant is greater than or equal to 0.2 ppm, flushing can stop, otherwise continue flushing until residual target is met or as required by the AHJ.

See Annex C for detailed guidance on system flushing.

104.4 Routine Water Quality Monitoring.

After routine flushing, water samples shall be collected for measuring water quality parameters (i.e., process control parameters including, at a minimum, disinfectant residual, temperature, and water age) as outlined in Table 104-1 or as required by the AHJ. Additional water sampling and testing for HPC and *Legionella* shall be performed for healthcare and long-term care building occupancy types as outlined in Table 104-2 or as required by the AHJ. The Responsible Party shall develop protocols for taking action if target levels are not met and shall maintain both written and digital records of all sample results.

TABLE 104-1
REQUIRED WATER QUALITY AND CHARACTERISTIC MONITORING REQUIREMENTS – ALL BUILDINGS

PARAMETER	METHOD & FREQUENCY	SAMPLE LOCATIONS	PERCENT SAMPLE LOCATIONS	TARGET LEVELS
Water age	Flushing protocol. Begin after initial flush; twice weekly thereafter	All plumbing fixtures (i.e., sinks, showers, drinking fountains),	100%	Less than 96 hours (document flushing protocol with frequency and duration)
Disinfectant residual after flushing[1]	Digital colorimeter instrument with proper reagents. On first filling, after initial flush, and weekly thereafter	Building entry point (cold water)	100%	≥ 0.2 ppm (mg/L) or the minimum residual concentration for the water supplier (set by state regulatory agencies when water is not self-supplied)
		Water heater discharge(s) (prior to initiating heating)	100%	Prior to water heating, the greater of 0.2 ppm (mg/L) or 80% of the entry point disinfectant residual
		Water softener discharge line (if applicable)	100%	The greater of 0.2 ppm (mg/L) or 80% of the entry point disinfectant residual
		Distal fixture for each major distribution system branch or riser or floor (hot and cold) [3]	15% of all plumbing fixtures, sample should be flushed sample, not first draw.	The greater of 0.2 mg/L or 80% of the entry point disinfectant residual
Temperature after flushing[2]	Digital thermometer. On first filling; monthly after initial flush until heating is initiated; then weekly thereafter heating system activation	Building entry point (cold)	100%	< 77°F (cold)[2]
		Water heater discharge(s)	100%	< 77°F (cold, prior to heating) and ≥ 140°F (after heating initiated)
		Return of recirculation loop	100%	< 77°F (cold, prior to heating) and ≥ 131°F (after heating initiated)
		Distal fixture for each major distribution system branch or riser or floor (hot and cold)[3]	15% of all plumbing fixtures, sample should be flushed sample, not first draw.	< 77°F (cold) and ≥ 131°F (hot) [4]
Sediment after flushing	Visual inspection. On first filling and weekly thereafter	Building entry point (cold)	100%	Water is clear, no visible discoloration, no visible sediment
		Water softener discharge	100%	
		distal fixture for each major distribution system branch or riser or floor (hot and cold)[3]	15% of all plumbing fixtures, sample should be flushed sample, not first draw.	

PARAMETER	METHOD & FREQUENCY	SAMPLE LOCATIONS	PERCENT SAMPLE LOCATIONS	TARGET LEVELS
pH after flushing	Digital instrument. On first filling, after initial flush, and monthly thereafter	Building entry point (cold)	100%	6.5-8.5 pH units based on pH scale 0 -14 [5]
		Water softener discharge	100%	Within 0.2 pH units of the entry point pH
		distal fixture for each major distribution system branch or riser or floor (hot and cold)[3]	15% of all plumbing fixtures, sample should be flushed sample, not first draw.	Within 0.2 pH units of the entry point pH

Note:

1. When incoming disinfectant residual is lower than 0.2 ppm, contractor shall coordinate with Water Purveyor and Authority Having Jurisdiction to determine acceptable value.
2. When incoming cold-water temperature is higher than 77°F, flush the building POE to reduce cold water temperature from potentially stagnant water conditions. If cold water temperature target level is not achievable due to local conditions (e.g., summer heat) than the cold water shall be equal to or lower than the incoming water temperature.
3. The required sampling sites should include, but not be limited to:
   a. Samples from floors for patient diagnostic and treatment areas, and patient or resident bed units, as well as additional floors. Three fixture samples (with one hot and one cold sample per fixture) should be collected from each floor. This is normally done as follows:
      i. Fixture closest to first delivery of hot and cold water from the riser
      ii. Fixture with one hot and one cold sample from the middle of the system
      iii. Fixture with one hot and one cold sample from the last outlet (distal fixture) before the water returns to heaters or is dispensed to the sewer system.
   b. Where multiple risers supply hot water to a limited number of rooms from a circulation loop, several locations corresponding to the loop should be sampled
   c. One additional hot and cold random sample should be collected from each floor when wings have extensive lengths of piping and complex building geometry and piping distribution pathways
4. All hot water temperatures at the fixture distribution point must be reviewed, set, and controlled for scalding hazard according to an Authority Having Jurisdiction, as well as consideration of risk to the building occupant (e.g., patients, children, and elderly).
5. Note the recommended pH value and range is based on US EPA National Primary Drinking Water Regulations and may vary based on utility disinfection method, supplemental disinfection method, water device/reservoir (e.g., spas, ornamental water features), and Authority Having Jurisdiction.

TABLE 104-2

ADDITIONAL WATER QUALITY AND CHARACTERISTIC MONITORING REQUIREMENTS – HEALTHCARE AND LONG-TERM CARE BUILDING OCCUPANCY ONLY

PARAMETER	METHOD & FREQUENCY	SAMPLE LOCATIONS	PERCENT SAMPLE LOCATIONS[1]	TARGET LEVELS
Heterotrophic plate count (HPC) or, alternatively, approved test by AHJ	Certified analytical laboratory sample method. On first filling and monthly thereafter	Building entry point (cold)	100% (flushed sample)	≤ 500 CFU/mL HPC
		Water heater discharge(s) (prior to initiating heating)	100% (flushed sample)	Note: for HPC assure results are within 1 log of the concentration in the prior measurement for the same location and no more than 0.5 logs above the geometric mean of all measurements for the location
		Water softener discharge line	100% (flushed sample)	
		Distal fixture for each major distribution system branch or riser or floor (hot and cold)[3]	15% of all plumbing fixtures (flushed draw)	
Culturable *Legionella*	Samples shall be analyzed by an ISO	Building entry point (cold)	100% (flushed sample)	As required by the Authority Having Jurisdiction.[2]

species or *L. pneumophila*	11731 ELITE certified analytical laboratory; alternative methods from an accredited laboratory; or AHJ approved equivalent. Quarterly sampling after water activation date and filling the system in part or in whole.	Water heater discharge(s)	100% of first draw	
		Return of recirculation loop	100% of first draw	
		distal fixture for each major distribution system branch or riser or floor (hot and cold)[3]	15% of all plumbing fixtures of first draw.	

Note:

1. The required sampling sites should include, but not be limited to:
    a. Samples from floors for patient diagnostic and treatment areas, and patient or resident bed units, as well as additional floors. Three fixture samples (with one hot and one cold sample per fixture) should be collected from each floor. This is normally done as follows:
        i. Fixture closest to first delivery of hot and cold water from the riser
        ii. Fixture with one hot and one cold sample from the middle of the system
        iii. Fixture with one hot and one cold sample from the last outlet (distal fixture) before the water returns to heaters or is dispensed to the sewer system.
    b. Where multiple risers supply hot water to a limited number of rooms from a circulation loop, several locations corresponding to the loop should be sampled
    c. One additional hot and cold random sample should be collected from each floor when wings have extensive lengths of piping and complex building geometry and piping distribution pathways
2. Results shall be interpreted as indicated in 2021 v1.1 CDC Toolkit for Controlling *Legionella* in Common Sources of Exposure page F5, Figure 1, Routine *Legionella* Testing or as directed by the Authority Having Jurisdiction.

104.5 Construction Water Usage

Water is used for many purposes during construction. The impacts of those uses on water quality during and post-construction need to be addressed in planning and scoping, and during construction activities. Contaminants that can be or have been introduced during construction may include sediment and debris, chemical contaminants (e.g. disinfection byproducts, inorganics), and waterborne pathogens, the presence of which should be minimized and kept independent from the potable water system, through means of an approved cross connection device.

Cross connection prevention devices should be installed prior to use of water systems to prevent the ingress of debris, chemical contaminants, and waterborne pathogens. In many cases, required flow rates and frequency of use for construction water uses are significantly different from those during beneficial occupancy. The differences between water use during construction and after beneficial occupancy require system design elements to accommodate construction water uses and practices that reduce the likelihood of contamination of the water system during construction and that promote worker safety and safety of nearby building occupants during construction.

Note: Common construction water uses are listed and reviewed in Table 104-3. Water used during construction may be supplied by temporary connections either to the water supply or to a segment of the building water sys-tem that is already connected and active. In both cases, backflow prevention should be practiced and may be required by code. Temporary connections can sometimes be left in place after construction and can pose water quality challenges because they are stagnant, oversized, or otherwise interfere with the turnover of water in the plumbing system. Temporary supplies can also have different drainage requirements than the post-construction plumbing system. Drainage that can accommodate construction wastewater must be available prior to use of temporary supplies.

Note: Any temporary hoses used for potable drinking or handwashing shall be maintained not to have additional non-potable connections to them. Unmanaged plumbing systems with building water supply connections may pose a hazard and contaminate the water system and/or supply. This will pose a health risk to construction workers and future occupants. All the construction water uses described in Table 105.1 pose potential backflow risks.

104.6 Alternative Construction Water Sources.

Alternatives to using the permanent potable BWS during extensive construction or renovation projects should be considered. Use of alternative systems can postpone filling the permanent system, can prevent the oversizing of pipes to accommodate higher than normal construction water flows that can be higher than those during normal operation and can promote water conservation. Temporary systems should be isolated from the permanent system via backflow prevention devices and should be labeled "temporary use." When construction is completed, branches to temporary piping should be removed and capped to avoid the creation of dead legs.

TABLE 104-3
CONSTRUCTION ACTIVITIES AND METHODOLOGIES FOR CONSTRUCTION USE OF POTABLE WATER

CONSTRUCTION USE FOR POTABLE WATER	CROSS CONNECTION CONTROL METHODS, DEVICES AND ASSEMBLIES	POTENTIAL IMPACTS ON WATER QUALITY
Temporary construction toilet facilities (Bathrooms, pantry, etc.)	All faucet types shall have an airgap ASME Al12.l.2 between the spout and bowl. Spout shall be without hose threads. Temporary piping shall be of NSF 61 approved mate-rials for potable water or faucet. Temporary piping should be labeled "non-potable: do not drink."" Tank type water closets shall have an approved ASSE 1002 ballcock. Flush Valve water closets and urinals shall have an approved ASSE 1037 flush valve.	Permanent or temporary connections into the water system; requires sufficient drainage to accommodate maximum flow. Backflow and cross connection installation and maintenance required. Document in the WMP with location and fixtures installed. Characteristics list: Infrequent turnover of water Tepid water in unconditioned spaces Exposed piping to the elements Dead legs and temporary unused piping not removed
Drinking water (hydration stations)	All faucet types shall have an airgap ASME A112.l.2 between the spout and bowl. Spout shall be without hose threads. Airgap ASME A112.1.2 on faucets any temporary piping shall be of approved materials for potable water. If supplied by a hose, the hose shall be composed of ANSI/NSF 61 certified material. The hose shall not supply water to any other non-potable outlet.	Drinking water or hydration stations must be connected to a commissioned and disinfected potable BWS maintained under a building WMP. Characteristics list: Infrequent turnover of water Tepid water in unconditioned spaces Exposed piping to the elements Dead legs if temporary and unused piping not removed
Material mixing (Cement, grout, etc.)	If supplied by continuous pressure it shall be protected by an ASSE 1056, ASSE 1020, or an ASSE 1013 certified vacuum breaker. All backflow prevention devices shall be installed per the	Connections to water for material mixing or point-of-use hose connections points must be protected by an approved cross connection device at the point-of-use.

CONSTRUCTION USE FOR POTABLE WATER	CROSS CONNECTION CONTROL METHODS, DEVICES AND ASSEMBLIES	POTENTIAL IMPACTS ON WATER QUALITY
	applicable standards and local codes. Label "non-potable, do not drink" downstream of the assembly. If supplied by a non-continuous hose supplied by an ASSE 1019, ASSE 1011, or ASSE 1052 Hose bib, labeled "non-potable, do not drink until commissioned and documented" downstream. All devices, assemblies and mechanisms intended to protect water supplies relative to cross connection or backflow shall be of a type recognized and approved.	All piping designed to supply potable water shall be maintained separate from non-potable and shall not supply non-potable water. A site-specific WMP shall be maintained for the duration of the construction process including a log of all cross-connection devices serving temporary construction water. All cross-connection installations shall be in accordance with the AHJ. Any temporary piping shall be removed in its entirety prior to commissioning of the potable water system. Characteristics list: Infrequent turnover of water Tepid water in unconditioned spaces Exposed piping to the elements Dead legs if temporary and unused piping not removed
Washdown (Dust-suppression, hydro- demolition, power washing)	If supplied by continuous pressure it shall be protected by an ASSE 1056, ASSE 1020, or an ASSE 1013 certified vacuum breaker. All backflow prevention devices shall be installed per the applicable standards and local codes. Labeled "non-potable, do not drink" downstream of the assembly. If supplied by a non-continuous hose supplied by an ASSE 1019, ASSE 1011, or ASSE 1052 Hose bib, labeled "non-potable, do not drink" downstream.	Characteristics list: Infrequent turnover of water Tepid water in unconditioned spaces Exposed piping to the elements Dead legs if temporary and unused piping not removed Avoid building air intakes and aerosol exposure to building occupants
Construction equipment with reservoirs (Cutting, paving, tankers)	If supplied by continuous pressure it shall be protected by an ASSE 1056, ASSE 1020, or an ASSE 1013. All installations shall be per the standards and local codes. Labeled "non-potable, do not drink" downstream of the assembly. If supplied by a non-continuous hose supplied by an ASSE 1019, ASSE 1011, or ASSE 1052 hose bibb, labeled "non-potable, do not drink" downstream. If supplied by non-continuous pressure downstream of an ASSE 1001 pipe applied vacuum breaker. If supplied by non-continuous pressure Airgap (ASME Al12.1.2) or an Airgap fitting (ASME Al12.1.3)	Characteristics list: Infrequent turnover of water Tepid water in unconditioned spaces Exposed piping to the elements Dead legs if temporary and unused piping are not removed Avoid building air intakes and aerosol exposure to building occupants.
Interim Fire Hydrant building water supply	ASSE 1013 labeled "non-potable, do not drink" downstream of the assembly.	Characteristics list: Infrequent turnover of water. (Needs approval from local Fire Dept and Municipality to connect)
Hose Bibbs, yard hydrants and other.	ASSE 1019, ASSE 1011, or ASSE 1052, labeled" non-potable, do not drink" downstream.	Characteristics list: Infrequent turnover of water

104.7 Pre-Installation Material Management.

Prior to installation, plumbing materials should be stored in a manner that protects them from contamination. Sanitary storage and handling of pipes and distribution system components is a common requirement for contractors for installation of new mains for drinking water systems and has been demonstrated to reduce the likelihood of contamination after installation and the effort required to disinfect new mains before they are put into service. The same benefits can be expected from sanitary storage of BWS plumbing materials.

Practices to prevent contamination during storage and pre- installation shall include but are not limited to the following best practices:

- Capping or wrapping pipe, valves, and other plumbing material;
- Capping or sealing the intake, discharge, and drain ports of water heaters and other water treatment devices such as water softeners;
- Storing plumbing system components in well-drained areas with low likelihood of water accumulation; and
- Avoiding long-term on-site storage of plumbing components prior to installation.

Note: Plumbing system components accidentally exposed to non-potable water or otherwise contaminated during storage should be disinfected and flushed prior to installation.

104.8 Water Quality Monitoring and Testing.

Generally, water quality monitoring should be conducted as specified by ANSI/ASHRAE 188 and the CDC report "Developing a Water Management Program to Reduce *Legionella* Growth & Spread in Buildings" or equivalent guidance (e.g., ANSI/ASHRAE 514 or AHJ). Since those resources provide only general recommendations and requirements for monitoring, and because those documents are primarily based upon water conditions within existing operational buildings, additional recommendations specific to water quality monitoring during construction activities are presented below.

104.8.1 Water Quality Parameters.

Water quality data can be found in water supplier water quality reports (See Annex A: Consumer Confidence Reports). These parameters can be measured at key milestones during construction and compared to data in the consumer confidence report. Measurements that should be collected, documented, and analyzed include, but are not limited to the following:

(1) Disinfectant residual type (e.g., chlorine, monochloramine)
(2) Disinfectant residual concentration (e.g., ppm, mg/L)
(3) Water temperature (e,g. hot and cold distribution)
(4) Water pressure
(5) Flow rate
(6) pH and
(7) Viable *Legionella* concentration (< 1 CFU/mL for building types C and D)
(8) Other water contaminants or pathogens of interest or AHJ

Process control parameter measurement (e.g. disinfectant concentration, water temperature and pH) should be made for each *Legionella* sample collected. Analysis of this data allows better interpretation of *Legionella* results and assessment of whether *Legionella* are well controlled. Measurements that can also be made, documented, and analyzed shall include the following:

(1) HPC (<500 CFU/mL)
(2) Turbidity
(3) Conductivity

Note: In general, HPC, turbidity, and conductivity trends (i.e., multiple readings over a period of time) are more indicative of water quality and system control than individual measurements, although single extremely high measurements may indicate water quality or process control problems requiring immediate attention.

104.8.2 When to Measure

Water quality should be assessed and sampled:

(1) Prior to design
(2) At the time of service connection
(3) Periodically, after the system is filled, flushed, and prior to disinfection
(4) During and after disinfection, per the disinfection standard adopted by the AHJ, and
(5) Prior to building occupancy, if occupancy is delayed for more than 3 weeks (21 calendar days) after disinfection

104.8.3 Where to Measure.

Minimum water quality measurements should include but not be limited to the following locations:

(1) the BWS point-of-entry (as near to the service connection as possible)

(2) the discharge of water storage facilities
(3) the hot water return location (e.g., system loop)
(4) at control locations or locations used for verification monitoring (process control)
(5) at representative plumbing fixtures on each branch of the BWS including the most distal points known for the high risk of stagnation, and
(6) locations intended for installation of unique fixture types known for high risk (e.g., ice machines, decorative water fountains, spas, or other).

Flow should be measured at the plumbing system entry point and on trunk lines of the cold and hot water distribution. Sample collection locations should be included in the plumbing system design and should include at least one sample collection location near enough to the service connection that building plumbing system processes do not significantly alter water quality of the samples and samples are representative of the water supply.

104.8.4 How to Measure.

Contractor water monitoring instruments/equipment shall include the following:

(1) Colorimeter (digital)
(2) Temperature (digital)
(3) Reagents (i.e., based upon disinfection type)
(4) Calibration solutions

104.8.5 Water Draws for Testing.

Water quality and water age vary widely within a plumbing system and two types of samples are required for assessing water quality in the system. First draw samples are used to assess conditions in the portion of the system nearest the sample collection point. First draw samples typically include volumes of water that have been stagnant and represent worst case water quality. Long-draw flush samples are collected to allow assessment of systemic water quality within the BWS plumbing, in the building service line or in the building supply. Water quality in first-draw samples is never representative of the building supply (from the purveyor) because water quality can degrade significantly over a short time in building plumbing. During construction, fixtures typically used in sample collection might not be available and the system design should explicitly include sample collection locations/ports. Sample collection locations should be installed, at a minimum, near the service entrance, along the main hot and cold distribution and at representative distal locations.

Note: For measures of biological water quality (e.g., HPC, coliforms, Legionella and other OPPPs) for both first-draw and long-draw sample types, aseptic techniques must be practiced during sample collection to reduce the likelihood of sample contamination. A certified analytical laboratory should be consulted for providing sample bottles for each test type, chain-of-custody forms to transmit samples to the laboratory, shipping procedures, adequate time for processing samples for results, and the method of documenting results. Samples can be contaminated by contact with fixture surfaces, samplers' skin or clothing or from splash. Samplers must follow the CDC protocol for sample collection (https://www.cdc.gov/legionella/downloads/cdc-sampling-procedure.pdf) or a similar protocol. Recommended procedures for collection of first-draw and long-draw flushed samples follow.

First-Draw.

Remove aerator or other flow restricting fittings, open fixture and collect first water out of fixture to determine the disinfectant residual available at the faucet's point-of-use. First draw samples often have low or no disinfectant residual due to decay and general bacteria growth from stagnation. First draw samples can have much higher microbiological concentrations than long-draw flushed samples.

Long-Draw Flush.

The longer the flush time before the sample draw, the further upstream in the piping system the test results will describe. Determine distance into water main or branch inside building that sample results are to represent. Calculate the time needed to flush (volume of water based on pipe size, divided by flow rate of fixture) in order to obtain water from that portion of the BWS. Flush for three to five times longer than time determined, and then collect sample. Long-draw samples will give a better indication of the water quality in the BWS and coming from the building water point-of-entry.

104.9 Pre-occupancy Disinfection and Building Opening

104.9.1 General

System Opening is the set of actions that should be taken to ready a building for normal operations after an extended period of no or limited operations. Systems that are being reopened after prolonged vacancy or partial vacancy shall comply with AWWA-IAPMO *Responding to Water Stagnation in Buildings with Reduced or No Water Use, ANSI/ASHRAE 188,* and Section 107.11.

104.9.2 Opening Communication.

The Responsible Party shall determine a final construction water quality date and communicate completion of water quality monitoring and testing with the building owner, any AHJ, and any construction water management team members. The BWDS shall by handed over to the building owner for ongoing operations and maintenance of the system at beneficial occupancy of the building. All monitoring data, logs, and water testing results shall be documented and given to the building owner in an orderly manner for building staff to maintain the system. The required documentation shall provide clear instructions to the building owner on any known hazards that may have emerged during the construction process and how they were resolved.

An occupancy date and communicate date of occupancy to all building occupants shall be determined and the steps required from maintenance staff shall be provided and available. The required steps shall provide clear instructions to occupants on how to avoid hazards and how to report concerns once a building is occupied and open for normal business operations.

104.9.3 Pre Startup Inspection.

The preparation of the documentation and pre startup inspection shall be conducted by the Responsible Party. The required inspection shall include but is not limited to:

(1) visually assessing the potable water system
(2) inspecting all components for the presence of contaminants and other adverse conditions
(3) checking that the BWDS equipment is working properly
(4) ensuring records are complete and provided to building owner
(5) flushing protocols that were performed are transferred to the building owner to perform and shall be continued during building turnover until the building is fully occupied for its intended use.

104.9.4 Final Disinfection.

Final disinfection shall take place before occupancy. Biofilms and, potentially, environmental pathogens are likely in any plumbing system, even those managed as described in this guidance and other guidelines such as ANSI/ASHRAE 188 and ANSI/ASHRAE 514. As directed in plumbing codes, building water systems must be purged and disinfected after construction/installation and prior to occupancy. Disinfection reduces the biofilm mass in the water system and reduces the concentration of pathogens that might be present, though it is unlikely to completely irradicate pathogen populations established in the system. Disinfection entails filling the building water system with a high concentration solution of disinfectant, holding the disinfectant in the system for sufficient time for the disinfectant to reduce the microbial population, and flushing the system to remove the high-concentration disinfectant solution, inactivated organisms, and biofilm materials.

Note: Disinfection shall be conducted per the AHJ. At the time of publication of this document, disinfection is conducted per AWWA Standard C651 (Disinfecting Water Mains) or 652 (Disinfection of Storage Facilities). Standard C651 was developed for disinfection of water mains in public water systems and directs use of very high concentrations of disinfectant - much higher than those required for effective disinfection of building water systems and high enough to pose a damage risk to plumbing system components. A new AWWA Technical Report called "*Disinfecting Building Potable Water Plumbing in New or Repaired Systems*" has been developed and should be referenced instead of Standard C651 and C652.

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Field Code Changed

Annex A (Informative)
105 Water Supply Water Quality

105.0 Foreword and Purpose

The Annex is informative and not a mandatory part of this manual but rather an expansion of definitions and understanding of establishing water quality within building water systems. Topics covered in this annex include sources of information on water quality in a filled building water system, chemical and physical processes that impact BWS water quality and system performance, and important water quality parameters. The discussion of important water quality parameters includes information on some water constituents and characteristics that are important in all installation processes, and some that are important only in rare cases.

105.1 Consumer Confidence Reports - Information That Water Purveyors Provide to Their Customers

Public water suppliers provide a Consumer Confidence Report, or report on water quality, to their customers on an annual basis. Often it is available through the water supplier's Intranet site. This report summarizes important infor-mation for you to understand but it may not provide all of the information that is important for your building's water system because its main purpose is to provide a status of regulatory compliance under the federal Safe Drinking Water Act. However, some water utilities do provide additional information that is helpful to their customers.

The US Environmental Protection Agency (EPA), under the Safe Drinking Water Act (SDWA), requires that all public water systems test and report on regulated water quality to their primacy agencies or regulators. In most situations, individual states have primacy for enforcing the regulations under the SDWA, to which they may also add requirements that are important within their states. The regulations focus on drinking water contaminants that could cause a public health risk; these are primary drinking water regulations such as Maximum Contaminant Levels (MCLs). When a contaminant reaches its MCL, the EPA has determined that it could be unsafe for consumers. The EPA has also provided Secondary Maximum Contaminant Levels (SMCLs) which are guidelines for aesthetic water quality such as taste and odor, color, and corrosivity. The EPA does not enforce SMCLs although some states do enforce them in various ways.

Even when water that is delivered to your building meets all SDWA and state regulations, and is safe to consume, it may not meet all of the requirements for your building's water system to operate effectively and provide good qual ity water at the distal outlets. For example, a water supply can be safe but contain very hard water which can cause scaling problems within a BWS. Or a water system may have old cast iron mains that periodically release iron rust which enters plumbing systems and settles there, causing discolored water and stains. In addition, once water enters a building's service line and plumbing system, water quality changes before it is used. For example, safe drinking water is not sterile or devoid of background microorganisms. If stagnant and tepid water conditions are inside a section of the building plumbing system, microorganisms will likely grow and spread causing associated problems. Conditions that promote a loss in the chlorine residual exacerbate this problem and can lead to the amplification of pathogens such as *Legionella* as well as an increase in disinfection by-products (e.g., trihalomethanes).

105.1.1 How Consumer Confidence Reports Can Help Design Engineers and System Operators

Engineers designing plumbing systems, building managers, and water system operators need a background under- standing of water quality for their building's supply. That information helps them anticipate and avoid water qual- ity degradation in their system, promotes healthier and more aesthetically pleasing water for building occupants, and extends the life of their plumbing system while also reducing maintenance costs. Examples of problems that can arise if water quality is not considered in system design and operation include:

- corrosion,
- staining of fixtures,
- scale formation leading to increased pressure loss, reduced efficiency of water heaters, and creation of environments where pathogenic microorganisms thrive,
- blooms of *Legionella pneumophila,* the bacterium that causes Legionnaires' disease (LD), and
- episodes of discolored or bad smelling or tasting water.

105.2 Overview of the Water Quality Information that is Most Important for Designers and System Managers

Building water supplies are not "pure" but contain a variety of natural and introduced chemicals and microorganisms. Completely pure water is corrosive and less pleasant tasting. Some of the chemicals in water are beneficial, added to the water by the water supplier to protect the water while it is in the water supplier's distribution system and to protect the water after it enters a customer's building system. Other chemicals and microorganisms are known to be harmful and are maintained at levels that the USEPA and state regulatory agencies believe are protective of public health. Some chemicals in water can be a nuisance and cause odors, staining of fixtures, and scale development. Finally, some water parameters in the building water supply are neither beneficial nor potentially harmful but can have an influence on what happens to water in building systems. Without deliberate management, building water systems can add a "surcharge" to contaminants; that surcharge increases risks to building occupants. Figure 1 provides an overview of the connectedness between the water supply, the building's water system, and the water quality at the endpoints where water is used.

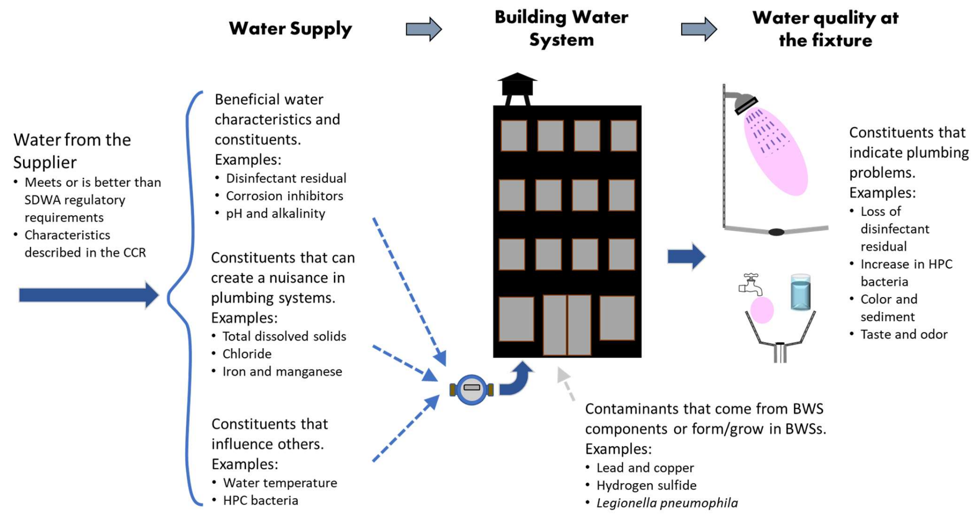

FIGURE 105-1
WATER QUALITY CHARACTERISTICS OF WATER SUPPLIES AND BUILDING WATER SYSTEMS

Table 105-1 lists water quality parameters for which a local water utility may have additional information to help you understand the water supplied to your specific building. Analytical laboratories can help determine relevant water information from water samples you collect and send to them for analysis. Smaller water utility providers tend not to test as many water parameters as larger system providers simply due to cost. Also, a water utility may have information for the overall local or regional water system but not for the water supplied to the specific site or building for construction. Some water parameters are very stable, while others change with time and distance from the water treatment plant. In some cases, water quality can change and fluctuate significantly from one time of day to another depending on water demand, or from day to day depending on which water source the water utility is using to supply the regional area.

Sampling and testing of water parameters can be arranged by the WMP team, as needed. In many cases, the WMP team will have to arrange for a certified contract analytical laboratory to provide sampling instructions and sample bottles. Different water parameters (and microbiological testing) have different requirements for sampling. Some require very careful sampling protocols. A few measurements will likely be performed by designated members of the WMP team, onsite, such as for disinfectant residual, pH, and water temperature (e.g., hot and cold). Some water parameters are more expensive to test for, and by testing multiple parameters together the WMP team and building owner can sometimes save on costs (such as for the metals including iron, manganese, copper, lead) but the turnaround time could be long. Many parameters are inexpensive and turnaround times are quick.

TABLE 105-1

IMPORTANT WATER QUALITY PARAMETERS FOR BUILDING WATER SYSTEMS

PARAMETERS OF INTEREST	INFORMATION TO REQUEST	WHY THEY ARE IMPORTANT
Parameters That Are Beneficial		
Chlorine or Chloramine Residual	Target residual for your area; actual annual maximum and minimum	Chlorine acts as a preservative, limiting bio- film and microbiological activity
pH	Annual average pH for localized area and whether it's adjusted for corrosion control	pH can affect corrosion and changes in pH affect water chemistry
Alkalinity	5-year average, minimum, and maximum	Sufficient alkalinity deters changes in pH and helps with corrosion control
Phosphate Inhibitor	Does the utility use a phosphate inhibitor for corrosion control?	Phosphate inhibitors can help to reduce corrosion.
Parameters That Cause a Nuisance		
Total Dissolved Solids	5-year average, minimum, and maximum	Solids can accumulate in plumbing and affect processes in use
Hardness	5-year average, minimum, and maximum	Hard water has calcium and magnesium carbonates which form scales
Conductivity	5-year average, minimum, and maximum	Conductivity is a general measure of the various salts in water and can affect processes in use.
Sodium	5-year average, minimum, and maximum	Sodium can, at high levels, cause a salty taste.
Chloride	5-year average, minimum, and maximum	Chlorides can cause a salty or bitter taste and can impact on corrosion.
Iron Manganese	5-year average, minimum, and maximum; whether iron and manganese are treated for reductions from the source of water supply	Iron and manganese can accumulate as sediment, cause staining, and color the water. Iron can cause a metallic flavor and decrease the chlorine residual.
Sulfate	5-year average, minimum, and maximum	Sulfate is a source of sulfur which can cause odors. Sulfate can also impact on corrosion.
Sulfides	Whether sulfides are treated for and a cause of customer complaints	Sulfides can cause odors such as with hydrogen sulfide.
Taste and Odor	Taste and odor issues that can occur and cause customer complaints	Tastes and odors cause complaints from consumers of water.
Color	5-year average, minimum, and maximum	Discolored water is not aesthetically acceptable and may contain adverse contaminants..
Parameters of Health Concern		
Copper	The water supplier's 90% reported value under the Lead and Copper Rule	Copper can cause staining, colored water, and a metallic flavor. Excessive copper levels are a health concern for susceptible populations.
Lead	The water supplier's 90% reported value under the Lead and Copper Rule	Lead is of health concern.
Total Coliform and *E. coli*	Whether the water utility is experiencing SOWA violations	Coliform bacteria are indicators of possible

		water contamination.
Parameters That Influence Others		
Water Temperature	Annual maximum and minimum	Warmer water has greater microbiological and chemical activity.
Ammonia	Maximum free ammonia and whether nitrification is experienced	Ammonia can encourage microbiological activity such as nitrification.
Heterotrophic Plate Count	Average and maximum for the warmest months of the year	Background levels of bacteria indicate whether the water is conducive for microorganisms to grow.

For More Information

USEPA Primary Drinking Water Regulations at:
www.epa.gov/ground-water-and-drinking-water/primary-drinking-water-regulation
USEPA Secondary Drinking Water Regulations at:
www.epa.gov/sdwa/secindary-drinking-water-standards-guidance-nuisanceOchemicals
Standards, manuals of practice, and other publications from the drinking water industry can be found at American Water Works Association: www.awwa.org

Information for residential, commercial, and industrial water systems can be found at Water Quality Association: https://wqa.org

Check your state's drinking water quality website for water quality regulations or facts that could be helpful to know.

Annex B: (informative)
106 S.T.A.R. Water Quality Parameters

106.0 General Considerations

The US Centers for Disease Control and Prevention (CDC) for education, training, and implementation of water management programs uses the acronym S.T.A.R to identify the four key water quality parameters for hazard control (see Table 106-1) in potable building water systems. Implementing hazard controls around these four parameters is imperative to limit the growth and spread of waterborne pathogens (e.g., *Legionella*) in building water systems. Each water quality parameter is described in more detail below indicating background, importance to building water systems, information to request, and potentially where to sample and when to test.

TABLE 106-1
STAR PARAMETER OVERVIEW

	WATER PARAMETER	CONTROL MEASURE	RECOMMENDATIONS
S	Sediment and Biofilm	Flushing, cleaning, and maintenance	Flush after an intrusion event (e.g., water main break). Clean and maintain water system components such as water heaters, mixing valves, aerators, showerheads, hoses, and filters regularly as indicated by water quality measurements.
T	Temperature	Control limits	Store hot water above 140°F(60°C) and maintain circulating hot water above 120°F(49°C). Store and maintain circulating cold water below the growth range most favorable to *Legionella* (77-113°F, 25-45°C). Note that *Legionella* may grow at temperatures as low as 68'F(20'C).
A	Water Age	Flushing	Flush low-flow pipe runs and dead legs at least weekly. Flush infrequently-used fixtures regularly.
R	Disinfectant Residual*	Control limits	Chlorine: Detectable residual as directed by WMP. Monochloramine: Detectable residual as directed by WMP

Reference: CDC *Legionella* Control Toolkit/ Note: *Disinfectant residual recommendations apply to disinfectant delivered by the municipal water authority. Supplemental disinfection system control limits are not prescribed here and must be dictated by the water treatment professional and WMP.

106.1 Soil/Sediments

Background: During construction activities sediment (e.g., soil, construction debris, or corrosion) can impact the building water systems by clogging strainers, screens, aerators, or causing ball valves to seize. Sediments also act as a nutrient for microbial growth in the system.

Importance to Building Water Systems: Sediment can increase during periods of stagnation due to the oxidizing of disinfectants which corrode the metallic piping as water age increases. Also, sediment reduces residual by consuming the disinfectant; sediment provides organic carbon as a nutrient for bacteria growth; shield bacteria from disinfection since pathogens commonly attach to sediment and/or carry the pathogen into an area in the building where water quality conditions are ideal for its' growth

Information to Request: The WMP team should discuss with the general contractor construction activities that will occur on the project that might increase risk of and/or lead to soil or sediment invasion (e.g., demolition, underground utility connections, utility tunnel work, excavation, or potential water main breaks). Additionally, emphasizing implementation of flushing protocols to avoid pipe corrosion. And, lastly, the proper storage of piping materials to avoid dust and debris settling into new piping exposed to construction site debris.

Where to Sample and How to Test: There are laboratory and field methods for measuring suspended solids (i.e., turbidity) in water. Turbidity for drinking water quality is commonly measured using nephelometry, a method that measures the scattering of light by suspended particles in the water. The measurement is typically expressed in Nephelometric Turbidity Units (NTU). The EPA has set the drinking water standard of 1 NTU for public water systems. Equally important though is on-site visual inspection of water as a means of early detection of suspended solids and related water quality problems. Turbid (cloudy) water, water with color and water with visible sediments (i.e., floaters) are all causes for concern and should initiate immediate follow-up measures including investigation of the cause of the sediments or color and mitigation (e.g., via high velocity flushing or implementation of corrosion control).

106.2 Water Temperature

Background: Water temperature can vary naturally from an approximate low of 40°F (5°C) to a high of 85°F (30 °C) for water sources that are affected seasonally such as rivers and reservoirs. Water temperature remains more consistent in groundwater sources. Water temperature tends to change after water enters building plumbing distribution or is stored for extended time in storage tanks. Water temperature becomes tepid by elevating toward ambient building temperatures.
Guidelines or Standards: In general, it is best to keep water as cold as possible as one would do with any consumable product. Colder water reduces chemical and microbiological activity.

Importance to Building Water Systems: In general, tepid water temperature increases the rate of microorganism activity and growth, decreases chlorine residual, increases corrosion, and impacts other water quality parameters.

Information to Request: The WMP team should obtain the annual minimum and maximum water temperature for the water provided to the building site's local region of the distribution system.

Where to Sample and How to Test: The water utility's information on water temperature should be verified for the water supplied to the building project site. Using a common water thermometer, the WMP team or facility operations personnel can test water temperature at the building's point-of-entry as well as distal taps throughout the building's plumbing system to understand how water temperature varies across the BWS, at different times of year, and within the hot and cold water systems. Tepid water could indicate stagnant conditions or other unfavorable water quality conditions.

106.3 Water Age/Stagnation

Background: During construction activities the BWS (in part or in whole) will likely experience low or no flow of water conditions throughout the distribution system. Minimal BWS usage over an extended period (e.g. weeks, months, or years) causes the water to becomes stagnant.

Importance to Building Water Systems: In addition to microbial hazards, stagnation will impact a decay of disinfectant residual, loss of corrosion control, release of metals into potable water, and create tepid water temperature conditions, all of which support the growth of *Legionella* and other waterborne pathogens.

Information to Request: The WMP team should discuss with the general contractor the use of the BWS during construction activities related to volume of water used. The level of water use by the construction team is likely inadequate to maintain water quality and avoid pre-mature growth and spread of microbial hazards. To maintain water quality the general contractor will need to implement a flushing protocol appropriate for the size and scope of the project under construction. Also, ask the contractor to consider using alternative or temporary potable water supply sources for construction activities for as long as possible to avoid pre-maturely filling the building owner's final premise plumbing system with water used for construction activities (e.g., water mixed for adhesives, muds, or mortars).

Where to Sample and How to Test: The WMP Team will want to periodically measure key water quality parameters (e.g., temperature and residual oxidant readings) to monitor and assure low water age. Depending upon the length of the construction project, measurements would likely be weekly monitoring could consist of water temperature and residual disinfectant readings. Water temperatures should be in a previously determined range(s) for hot water to remain hot, and cold water to remain cold. Residual disinfectant readings would indicate a distal and/or terminal fixture value in a previously determine acceptable range (e.g., $\geq$ 0.2 ppm to 4.0 ppm). Implementing flushing protocols would be the likely corrective action to reduce water age/stagnation and maintain proper temperature and residual disinfectant ranges.

106.4 Water Disinfectant Residual

Background: In the United States, the typical disinfectant residual (that is, the disinfectant that is maintained in the water after it leaves the treatment plant and passes through the distribution system pipes) that water suppliers carry in their drinking water is either a free chlorine residual or a chloramine (chlorine combined with ammonia) residual. The concentration of residual is expressed as mg/Lor ppm. This parameter is not consistently stable because both chlorine and chloramine dissipate with time, more quickly in warmer water and more quickly when exposed to other conditions wherein there is a demand for chlorine. For example, dissolved iron will exert a demand for chlorine. New copper pipe will exert a demand for chlorine. Biofilm will exert a demand for chlorine. Therefore, the chlorine or chloramine residual varies substantially throughout the BWS. In general, chlorine dissipates faster than chloramine, though, under some conditions, chloramine can decay rapidly. Those conditions are well known by drinking water sup- pliers who often have control plans in place when those conditions arise.

Guidelines or Standards: The US EPA requires that a minimum detectable residual (not currently defined as a numeric value at the national level) be maintained in most public drinking waters, but that it not exceed an average of 4.0 ppm. Many state primacy agencies have set numeric minimum residual level requirements that can be different for chlorine and chloramine. Not all public water supplies that use groundwater carry a disinfectant residual.

Importance to Building Water Systems: A free chlorine or chloramine residual acts as a preservative or deterrent to the regrowth of microorganisms in water. The longer water sits in plumbing and the warmer the water tem-perature is, the greater the rate of dissipation. Free chlorine is more likely to dissipate more quickly than chlora-mine. Once the disinfectant dissipates to a low enough level, it no longer deters regrowth of microorganisms. The timely turnover of water (e.g., flushing or construction usage) in the BWS can help to bring in fresher water containing an adequate disinfectant residual.

Information to Request: This information should already be available from the building site's local water utility's Consumer Confidence Report. However, you want to know whether the water provided to or within this building project has a free chlorine or chloramine residual, what the maximum and minimum levels are for the local area, what is the target disinfectant residual, and whether that residual varies seasonally. Request an average, maximum, and minimum residual for the most recent year. Also ask if the water utility performs any "chlorine burns" (i.e., the utility switches from a chloramine to a free chlorine residual for weeks at a time) to manage microorganism activity in the localized water utility system. These water utility activities can impact the building site's main water readings at the point-of-entry.

Where to Sample and How to Test: Disinfectant residual can be measured using test kits that are readily available. Testing should be done soon after a water sample is collected. Samples should be collected at the service connection, representing water entering the building, and at distal taps to determine how much the residual dissipates across the BWS. When a fixture is first used after a long stagnation period, the water usually has negligible or no residual disinfectant. Once the fixture has been flushed until the water temperature is relatively steady (e.g., hot and cold valves), the disinfectant concentration increases to the concentration in the water supply. Hot water may not sustain a disinfectant residual.

Annex C: (Informative)
107 Flushing

107.0 General Considerations

Flushing is a key element of water management during construction activities and after beneficial occupancy. As described in Table 107-1, at least four types of flushing are required during the water management construction phase of work: (i) an initial flushing conducted when the system is first connected to remove sediments, gross construction debris or other materials accumulated in the BWS ; (ii) routine flushing to maintain water quality (described in Section 107.3); (iii) flushing associated with final system disinfection immediately prior to transfer of water system responsibility to the building owner; or (iv) in response to adverse events or other hazardous conditions such as a) inadvertent introduction of non-potable water into the potable water system or b) detection of high concentrations of *Legionella* spp. or *L. pneumophila* in routine samples. The primary objective of the initial purge and post-disinfection flush is to remove debris, stagnant water with high bacteria levels, and, to the extent practicable, loose biofilm. As relatively high velocities are required to meet those objectives, the plumbing system should be designed with sufficient drainage capability for the large volumetric flows required. As biofilm can be tightly attached to pipe surfaces and can be present in components of the system that are poorly scoured (e.g., in low flow or dead zones in a mixing valve), complete removal of biofilm is not possible through flushing alone and should not be a design criterion for flushing.

TABLE 107-1
FLUSHING ACTIVITY PURPOSES, OBJECTIVES, AND CHARACTERISTICS

FLUSHING TYPE	PURPOSES	CHARACTERISTICS
Initial flushing (Prior to system filling and before disinfection)	• Removes debris, construction residuals, and environmental contaminants introduced into plumbing components during storage and installation	Velocity high enough to mobilize sediment; flushing from near point of entry outward to distal locations to avoid entrainment of contaminants deeper into the system; flushing duration required to turnover the supply line at least five times the volume of the pipe.
Routine flushing (water turn-over) (After the system is filled and before disinfection)	• Simulate occupancy by flushing water to maintain adequate disinfectant residual and maintain hot and cold water temperatures outside the growth range of OPPPs • Remove loose biofilm and organisms that accumulated during stagnation	Flushing conducted daily (building type D) or once per three days (building type C); when feasible, flow started impulsively (not gradual) with aerators and other flow-restricting components removed; flushing can be conducted via fixtures or flushing locations at distal outlets at the end of the branches.
Final disinfection flushing	• Remove water with high disinfectant concentration • Remove detached and degraded biofilm and other materials generated during disinfection	Flushing conducted per standards specified in code. Flushing may be conducted before disinfection to remove debris and reduce disinfectant demand. Flushing must be conducted after disinfection to purge the system of high disinfection concentration water that can damage plumbing materials and that can be higher than the US EPA maximum disinfectant residual level (MDRL) or above other limits on disinfectant concentration.
Adverse events or hazardous conditions flushing	The purpose of this type of flushing differs with the adverse event or hazardous condition that triggers the flushing. Examples: • Purging nonpotable water introduced into the potable water plumbing inadvertently • Proactive response to upsets in the building water supply. If the water supply is known or expected to have been compromised but water has not been drawn into the building system, flushing should be conducted at the point of entry.	Velocity high enough to mobilize sediment; flushing from near point of entry outward to distal locations to avoid entrainment of contaminants deeper into the system; flushing duration required to turnover the supply line at least five times the volume of the pipe. If the triggering event was high Legionella level detections or a suspected Legionnaire's disease case, flushing should be conducted as part of a remediation and disinfection process.

107.1 Inclusion of flushing points.

Flushing points for key segments of the system, including the service line, should be included in the system design. Flushing points should be chosen strategically and flushing should be performed methodically such that contaminants, sediments, and other water quality hazards and hazardous conditions are not entrained deeper into the plumbing system, and such that target flushing velocities can be achieved. Flushing points should be paired with drainage sufficient for the flows required to achieve target velocities. Ideally, flushing points are installed at the bottoms of vertical sections (e.g., risers) to allow sediments that accumulate at the section bottoms to be flushed out.

A critical flushing point is that building entry point. A dedicated flushing point as near the building entry point as possible and plumbed directly into the building (cold) supply allows operators to purge the building service line without drawing contaminants or water with degraded quality into the potable water system. It can also be sized to generate flows that produce high velocities in the service line and promote service line scouring and hygiene. Flushing should not be from hose bibbs or nearest fixture to the entry point. The service flushing point should be permanent. If the service connection flushing point is inside the building, there must be a drain or conveyance that accommodates the flushing flow.

High flows are required to achieve target velocities in service lines and other large diameter plumbing system components. Achieving high velocities for large diameter pipes (e.g., service lines) requires high volumetric flow rates and, in turn, the ability to drain high volumetric flows.

107.2 Flushing sequencing for initial flush and supplemental flushing

As detailed in the IAPMO/AWWA Manual of Practice for The Safe Closure and Reopening of Building Water Systems, the following flushing protocol should be used for whole-building flushing for the initial building flush or for supplemental flushing:

(1) Measure water quality prior to flushing. Work with water purveyor to flush hydrants if necessary.
(2) Flush the service main to the point(s) of entry (POE) to obtain representative temperature and disinfectant residual entering the building.
(3) Flush mechanical room cold water mains.
(4) Flush mechanical room potable service water heating equipment and piping.
(5) Flush all end points throughout the building
    (a) Cold water (first)
        i. Until temperatures at all POU locations are similar to that entering the building
        ii. Until disinfectant residual at all cold water POU locations are similar to that entering the building
    (b) Hot Water (before water heating initiated)
        i. Until temperatures at all POU locations are similar to that entering the building
        ii. Until disinfectant residual at all cold water POU locations are similar to that entering the building
    (c) Ensure that all other end use devices are brought on line and flushed after the building has fresh water.
(6) If discoloration appears, flush until the water runs clear.
(7) Consider automating flushing at key locations.
(8) Where possible, consider bypassing mixing valves to increase flow rates during flushing.

This protocol entails flushing sequentially (from the service connection outward toward fixtures) to promote high velocities in each segment that is flushed and to prevent entrainment of contaminants in an upstream plumbing section into downstream sections.

Note: The goal of flushing is for the cold-water disinfectant levels at the POU to be at least 80 percent of the incoming disinfectant at the POE. Lower percentages are indicative of something in the building's water distribution system that is reacting with the disinfectant and needs to be addressed.

107.3 Initial Flushing and Supplemental Flushing Velocities, Flows and Durations

107.3.1 Flushing Target Velocity and Duration.

Dedicated flushing points and plumbing fixtures used for flushing branches should be sized and flushed to generate a water velocity of at least 5 fps in as much of the BWS as feasible and no less than 2.5 fps throughout the system. Studies have shown that 2.5 fps may not be sufficient to detach and remove some sediments and that, although greater removal is possible at 5 fps, 5 fps does not assure sediments are removed, particularly in vertical pipe runs or in branches with many fittings or other features that hinder flow. Studies have also shown that velocities up to 5 fps are not effective for stripping/removing all biofilm, though loose biofilm that accumulates during periods of no flow can be removed at lower velocities, particularly if flow is started suddenly. Velocities higher than 5 fps improve sediment removal and should be achieved where feasible. Because the initial flush is not routine, velocities above the maximum specified for copper (5 fps in the UPC) will not significantly degrade plumbing materials and should be achieved where feasible.

Flows required to achieve 2.5 fps and 5 fps in standard sizes of pipes are presented in Table 107-2. The high flow rates for achieving 2.5 fps in large diameter copper pipes reinforce the need for dedicated flushing points and sufficient drainage to avoid overflow and flooding.

TABLE 107-2
FLOWS TO ACHIEVE 2.5 AND 5 FPS VELOCITY

PIPE NOMINAL DIAMETER (INCHES)	PEX			COPPER TYPE L		
	INNER DIAMETER (INCHES)	FLOW (GPM) TO ACHIEVE 5 FPS	FLOW (GPM) TO ACHIEVE 2.5 FPS	INNER DIAMETER (INCHES)	FLOW (GPM) TO ACHIEVE 5 FPS	FLOW (GPM) TO ACHIEVE 2.5 FPS
3/8	0.36	1.59	0.79	0.43	2.26	1.13
1/2	0.485	2.88	1.44	0.545	3.64	1.82
3/4	0.681	5.68	2.84	0.785	7.54	3.77
1	0.875	9.37	4.69	1.025	12.86	6.43
1½				1.505	27.72	13.86
2				1.985	48.23	24.11

107.3.2 Water Volume/ Flushing Duration

Due to non-ideal hydraulics and mixing in pipes and fittings, flushing a single pipe volume of water does not reliably remove contaminants from plumbing system segments. Theoretical and experimental studies demonstrate that a minimum of 4 to 5 pipe volumes must be flushed at the target velocity to achieve a high level of contaminant removal. Table 107-3 provides the volume in five pipe volumes of water and the flushing time in gallons per minute (gpm) required at 5 gpm for 10 linear feet of pipe of various diameter.

TABLE 107-3
FLUSHING BY PIPE SIZE AND VOLUME

PIPE NOMINAL DIAMETER (INCHES)	PEX				COPPER TYPE L			
	INNER DIAMETER (INCHES)	VOLUME IN 10 FT OF LINEAR PIPE (GAL)	VOLUME TO FLUSH TO COMPLETELY TURN OVER S VOLUMES FOR 10 FTOF LINEAR PIPE (GAL)	TIME TO FLUSH 10 FT OF LINEAR PIPE AT 5 GPM (SEC)	INNER DIAMETER (INCHES)	VOULME IN 10 FTOF LINEAR PIPE (GAL)	VOLUME TO FLUSH TO COMPLETELY TURN OVER S VOLUMES FOR 10 FT OF LINEAR PIPE (GAL)	TIMETO FLUSH 10 FT OF LINEAR PIPE AT 5 GPM (SEC)
3/8	0.36	0.05	0.26	3.17	0.43	0.08	0.38	4.53
1/2	0.485	0.10	0.48	5.76	0.545	0.12	0.61	7.27
3/4	0.681	0.19	0.95	11.4	0.785	0.25	1.26	15.1
1	0.875	0.31	1.56	18.7	1.025	0.43	2.14	25.7
1½					1.505	0.92	4.62	55.5
2					1.985	1.61	8.04	96.5

107.4 Routine Flushing to Turn Water Over between Filling and Final Disinfection

Stagnation (elevated water age) is the single most important determinant of water quality in a given plumbing system section. Water stagnation promotes loss of protective disinfectant residual, change in water temperature to tepid temperature that is more conducive to pathogen growth, can promote corrosion, and can have other negative water quality impacts. Many studies have demonstrated that periodic flushing (turning water over) has water quality benefits and reduces the likelihood that pathogens such as *Legionella* spp. are present or grow to problematic populations. Turning water over in pipes replaces old water with water that has higher disinfectant concentrations (assuming disinfectant is present in the branch supply) and that has temperature that is either higher or lower than temperatures that promote OPPPs growth. Studies have shown that a sudden change in shear stress at a pipe wall can shear loose biofilm that develops during stagnation and contribute to biofilm control. A down side to periodic water turnover is water wastage. Water wastage can be minimized by right-sizing plumbing (avoiding oversized pipe and fittings), delaying filling the system or parts of the system until necessary (dry systems do not need to be flushed), and by a strategic process for flushing fixtures.

107.4.1 Routine Flushing Frequency

The frequency for turning over water to maintain water quality remains unknown. Studies have shown that biofilm rebounds to pre-flushed levels on the order of days after turning water over and that *Legionella* populations (if present) also rebound, though probably more slowly. The rate of rebound differs from system to system and is dependent on the supply water quality and particularly the type and level of disinfectant in the supply. Standards such as ASHRAE 188 recommend flushing as a key element of water management, but do not specify a flushing frequency or maximum stagnation time. Some international standards and guidelines, particularly for management of water systems in health care or senior care facilities, recommend turnover frequencies ranging from once per day (only for health care and senior care facilities) to once per week. Based on research studies, existing guidelines and standards, and practical considerations such as work schedules and weekends, reasonable target water turnover targets are once per day for facilities intended for health care or senior care and twice per week for other facilities. Because routine water turn-over is a primary water quality control, it should be an explicit part of plans for water management during construction and should be documented.

107.4.2 Routine Flushing Technique

As with the initial flush, turning over a single pipe volume is insufficient to fully exchange water in a branch or plumbing system segment. Routine flushing should be long enough to turn over 4-5 pipe volumes for the segment/branch that is flushed. Alternatively, flushing can be conducted until the water temperature becomes stable. Although velocity is less important for routine flushing than for initial flushing, higher velocities are preferred and routine flushing should be conducted with aerators or other accessible flow restricting components removed. Higher velocities can also be achieved via designs with dedicated flushing points with sufficient drainage. To the extent possible, routine flushing flows should be started suddenly to generate sudden changes in shear in the plumbing system and contribute to removal of loose biofilm.

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