Meeting: NSF Joint Committee on Prevention of Injury and Disease Associated with Building Water Systems

Date: October 11, 2018

ASA Staff: Jim Kendzel

Attachments: Meeting Package and Draft Standard

This report is not an official report from NSF International and solely represents the discussions and decisions from the meeting as observed by the ASA staff person in attendance.

Background
The NSF Joint Committee on Prevention of Injury and Disease Associated with Building Water Systems is consensus body responsible for the development and approval of NSF/ANSI standards covered under the scope of the Committee. The JC is currently working on a new standard, NSF 444 - *Prevention of Disease and Injury Associated with Building Water Systems*. ASA is currently not a member of this Committee and participated as an observer via conference call.

NSF and Consulting Agreement
The NSF staff person provided the Committee an update on the issues surrounding NSF's announcement of a consulting agreement with Holmyer Consulting covering building water systems. The announcement raised concern about a potential conflict of interest with NSF also being the standards developer of the not yet completed NSF 444 -. The announcement of the agreement led to members of the Joint Committee resigning from the Committee including representatives from the CDC, VA, American Society of Health Engineers (ASHE) and the New York Department of Health.

NSF staff noted that NSF 444 has been under development for 3 years and hoped that the Committee could continue to move forward to complete the standard. Applications for new members of the Committee our currently under consideration. It was also noted that the NSF Council of Public Health Consultants approved at their annual meeting continued support for the completion of NSF 444.

NSF is in the process of considering the following two options moving forward and hopes to make a decision by the end of 2018:

- NSF continues to facilitate the development and publication of NSF 444; or
- NSF collaborates with another standards development body and hands over the facilitation of the standard development process to that organization.

Discussions on the Proposed Current Draft of NSF 444
The meeting package is attached, including the proposed draft standard. The draft standard has been bookmarked and highlighted by ASA staff to point ASA members to the sections of the directly related to plumbing systems in the building. The Committee spent the day going through the entire draft document; this summary represents my perception of key issues that might be relevant to ASA members.

Purpose
The committee agreed that the overall purpose of the standard is the prevention of injury and disease and that the scope should go beyond Legionella and cover other potential health related issues (physical, chemical, microbiological).

Referenced Standards
NSF staff noted a running list of "referenced standards" is being maintained but has not yet been incorporated into the draft. The intent of the referenced standard section is to list all normative standards referenced in the body of the standard.

Section 5 - General Requirements
Concern was raised about the first paragraph in section 5 requiring an independent audit under 5.2.10 Validation, of the requirement for third-party validation of the Water Management Program (WMP). It is standard practice not to require third-party programs in a product or system standard. This issue was raised again in several sections of the draft standard.

Some of the Committee believed the intent behind an “Independently audited” was not to require third-party audits but to require the audit program, whether done internally or by a third-party, be done independent of the management team responsible for the development and implementation of the WMP.

Section 6 - Premise Plumbing for Buildings

Item 6.2 Information about the system – a recommendation was made to include the location of the plumbing system components.

Item 6.3 Process flow diagram – recommendation made to add temperature gauges into the flow diagram.

Item 6.5 Control Measures – recommendation made to add temperature and time as a control method.

Sub-sections 6.7 Routine inspection, maintenance, service; 6.8 Routine monitoring; and 6.9 Verification have been developed by a task group and will be provided at a date following the meeting.

Section 7 Cooling Towers and Evaporative Condensers Water Systems

Item 7.11 Validation - general agreement to remove requirement that testing needs to be done by a lab separate from the water treatment service provider

Section 8 Building Construction and Design

Item 8.2.4 Major events during renovation – this item is being rewritten to require that major events during renovation be documented and the event be investigated by the WMP Team to determine if there is any negative impact on the existing buildings water system.

NEXT STEPS

A 2-hour call will be set up for some time in December 2018 to go over the sections not available for review at the October 11th meeting. Following the December call a revised draft of the standard will be issued based on the results of the October and December meetings.

Joint Committee on Prevention of Injury and Disease Associated with Building Water Systems

NSF International
Ann Arbor, Michigan
October 11, 2018

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NSF 444 – Prevention of Injury and Disease Associated with Building Water Systems
Joint Committee Meeting Agenda
October 11, 2018 – 8:30 AM to 4:30 PM U.S. Eastern Time

Teleconference & Online Access:
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Time	Agenda Item	Lead
8:30 AM	Roll Call Anti-Trust Statement Review Agenda Approval of 12/7/17 Meeting Summary Membership Review	Jessica Evans, NSF Secretariat
8:40 AM	Joint Committee Introductions	All
8:50 AM	Welcome	Steve Tackitt, JC Chair
9:00 AM	NSF 444 Draft Review: • Purpose, Scope, Definitions • Background • General Requirements	All
10:20 AM	Break	
10:40 AM	NSF 444 Draft Review: • Premise Plumbing • Cooling Towers	All
12:00 PM	Lunch	
1:00 PM	ANSI/ASHRAE Standard 188 & Guideline 12 Update	Chuck Gulledge, ASHRAE Treasurer
1:30 PM	NSF 444 Draft Review: • Pools, Spas & Hot Tubs • Decorative Fountains & Water Features • Construction & Design • Healthcare Environments	All
3:15 PM	Open Discussion	Steve Tackitt, JC Chair
4:00 PM	Upcoming Meeting Plan • In person 1 day meeting in 2019 Action Items	Jessica Evans, NSF Secretariat
4:30 PM	Adjourn	

NSF International Standard

NSF 444 – 2018

Prevention of Disease and Injury Associated with Building Water Systems

Draft

NSF International, an independent, not-for-profit, non-governmental organization, is dedicated to being the leading global provider of public health and safety-based risk management solutions while serving the interests of all stakeholders.

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NSF International Standard

Prevention of Disease and Injury Associated with Building Water Systems

Confidential Draft

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Prepared by
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Foreword[2]

Legionella and other opportunistic premise plumbing pathogens (OPPPs) can enter building water systems through the water main or other external sources. Populations of bacteria can amplify under certain hazardous conditions such as high water age, high sediment or biofilm levels, low hot water distribution temperatures, and low disinfection residuals. Anyone can become sick from OPPPs although immunocompromised people, the elderly, chronic smokers, and infants are particularly vulnerable. Potential sources of contamination include showers, sinks, therapy tubs and pools, drinking fountains, cooling tower water systems, and even the decorative water features in lobbies.

Moreover, the implementation of certain control measures to mitigate the microbial hazards may cause unintended physical and chemical hazards. For instance, increasing the hot water temperature in order to kill bacteria without addressing the use of the water at points of use could result in severe scalding injuries. Injesting high levels of chemicals such as lead or disinfection by-products in drinking water has also caused illness.

Consistent with the methodology of ASHRAE 188-2015 and the CDC toolkit, NSF 444: Prevention of Disease and Injury Associated with Building Water Systems has been developed to provide the means and methods to mitigate physical, chemical, and microbial hazards that may be present in the water systems (potable and non-potable) in a building. NSF 444 provides a consistent framework for the development of water management programs which will evolve with the dynamics of the building water system.

The Standard provides general requirements for developing a water management program. In addition, the Standard provides more specific requirements for the premise plumbing and cooling tower water systems, and construction and design requirements. Additional requirements specific to healthcare facilities are detailed as well as considerations for healthcare environments and devices.Although not included in the Standard at this time, it is important to include other types of building water systems such as water reuse and storage systems in the Program as well if the Program Team determines the risk of disease or injury may be significant.

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NSF Standard
for Building Water Systems —

Prevention of Disease and Injury Associated with Building Water Systems

1 Purpose

The purpose of this standard is to establish minimum practices necessary to prevent disease and injury from physical, chemical, and microbial hazards associated with water systems in buildings.

2 Scope

2.1 The minimum practices established by this standard apply to the design, construction, commissioning, operation, maintenance, repair, replacement, and expansion of new and existing building water systems (potable and non-potable) and their associated components.

2.2 This standard applies to human-occupied commercial, institutional, healthcare, multi-unit residential, industrial buildings, and entertainment venues, such as concert halls and sports arenas ("Applicable Buildings"). This standard does not include single-family residential buildings.

3 Definitions

3.1 aerosolization: The conversion of a physical substance, such as water, into the form of particles or droplets that are small and light enough to be carried on the air.

3.2 aerosols: Microscopic particles or droplets that are small and light enough to be carried by the air.

3.3 amplification (microbial): The growth of microorganisms.

3.4 applicable buildings: Human-occupied commerical, institutional, healthcare, multi-unit residential, industrial buildings, and entertainment venues.

3.5 at-risk individual(s): In the context of this Standard, persons considered to have greater potential of being susceptible to diseases or injury from water associated with building water systems compared to the general population.

3.6 bacteria (pl. of bacterium): A large domain of single-celled microorganisms, typically a few micrometers long that may cause infectious disease in humans.

3.7 biocide: An agent that kills or inactivates microorganisms by chemical or microbial means.

3.8 biofilm: Complex, heterogeneous microbial ecosystems that develop on virtually all surfaces in contact with non-sterile water. The extracellular polymeric substance (EPS) that makes up much of the biofilm structure typically is a hydrated polyanionic polysaccharide matrix.

3.9 biostat: An agent that prevents or suppresses bacterial growth by chemical or microbial means.

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3.10 blow down: Blow down is the total of all non-evaporative water losses from a cooling tower. When water evaporates from a cooling tower, dissolved solids (such as calcium, magnesium, chlorides, and silica) are left behind in the bulk water. As more water evaporates, the concentration of dissolved solids increases. If the concentration gets too high, the dissolved solids can precipitate, cause scale deposits and contribute to corrosion and microbial growth. The concentration of dissolved solids is controlled by "blow down", the process of discharging water containing high concentrations of dissolved solids, and replacing it with "make-up" water containing relatively lower concentrations of dissolved solids.

3.11 bromine: An element in the halogen series that is a powerful oxidizing agent. Reaction with water results in hypobromous acid, a disinfectant commonly used for industrial and recreational water treatment.

3.12 building water systems: Any water-receiving system that distributes its water to multiple uses (potable, utility (non-potable), or other and may also distribute to multiple locations within the building or site.

3.13 chiller: A chiller is a device that transfers heat from one medium to another by means of vapor compression or absorption-refrigeration cycles. The liquid may be re-circulated through a heat exchanger that uses water. In cooling towers, the heat from a refrigerant is transferred to water; the heat is then rejected from the heated water by means of evaporation. The cooled water, plus make-up water added to replace the water lost to evaporation (and to other, non-evaporative losses), is returned to the chiller and the process is repeated.

3.14 chlorine: An element in the halogen series that is a powerful oxidizing agent.

3.15 chlorine dioxide: A powerful, selective oxidizing agent that is an effective disinfectant.

3.16 coliforms: The group of bacteria associated with mammalian gut and include *E. coli*, *Salmonella*, *Shigella*, *Klebsiella*, and other pathogens often associated with water.

3.17 colonization (microbial): In engineered systems, the intrusion of microorganisms from the environment into the system and then amplification (growth) especially on surfaces of such systems.

3.18 combined halogen: The halogen species in the water that are bound to nitrogen, such as in amines, and therefore are not necessarily available to act as disinfectants to the same extent, if at all. The halogen in covalent bonds with nitrogen comprise the "combined residual"...

3.19 community-acquired infection: Any infection occurring outside a healthcare facility.

3.20 conductivity: Conductivity is a measure of the capacity of ions in water to carry electric current. Results of conductivity measurements are expressed as microsiemens/cm (µS/cm) or mmho/cm. Both measurements are temperature dependent. Conductivity measurement is used to estimate the amount of total dissolved solids (TDS) in the recirculating cooling water. Conductivity is used to initiate blow down, thereby managing TDS levels and determining cycles of concentration. Proper control of blow down based on measurement of conductivity is essential to effective control of the cooling water system.

3.21 confirmed process flow diagram: A process flow diagram that has been verified accurate as to the current as-built and operational conditions within the building (See process flow diagram).

3.22 control: To manage the physical and chemical conditions of an operation in order to meet established criteria.

3.23 control limits: A physical or chemical characteristic that describes conditions at a critical control point that can be measured and adjusted in real time (e.g., water temperature, disinfectant residual) (See critical control limits).

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3.24 control measure: Any action or activity that can be used to prevent or eliminate a hazardous condition or reduce it to an acceptable level.

3.25 control point: Any step in a process at which an action or activity can be applied to prevent or eliminate a hazard or hazardous condition or reduce it to an acceptable level. This includes, but is not limited to, critical control points.

3.26 cooling capacity: The amount of cooling a cooling tower can provide and is rated in tonnage. A ton is a unit of power used to describe the heat extraction capability of a chiller. A ton refers to the approximate amount of cooling power a ton of ice would provide if it melted over a 24-hour period. A refrigeration ton is equal to 12,000 BTU/hr.

3.27 cooling towers: Heat removal devices used to transfer process waste heat, typically using water as the heat-transfer medium.

3.28 cooling tower water system: One or more cooling towers and all associated equipment, such as chillers, condensers and piping with shared water.

3.29 copper/silver ionization: A dispersive process that introduces positively charged copper and silver ions into the water system.

3.30 corrective action: A specified procedure to correct the physical or chemical conditions at a critical control point when monitoring shows that control parameters (e.g., disinfectant dose) fall outside of the critical control limits. These are not responses to validation tests, such as measured conditions at a sampling point, or results from microbial testing of environmental or clinical samples.

3.31 corrosion: Generally refers to the process of oxidation that occurs on metal surfaces resulting in degradation of the surface and release of corrosion products into the system. Types of corrosion in building water systems include galvanic, chemical and microbiologically induced corrosion (MIC).

3.32 criterion: A standard upon which a judgment or decision can be based.

3.33 critical control limits: A maximum value, minimum value, or range to which a chemical or physical parameter (e.g., disinfectant dose or water temperature) is controlled at a critical control point in order to prevent, eliminate or reduce to an acceptable level the occurrence of a hazardous condition throughout the system (e.g., at sentinel points). These are parameters at critical control points that can be measured and controlled in real time.

3.34 critical control point: Locations in the building water system at which an action or activity must be applied to prevent or eliminate a hazard or hazardous condition or reduce it to an acceptable level, (e.g., the point at which a disinfectant is added, the point at which heated water is introduced into the hot water system, the point at which a backflow protection device is installed, the point at which flushing is initiated, the point at which a drift eliminator is used, or the point at which water treatment chemicals, such as biocides, are added to cooling tower water).

3.35 cross contamination: The process by which bacteria or other microorganisms are unintentionally transferred from one source to another.

3.36 cycles of concentration: A key parameter used to manage cooling tower operation is "cycles of concentration", defined as the ratio of make-up water volume to blow down water volume. Cycles of concentration can be approximated from the ratio of the conductivity of the blow down water to the conductivity of the make-up water. From a water efficiency standpoint, the goal is to maximize cycles of concentration, minimize the quantity of blow down water and thereby reduce the quantity of make-up water. However, the number of cycles is constrained by the chemistry of the make-up water, the heat load on the cooling tower and the quantity of environmental (e.g., airborne) contaminants captured by the water. Total dissolved solids (and conductivity) increase as cycles of concentration increase. High levels of dissolved

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solids can cause corrosion and buildup of scale, as well as contribute to an increase in microbial levels.

3.37 danger: A qualitative estimate of potential harm associated with a hazard; a function of [probability of an event] x [severity of the consequence]; the qualitative counterpart of the more quantitative term “risk”.

3.38 dead leg: Pipe branch that is capped off or rarely used and is typically 6 or more pipe diameters in length (e.g., a 6 in. length is a dead leg for a pipe of 1 in. diameter).

3.39 decorative fountain: A water feature used to enhance the aesthetics of a public space (e.g., architectural fountain).

3.40 deviation: The variation from a value or range of values. In building water systems, the degree to which a physical or chemical parameter (e.g., disinfectant dose) at a critical control point fails to fall within critical control limits, or the degree to which physical or chemical parameters at a sentinel point fail to fall within sentinel point limits.

3.41 disinfectant residual: The net amount of a disinfectant remaining in treated water after chemical demand exerted by the water is satisfied. The disinfectant residual level is dynamic, and decreases as a function of the chemistry of the water; the residual typically decreases at a faster rate as contact time and temperature increase.

3.42 disinfectants: Chemicals used for disinfection of building water systems (e.g., chlorine, chlorine dioxide, monochloramine, bromine, and ozone).

3.43 dissemination (environmental): Disbursement or distribution of a substance in air or water.

3.44 dissolved solids: Soluble materials in the water, either formed from constituents of the water itself (hardness, salts, etc.) or from the local environment (airborne particles, insects, salts, etc.). The amount of dissolved solids is expressed as mg/L.

3.45 domestic water system: See potable water system.

3.46 DPD: N, N-diethyl-p-phenylene diamine is a chemical indicator used in the colorimetric determination of the concentration of oxidizing biocides. DPD reacts with oxidizing biocides, including chlorine and bromine. DPD can be used to determine free and total halogen concentrations; combined residual is the difference between total and free halogen.

3.47 drift: Drift is the evaporated water in droplet form carried out of the tower with the air. The amount of drift must be controlled because the microorganisms, such as *Legionella*, carried in bio-aerosols that make up the drift can be inhaled by and infect humans. Drift is different from vapor, the pure gas phase of water that is liberated by evaporation.

3.48 drift eliminator: A drift eliminator is a device used to catch and condense aerosolized water droplets that are discharged from the cooling tower as drift. Drift eliminators are designed to change the direction of airflow abruptly, imparting centrifugal force to separate water from the air and cause small droplets to coalesce into large droplets that fall back into the tower basin.

3.49 drinking water disinfectants: Chemicals listed by the U.S. Enviornmental Protection Agency (USEPA) under Safe Drinking Water Act (SDWA) as acceptable for drinking water treatment(e.g., chlorine, chlorine dioxide, monochloramine, bromine, and ozone).

3.50 FIFRA: The Federal Insecticide Fungicide Rodenticide Act is the law that provides for federal regulation of pesticide distribution, sale, and use in the United States. All pesticides, including anti-microbial biocides that are distributed or sold in the United States must be registered by USEPA under FIFRA. Most States have pesticide regulations that are comparable to FIFRA and also require compliance for products sold, distributed or used in such State.

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3.51 fill: The component of the cooling tower that causes the circulating water to spread out over a large surface area, in order to increase the evaporation rate by exposing the water to a greater volume of air. There are two basic types of fill: splash and thin film.

3.52 free available chlorine (FAC): The total amount of hypochlorite ion and hypochlorous acid in the system available to act as disinfectants in water. When using chlorine-based biocides, FAC is the portion of the total chlorine that has not reacted with constituents of the water and is therefore available for disinfection.

3.53 free residual oxidant (FRO): The amount of available hypohalite (e.g., hypochlorite, hypobromite) ion and corresponding hypohalous (e.g., hypochlorous, hypobromous) acid in the system, available to act as a disinfectant in water.

3.54 haloacetic acids (HAA): A group of USEPA-regulated disinfection byproducts associated with chlorine.

3.55 halogen: A member of the group in the periodic table consisting of five chemically related elements: fluorine (F), chlorine (Cl), bromine (Br), iodine (I), and astatine (At). A number of compounds containing halogens, especially chlorine, bromine and iodine, have anti-microbial properties.

3.56 hazard: A microbial, chemical or physical agent or condition that can cause illness or injury in the absence of its control.

3.57 hazardous conditions: Physical or chemical conditions in the building water system that contribute to the potential for harmful human exposure to microbial pathogens and toxic chemicals.

3.58 healthcare associated infection (HAI): An infection occurring or acquired in a healthcare facility (See nosocomial infection).

3.59 healthcare facility: A healthcare facility is, in general, any location where in-patient or out-patient health care is provided. Healthcare facilities range from clinics and doctor's offices to urgent care centers, ambulatory surgery centers, longterm care facilities and hospitals of varying complexity. Clinical services cover a range of areas, including but not limited to,emergency rooms and trauma centers, medicine, surgery, neonatology and pediatrics, geriatrics, transplant, psychiatry, rehabilitation, dentistry, and eye care. Longterm care facilities, including residential treatment centers and geriatric care facilities (i.e. nursing homes), are healthcare institutions which have accommodation facilities and which engage in providing short-term or long-term medical treatment of a general or specialized nature. Healthcare facilities often include numerous non-clinical services that utilize water such as central supply, pharmacy, laboratory, and food service.

3.60 humidifier: A device for keeping the atmosphere moist in an area of a building.

3.61 hyper-chlorination: A procedure used for acute disinfection of building water systems by applying chlorine at concentrations that exceed typical levels of disinfectant in the system.

3.62 hyper-disinfection: A procedure used for acute disinfection of building water systems by applying disinfectants, such as chlorine, at concentrations that exceed typical levels of disinfectant in the system (See hyper-chlorination).

3.63 ice machine: A machine in a freezer or a stand alone applicance that automatically produces ice from a water source for human consumption.

3.64 immunocompromised (immune compromised): A condition describing an individual who has increased susceptibility to infections relative to the general population(See at risk individuals).

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3.65 intrusion (microbial). The input, often from environmental sources, of microorganisms into building water systems.

3.66 *Legionella* (plural legionellae): *Legionella* are common aquatic bacteria found in natural and man-made water systems, as well as occasionally in some soils. Legionellae, the plural of the genus *Legionella*, refers to more than one species of *Legionella* and is often used to refer to many species of *Legionella*.

3.67 legionellosis: The term used to describe any illness caused by *Legionella*.

3.68 Legionnaires' disease: An acute bacterial infection of the lower respiratory tract with accompanying pneumonia (See legionellosis).

3.69 louvers: The part of the cooling tower that blocks sunlight but allows air to be directed onto the fill. Louvers also help retain the splash from droplets falling from the fill.

3.70 make-up water: The water added to the system to replace water lost by evaporation, blowdown and other means.

3.71 microbes (microorganisms): A term used to describe microscopic life forms including bacteria, viruses and protozoa and may also include algae and fungi.

3.72 microbial validation: Evidence that hazard control has been effective under operating conditions. Secondary validation data can include, for example, test results from samples taken at sentinel points to determine if pathogenic microorganisms are present. Clinical disease surveillance data associated with the facility is another example.

3.73 monitoring: Conducting a planned sequence of observations or measurements. For purposes of this Standard, this refers only to measurements made at critical control points to determine if conditions are within critical control limits for the building water system.

3.74 monitoring instrument: A device used to measure and record physical or chemical parameters (e.g., water temperature, disinfectant residual) at a critical control point.

3.75 monochloramine: An inorganic chemical compound with the formula NH2Cl, which is a slow-acting, persistent disinfectant used to maintain a residual in public drinking water supplies. Monochloramine is energetically unstable in concentrated form.

3.76 N-Nitrosodimethylamine (NDMA): (dimethylnitrosamine (DMN)) It is a semi-volatile organic chemical that is highly toxic and is a suspected human carcinogen. NDMA in drinking water has been linked to use of monochloramine.

3.77 nebulizer: A device that creates a water mist, sometimes containing medications, used to treat respiratory illnesses.

3.78 nitrification: The microbial oxidation of ammonia into nitrites, followed by the oxidation of the nitrites into nitrates. In drinking water distribution systems where monochloramine is used as the secondary disinfectant, the presence of free ammonia can act as a substrate for ammonia-oxidizing microorganisms. The associated reactions can lead to the depletion of the disinfectant residual in the system, especially in buildings.

3.79 nosocomial infection: An infection occurring or acquired in a healthcare facility (See healthcare-associated infection (HAI)).

3.80 on-site water storage system: Storage system containing one or more tanks for holding cold, potable water.

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3.81 opportunistic pathogens of premise plumbing (OPPP): Naturally occurring microorganisms that persist and amplify in the premise plumbing, and that do not typically infect healthy individuals, but can cause disease in susceptible individuals (e.g. immunocompromised persons).

3.82 organic dispersant: Surfactants that promote system cleanliness by penetrating and loosening attached biofilms and associated deposits.

3.83 oxidant: A substance that oxidizes another substance; an oxidizing agent. Some oxidants, such as chlorine, chlorine dioxide, and ozone, are used to disinfect water.

3.84 oxidant residual: The net amount of an oxidant remaining in treated water after chemical demand exerted by the water is satisfied. Oxidant residual levels decrease more quickly as contact time and temperature increase (See disinfectant residual).

3.85 owner: Any person, agent, firm, partnership, corporation, or other legal entity having a legal or equitable interest in, or control of the premises. In some circumstances, a tenant may be considered an owner for the purposes of this standard if the tenant is contractually responsible for the maintenance of the building water systems.

3.86 pathogen (pathogenic microorganisms): A Microbe that has the ability to cause disease.

3.87 piping & instrumentation diagram (P&ID): A schematic drawing that shows the piping of the process flow together with the installed equipment and instrumentation, such as in a building water system. A standard set of symbols is used to prepare drawings of processes. The symbols used are generally based on ISA Standard 5.

3.88 Pontiac fever. A mild respirator illness caused by *Legionella* that usually resolved without the need for treatment. See legionellosis.

3.89 swimming Pool: Subset of aquatic venues designed to have standing water for total or partial bather immersion.

3.90 parametric validation: Evidence that hazard control has been effective under operating conditions. Primary validation data can include for example test results from samples taken at sentinel points to determine if disinfectant concentrations are within effective ranges.

3.91 potable water: Water intended for human consumption, including domestic hot and cold water for drinking, bathing, showering, cooking, dishwashing, and maintaining oral hygiene.

3.92 potable water system (domestic water system): A water distribution system in a building that provides hot or cold water intended for human consumption (e.g., drinking, bathing, showering, cooking, dishwashing, and maintaining oral hygiene).

3.93 premise plumbing: See potable water system.

3.94 primacy: Primary authority and responsibility for administration and enforcement of regulations, such as that delegated to States and Tribes by USEPA in connection with the rules under the Safe Drinking Water Act.

3.95 process flow diagram: A step-by-step schematic of a building water system showing how water is processed in the facility from the point that the water is received (e.g., intake) to the points at which it is dispensed (e.g., tap) and disposed to waste (or reuse). Typical processing steps include conditioning, storing, heating, cooling, recirculating distributing and tempering the water.

3.96 *Pseudomonas aeruginosa*: A bacterium commonly found in aquatic systems. An opportunistic

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pathogen that, when transmitted to susceptible people, can cause serious infections such as pneumonia.

3.97 public water system (PWS): 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 at least twenty-five of the same individuals more than 6 months per year. PWS include Community Water Systems (CWS) and non-community water systems (NCWS). NCWS include Transient Non-Community Water Systems (TNCWS) and Non-Transient Non-Community Water Systems (NTNCWS). NTNCWS includes most hospitals, nursing homes, hotels, educational institutions and many multi-unit residences.

3.98 record keeping and documentation: Record keeping and documentation include creating and maintaining complete, accurate, written descriptions of all aspects of the Program and any actions taken in connection with the Program.

3.99 respirable: A descriptor of the size and or shape of anything that can be inhaled by a human without triggering a gag or coughing reflex. The degree to which a particle is respirable may vary from individual to individual.

3.100 risk: An estimate of the level of danger of illness or injury that can be caused by a microbial, chemical or physical agent; a function of [probability] x [severity].

3.101 risk assessment: In healthcare settings, the risk assessment is a detailed process, including clinical surveillance, that identifies events, actual and potential risks, points of vulnerability, and prioritized areas for improvement based on the actual or potential impact on care, treatment or services.

3.102 routine: Refers to procedures performed as part of a regular process.

3.103 sampling point(s): The points throughout a building water system at which physical and chemical conditions (e.g., temperature, disinfectant residual) are representative of the likely worst-case portions of the system. The sampling points are the locations in the building water system at which water samples are tested for physical and chemical conditions (water temperature, disinfectant residual) to validate that the controls at critical control points specified by the Program are maintaining intended physical and chemical conditions (water temperature, residual disinfectant) throughout the building water system. Microbiological tests at sampling points can also be used as validation evidence. Sampling points are not critical control points.

3.104 sampling point targets: A maximum value, minimum value or range to which a chemical or physical parameter (e.g., disinfectant dose or water temperature) are maintained at a sampling point in order to prevent, eliminate or reduce to an acceptable level the occurrence of a hazardous condition. Sampling point limits are not critical control limits.

3.105 scalding: Burning by a hot liquid, such as water.

3.106 service line: The segment of a drinking water transmission line which connects the water main to the service connection at the building intake.

NOTE - In older buildings, service lines often were made of lead.

3.107 siphoning: Lifting of a liquid in a pipe over an elevation by the pressure of the atmosphere. In plumbing, this is a phenomenon that can cause non-potable water to mix with and contaminate potable water.

3.108 spa/hot tub: Structure intended for bathing or other recreational uses containing warm water where prolonged exposure is not intended.

3.109 surfactant: A chemical formulation that breaks the surface tension of water.

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3.110 tepid: Moderately warm water (about 25 °C to 55 °C (77 °F to 131 °F)). The microbial temperature range in which microbial growth is amplified..

3.111 total dissolved solids (TDS): The quantitative measure of organic and inorganic solids dissolved in the water, measured in mg/L. TDS can be measured directly by complicated analytical procedures, or estimated indirectly from the conductivity reading by multiplying the conductivity level by a conversion factor of 0.65

3.112 THAB: Total heterotrophic aerobic bacteria. The term THAB is a variant of "total aerobic population", "total aerobic count", "heterotrophic plate count" (HPC), "total heterotrophic bacteria" (THB) and other terms.

3.113 total residual oxidant (TRO): The total amount of all types of oxidizing halogen-containing compounds present; the sum of free residual oxidant (FRO) and combined halogen.

3.114 transmission (microbial): the physical transport of microorganisms in water, often as aerosol, from building water systems that can result in exposure of people to potentially dangerous conditions.

3.115 trihalomethanes (THMs): A group of USEPA-regulated disinfection byproducts associated with chlorine.

3.116 turbidity: A measure of water cloudiness, due to suspended particles.

3.117 utility water system: A building water distribution system that provides water intended for uses other than human consumption (a non-potable water system). This includes certain water systems where human contact is possible, such as cooling tower water, landscape irrigation system, or decorative fountains.

3.118 validation: Evidence that a Program, when implemented as intended, has effectively controlled the hazard(s) or hazardous conditions throughout the building water system. Validation is a quality control (QC) function.

3.119 verification: Evidence that a Program is being implemented as intended. Verification is a quality assurance (QA) function.

3.120 Water Management Program: A written document that encompasses the entire building water system management program.

3.121 Water Management Team: The cross-functional group of people designated by the building owner or manager to have authority and responsibility for developing, implementing, and maintaining the Program.

3.122 Water Safety Plan (WSP): HACCP-based process for water system management developed, by the WHO.

4 Background

4.1 Hazards associated with building water systems

Building water systems (Systems) may have one or more microbial, physical, or chemical hazards with the potential to cause disease and injury under certain hazardous conditions (see: Table 1. Hazards Associated with Building Water Systems). Each system shall be analyzed and a plan shall be developed to manage hazarous conditions in order to mitigate the potential for harm from such hazards.

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4.1.1 Physical hazards

Water is a physical hazard in some Systems because, under certain conditions, water can cause sever burns (scald). Scalding is a function of water temperature and exposure time (see Table 2. Scalding). The higher the temperature, the lower the exposure time that can cause second and third degree burns from heated water. Certain populations (e.g., the elderly, infants and young children, and the physically impaired), are more susceptible to scalding than healthy adults.

4.1.2 Microbial hazards

Environmental-source organisms (see: Table 3. Microbial Hazards) that can grow in Systems are microbial hazards. Hazardous conditions that support growth of these organisms include sediment, tepid water temperature, excessive water age, and lack of disinfectant residual. Important routes of exposure include inhalation and contact at sites such as mucous membranes, eyes, skin, and wounds. This Standard covers only environmental-source, biofilm-associated pathogens that grow in Systems under certain hazardous conditions. This Standard does not include fecal-source pathogens which may contaminate water due to inadequate treatment or intrusion.

4.1.3 Chemical hazards

Chemical hazards include metals and toxic compounds (see: Table 4. Chemical Hazards) that are corrosion products of or leachants from plumbing materials, as well as disinfectants and disinfection by-products from chemical intentionallly added to treat the water. Hazardous conditions that can increase the concentration of toxic chemicals to harmful levels incllude corrosive water and excessive water age. This Standard does not include chemical hazards due to deliberate or accidental contamination of distribution systems.

Table 1 – Hazards Associated with Building Water Systems

	Physical hazards	Microbial hazards	Chemical hazards
Premise plumbing	X	X	X
Cooling tower systems		X	
Spas/hot tub systems	X	X	X
Decorative fountains and waterfall systems	X	X	X
Ice machines/humidifiers		X	X
On-site water storage	X	X	X

4.2 Hazardous conditions

Hazardous conditions are the physical and chemical conditions that may amplify the potential for human expsosure to the hazards identified in Section 4.1 of the System. When implementing the requirements of this Standard, the conditions in the building water system that can contribute to the potential for harmful human exposure to microbial pathogens and toxic chemicals shall be evaluated. In addition, control measures that are implemented to minimize the hazardous conditions may result in unintended consequences. As the water management program develoiped using the requirements in this Standard will be site-specific, the unintended consequences shall be evaluated for each control measure put into

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place. Hazardous conditions include but are not limited to:

- poor influent water quality;
- sediment;
- water age;
- cross-connections;
- inadequate mangement of treatment systems (e.g. over softening, overdoing disinfectants); and
- disinfectant level too low or too high.

5 General requirements

Persons covered by this Standard shall develop and implement an independently audited water management program and plan (Program) to managae hazardous conditions associated with physical, chemical, and microbial hazards in all Systems. The water management program shall comply at a minimum with Section 5 and Section 6. The Program shall comply with all applicable sections of this Standard.

NOTE – In addition to the Systems covered in sections 5-11 of this Standard, other Systems may be included in the Program if the risk of disease or injury associated with pertinent hazards is considered by the Team to be significant. For Systems that are not specifically covered by this Standard (e.g. irrigation, water re-use systems), the Program for such systems shall meet the requirements of Section 5.

5.1 Compliance requirements

The Program shall be audited quarterly, including at least one on-site audit (Audit). The scope of the Audit shall include, at a minimuum, all verification and validation documents, and an on-site inspection of all Systems. ~~All audits shall be performed by an ISO/IEC 17065 accredited organization.~~ The audits shall confirm that all requirements of this Standard have been met.

5.2 Program

The building owner shall be responsibile for the Program, and may delegate authority and responsibility for Program development and implementation. The Program shall be the written water management plan together with documentation and records of all practices and procedures, including all aspects of treatment, monitoring, operation, maintenance, validation testing, and recordkeeping. All actions required by this Standard shall be documented and made available for inspection by the Team, auditors, and the AHJ.

5.2.1 Team

The Owner shall identify members of a Team with the authority and responsibility to develop and implement the Program. Members of the Team may be full-time employees, part-time employees, service providers, or vendors. The Team should include, at a minimum:

- the Owner;
- facilities management; and
- engineering staff.

Each member of the Team shall be familiar with the operating and maintenance requirements for the System and with the pertient rules and regulations of the AHJ. The following information about each team

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member shall be documented and recorded:

- name;
- position/job title and department;
- contact information (i.e. phone number and e-mail);
- specific responsibilities associated with the Program; and
- certifications or records of training, if any.

NOTE – It is useful to have avilable for the Team's reference copies of pertient local, regional, and national regulations and codes, and the identity of and contact information for each AHJ.

5.2.1.1 The team in a healthcare setting

For a healthcare environment, the water management Team shall include the following roles, when applicable, along with the required information in Section 5.2.1:

- facilities management;
- risk management personnel;
- facilities engineer;
- infection prevention personnel;
- infectious diseases/epidemiologist;
- nephrology;
- laboratory personnel;
- industrial hygiene and safety;
- dental personnel;
- sterile supply or biomedical personnel; and
- overall team coordinator.

NOTE: *Ad hoc* participation by other staff at the facility (e.g., department heads) may be appropriate depending on specific issues or agenda items at committee meetings.

A member of the Team shall be designated as the overall team coordinator to schedule routine meetings (at least biannually) and call emergency meetings when necessary.

5.2.2 Information about the building

The Program shall document information about the building, including:

- name of the building;
- address of the building;
- name, address, telephone number, and e-mail address of the building owner;
- building type (e.g. school, hotel, hospital);
- building use(s) (e.g. overnight stay, healthcare, parking structure);
- year constructed;
- recent additions or modifications;
- engineered drawings, if available;
- operating and maintenance manuals, if available;
- number of stories, including below-grade;
- total building occupancy capacity;
- water source(s) (e.g. municipal, wells); and
- primary and secondary disinfection methods for the source water, and whether the water is filtered or unfiltered.

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5.2.3 Environmental assessment

The Team shall perform a written environmental assessment of the System at least annually. The environmental assessment must include, at a minimum, consideration of: (a) general Building characteristics, (b) hot and cold potable water systems, and (c) cooling towers/evaporative condensers.

The environmental assessment is intended to (a) help identify any system characteristics and conditions that, in the absence of modification or control, would support amplification or transmission of microbial hazards, (b) to inform the selection and implementation of control measures, and (c) to facilitate the selection of representative sampling locations.

Updates to the environmental sssessment, attendant files and supporting information should accompany any significant construction or repair work that is done in the Building.

> NOTE – Environmental Asessment forms designed specifically for *Legionella* but useful for water management programs for multiple hazards are available from CDC: https://www.cdc.gov/legionella/downloads/legionella-environmental-assessment.pdf

5.2.4 Process flow diagrams

The Team shall prepare a process flow diagram (PFD) of each System, and shall confirm by inspection that the process flow diagram is accurate. The PFD shall be a schematic drawing of the entire building water system that shows the progressive flow of water and key components.

The PFD for each system shall be made a part of the Program.

5.2.5 Analysis of the Systems

Using the environmental assessment, the PFD, and other materials the Team deems necessary, the Team shall evaluate each System, including all parts, components, pipe configurations, or zones with hazardous conditons that, in the absence of modification or application of control measures, can increase the potential for disease and injury from identified hazards.

Based on the results of the analysis of the System, the Team shall determine:

- physical modifications to the building necessary to minimize hazardous conditions; and
- control measures and the point(s) at which they must be applied to minimize hazardous conditions.

5.2.5.1 Risk assessment for healthcare facilities

The process of building water system analysis (section 5.2.4) and establishing practices to prevent disease and injury from physical, chemical, and microbial hazards is thoroughly outlined in this standard. In addition to this effort, a Risk Assessment of water systems in healthcare buildings is required and should identify users of water who are at an increased risk because of physical condition or medical procedure. Spaces identified with high risk occupants and medical devices that use water should be evaluated by appropriate water management team members to adequately define and apply surveillance measures to verify and validate water quality. See Informational Annex X for additional information pertaining to water safety in healthcare settings and formulation of healthcare building Risk Assessments.

5.2.6 Control measures

Certain control measures are required by this Standard. Each control measure shall be included in the

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Program for that system. For each control measure, the Team shall determine:

— the specific control measure;
— the frequency and duration with which the control measure shall be applied;
— the point in the System at which the control measure shall be applied (control location); and
— the measureable physical, chemical, or temporal parameters within which the control measure must be maintained (control limits).

5.2.7 Monitoring

Monitoring is a requirement of this Standard. Monitoring refers to the scheduled measurement of physical, chemical, or temporal parameters associated with each control measure. The purpose of monitoring is to confirm that measured parameters associated with each control measure are maintained within a pre-established acceptable range (control limits). For each control measure and associated control limits, the Team shall specify:

— means of monitoring;
— method used for monitoring (e.g. analytical instrument, including any calibration requirements);
— frequency of monitoring; and
— the person responsible for monitoring.

NOTE – In this Standard, the term monitoring does not refer to the sampling and analysis of physical, chemical, and microbial hazards; sampling and analysis is called validation testing.

The Team's determination of monitoring requirements for each control measure, including the basis for its determinations, shall be documented and made a part of the water management program. All information and activities pertaining to monitoring shall be documented.

5.2.8 Corrective actions

Corrective action is a requirement of this Standard. Corrective action is a set of pre-established procedures that must be implemented within a specified time period when monitoring indicates that the measured physical, chemical, or temporal parameters associated with application of a control measure deviate from the pre-established acceptable range (control limits). The purpose of a corrective action is to restore parameters associated with application of a control measure to within the specified control limits. For each corrective action implemented, the Team shall document the following:

— person responsible for taking corrective action;
— a written procedure describing the corrective action, including confirmation of reliability;
— response time for implementing corrective action;
— the reason(s) for taking corrective action;
— the corrective action taken, including date and time; and
— outcome of corrective action (e.g. restoration of control measure to within control limits), including date and time.

NOTE - In this Standard, the term corrective action does not refer to actions taken based on the results of validation tests; actions taken based on the results of validation tests are called "validation responses".

The Team's determination of required corrective actions, including the basis for its determinations, shall be documented and made a part of the Program. All information and activities pertaining to corrective actions, including the required response time, shall be documented.

5.2.9 Verification

Verification is a requirement of this Standard. Verification is the review of all monitoring records and results

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of components of the Program. Verification shall include documentation and recordkeeping, in written or electronic form, of all parts of Sections 5.1.1-5.1.7 and all other activities described in this Standard, including the identity of the person(s) responsible for implementing and supervising each activity.

If the AHJ requires registration or similar recording of information about the building water system, true and complete copies of all associated documents shall be made a part of the Program.

The verification records for the Program shall be retained for a minimum of 3 years or per the AHJ's requirements and shall be made immediately available, on request, for review by auditors and the AHJ. This is the minimum amount of time to demonstrate that the Program has been successfully implemented and maintained.

5.2.10 Validation

Validation is a requirement of this Standard. Validation shall be third-party confirmation that the Program, when implemented as designed, is effectively controlling hazards/hazardous conditions within the System. For microbial validation, the laboratory conducting tests of water samples shall be certified under the *National Environmental Laboratory Accredidation Program* (NELAP) or as required by the AHJ.

All information pertaining to validation testing shall be documented and made a part of the Program.

5.3 Communications

The Team shall develop a communication strategy and plan concerning the functions of the Program independent of automatic work scheduling programs. The Team shall meet on a scheduled basis with the Owner to discuss changes to the Program, and resource requirements necessary for operating, maintaining, and servicing the Systems in accordance with the Program.

5.4 Backflow prevention

The Building shall meet all requirements under local, regional, and national regulations and codes pertaining to the configuration, maintenance, and inspection of backflow prevention devices. Unprotected cross connections identified within building water systems shall be eliminated. Copies of all such regulations and codes shall be documented and made a part of the Program. Inspections of the backflow device or valves determined by regulation shall be included in the Program.

5.5 Personal protective equipment

Personal protective equipment (PPE) shall be selected by the Team. Respiratory protection shall be in accordance with the Occupational Safety and Health Administration (OSHA) Respiratory Protection Standard (29 CFR 1910.134 and 29 CFR 1926.103) and any applicable state or local regulations, and as recommended by the manufacturers of chemicals used to clean and treat the System. Other PPE (e.g., gloves, eye protection) shall be selected by the Team as appropriate.

5.6 Contingency reponse program

The Team shall develop a contingency response program for the following events:

- in the event of a known or suspected case of disease or injury associated with the use of the System;
- in the case of directive issued by national, regional, and local health departments;
- if the System(s) is known or suspected to be contaminated; and
- circumstances where other actions are determined by the Team to be necessary to prevent

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exposure of people to microbially- or chemically-contaminated water.

The contingency response program shall include:

- internal communication strategy and plan for building occupants;
- process decision tree concerning emergency shut down;
- provisions for emergency water supply during shut down;
- emergency cleaning, maintenance, and remediation strategy; and
- water sampling and testing protocol for agents of concern.

6 Premise plumbing for buildings

6.1 Section scope

This section covers all plumbing within the Building. Premise plumbing is all plumbing and fixtures with direct connection to the potable water supply system, where end uses may include but are not limited to drinking, cooking, bathing, showering, plumbing fixtures, oral hygiene, dishwashing, and laundry. All pipes and fixtures that deliver water to points of use after it is received by the Building, and all equipment that processes or stores water between the point where potable water is received and points of use, shall be considered within the Building. Buildings that should be considered but are not limited to institutional, commercial, multi-unit residential, healthcare, and industrial facilities, as well as entertainment venues. This section does not include non-potable systems such as irrigation and fire suppression systems.
In order for the Owner to comply with this section, all of the applicable requirements of this section shall be met.

6.2 Information about the system

The Team shall prepare a written description of the System, including:

- All sources of the potable water supply (e.g. utility, well, reclaimed water)
- Number and type of water heaters
- Number and type of water softeners
- Number and type of water filters/screens (point of entry, point of use)
- Number and type of tempering valves (centralized, point of use)
- Number of hot water recirculation loops
- Number and type of decorative fountains/water features
- Number and type of ice machines
- Number and type of water storage facilities
- Number and type of water coolers, drinking water fountains/dispensers
- Approximate number of sink taps and showerheads/hoses

6.3 Process flow diagram

In conjunction with the description of the System in 6.2, the Team shall prepare a process flow diagram (PFD) of the System, and shall confirm by inspection that the PFD is accurate. The PFD, which may include supplemental schematics, shall show the progressive flow of water and location of key components (where applicable), including:

- All sources of the potable water supply to building (utility, well)
- All locations where supply water is received (intake location)
- All pumps
- Chemical injection point(s)
- Chemical measurement point(s)

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— Whirlpool spas/hot tubs
— Swimming pools
— Washing machines,
— Ice machines
— Drinking fountains
— Water coolers
— Juice/soda/water dispensers
— Dishwashers
— Back-flow prevention devices
— Water-hammer arrestors
— Water heaters
— Water disinfection systems
— Tempering valves (central or POU),
— Thermal expansion tanks
— Hot water storage tanks
— Cold water storage tanks
— Showerheads and hoses
— Electronic faucets
— Faucet aerators
— Faucet flow restrictors
— Non-steam aerosol generating humidifiers
— Infrequently used equipment (eyewash stations, emergency showers)
— Water softeners
— Water filters or screens (including those used either at point of entry (POE) or at point of use (POU)
— Pipes, valves and fittings
— Electronic (sensor) faucets
— Manual faucets
— Faucet flow restrictors
— Misters, atomizers, air washers and humidifiers (centrally installed)
— Aerosol generating humidifiers (non-steam)
— Decorative fountains/water features
— Medical devices that use water (e.g., CPAP machines, hydrotherapy equipment, bronchoscopes, heater-cooler units, dialysis)
— Irrigation systems/lawn sprinklers

NOTE – Operating and maintenance manuals shall be available for all of the above equipment and components.

NOTE – A PFD is not a complicated engineering drawing. The PFD should have sufficient detail to enable the systematic identification and characterization of hazardous conditions, but should be simple enough for every member of the Team to understand. The PFD should be confirmed as accurate by visual inspection.

NOTE – In healthcare facilities, floor plans should be annotated to show patient care areas and areas designated for care of patients considered more vulnerable than the general census, e.g., solid organ transplant, hematopoietic stem cell transplant (HSCT) and neonatal intensive care units. The annotated floorplans are used in performing a Risk Assessment. (see: Section __. Risk Assessment)

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6.4 Analysis of the system

6.4.1 Hazards

Using the environmental assessment, the PFD and such other information as it deems useful, the Team shall perform a step-by-step analysis of the System for hazardous conditions associated with the following physical, chemical, and microbial hazards and such other hazards as the Team identifies.

Table 1. Microbial hazards (partial list) in premise plumbing and associated health effects

Hazard	Hazardous Condition(s)	Health Effects
Legionella spp.	Low to no disinfectant residual, low flow, increased water age, stagnancy, poor temperature control, nutrients (e.g. AOC, biofilm), scale formation	Pneumonia, Pontiac fever
Pseudomonas aeruginosa		Pneumonia; wound infection
Non-tuberculous mycobacteria (NTM)		Pneumonia; wound infection (skin and soft tissue); systemic disease, bacteremia
Fecal pathogens	Cross-connections	Ex. Cryptosporidiosis

Table 2. Physical hazards in premise plumbing and associated health effects

Hazard	Hazardous Condition(s)	Health Effects
Water	see: Table__ [temp x time]	Scalding

Table 3. Chemical hazards in premise plumbing and associated health effects

Hazard	Hazardous Condition(s)	Health Effects
Acute hazards and health effects		
• Chlorine	too high or too low concentrations	chemical burns
• Chlorine dioxide		
• Monochloramine		
• Chlorite		
• Nitrate		
• Copper Ions		
• Silver ions		
• Lead		
• Copper		
Long term hazards (Disinfection By-products)		
• THM	high levels of disinfectants, nutrients, interaction with piping materials, DBPs exceeding MCLs	Carcinogens
• HAA		Carginogens
• Chlorite		
• Chlorate		
• Nitrites		
• Nitrates		
• Nitrosamines (e.g., NDMA)		
• Lead		

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• Copper		

6.4.2 Hazardous conditions

6.4.2.1 Hazardous conditions associated with microbial hazards in premise plumbing systems

Hazardous conditions associated with microbial hazards are physical and chemical conditions that, in the absence of modification or control measures, can support the entry, amplification and transmission of pathogens.

6.4.2.1.1 Entry

Conditions that, in the absence of physical modification or control, can support entry of pathogens into the System include pathogen-contaminated source water. These include but are not limited to:

- Source water (under upset conditions). Frequent distribution system disruptions (e.g., water main breaks)
- Source water (under normal conditions). Regulation compliant drinking water is not intended to be sterile. Under normal conditions treated source water may contain environmental-source pathogens. Premises that are located far from the water treatment facility may receive source water in which the level of residual disinfectant has declined, thereby providing less inhibition of pathogens than intended
- Cross connections with non-potable water

6.4.2.1.2 Growth and Occurence

General conditions that can support growth and occurence of pathogens include:

- Sediment
  The accumulation of sediment, such as scale, dirt, mineral deposits, etc., can support the growth of pathogens. Sediment provides a high-surface area structure on which biofilm can grow. It also acts as a thermal insulator protecting pathogens from high temperatures and as a barrier to biocides. System components that are prone to accumulating sediment include, but are not limited to hot and cold-water storage tanks and dead legs
- Temperature
  Water at temperatures between about 25°C and 42°C (77°F and 108°F) is optimal for growth of environmental-source pathogens. Water within this range is typical of many portions of potable water systems, especially hot water systems
- Water age
  Excessive water age can lead to water temperatures favorable to growth of environmental-source pathogens, accumulation of nutrients and loss of disinfectant residual
- Insufficient disinfectant residual
  Lack of a persistent disinfectant residual throughout the System increases the likelihood of microbial growth. Disinfectant residual declines as water ages and water temperature increases. There is often no residual disinfectant remaining after the water is heated for use in the hot water system

System configurations and specific conditions that, in the absence of modification or application of control measures, can increase the potential for microbial amplification include:

- Flow imbalance
- Dead legs
- Stagnant zones
- Infrequently used fixtures
- Build-up of biofilm

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— Flow restrictors
— Low flow fixtures
— Water hammer

NOTE – Buildings that use greywater may result in lower flow rates.

Table 4. Hazardous conditions associated with microbial hazards

Hazard	Sediment	Temperature	Water age	Primary and supplemental residual disinfectants	Nutrients/other
Legionella spp.				residual below levels needed for disinfection	
Pseudomonas aeruginosa					
Non-tuberculous mycobacteria (NTM)					
Fecal coliforms					

6.4.2.1.3 Mode of transmission

Components of premise plumbing that can produce aerosols containing microbial pathogens have been associated with outbreaks of disease. These include, but are not limited to sink faucets, showerheads, toilets, humidifiers using potable water and respiratory therapy equipment that have been filled or rinsed with tap water.

Table 5. Modes of transmission for microbial hazards

Hazard	Inhalation	Ingestion	Skin contact	Aspiration	Indirect exposure
Legionella spp.	Yes	No	No	Yes	No
Pseudomonas aeruginosa	No	Yes	No	No	Contaminated water coming into contact with lab samples
Non-tuberculous mycobacteria (NTM)	No	Yes	No	No	Contaminated water coming into contact with lab samples

6.4.2.2 Hazardous conditions associated with physical hazards

The primary physical hazard of concern in this Standard is water itself; the hazardous condition associated with water in premise plumbing systems is temperature, at levels above which scalding may

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occur.

Table 6. Hazardous conditions associated with physical hazards

6.4.2.3 Hazardous conditions associated with chemical hazards

The hazardous conditions associated with chemical hazards include excess feed of disinfectants, temperatures, residence times and water age that favor formation of toxic disinfectant by-products (DBP); the presence of plumbing materials that may react with disinfectants or from which toxic compounds may be leached, corrosivity of the water and water age.

Table 7. Hazardous conditions associated with chemical hazards

Treament chemicals	Dose (maximum)	Other (residence time, temp, plumbing materials, water corrosivity)
• Chlorine	4.0 ppm, what dose causes toxicity	
• Chlorine dioxide		
• Monochloramine		
• Copper Ions		
• Silver ions		

Disinfection By-products	consider MCL for DBPs	
• THM		
• HAA		
• Chlorite		
• Chlorate		
• Nitrites		
• Nitrates		
• Nitrosamines (e.g., NDMA)		

Corrosion products		
• Lead		
• Copper		

6.5 Control measures

Based on the results of the analysis of the System in Section 6.4, the Team shall determine which hazardous conditions are significant and require control, and the the control measures necessary for managing the hazardous conditions. Additional control measures not included in this section may be incorporated. All information about control measures shall be documented, including:

- The control measure
- The control location
- The control limits
- Monitoring means, method and frequency
- Corrective actions

NOTE – For each control measure, the Team shall document water parameters or other system conditions know to adversly affect efficacy, and shall establish control limits for and monitor such parameters. If the conditions that adversely affect efficacy are unknown, results may be unpredictable

and the measure should not be relied on for control.

In evaluation possible control measures, the Team shall consider possible unintended consequences including, without being limited to:

- Toxicity of treatment chemicals at the intended dose
- Toxictiy of by-products of treatment chemicals, including both regulated and unregulated by-products, taking into account interactions with plumbing materials
- Release of toxic compunds from plumbing materials
- Adverse affects on plumbing materials, including metals and non-metals
- Support of growth of competing pathogens

NOTE – For each control measure, the Team shall identify toxic by-products of concern, and competing pathogens that may be advantaged and shall establish means, method and frequency for testing for such DBPs and competing pathogens.

6.5.1 Chemical treatment

The use of treatment chemicals is necessary or useful for a number of purposes, including microbial control and corrosion control. (see: Table ___. Chemicals used for treament of potable water and premise plumbing systems).

Table 8. Chemicals used for treament of potable water and premise plumbing systems

Chemical(s)	Purpose
Chlorine	Microbial control
Chlorine dioxide	Microbial control
Monochloramine	Microbial control
Copper ions	Microbial control
Silver ions	Microbial control
Sodium silicate	Corrosion control
Phosphates	Corrosion control

NOTE – Ozone also is an EPA-approved oxidizing biocide used by utilities to treat potable water. However, ozone reacts very quickly and does not maintain a disinfectant residual. Ozone therefore is not used as a secondary disinfectant in community drinking water distribution systems or as a supplemental disinfectant in buildings.

NOTE – Ultraviolet (UV) disinfection, considered non-chemical treatment, exposes water to UV light at within the range that inactivates bacteria. UV disinfection can be highly effective at the point of use, but does not provide a disinfecting residual. UV therefore is not used as a secondary disinfectant in community drinking water distribution systems or as a supplemental disinfectant in buildings.

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Criteria that shall be considered by the Team in specifying each treatment chemical include:

- Compatibility with other treatment chemicals
- Potential effects on the efficacy of the biocide(s) used for microbial control
- Federal, state, and local regulations pertaining to chemical usage and discharge
- General safety and handling concerns
- Compatibility with the materials of construction of the System
- Site-specific water chemistry characteristics

Considerations of SDWA requirements when incorporating treatment chemicals in a Program.
All chemicals shall be used prior to their expiration date. If a chemical is not used prior to its expiration date, it shall be disposed of in compliance with all pertinent rules and regulations.

The Team shall document the following information for all chemicals used to treat the premise plumbing system:

- Brand name;
- Active ingredient(s) (generic name);
- Manufacturer;
- Expiration date or recommended storage time, if available
- AHJ approved label(s)
- Global harmonized safety data sheets (SDS)
- NSF 60 certification
- Manufacturer's literature, including usage instructions and precautions, if available

All information pertaining to treatment chemicals shall be documented and made a part of the Program Record.

6.5.2 Screens and filters

A physical barrier to microbial transmission at individual taps is sometimes established by means of point-of-use (POU) filters. POU filters are treatment devices, typically applied to a single tap, for the purpose of removing contaminants in the water before it exits the system. POU filters with an nominal pore size of 0.2 microns have been reported effective for preventing environmental transmission of *Legionella*. POU devices that are not replaced timely may become fouled and provide media that supports microbial growth.

In some circumstances, it may be useful to establishing a physical barrier to intrusion by means of point-of-entry (POE) screens or filters. POE screens/filters typically are installed at the point where supply water is received, for the purpose of removing particulates in the water before it enters the building. POE screens typically remove particles larger than 25 microns, but are available at smaller screen sizes. They are especially useful for modulating the effect of hydraulic transients in water mains, disruptions that can cause a surge in particulates and turbidity in received water. POE devices that are not backwashed timely may become fouled and provide media that supports microbial growth.

6.5.3 Flushing

Flushing is a control measure used to help reduce water age. Flushing replaces aging water, in which the level of disinfectant residual is declining with residence time, with newer water. Flushing also helps purge sediment and turbid water from the water system. Flushing protocols typically include opening all taps and drain valves for the time necessary to purge the old or turbid water from pipes, fixtures and other areas and components containing old or turbid water. Hot and cold water should be flushed based on the

use of the water in areas of the building. Effective flushing can take from a few minutes to many hours, depending on the size of the system, pipe and component size, flow rates and the total volume of water and debris to be flushed. Flushing can either be automatic or manual. When flushing, the practitioner should consider use of auxiliary drain valves to facilitate flow through areas or components that are not necessarily flushed by opening taps at normal points-of-use. Auxiliary drain valves also can help speed system flushing, especially where there are flow restrictions. When high-turbidity events occur, potentially affected system components and critical water parameters should be checked to determine if flushing the potable water systems is needed. When flushing the system, POU screens and filters should be removed based on the manufacturer's recommendations.

6.5.4 Cleaning and Maintenance

Routine cleaning and maintenance is an important control measure. Cleaning protocols should remove biofilm, bacteria, scale, accumulated sediment and other deposits in potable water systems. Faucets and showers typically are addressed in cleaning and maintenance programs; however, all building water system components should be considered for routine scheduled cleaning and maintenance. Examples of items prone to fouling that should be considered for periodic cleaning and maintenance include media filters, such as carbon filters and water softeners, electronic faucets, local and point-of-use mixing valves, water hammer arrestors, air chambers and non-flow through expansion tanks. Other piping and components also should be evaluated to determine if they should be included in cleaning and maintenance programs. Cleaning and maintenance programs shall, at a minimum, follow manufacturer's recommendations.

6.6 Equipment

Operating and maintenance (O&M) manuals shall be available for all of equipment and components where operation and maintenance functions are performed by the Building staff. Third-party service firms or vendors that own/operate on-site equipment are expected to have their own O&M manuals.

6.6.1 Chemical feed equipment

All equipment use for feeding treatment chemicals shall be compatible with such chemicals under conditions associated with intended service, and shall be maintained and calibrated as recommended by the manufacturer. Selection of chemical feed equipment shall be at the discretion of the Team.

For each item of chemical feed equipment, the following information shall be documented:

- Manufacturer
- Model number if available
- Operating and maintenance manual
- Calibration requirements
- Service and maintenance records, including calibration
- Person responsible for calibration, service, and maintenance, including pertinent certifications and contact information

NOTE – The manufacturers of chemical feed equipment typically provide instructions and recommendations for use, calibration, maintenance, and service. Such manufacturer-provided instructions and recommendations are incorporated in this Standard by reference. Where there are differences between the requirements of this Standard and manufacturers' instructions or recommendations, the more stringent or specific shall apply.

6.6.2 Monitoring equipment

All equipment used for monitoring treatment chemicals shall be compatible with such chemicals under

conditions associated with intended service, and shall be maintained and calibrated as recommended by the manufacturer. Selection of monitoring equipment shall use an EPA-approved method or a method from *Standard Methods for the Examination of Water and Wastewater*. The choice, where available, shall be at the discretion of the Team.

For each item of monitoring equipment, the following information shall be documented:

- Manufacturer
- Model number if available
- Operating and maintenance manual
- Calibration requirements
- Service and maintenance records, including calibration
- Person responsible for calibration, service, and maintenance, including pertinent certifications and contact information

NOTE – The manufacturers of chemical monitoring equipment typically provide instructions and recommendations for use, calibration, maintenance, and service. Such manufacturer-provided instructions and recommendations are incorporated in this Standard by reference. Where there are differences between the requirements of this Standard and manufacturers' instructions or recommendations, the more stringent or specific shall apply.

6.7 Routine inspection, maintenance, service

6.8 Routine monitoring

6.9 Verification

6.10 Validation

Validation is confirmation that the Program, when implemented as designed, effectively controls the hazardous conditions that make identified hazards dangerous (see: Parametric validation, below). Validation is necessary initially, during Program development and also on an ongoing basis. Validation evidence can be qualitative, semi-quantitative or quantitative.

6.10.1 Parametric validation

Parametric validation is data from testing to confirm that measureable or observable physical and chemical parameters—e.g., pH, temperature, flow, scale, sediment, algae— at representative locations in the System are being maintained at target levels. Representative locations may be varied periodically as part of the validation plan. The conditions under consideration may be, but are not necessarily, measured or observed in real time and may be, but are not necessarily, quantifiable. In general, results of parametric validation give a measure of how well the Program is working relative to the objective of the identified hazardous conditions that support microbial growth and transmission or make other hazards dangerous.

6.10.2 Microbial validation

Microbial testing of environmental water samples is a method of validation for some microbial hazards. The frequency of sampling, the number and types of samples and the test methods used to evaluate samples may vary. Types of samples include swabs and bulk water. Methods include dip slides and spread plate culture with various types of media. In general, results of environmental sampling and testing give a measure of how well the Program is working relative to the objective of general microbial control and mitigation of microbial growth and transmission, but do not correlate with health risk and are not predictive of disease.

6.10.3 Responses to validation test results

The Team should develop validation targets and responses that are at least as stringent/specific as those required by the AHJ, if any. The Building-specific validation responses developed by the Team will help guide decisions about continued environmental sampling and testing, making system modifications, and implementing short-term (remedial) or long-term (routine) control measures.

If results from validation testing indicate that the program is not meeting the control objectives established by the Team, the Team shall:

- Review the sample collection, handling and testing procedures to confirm that the results are not due to errors
- Confirm that sytem equipment is in good working order and functioning as intended
- Review records to confirm that the Program was implemented as designed
- Review assumptions about operating conditions, such as the physical and chemical characteristics of the water supplied to the building
- Re-evaluate fundamental aspects of theProgram, incuding the analysis of hazardous conditions, cleaning and maintenance procedures, chemical treatment and other factors that could affect results of validation testing
- If review or re-evaluation of the Program indicates deficiencies, adjust the Program as necessary
- After careful review, re-evaluation and possible adjustment of the Program, consider whether short-term control measures, such as remedial treatment, are needed

6.11 Remedial treatment/action

6.11.1 Remediation of microbial contamination

Systems colonized by microbial pathogens sometimes require remedial treatment. Even when successful, remedial treatment is only a temporary measure. Re-colonization is likely unless the underlying reasons for colonization are addressed, and an appropriate Program is implemented.

Common remedial treatment methods include:

6.11.2 Hyper-chlorination

Hyper-chlorination is the application of chlorine for a relatively short period, for example, one to twenty-four hours, at concentrations above maximum levels permitted for potable water. Typically, the chlorine is introduced upstream of the area to be treated and is distributed throughout the System, with sequential flushing through every fixture for several minutes. Because chlorine concentrations are above the maximum levels permitted for potable water, precautions should be taken to prevent use of the water during treatment, including providing adequate occupant notification. The probability of corrosion and other damage to plumbing system components and piping increases with chlorine concentration, time and temperature. Hyper-chlorination often results short-term reductions in culture results, followed by rebound to higher than pre-treatment levels, can damage the plumbing system and can make future efforts to treat colonization more difficult. For these reasons, hyper-chlorination should be used only with extereme caution. If the root cause of System contamination is not adequately addressed, recolonization is likely.

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6.11.3 Superheat and flush

Superheat and flush (a/k/a thermal shock) is the use of very-high temperature water for remediation of potable hot water systems. Thermal shock of system components that can be isolated, such as hot water storage tanks, may be effective when temperature is maintained at greater than 70°C (158°F) for at least 20 minutes. In contrast, thermal shock of entire Systems has significant practical challenges, is frequently ineffective and often leads to rapid re-colonization, with pathogen levels rebounding to higher-than-pre-treatment levels. Also, there is significant risk of severe scalding associated with systemic superheat and flush. Damage to plumbing system components is likely. For these reasons, systemic superheat and flush is NOT recommended.

6.12 Start-up and commissioning

Prior to being put into service, initially and after construction or repair, or when not in service for a period of more than [2 weeks] (such as in seasonal systems), the System shall be inspected for any defects that may result in uncontrolled hazardous conditions. The results of the inspection shall be documented in the Program Record. Inspection shall include:

- Condition of treatment filters or media
- Condition of water heater
- Condition of treatment chemicals (note expiration dates)
- Condition of drains and valves
- Condition of air release vent screens
- Condition of backflow preventers
- Condition of sampling taps

Prior to start-up of the System:

- Start water flow and fully charge the System
- Thouroghly flush the System with clean, unheated supply water
- Check for leaks
- Confirm that all valves open and close fully
- Disinfect the System (see: Startup disinifection)
- Flush with clean, cold potable water before System is put into service

The Team shall sample and test water quality parameters (hardness, alkalinity, pH (?)) and THAB on two consecutive days before System is put into service.

6.12.1 Construction and repair

When opened for construction/repair, the System shall, at a minimum:

- Be disinfected by flushing with a halogen-based disinfectant (e.g., chlorine) before being returned to service.

  NOTE – It is important to refer to local codes for requirements for disinfecting potable water systems after repair or construction

- Be thoroughly flushed with clean, cold potable water before being returned to service.

If only a portion of the System is involved, disinfection may be implemented for only that portion. Precautions should be taken to prevent exposure of occupants to aerosols or high concentrations of chemical disinfectants (or associated fumes) during flushing.

6.13 Intermittent use (e.g., seasonal use)

Under certain circumstances, potable water systems are used intermittently—e.g., vacation properties, off-season hotels, schools during vacations. When the System is not used for an extended period of time, the System shall, at a minimum:

- Be disinfected by flushing with a halogen-based disinfectant (e.g., chlorine) before being returned to service. It is important to refer to local codes for requirements for disinfecting potable water systems after repair or construction
- Be thoroughly flushed with clean, cold potable water before being returned to service

If only a portion of the System is involved, disinfection may be implemented for only that portion. Precautions should be taken to prevent exposure of occupants to aerosols or high concentrations of chemical disinfectants (or associated fumes) during flushing.

6.14 Requirements for healthcare settings

In healthcare facilities, clinically-significant microbial hazards also include, but are not limited to:

- *Burkholderia cepacia complex*
- *Naegleria fowleri*
- *kliebsiella*
- Fungi
- Viruses
- Protists

The Team shall develop validation targets and responses that are at least as stringent/specific as those required by the AHJ, if any, taking into account the nature of the Building's patient/resident population(s).

6.14.1 Clinical surveillance

Clinical surveillance is a special means of validation generally limited to healthcare facilities. Clinical surveillance in healthcare facilities is the collection and interpretation of health-related data about the occupants (patients and staff), rather than the System or its components. Depending on the specific pathogen and disease states, clinical surveillance data can provide evidence of exposure to pathogens or chemicals, and indicate the need to investigate the possible presence of the relevant hazardous condition and possible circumstances or places of exposure.

6.14.2 Risk Assessment

Certain groups of people are considered at relatively higher risk for disease and injury from hazards than the general population. The Risk Assessment is an evaluation that considers patient/resident occupied areas—especially areas designated for care of the most vulnerable patients, in the context of the analysis of hazardous conditions associated with each hazard. The Risk Assessment is used most often to inform the selection of sampling locations and decisions about type and frequency of validation testing and clinical surveillance, and sometimes about the use of additional control measures.

6.15 Government Regulations

There are no enforceable regulatory limits or monitoring requirements for *Legionella* in public water systems. Federal regulations cover potable water disinfectants and drinking water treatment practices. In general, States have primary authority and responsibility (Primacy) for administration and enforcement, but do not have the authority to waive compliance obligations of Federal regulations.

Federal pesticide regulations. EPA-Office of Pesticide Programs (OPP) regulates chemical disinfectants as antimicrobial pesticides under the authority of the *Federal Insecticide, Fungicide and Rodenticide Act* (FIFRA). Chemical disinfectants must be EPA-registered under FIFRA. Compliance

obligations under FIFRA are independent of those under the *Safe Drinking Water Act* (SDWA).

Federal drinking water regulations. EPA-Office of Ground Water and Drinking Water (OGWDW) regulates the treatment of drinking water under authority of the *Safe Drinking Water Act* (SDWA). Drinking water regulations covers most buildings that treat the water they receive from a municipal utility, for example, by adding a chemical disinfectant. Coverage of both domestic hot and cold water systems is unequivocal. Compliance obligations under SDWA are independent of those under FIFRA.

State and local regulations. In addition to Federal regulations, State pesticide and drinking water regulations, as well as local laws, may apply. Certain non-governmental certifications of water treatment chemicals and equipment may also be required in some jurisdictions.

7 Cooling Towers and Evaporative Condensers Water Systems

7.1 Scope

This section covers all building-associated cooling towers and evaporative condensers used in connection with HVAC systems and systems in connection with process cooling. The system shall be analyzed and controlled to minimize microbial and chemical hazards. Field erected towers are not included in the scope of the Standard.

In order for the owner of a cooling tower to comply with this section, all of the applicable requirements of this section shall be met.

In some jurisdictions, there are rules, regulations and codes that cover owners and operators of buidings and other premises that are equipped with cooling towers. Where there are differences between the requirements of this Standard and such rules, regulations and codes, the more stringent or specific shall apply.

7.2 System description

The Team shall prepare a written description of the cooling tower system, including:

- quality of makeup water;
- purpose served (e.g., comfort cooling, process cooling);
- number of towers;
- for each tower, location (e.g.,roof);
- for each tower, usage patterns (e.g., seasonality);
- for each tower, number of cells;
- number and type of basin heaters, if applicable;
- number of pumps;
- type of filtration system (e.g. side-stream, in-line);
- access to the cooling water system;
- number of chillers or heat exchangers; and
- for each chiller or heat exchanger, location (e.g., basement).

7.3 Process flow diagrams

In conjunction with the system description in 7.2, the Team shall prepare a process flow diagram (PFD) of the cooling tower system, and shall confirm by inspection that the process flow diagram is accurate. The process flow diagram shall be a schematic drawing of the entire cooling tower system that shows the progressive flow of water and key components, including:

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- all chillers, heat exchangers or other heat-transfer devices;
- all cooling towers or evaporative condensers;
- tower basin;
- remote sump or cold well storage;
- location of all basin heaters;
- chemical injection point(s) and chemical storage locations;
- chemical measurement point(s);
- the point(s) where flow is measured, if applicable;
- the point(s) where temperature is measured;
- the point(s) where pH is measured;
- the point(s) where conductivity is measured;
- location of pumps;
- the location of the float valve, if applicable;
- the location of blow down lines, blow down valve, and associated control mechanisms;
- the location of makeup lines, make-up valves and associated control mechanisms;
- the location of valves for draining;
- the location of equalizing lines, if applicable;
- the location of valves for equalizing, if applicable;
- the location(s) where water samples for microbial testing are taken;
- the location(s) of all filtration systems;
- the location(s) where water samples for chemical testing are taken; and
- the location of all spray nozzles.

The process flow diagram shall be made a part of the Program Record.

NOTE — Process flow diagrams typically are simple schematics that can be readily understood by all members of the Team; they are not complex as-built drawings.

7.4 Hazard analysis of the cooling tower system

7.4.1 Hazards

The Team shall evaluate the cooling tower water system for the following physical, chemical, and biological hazards, and hazardous conditions in the development of the water management program. The cooling tower water system shall be inspected for associated hazardous conditions that may amplify the hazard and determine the control measures necessary to mitigate the hazards and hazardous conditions.

Potential biological hazards include but are not limited to:

- *Legionella* (inhalation)

Potential chemical hazards include but are not limited to:
- corrosive chemicals
- oxididizing chemicals

7.4.2 Associated hazardous conditions

Using the process flow diagram(s) and other materials the Team deems necessary or useful, the Team shall evaluate the entire cooling tower sytem and all parts, components, pipe configurations or zones with potentially hazardous conditions that, in the absense of modification or application of control measures, can increase the potential for *Legionella* amplification and transmission. Items that can contribute to potentially hazardous conditions include:

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- flow imbalance;
- dead legs;
- stagnant zones;
- lack of disinfectant residual;
- excess disinfectant due to overfeed (e.g. cause of corrosion issues);
- accumulation of sediment;
- sources of elevated organic contamination, including, but not limited to windblown debris, bird waste and plant material
- design configurations that allow direct sun exposure on basin, deck or fill;
- scale and corrosion;
- buildup of biofilm, organic fouling or algae;
- blockages;
- drift with potential for human exposure (e.g. inefficient drift elimation strategies);
- system components that adversely affect control measures;
- improper storage and handling of chemicals; and
- improper training of personell.

Based on the results of the analysis of the cooling tower system, the Team shall determine:

- physical modifications to the cooling tower system necessary to mitigate hazardous conditions; and
- control measures and the point(s) at which they must be applied to mitigate hazardous conditions.

The Team's analysis of the cooling tower system, including the basis for its determinations and recommendations, shall be documented and made a part of the Program Record.

7.5 Control measures

The use of treatment chemicals is necessary or useful for a number of purposes, including microbial control, pH control, corrosion control, foam control, and scale and deposit control. Criteria that shall be considered by the Team in specifying each treatment chemical include:

- compatibility with other treatment chemicals;
- potential effects on the efficacy of the biocide(s) used for microbial control;
- federal, state, and local regulations pertaining to chemical usage and discharge;
- general safety concerns;
- compatibility with the materials of construction of the cooling tower system; and
- site-specific water chemistry characteristics.

All chemicals shall be used prior to their expiration date. If a chemical is past its expiration date, it shall be disposed of in compliance with all pertinent rules and regulations.

The Team shall document the following information for all chemicals used to treat the cooling tower system:

- brand name;
- active ingredient(s) (generic name);
- manufacturer;
- expiration date or recommended storage time, if available;
- AHJ approved label(s); and
- global harmonized safety data sheets (SDS).

All information pertaining to treatment chemicals shall be documented and made a part of the Program Record**.**

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7.5.1 Biocides

The microbial control requirements of this Standard shall be met by using biocides. The use of oxidizing biocides is required by this Standard. Only biocide products registered by the EPA under FIFRA and by the corresponding AHJ shall be used. Biocide use for the control of *Legionella* may also be limited by the AHJ. Users of this Standard must ensure that the chosen microbial control method meets the requirements of the AHJ. Registered biocide products shall bear a regulation-compliant label that states explicitly that the product is for use in cooling towers, and specifies application parameters.

> NOTE — Microbial control is improved by varying the stress on microorganisms. Varying stress can be accomplished by using more than one type of biocide, e.g., an oxidizing biocide and a non-oxidizing biocide. If using only one type of biocide, varying stress can be accomplished by changing the biocide dosing regimen. For example, since the application of non-oxidizing biocides at permitted use dosages may eventually select out/establish resistant species of bacteria and algae, the use of only one non-oxidizing biocide will usually require eventual application of another biocide or a change in the biocide application regimen.

7.5.1.1 Oxidizing biocides

The use of oxidizing biocides is required by this Standard. Oxidizing biocides include non-stabilized oxidizing biocides and stabilized oxidizing biocides.

Alternatives to the use of oxidizing biocides are allowed by this Standard so long as (a) the team documents site-specific technical reasons why an oxidizing biocide is impracticable (e.g., the oxidant demand of the water is greater than 5 ppm in one hour); and (b) there is independent, documentary data demonstrating that such alternative can achieve at-least-equivalent efficacy to the benchmark performance of oxidizing biocides, under intended use conditions. Where there is an AHJ, the specific requirements for data evidencing the efficacy of alternative oxidizing biocides shall be at the discretion of the AHJ.

7.5.1.1.2 Non-stabilized oxidizing biocides

Non-stabilized oxidizing biocides shall be selected from those with the active ingredients chlorine, bromine, chlorine dioxide, or mixtures thereof.

Alternatives to those with the active ingredients chlorine, bromine, chlorine dioxide, or mixtures thereof are allowed so long as there is independent, documentary data demonstrating that such alternatives can achieve at-least equivalent efficacy. Where there is an AHJ, the specific requirements for data evidencing the efficacy of alternative non-stabilized oxidizing biocides shall be at the discretion of the AHJ.

7.5.1.1.3 Stabilized oxidizing biocides

Stabilized oxidizing biocides shall be selected from those with the active ingredients chlorine, bromine, or mixtures thereof, plus a stabilizer.

Alternatives to those with the active ingredients chlorine, bromine, or mixtures thereof are allowed so long as there is independent, documentary data demonstrating that such alternatives can achieve at-least equivalent efficacy. Where there is an AHJ, the specific requirements for data evidencing the efficacy of alternative non-stabilized oxidizing biocides shall be at the discretion of the AHJ.

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7.5.1.2 Non-oxidizing biocides

Non-oxidizing biocides shall be selected at the discretion of the Team. Examples of acceptable non-oxidizing biocides include those with the active ingredients isothiazolone, glutaraldehyde, tetra-*kis*-hydroxymethyl phosphonium sulfate (THPS), and 2,2-dibromo-3-nitrilopropionamide (DBNPA).

Alternatives to those examples are allowed so long as there is independent, documentary data demonstrating that such alternatives can achieve at-least equivalent efficacy. Where there is an AHJ, the specific requirements for data evidencing the efficacy of alternative non-oxidizing biocides shall be at the discretion of the AHJ.

7.5.2 Other treatment chemicals

Treatment chemicals other than biocides, such as those used for pH control, scale control, corrosion control, and foam control, shall be selected at the discretion of the Team.

Table 7.1 - Treatment chemicals

Category	Purpose	Chemical(s) allowed
oxidizing biocides (non stabilized)	microbial control	chlorine, bromine, chlorine dioxide or mixtures thereof
oxidizing biocides (stabilized)	microbial control	chlorine, bromine or mixtures thereof plus stabilizer
non-oxidizing biocide	microbial control	Team makes selection
organic dispersants	break up biomass	Team makes selection
dispersants	disperses suspended solids and corrosion by products	Team makes selection
pH adjustment agent	adjust pH	Team makes selection
scale and deposit control	control scale	Team makes selection
foam control	control foam	Team makes selection
corrosion control agents	control corrosion	Team makes selection

7.6 Routine Operation

7.6.1 Cycles of concentration

A key parameter used to describe cooling tower operation is "cycles of concentration". This is calculated as the ratio of the concentration of dissolved solids (measured as conductivity) in the blowdown water compared to the concentration of dissolved solids in the make-up water. The cycles of concentration are equal to the ratio of the volume of make-up water to the volume of blowdown water. The number of cycles is site-specific, determined by the chemistry of the make-up water, heat load, and the quantity of environmental (e.g., airborne) contaminants captured by the water. Dissolved solids (and conductivity) increase as cycles of concentration increase; high levels of dissolved solids can cause corrosion and buildup of scale, increase microbial concentrations, and can significantly affect the performance of water treatment chemicals.

The Team shall develop a plan for managing the cycles of concentration, including:

— the target number of cycles of concentration and associated conductivity set point;

— procedures for using an on-line conductivity meter to measure continuously the conductivity of both the blowdown water and of the make-up water; and

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— the conductivity set-point at which blowdown is initiated.

NOTE 1 — Conductivity typically is measured in as mmho/cm, the reciprocal of ohms or microSiemens per centimeter, µS/cm. The conductivity set point at which automatic blowdown is actuated is typically 800 mhos -1,000 mhos.

NOTE 2 — Alternatives to the use of a conductivity controller are allowed as long as independent evidence demonstrating its effectiveness is included in the Plan.

All information pertaining to cycles of concentration including conductivity data shall be documented and made a part of the Program Record.

7.7 Equipment

7.7.1 Chemical feed equipment

All equipment used for feeding treatment chemicals shall be compatible with such chemicals under conditions associated with intended service, and shall be maintained and calibrated as recommended by the manufacturer. Selection of chemical feed equipment shall be at the discretion of the Team.

For each item of chemical feed equipment, the following information shall be documented:

— manufacturer;

— model number, if available;

— operating and maintenance manual;

— calibration requirements;

— service and maintenance record, including calibration; and

— person responsible for calibration, service and maintenance, including certifications and contact information.

NOTE — The manufacturers of chemical feed equipment typically provide instructions and recommendations for use, calibration, maintenance, and service. Such manufacturer provided instructions and recommendations are incorporated in this Standard by reference. Where there are differences between the requirements of this Standard and manufacturers' instructions or recommendations, the more stringent or specific shall apply.

All information pertaining to chemical feed equipment shall be documented and made a part of the Program Plan.

7.7.2 Monitoring equipment

Monitoring equipment includes equipment, devices and instruments, including associated parts and reagents, used for measuring and monitoring treatment chemicals and other parameters. Selection of monitoring equipment shall be at the discretion of the Team, subject to the method requirements set forth below. Where available, equipment, devices, and instruments shall use an EPA-approved method, an ANSI-approved method or a method published in *Standard Methods for the Examination of Water and Wastewater* (most recent addition).

Monitoring equipment shall include:

— temperature sensor;

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— pH meter (automated, on line);

— device for measuring residual concentration of oxidizing biocide (manual or continuous, on line monitoring; see Methods, below); and

— conductivity meter.

For each item of monitoring equipment, the following information shall be documented:

— manufacturer;

— model number, if available;

— method employed by the device;

— operating and maintenance manual;

— calibration record; and

— person responsible for calibration, service and maintenance, including certifications and contact information.

NOTE — The manufacturers of monitoring equipment typically provide instructions and recommendations for use, calibration, maintenance, and service. Such manufacturer provided instructions and recommendations are incorporated in this Standard by reference. Where there are differences between the requirements of this Standard and manufacturers' instructions or recommendations, the more stringent or specific shall apply.

All information pertaining to monitoring equipment shall be documented and made a part of the Program Plan.

7.7.3 Personal protective equipment

Personal protective equipment (PPE) shall be selected by the Team in accordance with NIOSH N95 requirements for *Legionella*, and additionally as recommended by the manufacturers of chemicals used to clean and treat the cooling tower water system.

For each personal respirator, the following information shall be documented:

— model number or name of device, if available;

— OSHA requirement for method employed by the device; and

— person responsible for calibration, service, and maintenance, including applicable certifications or training confirmation and contact information

All information pertaining to PPE as required shall be documented and made a part of the Program Plan.

NOTE — Service of the cooling tower should not be performed unless the cooling tower fan motor is tagged out/locked out, and other manufacturer recommended safety precautions are taken.

7.8 Routine inspection, maintenance, service

Inspection and evaluation of the cooling towers shall be performed (a) once per week, (b) quarterly, and (c) prior to any start-up or re-start. Inspection and evaluation shall be by a building employee or other person designated by the building owner who is familiar with the cooling tower system and its operation, and has

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reviewed and understood the Program Plan, as well as the operating and maintenance manuals provided by the manufacturer(s) for the specific make and model of the cooling tower. Results of all inspections and evaluations shall be made a part of the Program Record.

Workers engaged in cooling tower cleaning shall wear such eye protection, gloves, face respirator, or such other personal protection equipment as recommended on the labels of chemicals used for treatment and as required by OSHA for *Legionella*.

The manufacturers of cooling towers and associated equipment typically provide instructions and recommendations for inspection, service, and maintenance. Such manufacturer provided instructions and recommendations are incorporated in this Standard by reference. Where there are differences between the requirements of this Standard and manufacturers' instructions or recommendations, the more stringent (including as to frequency) or specific shall apply.

7.8.1 Weekly inspection and evaluation

The weekly inspection and evaluation shall include visual observation of all wetted components of the cooling tower that can be seen safely during operation of the system, without entering the interior of the tower. Inspection and evaluation shall include the cooling tower exterior, hot deck, interior (viewed from outside), basin and accessible components, chemical dosing equipment, stored treatment chemicals, and any control equipment. If there are any findings listed in Table 7.2 - Inspection and evaluation with associated evaluation response, the appropriate response shall be initiated, completed, and documented within the maximum response time determined by the Team.

7.8.2 Quarterly inspection and evaluation

The quarterly inspection and evaluation shall include visual observation of all wetted components of the cooling tower that can be seen safely, without requiring draining or otherwise interrupting operation of the system. This includes observations that require entering the interior of the tower. Inspection and evaluation shall include the cooling tower exterior, hot deck, interior, basin and accessible components, chemical dosing equipment, stored treatment chemicals, and any control equipment. If there are any findings listed in Table 7.2 - Inspection and evaluation with associated evaluation response, the appropriate response shall be initiated, completed, and documented within the maximum response time determined by the Team.

7.8.3 Inspection and evaluation prior to start-up or re-start

Inspection and evaluation prior to start-up shall follow the same procedures as required for quarterly inspection and evaluation (Table 7.2 - Inspection and evaluation with associated evaluation response), except that prior to start-up from a drained condition, any areas not visible when the system is filled with water that are visible when the system has been drained shall also be examined.

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Table 7.2 – Inspection and evaluation with associated evaluation response

Findings of inspection and evaluation	Evaluation response
hot water deck: visible deposits, debris in distribution nozzles	remove visible deposits, debris in distribution nozzles
hot water deck: broken or missing distribution nozzles	repair or replace broken or missing distribution nozzles
hot water deck: unbalanced flow between sections of hot water deck	balance flow between sections of hot water deck
hot water deck: loose, unsecured distribution deck covers	secure distribution deck covers
damaged, dirty, missing or non-functioning components	components shall be cleaned, repaired or replaced as needed to return to full function
leaking seals, gaskets	repair or replace as needed to prevent leaks
disconnections; loose or improper connections	make proper connections
visible dirt or debris	remove visible dirt and debris by mechanical cleaning
visible accumulation of biomass, slime, algae or organic fouling	remove accumulated biomass, slime and algae by chemical or mechanical cleaning, as needed; re-evaluate microbial-control provisions of Program
visible scale, mineral, or corrosion deposits on surfaces or components; physical deterioration	remove surface deposits by chemical or mechanical cleaning, as needed; repair or refinish if functionality or structural integrity is compromised; re-evaluate corrosion control and scale control provisions of Program
blockages	determine cause and remove blockage
missing or damaged louvers	repair or replace
missing or damaged drift eliminators	repair or replace
dirty, missing, or damaged counter-flow spray nozzles	clean; repair or replace as needed to assure even spray
missing or damaged fill, air entrance surfaces and air exit surfaces	repair or replace
disconnections; loose or improper connections	make proper connections
uneven water flow across tower fill, distribution deck, nozzles, and piping between adjacent cooling towers	determine reason for uneven flow; clean, repair, replace or adjust components as needed to assure even flow
visible dirt or debris on fill, interior surfaces, or components	remove visible dirt and debris by chemical or mechanical cleaning, as needed
visible scale, mineral, or corrosion deposits on fill, interior surfaces or components	remove surface deposits by mechanical cleaning; repair or refinish if functionality or structural integrity is compromised
visible accumulation of biomass, slime, algae or organic fouling on fill, interior surfaces or components	remove accumulated biomass, slime and algae by chemical or mechanical cleaning, as needed; re-evaluate microbial-control provisions of Program
physical deterioration or damage of drift eliminators and fill packing, or corrosion on the fill	repair or replace; re-evaluate corrosion control provisions of Program
leaking, broken or malfunctioning pumps	repair or replace pumps to full functionality, without leaks
Chemicals	
insufficient quantity of stored chemicals	order chemicals
chemicals past expiration date	order chemicals; properly dispose of out-of-date chemicals
Chemical dosing equipment	
broken or malfunctioning chemical feed pump, tubing, etc.	repair or replace
Monitoring equipment	
broken or malfunctioning conductivity monitoring	repair or replace

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Table 7.2 – Inspection and evaluation with associated evaluation response

Findings of inspection and evaluation	Evaluation response
equipment	
broken or malfunctioning pH monitoring equipment	repair or replace
broken or malfunctioning temperature monitoring equipment	repair or replace
broken or malfunctioning biocide residual monitoring equipment	repair or replace
Operating equipment	
malfunctioning or broken blowdown system	repair or replace
malfunctioning or broken make-up water system	repair or replace
malfunctioning or broken recirculation pump	repair or replace

7.8.4 Cleaning, preventive maintenance and service

Operation shall be in a manner that controls microbial growth on all components of the cooling tower water system, including but not limited to scheduled cleaning and maintenance and timely service of malfunctioning or broken components.

NOTE — The manufacturers of cooling towers and associated equipment typically provide instructions and recommendations for cleaning, preventive maintenance, and service. Such manufacturer provided instructions and recommendations are incorporated in this Standard by reference. Where there are differences between the requirements of this Standard and manufacturers' instructions or recommendations, the more stringent (including as to frequency) or specific shall apply.

The Team shall develop written procedures including instructions on documentation for cleaning, maintenance, and service of the cooling tower water system, as follows:

7.8.4.1 Cleaning

All components of the cooling tower water system shall be cleaned on a scheduled basis and on an unscheduled basis, as needed. Cleaning shall follow written procedures recommended by the manufacturer or as specified by the Team, including a list and location of all components and parts to be cleaned and, for each:

- means of cleaning;
- method used for cleaning;
- frequency of cleaning;
- schedule of cleaning; and
- the person responsible for cleaning

NOTE — In general, any person who performs cleaning that involves the application of anti-microbial pesticides (e.g., biocides) shall be certified in accordance with the requirements of the AHJ.

All information pertaining to the cleaning of the system, including the identity of the person responsible for cleaning, shall be documented and made a part of the Program Record.

7.8.4.2 Preventive maintenance and service

All components of the cooling tower water system shall be maintained on a scheduled basis and on an unscheduled basis, as needed. Maintenance shall follow written procedures recommended by the manufacturer or as specified by the Team, including a list and location of all components and parts to be maintained and, for each:

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— means of maintenance;
— maintenance method;
— frequency of maintenance;
— schedule of maintenance; and
— the person responsible for maintenance.

All information pertaining to the preventative maintenance and service of the system, including the identity of the person responsible for maintenance, shall be documented and made a part of the Program Record.

7.8.4.3 Replacement in kind

Any replacement part or equipment used in a cooling tower water system shall comply with the manufacturer's design and performance specifications. As applicable, replacement materials shall be corrosion resistant and effectively prevent the penetration of sunlight. The person(s) responsible for replacement, as well as the protocols for replacement, shall be included in the Program Record.

7.8.4.4 Compliance with local construction codes

Any alteration or replacement of a cooling tower system must comply with the construction codes of the AHJ.

All information pertaining to preventive maintenance of the cooling tower water system, including the identity of the person responsible for preventive maintenance, shall be documented and made a part of the Program Record.

7.9 Routine Treatment

Routine chemical treatment of the cooling tower water system is required by this Protocol. Chemical treatment shall include, without being limited to microbial control, scale control, and corrosion control at intervals specified in this Protocol or, where not specified in this Protocol, as determined by the Team. All chemicals shall comply with the regulations of the authority having jurisdiction. Routine chemical treatment shall be implemented whenever the cooling tower is filled with water, whether or not it is being used for cooling. Whenever the cooling tower contains water, the water in the tower must be circulated for at least one hour at intervals not exceeding 72 hours while being treated in accordance with this Protocol.

The applicator of a product requiring registration (e.g., a biocide) shall be certified in accordance with the requirements of the AHJ. The name, contact information, and certification of the person shall be documented and made a part of the Program Record. In addition, the name, registration number, and contact information for the person's employer, if available, shall be documented and made a part of the Program Record.

Treatment chemicals shall be as specified in Table 5.1 - Treatment chemicals, of this Protocol. Treatment chemicals shall be fed at a point in the system to ensure that sufficient mixing can be achieved prior to chemicals reaching the hot water deck and evaporative cooling components of the equipment. (The water after the chiller or heat exchanger is hot water.) If treatment chemicals cannot be fed at a point in the recirculating loop after the chiller or heat exchanger and before the hot water deck and evaporative cooling components, feed shall be at a point determined by the Team to afford the best chemical mixing and distribution practicable for the specific cooling tower water system.

> NOTE 1 — In general, liquid chemicals should not be batch fed directly into the basin of the cooling tower; solid chemicals should not be dropped directly into the basin of the cooling tower.
>
> NOTE 2 — The quality and type of source water must be considered in the development of a treatment Program. Cooling towers are supplied from a wide variety of water sources, including EPA-compliant potable water, recycled water, and grey water. Sometimes, pre-treatment of hard source water (e.g., partial softening) is necessary or useful. Often, filtration is necessary or useful to help reduce the level of dirt,

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suspended solids, especially in systems using enhanced chiller tubes or prone to high debris or organic loading. Some AHJs strictly regulate the type of water allowed as make-up water for cooling towers.

7.9.1 Microbial control treatment

Routine chemical treatment for microbial control is required by this Protocol using one or more chemical biocides, including at least one oxidizing biocide. Only biocide products registered by the EPA under FIFRA and by the corresponding AHJ shall be used. Registered biocide products shall bear a regulation-compliant label that states explicitly that the product is for use in cooling towers.

NOTE 1 — If a cooling tower in the system has cells that are used intermittently, or if the recirculating water system contains multiple pumps, chillers or heat exchangers, the use of all such components that contain water or are wet when off line should be rotated systematically (e.g., at intervals not to exceed 72 hours) ensure that all wet parts of the system are routinely flushed with treated water that has intended levels of biocide at the required pH.

NOTE 2 — If using only an oxidizing biocide, varying stress can be accomplished by changing the biocide dosing regimen. For example, if chlorine (an oxidizing biocide) is applied daily at a dose of 0.5-1.5 ppm FRO, varying the stress on microorganisms can be accomplished by increasing the chlorine dose to 4.0 ppm FRO for 1 hour, 3 times per week.

7.9.1.1 Oxidizing biocide

The use of an oxidizing biocide shall form the foundation of the microbial control treatment program. Alternatives to the use of oxidizing biocides are allowed by this Protocol so long as (a) the Team documents site-specific technical reasons why an oxidizing biocide is impracticable (e.g., the oxidant demand of the water is greater than 5 ppm in one hour); and (b) there is independent, documentary data demonstrating that such alternative can achieve at-least-equivalent efficacy to the benchmark performance of oxidizing biocides. The specific requirements for data evidencing the efficacy of alternative oxidizing biocides shall be at the discretion of the AHJ.

An oxidizing biocide shall be added at least 3 days/week, up to 7 days/week, either continuously or semi continuously (e.g., slug fed 1-3 times per day);

— If a non-stabilized oxidizing biocide is used, it shall be added to the cooling tower water in an amount sufficient to achieve an average daily free residual oxidant (FRO) level within the range set forth on the product label, as determined by the Team;

— If a stabilized oxidizing biocide is used, it shall be added to the cooling tower water in an amount sufficient to achieve average daily Total Halogen and FRO levels, within the ranges set forth on the product label, as determined by the Team.

NOTE 1 — Some oxidizing biocide formulations are “stabilized” with additives such as sulfamic acid, and require special handling. If stabilized oxidizing biocides are fed at amounts exceeding the manufacturer-specified levels, the biocide can become “over stabilized”, decreasing anti-microbial efficacy.

NOTE 2 — Chlorine in water exists as two chemical species in equilibrium: hypochlorite ion and hypochlorous acid. Hypochlorous acid is the far stronger disinfectant. The ratio of hypochlorous acid to hypochlorite ion in water is a function of pH. At pH 6–7 hypochlorous acid dominates; at pH > 8.5 hypochlorite ion dominates. Additional chlorine or longer contact time is generally required to compensate for this equilibrium shift when treating water with a pH above 7.6. For bromine, a similar equilibrium relationship exists between hypobromous acid and hypobromite ion, with hypobromous acid being the far stronger disinfectant. Additional bromine or longer contact time is generally required to compensate for this equilibrium shift when treating water with a pH above 8.7. To lower the pH of the water, pH adjustment agent (acid) may be added, and/or the number of cycles reduced (i.e., by blowdown), in order to achieve and maintain pH at the target levels. The rate of disinfection by chlorine dioxide is substantially unaffected by pH. However, chlorine dioxide readily strips out of water, so the residual typically is lost when the water circulates over the tower packing.

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7.9.1.2 Non-oxidizing biocides

Microbial control is improved by varying the stress on microorganisms. Varying stress can be accomplished by using more than one type of biocide, e.g., an oxidizing biocide and a non-oxidizing biocide.

When non-oxidizing biocides are used in conjunction with oxidizing biocides:

— the non-oxidizing biocide shall be added (slug fed) at least once per week, or more frequently as the Team determines is needed to maintain microbial control;

— the dose of the non-oxidizing biocide shall be within the range set forth on its approved label; and

— at least 3 hours of contact time shall be allowed after addition of the non-oxidizing biocide prior to the tower blowdown, in order to allow for sufficient mixing and contact time by the non-oxidizing biocide.

NOTE — If using only an oxidizing biocide, varying stress can be accomplished by changing the biocide dosing regimen. For example, if chlorine (an oxidizing biocide) is applied daily at a dose of 0.5-1.5 ppm FRO, varying the stress on microorganisms can be accomplished by increasing the chlorine dose to 4.0 ppm FRO for 1 hour, 3 times per week.

7.9.1.3 Organic dispersants

Organic dispersants shall be added as determined necessary or useful by the Team to maintain concentrations at levels recommended by the manufacturer. The Program Plan must include a detailed description of the process along with the rationale for determination, including any calculations or manufacturer recommendations.

NOTE — Organic dispersants are surfactants that promote system cleanliness by penetrating and loosening attached biomass and deposits. Organic dispersants are not biocides but can enhance the performance of biocides. Organic dispersants are especially beneficial in systems prone to persistent algae blooms and biofilm. When applying organic dispersants, care must be taken to minimize foaming.

7.9.2 Corrosion control treatment

Routine treatment for corrosion control is required by this Protocol, unless the Team documents that the materials of construction are not subject to corrosion and do not require corrosion control treatment. Corrosion inhibitors shall be selected and added as determined necessary or useful by the Team.

NOTE — Corrosion control chemicals typically include inhibitors selected based on site-specific water quality characteristics and on the requirements of the system's metallurgies—e.g., galvanized steel, mild steel, stainless steel, and copper. Corrosion inhibitors typically are classified as reactive inhibitors, precipitating inhibitors, and filming inhibitors; proper combination of inhibitors can provide multi-metal protection. Examples of acceptable corrosion control agents for protection of steel include ortho-phosphates, complex phosphates, zinc and molybdate. Examples of acceptable corrosion control agents for protection of copper include tolytriazole, benzotriazole, and halogen-resistant azoles.

7.9.3 pH control treatment

Control of pH facilitates effective use of oxidizing biocides. Control limits for pH shall take into account the specific oxidizing biocide being used. Control of pH also is beneficial for managing scale and deposits. pH control agents shall be selected and added as determined necessary or useful by the Team. As an alternative or adjunct to the use of pH control agents, pH may be adjusted (lowered) by blowdown, which decreases the number of cycles of concentration.

NOTE — When feeding acids (e.g., for pH control), the acid should be diluted as much as possible before dosing, to minimize corrosive effects. In selecting a pH control agent, the site-specific water chemistry,

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compatibility with other treatment chemicals and corrosivity to cooling tower metallurgies should be considered. Sulfuric acid and hydrochloric (muriatic) acid are example of acceptable pH control agents.

7.9.4 Scale and deposits control treatment

Routine treatment for scale and deposit control is required by this Protocol. Scale and deposit inhibitors shall be selected and added as determined necessary or useful by the Team.

NOTE — Chemicals used for scale and deposit control typically act by increasing the solubility of the scale forming impurities and by modifying the crystal structure of the minerals. Control of scale and deposits can be achieved by careful control of pH, the addition of scaling-threshold inhibitors and crystal-modifying polymers. In addition, polymeric dispersants are sometimes used to inhibit deposits from adhering to surfaces, particularly heat transfer surfaces. Examples of acceptable scale-control agents include but are not limited to dispersing polymers, PBTC, orthophosphate, polyphosphate, and phosphonates. While orthophosphate, polyphosphate, and phosphonates are effective for scale control, they supply nutrients at levels not normally available for microorganisms and thus can increase microbial growth, necessitating use of additional biocides and corrosion control agents.

7.9.5 Foam control treatment

Some chemicals used to treat cooling towers, especially organic dispersants, can cause foaming. A moderate amount of foam is not problematic; however, when significant foaming occurs, with foam exiting the tower, control may be required. A foam control agent shall be used as determined necessary by the Team.

NOTE — Anti-foaming agents shall be added sparingly; excessive amounts of anti-foaming agent may compromise efficacy of biocides. Silicone-based and water-based foam control agents are generally acceptable; oil based foam control agents should not be used.

7.10 Monitoring

Monitoring refers to the scheduled measurement of physical, chemical, and temporal parameters associated with control measures in order to confirm that parameters associated with control measures are maintained within a pre-established acceptable range (control limits). Monitoring requirements determined by the Team shall include:

- measured parameter;
- means of monitoring;
- method used for monitoring (e.g., analytical instruments, including calibration requirements);
- specific monitoring point;
- frequency of monitoring; and
- the person responsible for monitoring.

If monitoring shows that the measured parameter is outside of pre-determined acceptable parameters, corrective actions shall be as specified by the Team to restore levels to within acceptable parameters.

NOTE 1 — In this Standard, the term monitoring does not refer to microbial sampling and analysis; microbial sampling and analysis is called “testing”, and is part of validation. (See: Section 12 - Validation)

NOTE 2 — A preferred location at which measureable chemical treatment parameters are monitored is a point in the recirculation loop just prior to where treatment chemicals are injected. If it is not feasible to collect samples from the recirculating water line prior to the chemical injection point, samples may be taken from other locations determined by the Team to be representative of the water in the system (e.g. bulk water in the basin as far as possible from the make-up water line).

NOTE 3 —In order to obtain results representative of the overall conditions of the water in the system, the system must be operating with water circulating for at least one hour prior to measuring parameters for monitoring purposes.

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All information pertaining to monitoring shall be documented and made a part of the Program Record.

7.10.1 Monitoring of oxidizing biocides

The residual level of oxidizing biocides shall be measured on any day the oxidizing biocide is used. When application is by slug-dosing, measurement shall be at least 60 minutes after dosing.

7.10.1.1 Monitoring of non-stabilized oxidizing biocides

The residual concentration of non-stabilized oxidizing biocide in the system shall be monitored, as follows:

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measured parameter	free residual oxidant (FRO) and total residual oxidant (TRO)
means of monitoring	handheld or automated DPD analyzer, or as required by the EPA registered label and biocide manufacturer's recommendations; amperometric halogen probe
calibration requirements	as specified by manufacturer
frequency	whenever used, either before or at least 60 minutes after dosing

7.10.1.2 Monitoring of stabilized oxidizing biocides

The residual concentration of stabilized oxidizing biocide in the system shall be monitored, as follows:

measured parameter	free residual oxidant (FRO) and Total Residual Oxidant (TRO)
means of monitoring	handheld or automated DPD analyzer, or as required by the EPA registered label and biocide manufacturer's recommendations; amperometric halogen probe
calibration requirements	as specified by manufacturer
frequency	whenever used, either before or at least 60 minutes after dosing

Acceptable residual levels of oxidizing biocides shall be as specified by the Team. If the measured residual is outside of the pre-determined acceptable parameters (control limits), corrective actions shall be as specified by the Team to restore levels to within acceptable parameters.

NOTE — Continuous, automated measurement of oxidizing biocide residual levels is preferred. Measurements, whether automated or manual, shall be made by an approved method—e.g., amperometric, colorimetric (DPD). The use of oxidation reduction potential (ORP) is allowed to be used in conjunction with control, at the discretion of the Team. However, ORP does not meet the oxidizing-biocide monitoring requirements of this Standard, which can be met only by using an approved method.

7.10.2 Monitoring of non-oxidizing biocides

The dose and time of application of non-oxidizing biocides shall be monitored, as follows:

recorded parameter	total amount of biocide dosed (calculated concentration per unit volume of water)
means of monitoring	calculation based on measured volume or amount injected by chemical feed pump and total water volume of the system; written records
method used for monitoring	calculations based on measured volume and time
calibration requirements	as specified by manufacturer of dosing equipment
frequency of monitoring	when dosed

NOTE — The residual concentrations of non-oxidizing biocides are not readily measured in the field. Therefore, monitoring of non-oxidizing biocides is based on the amount and frequency of chemical of a given concentration added to the total volume of water in the cooling tower water system:

Acceptable parameters for non-oxidizing biocides shall be determined by the Team. If the amount or frequency of addition of non-oxidizing biocides are outside of the pre-determined acceptable parameters (control limits), the frequency or amount of the chemical dosed shall be adjusted to conform to the acceptable parameters.

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7.10.3 Monitoring of pH

The pH of the cooling tower water shall be monitored, as follows:

measured parameter	pH of the water
means of monitoring	pH meter
method used for monitoring	pH electrode
calibration requirements (incl. cleaning electrodes)	per manufacturer's instructions
frequency of monitoring	continuous

Control limits for pH shall be determined by the Team. If the pH level is outside of the control limits, the pH shall be adjusted by addition of a pH control agent, or by blowdown.

7.10.4 Monitoring of conductivity

The conductivity of the cooling tower water shall be monitored, as follows:

measured parameter	conductivity of the water
means of monitoring	on-line conductivity detector
method used for monitoring	reciprocal of the AC resistance of the water between two electrodes
Calibration requirements (incl. cleaning electrodes)	per manufacturer's instructions
frequency of monitoring	continuous

7.10.5 Monitoring of flow

As determined by the Team, monitoring of flow rates or the total volume of water used, where appropriate, shall be recorded for the cooling tower make-up water, blowdown water, and re-circulation water.

7.10.6 Monitoring of temperature

The temperature of the cooling tower shall be monitored, as determined by the Team.

7.10.7 Monitoring of other control measures

Other control measures determined by the Team to be essential to the safe operation of the cooling tower water system shall, at the discretion of the Team, be monitored. Control limits for such other control measures shall be determined by Team. If the measured parameters are outside of the control limits, corrective action shall be as specified by the Team to restore levels to within control limits.

7.11 Validation

Validation testing is required by this Standard. Validation is confirmation that the microbial control procedures implemented are effectively controlling bacterial contamination in the cooling tower water system. The laboratory conducting tests of water samples shall be independent of and unaffiliated with the water treatment service provider, and shall be accredited to a nationally recognized standard such as ISO/IEC 17025, AIHA/EMLAP, the TNI Standard, or equivalent as required by the AHJ. The laboratory shall have a *Legionella* method listed on their Scope of Accreditation. If performing *Legionella* tests, the laboratory may also be certified proficient by the CDC *Environmental Legionella Isolation Techniques*

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Evaluation (ELITE) program. The individual/company collecting water samples for quarterly *Legionella* validation testing shall be independent of and unaffiliated with the water treatment service provider.

All information pertaining to validation testing shall be documented and made a part of the Program Record.

Microbial tests of water samples shall be as follows:

7.11.1 Total aerobic bacteria

Testing of water samples for total bacteria (HPC; a/k/a THAB) shall be as follows:

Analyte: Total aerobic bacteria (HPC; a/k/a THAB)
Method: dip slides; culture, using the standard plate-count methods described in *Standard Methods for the Examination of Water and Wastewater* (most recent edition);
Frequency: quarterly (intervals not exceeding 90 days)
Sample size: 100 mL
Sample point: a point in the recirculation loop just prior to the point where treatment chemicals are injected. If it is not feasible to collect samples from the recirculating water line prior to the chemical injection point, then samples may be taken from other locations determined by the Team to be representative of the water in the system (e.g. bulk water in the basin as far as possible from the make-up water line). The sampling point for total aerobic bacteria may be the same as the sampling point for *Legionella* and for monitoring chemical parameters.

HPC tests are time sensitive. The sample must be inoculated onto the culture media within 8 hours of sampling, or the test results may be invalid; water sample holding times longer than 24 hours are not acceptable. Dip slides should be processed in strict adherence to the manufacturer-provided protocol (e.g., including incubation and disposal) or the test results may be unreliable.

NOTE 1 — More frequent testing for total aerobic bacteria (e.g. weekly) may be performed for operational purposes. This operational sampling and testing does not have to be by an independent party and may be performed by facility staff or by the water treater.

NOTE 2 — Results of total bacteria validation testing are not a reliable predictor of *Legionella* contamination. However, this form of validation results in a quick measure of the overall bacteriological quality in a water system.

7.11.2 *Legionella*

Testing of water samples for *Legionella* shall be as follows:

Analyte: *Legionella*
Method: culture
Frequency: intervals not exceeding 90 days
Sample size: no less than 100 mL
Sample point: a point in the recirculation loop just prior to the point where treatment chemicals are injected. If it is not feasible to collect samples from the recirculating water line upstream of and as close as possible the chemical injection point, samples may be taken from other locations determined by the Team to be representative of the water in the system (e.g. bulk water in the basin as far as possible from the make-up water line). The sampling point for *Legionella* may be the same as the sampling point for total bacteria and for monitoring chemical parameters.

7.11.2.1 Emergency testing *for Legionella*

Emergency sample collection and *Legionella* culture testing shall be conducted under the following conditions:

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— mechanical breakdown of the cooling tower water system of more than 72 hours duration, or such other time period as the Team determines is sufficient to allow proliferation of *Legionella*;

— a power failure affecting the cooling tower water system of more than 72 hours duration, or such other time period as the Team determines is sufficient to allow proliferation of *Legionella*;

— a loss of biocide treatment of more than 72 hours duration, or such other time period as the Team determines is sufficient to allow proliferation of *Legionella*;

— failure of conductivity control to maintain proper cycles of concentration of more than 72 hours duration, or such other time period as the Team determines is sufficient to allow proliferation of *Legionella*; and

— such other conditions, as determined by the AHJ.

7.11.3 Sampling supplies

Equipment and supplies for collecting water samples for microbial testing shall include:

— 100 mL sterile polyethylene bottles for water samples with de-halogenation chemical (e.g., 0.1N sodium thiosulfate, tablets or powder); this may already be included in some purchased sample bottles);

— water proof labels;

— chain-of-custody forms; and

— insulated shipping container.

NOTE — Independent laboratories that meet the qualification requirements of this Standard typically provide sampling supplies as part of their testing services.

7.11.4 Sample handling

If not already present in the sample bottle, a de-halogenation chemical (e.g., 0.1N sodium thiosulfate, tablets or powder) shall be added immediately to all water samples being tested for bacteria, including heterotrophic bacteria and *Legionella*. Samples shall be preserved, stored, handled, and shipped in accordance with the written instructions provided by the testing laboratory.

7.11.5 Interpretation and use of validation results

7.11.5.1 Review and re-evaluation of the Program

If results from Validation testing indicate that the Program is not meeting the microbial control objectives established by the Team, the Team shall:

— review the sample collection, handling, and testing procedures to confirm that the results are not due to sample collection, handling, or testing errors.

— review Verification records to confirm that the Program was implemented as designed.

— review assumptions about operating conditions (e.g., characteristics of the make-up water).

— re-evaluate fundamental aspects of the Program, including the analysis of hazardous conditions; cleaning and maintenance procedures; treatment chemicals used; means, method, and

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frequency of chemical dosing; means, method, and frequency of monitoring, and such other aspects of the Program that could affect results of validation testing.

7.11.5.2 Total aerobic bacteria test results

If total aerobic bacteria (a/k/a THAB) tests indicate bacterial counts $\leq 10^4$ cfu/mL (4 logs), the Program and validation testing program shall be maintained.

If total aerobic bacteria (a/k/a THAB) tests indicate bacterial counts $>10^4$ cfu/mL the Program shall be reviewed by the Team (Section 7.11.5.1 - Review and re-evaluation of the Program).

NOTE — The precision of some plated microbial testing methods, such as HPC, is an order of magnitude (i.e., a factor of 10). Numerical differences less than order of magnitude are not statistically significant. Values obtained from plated HPC samples of cooling tower water are useful for order-of-magnitude comparisons.

7.11.5.3 *Legionella* test results

The testing laboratory shall perform serotyping of *Legionella* positives.

If routine *Legionella* tests indicate the presence of *Legionella* spp. counts <10 cfu/mL, the Program shall be maintained.

If routine *Legionella* tests indicate the presence of *Legionella* spp. counts $\geq$10 cfu/mL to 10^3 cfu/mL (i.e., 1-3 logs):

— the Program shall be reviewed by the Team (Section 7.11.5.1 Review and re-evaluation of the Program);

— visual inspection of the cooling tower shall be conducted in accordance with Table 7.2. Inspection and evaluation with associated evaluation response, to determine if full cleaning (drained) or repair is required;

— on-line remedial treatment (Section 7.12.1 On-line remedial treatment) shall be implemented within 72 hours;

— the level of oxidizing biocide used for routine treatment may be fed up to the maximum label dose;

NOTE — An organic dispersant may be added in conjunction with the oxidizing biocide.

— if a non-oxidizing biocide is being used, then it may be changed (e.g., from glutaraldehyde to isothiazalone or vice versa) and may be fed up to the maximum label dose; and

NOTE — An organic dispersant may be added in conjunction with the non-oxidizing biocide.

— At least three but not more than seven days after on-line remedial treatment, the water in the cooling tower water system shall be re-tested. The building shall continue to retest at the same time interval until two consecutive readings show acceptable improvement.

NOTE — Repeated assessments should include performing serotyping and speciation of legionellae in order to determine dominant cooling tower populations and as part of the process needed to link environmental isolates to clinical specimens. The Serotyping and speciation could also be included in the Program Plan in order to further evaluate the efficacy of treatment.

If routine *Legionella* tests indicate *Legionella* spp. counts $\geq 10^3$ cfu/mL (i.e., 3 logs):

— the Program shall be reviewed by the Team (Section 7.11.5.1 Review and re-evaluation of the Program);

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— visual inspection of the cooling tower shall be conducted in accordance with Table 8.1. Inspection and evaluation with associated evaluation response, to determine if full cleaning (drained) or repair is required;

— on-line remedial treatment (Section 7.12.1 On-line remedial treatment) shall be implemented immediately but no more than 24 hours, followed by full cleaning (drained);

— off-line remedial treatment (Section 7.12.2 Off-line remedial treatment) shall be implemented immediately following on-line remedial treatment but no more than 24 hours;

— the level of oxidizing biocide used for routine treatment may be increased up to the maximum label dose;

— if a non-oxidizing biocide is being used, then it may be changed (e.g., from glutaraldehyde to isothiazalone) and may be fed up to the maximum label dose;

— at least three but not more than seven days after on-line remedial treatment, the water in the cooling tower system shall be re-tested. The building shall continue to retest at the same time interval until two consecutive readings show acceptable improvement.

If re-testing indicates *Legionella* counts $\geq 10^3$ cfu/mL (i.e., 3 logs), the owner shall consult with the AHJ.

NOTE 1 — The precision of some plated microbial testing methods, such as *Legionella* culture, is an order of magnitude (i.e., a factor of 10). Numerical differences less than an order of magnitude are not statistically significant. The precision of *Legionella* isolation by US laboratories in the ELITE program was evaluated by CDC. Results indicated that laboratories are generally capable of consistent, reliable *qualitative* characterization of environmental samples for the presence or absence of legionellae. Standard deviation of quantitative results was nearly one order-of-magnitude. These results, which are consistent with European studies, indicate that values obtained from plated culturing samples of cooling tower water are useful for order-of-magnitude comparisons. However, the bacterial enzyme culture method has been validated according to ISO/TR 13843 and demonstrated highly reliable and repeatable quantitative results.

NOTE 2 — Repeated assessments of *Legionella* populations $\geq 10^3$ cfu/mL should include performing serotyping and speciation of legionellae in order to determine dominant cooling tower populations and as part of the process needed to link environmental isolates to clinical specimens. The serotyping and speciation could also be included in the program plan in order to further evaluate the efficacy of treatment especially when counts are persistently $>10^3$ /ml.

7.12 Remedial treatment

Cooling tower water systems shall be remediated when validation results exceed specified limits, or when required by the AHJ. Remedial treatment includes on-line remedial treatment (Section 7.12.1 On-line remedial treatment) and off-line remedial treatment (Section 7.12.2 Off-line remedial treatment).

Remedial treatment shall be with an oxidizing biocide. Non-oxidizing biocides and organic dispersants may be used as adjuncts to the oxidizing biocide, as determined necessary or useful by the Team.

NOTE — Non-stabilized chlorine is generally the preferred oxidizing biocide for remedial treatment. Stabilized oxidizing biocides may become overstabilized at higher-than-normal doses. Therefore, it is more difficult to maintain an acceptable free residual with stabilized chlorine, bromine, or chlorine dioxide compared to unstabilized chlorine, especially for remedial treatment where higher free residual oxidant (FRO) levels are required. In all cases, remedial treatment with oxidizing biocides must measure and document FRO at prescribed intervals.

7.12.1 On-line remedial treatment

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Prior to on-line remedial treatment, the Team shall:

— follow the inspection and corrective action procedures in Section 7.8.2; and

— lower the conductivity of bulk water in the tower as far as possible by blowdown (decreasing the number of cycles)

NOTE — Lowering conductivity improves the efficacy of treatment.

On-line remedial treatment, while the cooling tower is still being operated, shall be implemented as follows:

— increase the concentration of FRO of the oxidizing biocide to 5 ppm (+/- 1 ppm);

— add organic dispersant as determined necessary or useful by the Team;

— add oxidizing biocide as needed to maintain the 5 ppm average residual of free residual oxidant (FRO) over the at least 1-hour treatment period;

NOTE — A longer treatment period is acceptable.

— FRO shall be measured every 30 minutes; adjust feed as necessary to maintain at 5 ppm (+/- 1 ppm);

— pH shall be measured at least every 30 minutes; pH shall be adjusted as necessary to maintain at the level required for efficacy of the oxidizing biocide selected by the Team;

— after at least 1-hour, blowdown the system as rapidly as possible, continue flushing system until FRO is 1.0 ppm or less and water is clear; and

— immediately re-passivate all metals by restoring all controls to levels for routine treatment.

When on-line remedial treatment has been completed, routine treatment shall be resumed immediately.

NOTE — The rate of disinfection by chlorine- and bromine-based oxidizing biocides slows at higher pH values; pH adjustment agent may be added to achieve and maintain pH at the levels required, or additional oxidizing biocide may be used to compensate for pH effects on equilibrium.

7.12.2 Off-line remedial treatment

Prior to off-line remedial treatment, the Team shall:

— follow the inspection and required corrective actions in Section 7.8; and

— lower the conductivity of bulk water in the tower as far as possible by blowdown (decreasing the number of cycles).

NOTE 1 — Lowering conductivity improves the efficacy of treatment.

NOTE 2 — During off-line remedial treatment, the fans will be off and the chillers are not operating.

Off-line remedial treatment shall be implemented as follows:

— the conductivity sensor, pH sensor, halogen sensor, and routine chemical feed shall be disengaged if linked to controls;

— organic dispersant shall be added as determined necessary or useful by the Team;

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— oxidizing biocide shall be added in an amount sufficient to achieve 10.0 ppm (+/- 2 ppm) (FRO) for at least 1 hour;

NOTE — A longer treatment period is acceptable.

— FRO shall be measured every 30 minutes; adjust feed as necessary to maintain at 10.0 ppm
(+/- 2 ppm) over the 1-hour treatment period;

— pH shall be measured at least every 30 minutes; pH shall be adjusted as necessary to maintain at level required for efficacy of the oxidizing biocide selected by the Team; and

NOTE — The rate of disinfection by chlorine-based oxidizing biocides slows at higher pH values; pH adjustment agent may be added to achieve and maintain pH at the levels required or additional oxidizing biocide may be used to compensate for pH effects on equilibrium.

— blowdown the system as rapidly as possible, continue flushing system until FRO is 1.0 ppm or less and water is clear. Immediately re-passivate all metals by restoring all controls to levels for routine treatment.

When off-line remedial treatment has been completed, maintenance treatment shall be commenced immediately.

7.13 Start-up procedures

NOTE — The manufacturers of cooling towers and associated equipment typically provide instructions and recommendations for start-up. Such manufacturer provided instructions and recommendations are incorporated in this standard by reference. Where there are differences between the requirements of this standard and manufacturers' instructions or recommendations, the more stringent or specific shall apply.

7.13.1 Initial/Seasonal start-up

In the case of a new or replacement cooling tower, the Team shall develop a Program and Plan. The cooling tower system shall be treated to prevent corrosion (e.g., passivated) in accordance with the manufacterer's instructions. Prior to start-up of a new or replacement cooling tower or after a shutdown of more than five consecutive days, the cooling tower system shall first be inspected and evaluated in accordance with Section 7.8 of this Standard. If the inspection and evaluation reveal deficiences or problems, such deficiencies or problems shall be corrected and the cooling tower system shall be reinspected and evaluated prior to start-up. After results of an inspection and evaluation are satisfactory, the following procedures shall be implemented:

- confirm that cooling tower fans are off;
- drain any water that is in any portion of the cooling tower system;
- flush the entire cooling tower system with clean water;
- mechanically clean louvers, drift eliminators, and accessible fill surfaces;
- replace the media in filtration systems;
- replace filter bags, cartridges and disks as needed;
- fill the cooling tower system with clean water;
- add appropriate neutralizing agent, if required, to remove any treatment that was introduced as part of a dry lay-up procedure;
- initiate routine chemical treatment;
- prior to operating the cooling tower fans, run water recirculating pump(s) and adjust valves to bring all parts of the system on-line including all piping, heat exchangers and filtration equipment;

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- maintain the microbiological control treatment without cooling tower fans by temporarily closing the blowndown for at least 6 hours (or longer as needed) until control limits for microbial controls (oxidizing biocide residual, pH) are established; and
- after obtaining acceptable results for all microbiological control parameters, turn on the cooling tower fans.

Once all these procedures are completed and documented the cooling tower system shall be operated, treated and maintained in accordance with Section 7.8.2 of this standard.

NOTE — Managing the water conditions during the initial operation of a new or replacement cooling tower system is essential to preventing premature corrosion of metals, especially galvanized steel. Hardness, alkalinity, pH levels and concentration of oxidizing biocide are especially important. Manufacturer's recommendations should be reviewed prior to start-up.

7.13.2 Re-start after short-term shutdown (idle period)

After an idle period of more than three and less than five consecutive days, where the cooling tower system has not been completely drained of water (and during which idle period the water has not been circulated and treated routinely), the cooling tower system shall first be inspected and evaluated in accordance with Section 7.8 of this standard. If the inspection and evaluation reveal deficiences or problems, such deficiencies or problems shall be corrected and the cooling tower system shall be reinspected and evaluated prior to start-up. After results of an inspection and evaluation are satisfactory, the following procedures shall be implemented:

- confirm that cooling tower fans are off;
- replace filter bags, cartridges and disks, as needed;
- initiate routine chemical treatment, including microbial control;
- operate the recirculation pumps for at least three hours while fans are turned off;
- confirm that microbial control parameters (oxidizing biocide level, pH level) are within acceptable parameters (control limits);
- turn on the cooling tower fans;
- test the water to be sure that acceptable levels of corrosion inhibitors have been maintained in the system. If levels are insufficient, take corrective action to restore levels to within acceptable parameters; and
- flush all filtration devices and associated suction and distribution lines to drain. Re-fill the filtration device with treated water from the cooling tower.

7.14 Shut down and de-comissioning

Cooling tower water systems may be shut down, in whole or in part, for a variety of reasons; these include cleaning, maintenance, low load, or off season. Whenever the cooling tower system contains water, the water should be circulated on a daily basis and, if applicable, the basin sweeping system and/or filtration system should be run even when there is no cooling load. This helps maintain water treatment, minimize sediment build-up, and reduce the possibility of stagnant zones.

NOTE — The requirements for cooling tower shutdown apply to any individual cell of the cooling tower that contains water, where the cell has been isolated (e.g., by means of isolation valves) from the water in the other cells of the same cooling tower.

7.14.1 Short-term shut down (wet lay-up)

Whenever the cooling tower water system is shut down or out-of-service, without draining, for less than or equal to five consecutive days, the following procedures shall be implemented:

— continue routine chemical treatment, including associated monitoring; and

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— circulate water throughout the entire cooling system, including any filtration system, at least daily.

Duration of water circulation each time shall be the longer of one hour, or sufficient time to ensure that the total system volume is turned over five times, as determined by the Team.

7.14.2 Long term/seasonal shut down (dry lay up)

Whenever the cooling tower water system is shutdown for longer than five consecutive days, the following procedures shall be implemented:

— drain to waste all water in the cooling tower water system by opening all drain valves associated with all system sub-sections, including without limitation:

- — cooling tower;
- — basins;
- — system piping;
- — chillers/heat exchangers; and
- — filtration systems.

— confirm that all potential deadlegs are drained;

— force water out of deadlegs and low spots in the lines with blown air, if feasible;

— use desiccants in water boxes and other locations if feasible; and

— keep the system closed until it is needed.

NOTE — When preparing a cooling tower water system for long term/seasonal shutdown, it is beneficial to apply lay-up treatment, such as blanketing with an inert gas or applying appropriate liquid or vapor phase corrosion inhibitors to protect against corrosion. It is recommended to keep the system closed until it is needed.

7.14.3 Discontinued use

The owner of a cooling tower shall notify the AHJ within 30 days after removing or permanently discontinuing use of a cooling tower. Such notice shall include a statement that the cooling tower has been treated in accordance with Section 7.12.1 and drained in accordance with section 7.14.2.

7.15 Requirements for healthcare facilties

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8 Building Construction and Design

Before starting new construction, renovations, refurbishment, replacement, or repurposing of an existing building or part of an existing building (e.g. room, wing), or installation of new equipment, the Owner shall establish a Responsible Person to consider the effect of any project on the building water system. This person shall review the proposed design and construction scope and its possible impact on the building water system, and to document actual and potential impacts on the building water system before, during, and after the project. The Responsible Person shall be a person with an understanding of local building codes, or the Owner themselves.

8.1 Prior to action

The Owner and/or Responsible Person shall meet with the construction team to develop a work plan prior to starting any new construction, renovation, refurbishment, replacement, or repurposing of a facility or a portion of a facility. The following activites shall be completed prior to occupancy of a building or before construction activities begin. The work plan shall include:

- the proposed work to be completed;
- labelling requirements;
- the area(s) that could be affected;
- shut off procedures, if any;
- flushing procedures, if any;
- disinfection procedures, if any;
- all replacements or installation of equipment, valves, and piping;
- assessment of supply water;
- existing building design requirements
- analysis of existing building water systems
- determine locations where control measures can be applied
- potential modification to existing control measures; and
- evaluation of new and existing materials for compatability with each other and the water supply.

A survey of the building water systems to determine the potential for proliferation of hazards and hazardous condtions shall be completed prior to occupancy of the building.

8.2 During Action

The Responsible Person shall provide updates to the Owner on the progress of the work plan. Any deviation from activities detailed in the initial plan shall be documented with the reason why.

8.2.1 Access to equipment

The Responsible Person shall ensure adequate access for continuous maintenance to all water system components and equipment.

8.2.2 System connections

The following parameters shall be monitored on a non-isolated building water system at a frequency

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determined by the Responsible Person:

- pH;
- temperature;
- pressure;
- turbidity;
- disinfectant residual;
- hazards and hazardous conditions; and
- other parameters determined by the Responsible Person.

Corrective actions shall be implemented if monitoring determines that parameters are outside of expected control limits.

8.2.3 System labeling

The Responsible Person shall ensure all piping and valves are labeled appropriately.

8.2.4 Major events during renovation

Buildings shall meet the EPA Safe Drinking Water Act requirements.

8.3 After Construction

The Owner and/or Responsible Person shall inspect the new construction or construction area of the existing building for compliance to the original work plan. Any deviations not already documented shall be included. Prior to occupancy, the following parameters shall be monitored in the construction area at representative outlets:

- pH;
- temperature;
- pressure;
- turbidity;
- disinfectant residual;
- hazards and hazardous conditions; and
- other parameters determined by the Responsible Person.

The Responsible Person shall at a minimum sample the potable water as close to the entrance of the building as possible and in the construction area of the building for total bacterial count and confirmation of an acceptable disinfectant residual before allowing occupancy.

8.3.1 Commissioning or recomissioning

Prior to commissioning of a new building or recomissioning of an existing building or area of the building, samples of the water for microbial analysis and for confirming disinfectant residual shall be taken at a point or points determined by the Responsible person.

If the bacterial count is > 500 cfu/mL, the system shall be inspected and remediated prior to putting it into service.

If there is < 0.2 ppm FAH, the system shall be inspected to determine a corrective action necessary to achieve an acceptable disinfectant residual.

8.3.2 Water management program

The water management program shall be updated to include:

- review and addition of Team members;

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- new or updated flow diagrams;
- locations of new equipment;
- new or modified control measures;
- SDS for applicable materials;
- start-up procedures for equipment;
- installation and operation manuals for equipment (i.e. operating procedures);
- balancing reports; and
- flushing and disinfection activities.

8.3.3 Records of construction

The Owner shall be responsible for keeping all documentation and records of construction performed on the building. The following records shall be kept at an easily accessible location on premises or in a secure offsite location indefinitely:

- schematic diagrams of water systems;
- stack and riser diagrams;
- locations of all valves and models of all valves, fixtures, fittings;
- locations and types of pumps;
- locations of outdoor air intakes;
- all installation and operation manuals for existing equipment;
- locations of no-flow and low-flow portions of [existing?] building water systems; and [define both terms]
- description of plumbing materials.

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ANNEX A

Healthcare Environments

A.1 Purpose and Scope

Healthcare settings have been recognized as an important area for implmentation of water safety practices since building occupants may be at higher risk for disease or injury. Accordingly, this Informational Annex provides guidance for implementation of water safety programs in healthcare settings. The content of the Annex is complementary to the Standard, and aims to provide *additional* considerations that may be specific, or particularly relevant, to healthcare settings. Since the types of settings and services in healthcare utilizing water are numerous, this annex indicates overarching principles and examples related to risk management that can be used, as determined to be appropriate, by each setting.

A.2 Hazards in Healthcare Environments

The Standard provides information on microbial hazards related to building premise plumbing. In healthcare facilities, clinically-significant microbial hazards also include, but are not limited to:

- *Burkholderia cepacia* complex;
- *Mycobacterium avium* complex;
- *Naegleria fowleri;*
- *Klebsiella* spp;
- protists including fungi; and
- viruses.

The U.S. Centers for Disease Control and Prevention (CDC) provides information on water management programs for healthcare facilties, and includes a comprehensive list of opportunistic pathogens of premise plumbing and examples of outbreaks.

A.3 Water Management Teams in Healthcare Environments

A.3.1 Team members

The water management team in the healthcare setting is described in Section 5.2.1.1 of the Standard. It is recognized that not every facility will have personnel in each position listed. However, if key roles are not formally staffed, the functions of those roles for water safety should be assigned to existing staff. Key roles on the water safety team in healthcare include at least: engineering, facilities management, infection prevention and control, and industrial hygiene/safety. Other functions not specifically staffed at the facilty may also need to be included on the Team as appropriate for the serivices provided.

A.3.2 Team meetings

Per Section 5.2.1.1, the overall team coordinator is to schedule at least biannual team meetings. Discussions at these meetings should include review of verification and validation data collected since the previous meeting and any changes that may need to be made to policy or program implementation. The findings from the data review may indicate that more frequent meetings are necessary (e.g. monthly, quarterly) until program implementation is optimized.

A.3.3 Communication

The Water Management Team should develop a plan for communication of key events to pertinent staff so that appropriate responses can be considered. Key events could include, for example: cases of

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definite or possible healthcare-associated Legionnaires' disease or other infections potentially related to water exposure at the facility, or results of routine environmental sampling for water pathogens to inform clinicians to have heightened awareness for clinical cases. The team should determine the communication mechanism(s) that will be used for notifications such as distribution of electronic mail alerts.

A.3.4 Reporting

As indicated in Section 5.2.1 of the Standard, the Water Management Team is to meet periodically. These meetings should review program implementation and assess data to inform any changes. Key findings should be reported at least to facility leadership as deemed appropriate, and to the Infection Control Committee.

A.4 Risk Management

A.4.1 Risk Assessment in Healthcare Environments

The Standard provides requirements for assessing buildings for hazardardous conditions, and implementing controls and verifications to address them. Risk management in healthcare settings should include additional considerations such as:

- characteristics of patients or residents in the setting (e.g. immunosuppressed patients, dementia patients),
- the services provided (e.g. respiratory therapy),
- the types of devices used,
- the processes/practices that utilize water,
- the nature of the water use (e.g. potential for aerosolization)
- past occurrences of water-associated disease or injury (e.g. healthcare-associated *Legionella* disease, scald injury)
- findings from any clinical or environmental validation testing (see section XX in this Annex).

Methodical and routine assessment of risks and their management associated with these specialized components should be included in healthcare facility water management plans along with the general components listed in the Standard. This process would be akin to other risk assessments traditionally conducted in healthcare (e.g. infection control risk assessments for construction activities). Conducting the risk assessment is a team effort that brings together expertise in engineering/facilities management, clinical/infection prevention, and environmental/safety disciplines (see Sections 5.2.1 and 5.2.1.1 of the Standard for Water Management Team members). In addition, facilities with multiple buildings should assess each building for risk factors and implement water safety practices accordingly. See Table 1 (special considerations for water safety in healthcare environments) and Table 2 (special considerations for water safety in associated with healthcare devices) for guidance.

A.2.2 Risk Ranking for Healhcare Environments

The water management team should create a ranking matrix that defines the risk level of the patient population in the respective environments.

Example:
Low: Office / Exam room
Medium:General patient population
High: Surgery
Highest:Transplant units, protective environments

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A.3 Special Considerations for Water Safety in Healthcare Environments

NOTE: This table may not be comprehensive in listing all environments or providing all special considerations for water safety for different healthcare systems. Rather, the information is to be used as an EXAMPLE of how to assess various settings.

Environment	**Special Considerations for Water Safety** (**M**icrobial, **C**hemical, **P**hysical, **S**pecial Guidelines)		**Risk: Low Medium High**
Hospital (general patient areas)	P, S P,M P S	• General water management for buildings is addressed in the Standard [cite premise plumbing section]. However, there may be requirements for prevention of scald injury that limit the discharge temperature of hot water, necessitating a balance between scald prevention and bacterial control. Review local codes for temperature specifications, as well as design and construction guidelines (FGI) • Specialty care units/areas (e.g. Cardiology, Gastrointestinal) may have specific procedures or devices with water use; the risk assessment for the hospital should consider these special uses of water. • Review areas of the facility that may have low water usage or water stagnation, which could encourage biofilm growth (e.g. collection of water in shower hoses) • Clinical surveillance for illnesses caused by water-associated pathogens	Medium
Out Patient (general patient clinics)		• Risk management based on services provided at the clinic and whether patients visiting the clinic are at heightened risk (e.g. cancer clinic) • Clinics in leased spaces – consider where responsibilities lie for water safety. For example, building water management may be the responsibility of the building owner, whereas device water safety may be the responsibility of the clinic.	Low-Medium
Transplant Units / Protective Environments	S, M	• Patients in these areas are often on immunosuppressive therapies and are at high risk for contracting disease after exposure to infectious agents. Recommendations for hospital infection control in HSCT recipients are outlined in the CDC Guideline for Environmental Infection Control in Healthcare Facilities https://www.cdc.gov/infectioncontrol/guidelines/environmental/index.html • Recommendations include periodic culture for *Legionella* and consideration of water use restrictions (e.g. showering) if water is contaminated with *Legionella*.	Highest
Other areas that treat severely immunocompromised persons (e.g. Burn Units, Hematology/Oncology)	M M	• Patients in these areas are often immunocompromised and are at high risk for contracting disease after exposure to infectious agents. • Risk for transmission of aerosolized pathogens; limit exposure when possible (e.g. avoid indoor decorative fountains) and follow manufacturer's instructions for cleaning and maintaining water-using devices.	Highest

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	M	• Tap water carries opportunistic pathogens (*Pseudomonas aeruginosa*) that can infect burn patients	
Intensive Care Units (e.g., Medical, Surgical, Neonatal)	M M M M	• Patients with higher severity of illness may be at higher risk for infection • Patients in neonatal intensive care units are especially vulnerable to infections because of immature immune systems, diminished functions/varying stages of development, and exposure to invasive procedures and devices • Ice machine cleaning and maintenance in accordance with manufacturer's instructions is important in this area since severely ill patients may be given ice chips to consume (aspiration risk) • Traps in sinks can harbor pathogens • Assess location and type of toilets (e.g. toilets that flush have potential to spray area) and spray hoppers to limit contamination of patient care areas	High-Highest
Long Term Care (e.g. Assisted Living, Skilled Nursing)	P P P P	• Risk of scald injury from hot water due to limited sensation/mobility/ cognitive awareness. There may be local codes that set hot water temperature limits. • Residents may not use shower facilities as often as occupants of other buildings, resulting in greater potential for water stagnation • Potential for physical harm: Slips/falls (e.g. mobility/balance issues can affect reaction to hot/cold water • Rehabilitation and spinal cord injury centers/units have similar risks associated with water	High
Dialysis	C	• Water for use in dialysis is highly regulated; follow AAMI Standards • Consideration of effects of premise plumbing water treatment on dialysis patients (disinfection byproducts) and on compatibility with reverse osmosis membranes • Facilities with point-of-entry water treatment systems should be aware of potential issues if dialysis is done on site. Consider separate water supply for dialysis area.	High
Dental	S	• Guidelines pertaining to water safety in dental setting: o ADA guidelines for apparatus and water supply http://www.ada.org/en/member-center/oral-health-topics/dental-unit-waterlines o CDC Summary of Infection Control Practices for dental settings https://www.cdc.gov/oralhealth/infectioncontrol/guidelines/ o OSAP Checklist for Dental Unit Waterlines: http://c.ymcdn.com/sites/www.osap.org/resource/resmgr/checklists_new/duwl_-_checklist_for_dental_.pdf?hhSearchTerms=%22DUWL%22 • Address water safety requirements for both surgical and non-surgical dental procedures. • See Table 2 in this Annex for information on dental unit water lines	Medium

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Surgery (Inpatient and Outpatient)	M M	• Patients in these areas may be immunocompromised and at higher risk for infection, particularly in inpatient surgical settings. • Risks for inpatient and outpatient surgical settings are dependent on the types of surgical procedures and devices used (e.g. heater-cooler devices, ECMO, endoscopes) • General recommendations: do not use tap water in operating rooms; do not use non-sterile ice	Medium - High
Medical spas/fitness areas		• These areas may include heated and/or non-heated tubs or pools for therapy or relaxation purposes. • Compared to non-medical or healthcare pools and tubs, users of these devices in medical spas or healthcare facilities may be at increased risk of disease from waterborne pathogens or injuries. Proper maintenance of these devices is critical in these settings.	Medium
Pharmacy		• Stringent rules for water quality in medication preparation (USP, PDA and FDA) • Example: Contamination of skin-sterilizing solutions and fresh antibiotic preparations from powders during compounding • Use splash guards to avoid contamination of areas with water	High
Central Supply		• Follow standards for water quality and use when processing medical devices: o Association for the Advancement of Medical Instrumentation (AAMI) o Centers for Disease Control and Prevention (CDC). Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008. (https://www.cdc.gov/hicpac/pdf/guidelines/Disinfection_Nov_2008.pdf) o Food and Drug Administration (FDA). Reprocessing Medical Devices in Health Care Settings: Validation Methods and Labeling, 2015. https://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM253010.pdf • See Table 2 for information on re-useable medical devices	Medium

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A.4 Special Considerations for Water Safety Associated with Healthcare Devices

NOTE: This table may not be comprehensive in listing all devices or providing all special considerations for water safety for different healthcare systems. Rather, the information is to be used as an EXAMPLE of how to assess various devices.

Device	**Special Considerations for Water Safety**	**Risk (Low, Medium, High)**	**References and Resources [Section Incomplete]**
Heater-cooler devices	• Potential for Nontuberculous Mycobacteria (NTM) and other opportunistic pathogens (e.g., *P. aeruginosa*) to grow in the water reservoirs of these devices, with risk of transmission to patients if microbial-colonized water is aerosolized coincident with surgery • Considerations for minimizing NTM and other pathogen transmission risk: o Ensure the device is vented toward the operating room exhaust vents and is not vented toward the surgical field o Strict adherence to manufacturer's instructions for the frequency and processes for cleaning and disinfection o Do not use tap water in the device o Remove devices from service if they show evidence of bacterial growth in the lines • There may be contamination with NTMs or other pathogens at the manufacturing site o Always perform manufacturer's instructions for cleaning and disinfection upon receipt of instrument and before placing in use o Consider environmental, air, and water sampling if contamination is suspected	M	FDA website Perkins KM, Lawsin A, Hasan NA, Strong M, Halpin AL, Rodger RR, Moulton-Meissner H, Crist MB, Schwartz S, Marders J, Daley CL, Salfinger M, Perz JF. Notes from the Field: Mycobacterium chimaera Contamination of Heater-Cooler Devices Used in Cardiac Surgery - United States. MMWR Morb Mortal Wkly Rep. 2016;65(40):1117-1118. Schreiber PW, Kuster SP, Hasse B, Bayard C, Rüegg C, Kohler P, Keller PM, Bloemberg GV, Maisano F, Bettex D, Halbe M, Sommerstein R, Sax H. Reemergence of Mycobacterium chimaera in Heater-Cooler Units despite Intensified Cleaning and Disinfection Protocol. Emerg Infect Dis. 2016 ;22(10):1830-3.
Respiratory care devices	• Examples of devices: nebulizers, continuous positive airway pressure (CPAP)	H	CDC. Guidelines for prevention of nosocomial pneumonia (2003)

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that use water for filling and/or cleaning	• Risk of bacterial growth and transmission (e.g. *Ralstonia mannitolytica* infection in neonates, *Pseudomonas aeruginosa, Burkholderia cepacia*)
	• Follow CDC recommendations and manufacturer's instructions for maintenance, cleaning and disinfection
	  o Use sterile water, or as specified by manufacturer, to fill the devices
	  o Empty devices daily
	  o Replace tubing at specified frequency
	• Some patients may bring personal respiratory devices such as CPAPs for use in the facility
	  o Consider providing education on proper maintenance, cleaning and use
			Arnow PM, Chou T, Weil D, Shapiro EN, Kretzschmar C. Nosocomial Legionnaires' disease caused by aerosolized tap water from respiratory devices. J Infect Dis 1982;146:460–7
			
			Jhung MA, Sunenshine RH, Noble-Wang J, Coffin SE, St John K, Lewis FM, Jensen B, Peterson A, LiPuma J, Arduino MJ, Holzmann-Pazgal G, Atkins JT, Srinivasan A. A national outbreak of Ralstonia mannitolilytica associated with use of a contaminated oxygen-delivery device among pediatric patients. Pediatrics. 2007;119(6):1061-8.

Ice machines	• Risks: Pathogen growth and transmission to patients (e.g. NTMs, *Legionella*) • Ice machine management is addressed in the Standard [cite section]. In healthcare settings, routine maintenance and cleaning of ice machines is critical since patients may aspirate water when ingesting ice or ice chips. • Consider installation of 0.22 micrometer pore size filter between water source and ice machine. • Avoid installing activated carbon filters in-line with ice machines	M	Graman PS, Quinlan GA, Rank, JA. Nosocomial legionellosis traced to a contaminated ice machine Infect Control Hosp Epidemiol. 1997;18(9)L637-640. Yorioka, K, S. Oie, K. Hayashi, H. Kimoto, H. Furukawa. Microbial contamination of ice machines is mediated by activated charcoal filtration systems. J Environ. Health 2016;78(10);32-35.
Hydrotherapy tanks and pools	• General management of these devices is addressed in the Standard [cite Whirlpools/Spas/Hot Tubs section]. In the healthcare setting, special considerations when assessing risk include the following: o There are numerous reports of the transmission of water-associated opportunistic pathogens to patients in healthcare settings by ingestion,	H	

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	inhalation or direct contact with hydrotherapy water contaminated with pathogens (e.g. *Legionella*, NTMs, *Pseudomonas, Acinetobacter,* Adenovirus). o Assess the use of hydrotherapy pools on a case-by-case basis and consider if alternative aseptic techniques should be used for wound management. o Maintain stringent cleaning and disinfection practices in accordance with the manufacturer's instructions o Potential for hypersensitivity pneumonitis (e.g., hot tub lung).		
Patient showers	• General building water management practices are described in the Standard [cite Section] • In healthcare settings, special considerations when assessing risk include the following: o The potential for transmission of water-associated pathogens (e.g. *Legionella*, NTMs) from showers to high-risk patients o Low use of showers in some settings increased the risk of water stagnation and bacterial growth (e.g. long term care facility areas with low-mobility residents). o Avoid the installation of low flow, misting showerheads to reduce aerosolization of opportunistic pathogens. o Use of shower hoses may allow for water stagnation if hoses are not drained after use. o Risk of scald injury. Some facilities and jurisdictions have specific requirements for maximum water	M	

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	temperature to reduce the risk of scald injury. o Risk of slips and falls (e.g. long term care facility areas with low-mobility residents)		
Patient sinks	• General building water management practices are described in the Standard [cite Section] • In healthcare settings, the association of these devices with infections is not well-characterized. • In healthcare settings, special considerations when assessing risk include the following: o There have been reports of colonization of patient sinks with pathogens (e.g. *Serratia, Pseudomonas,* and *Mycobacterium*). o Potential for aerosolization of respiratory pathogens (e.g. NTMs, *Legionella*), though the risk is largely theoretical. o Clean equipment placement (sometimes placed next to sink and can be splashed with water) o Clinical staff should not dispense drinking water from patient bathroom sinks.	L	
Birthing tubs, pools	• General management of these devices is addressed in the Standard [cite Whirlpools/Spas/Hot Tubs section]. In the healthcare setting, special considerations when assessing risk include the following: o The potential for infection of the mother or the newborn (e.g. *Legionella*, *Pseudomonas*) o The potential for non-infectious injury including drowning, near drowning, hyponatremia and water intoxication	M	Granseth G, Bhattarai R, Sylvester T, Prasai S, Livar E. Notes from the Field. Two Cases of Legionnaires' Disease in Newborns After Water Births — Arizona, 2016. MMWR Morb Mortal Wkly Rep 2017;66:590–591.
Humidifiers	• Humidifier management is addressed in the Standard [cite section].		CDC. Guidelines for Environmental Infection Control in Health-Care Facilities (2003)

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	• In healthcare settings, follow CDC guidelines for environmental infection control and use of humidifying devices especially for areas with high-risk patients. • Potential for growth and aerosolized transmission of pathogens (e.g. NTMs, *Legionella*, *Acremonium killensis*, *Pseudomonas, Acinetobacter, Elizabethkingia*) • Implicated in pseudo-infections		
Water baths used for thawing or warming materials	• Potential risk for contamination of materials (e.g. blood products) being warmed in water baths o Some evidence in the literature o Water baths have been implicated in pseudo-outbreaks • Ensure products warmed in water bath are enclosed in protective wrap	L	Berger et al. An outbreak of *Halomonas phocaeensis* sp. nov. bacteraemia in a neonatal intensive care unit J. Hosp. Infect. 2007;67(1):79-85
Extracorporeal membrane oxygenation (ECMO) devices	• Potential for bacterial colonization of the water reservoir used in these devices (e.g. *Mycobacterium chimaera*) and aerosolization during operation. • Theoretical link to isolation of *M. chimaera* from EMCO patients • Clean and disinfect instrument following manufacturer's instructions upon receipt by facility and before any use. • Regularly and routinely, follow manufacturer's instructions for maintenance, cleaning, disinfection, and use	L	Trudzinski et al. Clinical implications of Mycobacterium chimaera detection in thermoregulatory devices used for extracorporeal membrane oxygenation (ECMO), Germany, 2015 to 2016. Euro Surveill. 2016;21(46). pii: 30398
Dental unit waterlines	• Potential for growth of pathogens in biofilm (e.g., NTMs, *Legionella*) • Potential risk for transmission of pathogens but few reports in the literature o *Legionella* infection o Outbreak of *Mycobacterium abscessus* infections in patients undergoing pulpotomy procedures in a pediatric dental practice		CDC Summary of Infection Control Practices for dental settings https://www.cdc.gov/oralhealth/infectioncontrol/guidelines/ OSAP Checklist for Dental Unit Waterlines: http://c.ymcdn.com/sites/www.osap.org/resource/resmgr/checklists_new/duwl_-

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	• Follow recommendations from the American Dental Association (ADA) and the CDC for maintenance of dental unit waterlines o Surgical procedures – use sterile water or sterile saline o Non-surgical procedures – use water that meets the Environmental Protection Agency standard for drinking water (≤ 500 colony forming units of heterotrophic bacteria per milliliter); recommendation to routinely test dental unit waterlines for heterotrophic bacteria.		_checklist_for_dental_.pdf?hhSearchTerms=%22DUWL%22 Ricci et al. Pneumonia associated with a dental unit waterline. Lancet 2012;379(9816):684 Peralta et al. Notes from the Field: *Mycobacterium abscessus* Infections Among Patients of a Pediatric Dentistry Practice--Georgia, 2015. MMWR;65(13):355-6
Electronic faucets	• Reports of contamination by Gram negative bacteria (e.g. Pseudomonas contamination in neonatal intensive care unit faucets) • Risk of bacterial growth and transmission is not well defined. There may be different risks depending on the design and materials used • Maintain heightened awareness of potential issues in high risk areas.		
Faucet aerators	• Reports of contamination by Gram negative bacteria • Risk of facilitating transmission of bacteria • Some healthcare facilities and jurisdictions do not allow their use in patient care areas o Some have switched to use of laminar flow devices • If aerators are used o Maintain heightened awareness of potential issues in high risk areas. o Implement routine maintenance and cleaning according to manufacturer's instructions		
Spray hoppers	• Biologic plausibility but not much evidence of transmission of pathogens	L	

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	• Typically located in utility regions, but some may be located in patient care areas (e.g., intensive care units) o Potential risk for transmission of enteric pathogens (e.g. *Clostridium difficile*, carbapenemase-resistant Enterobacteriaceae) o Ensure routine cleaning and maintenance		
Decorative water features (decorative fountains and water walls)	• Risk of bacterial growth and transmission resulting in infections (e.g. *Legionella* and *Mycobacterium*), particularly when the water features are open (unsealed). o Enclosing the decorative feature mitigates the transmission risk. • Facility Guideline Institute (FGI) indicates that indoor, open decorative water features should not be installed in hospitals and outpatient facilities. o It is especially important to avoid installing these devices in facilities and areas where immunocompromised persons are treated (e.g. hematology-oncology units). o However, it should be noted that patients without known compromised immune function may also be infected, and it is not feasible to limit the location of all patients. Therefore, avoiding installation of these devices in all indoor areas would be the easiest way to mitigate risk. • If indoor decorative water features will be installed: o Consider selection of closed (sealed) models, or, less ideally, models with minimal aerosolization such as bubblers	M L	FGI *Guidelines for Design and Construction of Hospitals and Outpatient Facilities* Haupt et al., An outbreak of Legionnaires disease associated with a decorative water wall fountain in a hospital. *Infect. Control Hosp. Epidemiol*. 33(2):185-191 Palmore TN et al., A cluster of nosocomial Legionnaire's disease linked to a contaminated hospital decorative water fountain. *Infect. Control Hosp. Epidemiol*. 30(8):764-768.

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	o Adhere to strict cleaning and disinfection protocols in accordance with manufacturer's instructions o Avoid the use of lighting features that could warm the water to optimal bacterial growth temperatures. • Considerations for outdoor decorative water features o Do not place these features near building entrances. Rather, place them in a manner that limits close access to reduce exposure to aerosols o Adhere to strict cleaning and disinfection protocols in accordance with manufacturer's instructions o Select features with minimal aerosolization such as bubblers • Other decorative water devices o Living plants on vertical structures ("living walls"): Low risk for infection. Ensure watering system does not leak and result in moist walls or pooled water on the ground. o Fish tanks: These decorative features should be cleaned on a routine basis and should be covered.	L L	
Reusable Medical devices (e.g. endoscopes, arthroscopes)	• Depending on various factors such as the device and the nature of the procedure (critical, semi-critical, non-critical), these devices may be reprocessed (in part or fully) in Central Supply or at the procedure setting. Use of water for reprocessing devices should be of appropriate quality regardless of the location at which reprocessing steps occur. • Poor-quality water used for reprocessing medical devices can affect both the patient (e.g. cross contamination, transmission of infection, adverse reaction) and the device		FDA website: Reprocessing of Re-useable Medical Devices FDA. Reprocessing Medical Devices in Health Care Settings: Validation Methods and Labelling. 2015. Includes a list of resources for developing reprocessing instructions (e.g. CDC, AAMI)

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	(damage, decreased cleaning efficacy, interference with disinfection/sterilization) • Follow manufacturer's instructions for reprocessing, including the type of water to be used for each step in the process.		

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A.5 Validation

Validation is the process of assessing whether the implemented Water Management Program is effectively controlling identified hazardous conditions. The facility water management team should use the building risk assessment and hazardous condition analysis to identify validation needs and processes.

In healthcare facilities, there are two general types of validation processes:

a. Environmental validation is the process of measuring the presence of a hazard in the environment. *NOTE: This is not the same practice as the routine monitoring of controls implemented to limit hazardous conditions*. This process typically is associated with the analysis of water samples for detection of bacteria. The type of bacteria tested is dependent on the risks/hazards for each particular setting. In some instances such as dental unit waterline management, validation testing measures total bacteria (i.e., heterotrophic plate counts) as an indication of water quality. In other situations such as premise plumbing management in acute care facilities, water samples are tested for specific pathogens; this type of testing is primarily undertaken for detection of *Legionella* bacteria. When considering implementation of environmental validation, several factors should be addressed:
    i. The hazards or quality indicators for which the setting/device will be tested
    ii. The scientific validity of conducting the testing
    iii. The frequency of the testing
    iv. The locations of the sampling
    v. The sampling procedures
    vi. The type of analysis
    vii. Criteria for selection of the testing laboratory
    viii. Interpretation of the results
    ix. The actions, if any, that will be taken upon receiving the results of the testing. The actions may be different based on the setting. For example, thresholds for action may be more stringent in areas with high risk patients such as transplant units and protective environments.

    The water management team defines appropriate hazard testing for the risk ranking of the space. Required validation tests and frequencies are matched to the risk level. For example:

Environment Risk Ranking	Validation Testing Frequency
Highest	X tests per location / quarter
High	X tests per location / year
Medium	
Low	

b. Clinical validation is the surveillance of patients for disease or injury related to a hazard. The potential types of disease (e.g., type of healthcare-associated infection) and/or injury (e.g., scalding) should be assessed for each setting or device. Identification of disease or injury associated with the setting/device indicates the potential need for remedial actions to mitigate a risk, and subsequent assessment of routine controls for optimized inhibition of the hazardous condition.
    i. Consider implementing practices (e.g. education) to promote heightened awareness of potential clinical risks to facilitate early recognition of an issue and prevent subsequent cases.

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Annex B

References

Centers for Disease Control and Prevention (CDC). Guidelines for Environmental Infection Control in Health-care Facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Morbidity and Mortality Weekly Reports. 52 (RR10):1-42; 2003. www.cdc.gov/mmwr/preview/mmwrhtml/rr5210a1.htm

NOTE: See Section D (pp. 54-85) for guidance on environmental infection control in healthcare related to Water, including information on bacteria associated with water and moist environments

CDC. Guidelines for Preventing Healthcare-associated Pneumonia. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. Morbidity and Mortality Weekly Reports. 53(RR03):1-36; 2003. www.cdc.gov/mmwr/preview/mmwrhtml/rr5303a1.htm

Centers for Medicare & Medicaid Services. Memorandum: Requirment to Reduce *Legionella* Risk in Healthcare Facility Water Systems to Prevent Cases and Outbreaks of Legionnaires' Disease (LD). Ref: S&C 17-30. June 9, 2017. https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGenInfo/Downloads/Survey-and-Cert-Letter-17-30.pdf

APIC Text of Infection Control and Epidemiology. Chapter 115: Water System Issues and Prevention of Waterborne Infectious Diseases in Healthcare Faciliities. October 3, 2014.