ASHRAE Guideline 12-2000R

Public Review Draft

Proposed Revision of Guideline 12-2000, Managing the Risk of Legionellosis Associated with Building Water Systems

Third Public Review (November 2018)
(Draft Shows Proposed Independent Substantive Changes to Previous Public Review Draft)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed guideline, go to the ASHRAE website at www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the guideline (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

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(This foreword is not part of this guideline. It is merely informative material and does not contain requirements necessary for conformance to the guideline. It has not been processed according to the ASHRAE requirements for a guideline and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE.)

FOREWORD

This independent substantive change to the previous public review draft reflects input from comments received during the second public review.

Note: This public review draft makes proposed independent substantive changes to the previous public review draft. These changes are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the previous draft are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it related to the proposed substantive changes.)

Modify Section 3 as shown. The remainder of Section 3 is unchanged.

3. DEFINITIONS OF TERMS

Note: The users of this guideline are expected to range from experienced professionals to those with no experience in managing the *risk* of *legionellosis* associated with *building water systems*. To effectively communicate with all users, the definitions of terms, abbreviations, and acronyms in this section are intended to be concise and are defined in the context of their use in this guideline. Terms that are not defined are intended to have their ordinarily accepted meanings, within the context in which they are used, based on the Standard American English language usage as found in an unabridged dictionary.

[. . .]

~~***biodispersants:*** chemicals added to water that are intended to penetrate, loosen and disperse *microbial* masses or deposits.~~

[. . .]

blowdown (bleed): the intentional discharge of system water and replacement ~~typically replacing it~~ with supply water to maintain a desired water quality.

[. . .]

~~***concentration ratio:*** see *cycles of concentration.*~~

[. . .]

control measure: ~~a *disinfectant*~~ the *disinfection*, heating, cooling, filtering, flushing or other means~~, methods, or procedures used~~ to maintain the physical or chemical conditions of water to within *control limits.*

[. . .]

cycles of concentration ~~(concentration ratio)~~: the ratio of the concentration of dissolved solids, such as chloride, in the evaporative cooling system to the concentration of dissolved solids in the make-up water.

[. . .]

disinfectant residual (~~free disinfectant residual,~~ residual): the net amount of a chemical *disinfectant* remaining in treated water after chemical demand exerted by the water is satisfied.

disinfection: the process of killing or inactivating ~~pathogens~~ microorganisms.

[. . .]

~~***free disinfectant residual:*** see *disinfectant residual.*~~

[. . .]

HVAC: heating, ~~ventilation~~ ventilating, and air conditioning

[. . .]

non-potable: water not intended for human consumption, such as drinking, bathing, showering, hand washing, teeth brushing, food preparation, dishwashing, and maintaining oral hygiene.~~that is not fit for drinking or for personal or culinary use and that has the potential to cause harmful human exposure to *Legionella*.~~

[. . .]

potable water system: a building water distribution system that provides hot or cold water intended for human consumption, such as drinking, bathing, showering, hand washing, teeth brushing, food preparation, dishwashing, and maintaining oral hygiene. ~~direct and indirect human contact or consumption.~~

[. . .]

remedial treatment: short term application of chemical, physical, or biological measures beyond those regularly applied to maintain water conditions to within *control limits*.

[. . .]

risk management: systematic ~~practices~~ activities to reduce *risk*.

secondary disinfection: see *disinfection, secondary*.

siphoning: water flow from one source to another due to atmospheric pressure.~~unwanted reverse water flow and mixing of one liquid into another, due to atmospheric pressure, applied system pressure or induced system pressure.~~

[. . .]

turbidity (turbid): cloudy condition of water due to the presence of fine particulate materials in suspension.~~the loss of water transparency due to the presence of suspended particulates making the water appear discolored.~~

validation: initial and ongoing confirmation that the *Program*, when implemented as designed, ~~effectively~~ *controls* ~~the~~ *hazardous conditions* throughout the *building water systems.*

Modify Section 4 as shown. The remainder of Section 4 is unchanged.

4. LEGIONELLOSIS AND *LEGIONELLA*

This section contains information on *Legionella* and *legionellosis* intended to provide context for the practical information and guidance contained in Sections 5 – 12 and Appendices C and D of this guideline.

4.1. Infection and Disease

Legionellosis is a broad term for illness caused by any of at least 60 species of *Legionella* bacteria.[1] Legionnaires' disease and Pontiac fever are the two most common types of *legionellosis*. Legionnaires' disease is a severe form of pneumonia, which frequently requires hospitalization. While approximately 9% of all Legionnaires' disease cases are fatal, ~~overall, mortality associated with~~ fatalities in healthcare-associated Legionnaires' disease cases are ~~is~~ higher at 25%.[2,3] Legionnaires' disease occurs when *Legionella* bacteria invade human immune cells in the deep regions of the lungs. Pontiac fever is a self-limited, influenza-like illness that may often go undetected and is not associated with mortality.

People at highest *risk* for Legionnaires' disease are smokers; those receiving treatment for burns or receiving chemotherapy for cancer; those ~~who have undergone~~ receiving treatment associated with solid organ or bone marrow transplantation~~, or bone marrow transplantation~~; those with underlying diseases, such as cancer, renal disease, diabetes and chronic lung disease; those ~~who are~~ taking drugs that weaken the immune system; those who are otherwise *immunocompromised*; and the elderly.[4] However, many cases have been reported in otherwise healthy individuals and in all age groups, including infants. Most cases of Legionnaires' disease are sporadic, meaning they are not associated with a known *outbreak*.[5]

Infection is possible in any building environment where people can be exposed to water contaminated with

Legionella. In the case of *aerosols*, infection may result from inhaling *Legionella* carried in a ~~the~~ fine spray of microscopic water droplets that may not be visible. Infection is also possible by *aspiration*, where water contaminated with *Legionella* can unintentionally enter the lungs ~~after~~ while eating or drinking. ~~The~~ *Legionella* contaminated water is usually associated with human-made water systems, such as plumbing systems, cooling towers, decorative fountains, and hot tubs. However, Legionnaires' disease is relatively rare, accounting for approximately 2-5% of community-acquired pneumonia cases. Legionnaires' disease *outbreaks* are most often associated with water systems in hotels, hospitals, long-term care facilities, resorts, and cruise ships.[5]

4.2. *Legionella*

There are many different species and species serogroups of *Legionella* bacteria, a number of which can cause disease. ~~The majority of~~ Most reported cases of disease ~~is~~ are caused by species *Legionella pneumophila*. There are at least 15 serogroups of *Legionella pneumophila,* however serogroup 1 is responsible for most reported cases. The disease causing potential of various other *Legionella species*, serogroups, and subtypes in all populations has not been established. The distribution in the environment of individual *Legionella* strains may vary by location and over time. The distribution of strains also varies worldwide. *Legionella* colonization of individual *building water systems* is related to site-specific conditions, such as system design, system operation and *building water system* disruptions. ~~The ability of various *Legionella* species, serogroups, and subtypes to cause disease in all populations is unknown. Therefore, it is important to consider any *Legionella* strain potentially disease causing.~~

Microbial testing that indicates the presence of a large quantity of a *Legionella* strain with low disease-causing potential may represent little or no potential for disease in humans, while the presence of a small quantity of a *Legionella* strain with ~~high~~ established disease-causing potential, such as *Legionella pneumophila* serogroup 1, may represent a relatively higher potential for disease in humans.

[. . .]

4.2.1. Habitats

4.2.2. *Legionella* in Building Water Systems

Legionella are present, often in very low or undetectable concentrations, in most natural water sources. Physical and chemical conditions in *water utility* distribution systems and *building water systems* may support significant increases in the numbers of *Legionella.*

Eliminating uncontrolled *growth* of *Legionella* in *building water systems* is the central mechanism for managing the *risk* of disease. Complete elimination of *Legionella* bacteria from *building water systems* is difficult to achieve and typically not sustainable. Determining success in *control* of *Legionella growth* in *building water systems* should take into account that *Legionella* bacteria are part of the natural water environment and can be controlled, but not completely eliminated.

[. . .]

Building water systems also have characteristics that can make them prone to significant *biofilm* formation, *microbial* colonization and *Legionella growth*, such as:

[. . .]

~~4. **Dead legs.** *Legionella* can thrive in locations where there is little or no flow, such as *dead legs*. *Dead legs* can provide conditions that favor *growth* and can be a source for reseeding of *Legionella* into the rest of the *building water system*.~~

~~5.~~ 4. **Cross connections.** The plumbing systems in buildings offer numerous opportunities for *cross connections* between potable and *non-potable* water, which can introduce *Legionella* into the potable water. *Cross connections* between hot and cold water can result in water temperatures favorable for *Legionella growth*.

~~6.~~ 5. **Plumbing materials.** *Building water systems* are constructed using a greater variety of materials than utility water distribution systems. These materials include copper, brass, galvanized steel and a wide range of plastics and elastomers. These materials may be adversely affected by treatment chemicals, may provide nutrients that can support the *growth* of *Legionella*, may reduce *disinfectant residuals* and may promote *biofilm* formation.

~~7.~~ 6. **Accumulation of sediment.** *Building water systems* have numerous places where sediment can accumulate. Sediment can provide a home for *biofilm* and can insulate *Legionella* from *disinfectants* and elevated water temperatures. Filters, by design, accumulate sediment and if not maintained properly can provide a substantial *growth* media for bacteria and diminish *disinfectant residual*.

[. . .]

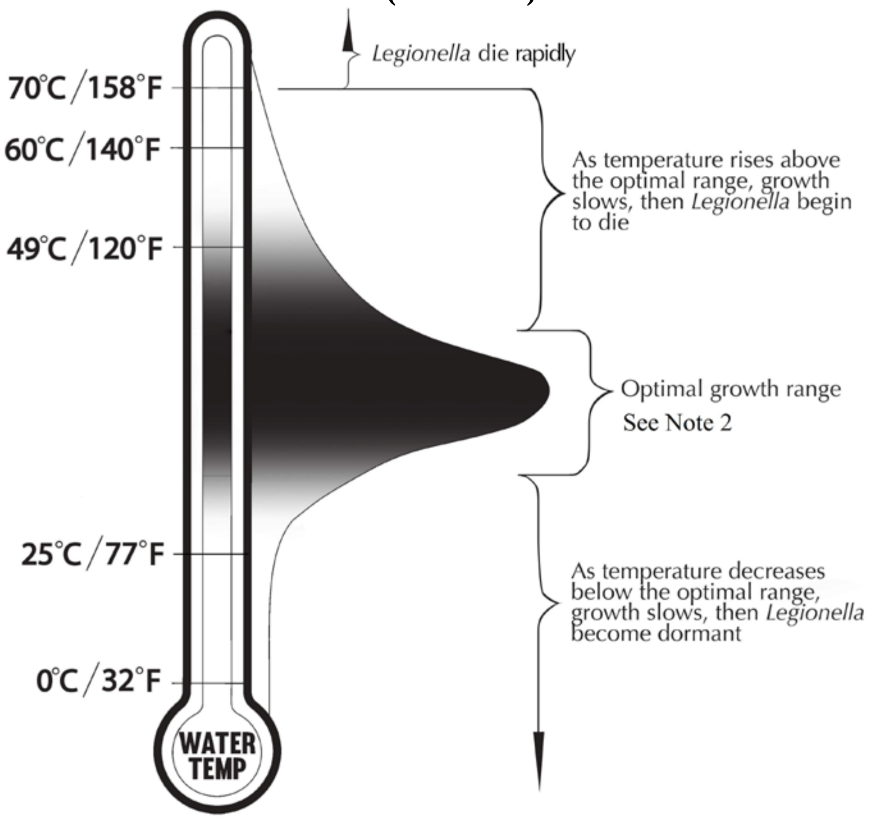
4.2.2.1. Intrusion (*Legionella* getting into the system)

4.2.2.2. Growth

[. . .]

2. **Temperature.** Water temperature is a significant factor that influences the survival and *growth* of *Legionella*. In laboratory controlled conditions, *Legionella* ~~can~~ generally grows on artificial media at ~~water~~ temperatures between 77°F and 113°F (25°C and 45°C) and may grow very slowly at temperatures as low as 68°F (20°C), temperatures often found in many parts of *building water systems*.[8] The optimal ~~water~~ temperatures for *Legionella growth* are generally between ~~77~~85°F and 108°F (~~25~~30°C and 42°C). *Legionella pneumophila*, the species of *Legionella* responsible for most Legionnaire's disease, generally grows in laboratory conditions between 95°F and 99°F (35°C and 37°C), the peak of its *growth* range. Other *Legionella* species may have different optimal *growth* range peak temperatures. *Legionella growth* slows and they begin to die at water temperatures between 113°F and 120°F (45°C and 49°C). As water temperature increases, the time for *Legionella* to die becomes shorter and *Legionella* will die rapidly at temperatures at or above 158°F (70°C). Maintaining water temperatures that are sufficiently hot or cold throughout the *building water system* can be practically challenging, especially when the system includes un-insulated pipes, *dead legs*, long pipe runs, areas where cold water pipes are located near hot water, steam or other heated pipes, and situations where portions of the system may go unused for extended periods. *Biofilm*, debris, and accumulated sediment may provide thermal insulation sufficient for *Legionella* to survive, even when the water temperature is outside the optimum temperature range. ~~Temperature controls may help to control the *growth* of *Legionella*, though~~ Maintaining hot water temperature above 120°F (49°C) at all points throughout the entire building hot water system may be necessary to help *control* the *growth* of *Legionella*.[8] See Figure 4.2.2.2.

Figure 4.2.2.2
Temperature Effects on Survival and Growth of *Legionella* in Laboratory Conditions
(See Note 1)



Note 1: In *building water systems*, the temperature below which *Legionella* is dormant, the temperatures and speed at which *Legionella* grow and the elevated temperatures and speed at which *Legionella* die are affected by numerous environmental variables, such as pH, salts and minerals, *Legionella* species, *Legionella growth* phase and association with *biofilms*.

Note 2: Legionella pneumophila, the species of *Legionella* responsible for most Legionnaire's disease, generally grows in laboratory conditions between 95°F and 99°F (35°C and 37°C), the peak of its *growth* range. Other *Legionella* species may have different optimal growth range peak temperatures.

[. . .]

4. **Disinfectant Residual.** Water treatment plants typically add a secondary chemical *disinfectant*, such as chlorine, ~~or~~ monochloramine, or chloramine to the water leaving the treatment plant. The *secondary disinfectant* is intended to persist and *control microbial growth* in water throughout the distribution system. The *disinfectant residual* begins to decline as soon as water leaves the treatment facility. As a result, *disinfectant residuals* from the utility water system may not be high enough to limit *Legionella growth* in *building water systems*. Buildings farthest from the water treatment plant may receive water with little or no remaining *disinfectant residual*. Generally, the lower the concentration of *disinfectant residual* in the supply water entering the building, the more likely it contains microorganisms, including *Legionella*. However, even when water entering the building has a high *disinfectant residual*, this *residual* may not persist throughout the *building water systems* all the way to the *points of use*. *Disinfectant residual* declines as *water ages* and water temperature increases~~, leading to higher levels of contamination~~. There may be no *residual disinfectant* remaining after the water is heated for use in the hot water system. Lack of a persistent *disinfectant residual* throughout the various *building water systems* may increase the likelihood of *Legionella growth*. Addition of a *supplemental disinfectant* may be ~~required~~ necessary to generate a *disinfectant residual* throughout *building*

water systems.

4.2.2.3. Transmission (*Legionella* Release Such That People Can Be Exposed)

There are numerous ways *Legionella* can be transmitted to and infect humans. There is evidence that inhalation of *aerosols* by a susceptible host is the primary means of infection. Other means of infection include *aspiration* of water containing *Legionella* while drinking, eating or vomiting, or introduction directly into the lungs during certain medical procedures. *Legionella* transmission from person-to-person contact has been reported only once.[10]

[. . .]

Dental unit water lines have been implicated as a source of *Legionella* transmission, which may occur by either inhalation of *aerosols* or *aspiration* of small volumes of water.[~~10~~11] Ice machines have also been implicated as the source of transmission by *aspiration* in cases of Legionnaires' disease.

[. . .]

FIGURE 4.2.2.3 Steps 1 – 5 Factors and Events Leading to Legionnaires' Disease

1	2	3	4	5
Entry (*Legionella* entering *Building Water Systems*)	**Growth** (A significant increase in the numbers of *Legionella*)	**Transmission** (*Aerosols* from Faucets, Shower Heads, Cooling Towers, Fountains, Spa, Etc.)	**Exposure of Susceptible Human Host** (Multiply in Human Host)	**Legionnaires' Disease**
Factors: *Disinfectant Residual* Level in Water Supply to the Building Water Supply Disruptions	**Factors:** Temperature *Disinfectant Residual* System Design Dirt/Sediment Nutrients *Microbial* Associations	**Factors:** Temperature Humidity *Aerosol* Production Distance from Source *Microbial* Associations	**Factors:** Ability of bacteria to cause disease Virulence Age Disease Immunodeficiency	

4.3. References:

[. . .]

10. Correria, A.M, Ferreira, J.S., Borges, V., et al. (2016). Probable Person-to-Person Transmission of Legionnaire's disease. *New England Journal of Medicine*, *374*(5), 497-498.

~~10.~~11. Ricci, ML., Fontana, S., Pinci F., et al. (2012). Pneumonia Associated with a Dental Unit Waterline. *Lancet*, *379*(9816), 684.

Modify Section 5 as shown. The remainder of Section 5 is unchanged.

5. POTABLE WATER SYSTEMS

Characteristics of both hot and cold *potable water systems* influence colonization and subsequent *growth* of *Legionella*. *Potable water systems* that have been opened for repair, have experienced *turbidity* at multiple outlets or are being newly commissioned may be at increased likelihood of colonization. Components of *potable water system* that generate *aerosols*, when functioning as designed, include, but are not limited to, showerheads, faucets, aerators, and spray nozzles. Other sources of *aerosols* include water impingement on surfaces, such as sinks. In addition to *aerosols*, *aspiration* of contaminated water from components such as ice machines and water fountains can occur. A report by the US Centers for Disease Control (*CDC*)[1] states that 66% of all water borne disease *outbreaks* associated with potable water reported for the period 2011-2012 were attributed to *Legionella*.

[. . .]

Maintaining a consistent, measurableConsistently maintaining a *disinfection residual* adequate to *control Legionella* throughout the entire *potable water system* can be an effective means of *Legionella* control, especially where water temperatures cannot be reliably maintained at target levels throughout the system or where stagnant or low-flow conditions may exist.

[. . .]

5.1. System description

5.2. System Design/Engineering, Installation, Commissioning

Planning to *control* the conditions that increase the potential for *Legionella growth* should start with the architecture, design, and engineering of buildings. Building layout and location of water fixtures will significantly affect the number, length, and complexity of pipe runs, the occurrence of *dead legs* and the use of water and energy. *Process flow diagrams* are important. *Process flow diagrams* for *potable water systems*, including hot and cold water systems, should be consistent with final system design and should be provided with the contract documents. In addition to relatively simple *process flow diagrams*, more detailed plans showing pipe sizes, valve and *control locations* (if provided), risers, direction of flow, the location of all *points of use* (faucets, showers, humidifiers, etc.), water filtration systems (if provided), points for water treatment (if provided), points for confirmation (*verification* and *validation*) (if provided), the location and description of all water system components, how water is conditioned, stored, heated, cooled, recirculated, and delivered to end-point uses, and other appropriate hot and cold *potable water system* information should be consistent with the final system design and should be provided with the contract documents.

The design and component selections appropriate for any particular facility may be unique and should take into consideration factors such as the building use, location, and occupancy, including *at-risk individuals*. The following system design recommendations apply to every portion of the *potable water system*, including all components and branches, from the *building water system* intake to all *points of use*.

5.2.1. Piping system design

[. . .]

6. **Sampling points**. The addition of points at appropriate locations throughout the hot and cold potable *building water systems* to provide access for sampling or measuring parameters (such as chemical, biological, temperature, pressure, pH) and for confirmation (*verification* and *validation*) should be considered. These points should be located so as to directly sample or measure water moving through the system, and should not be located in *dead legs*.

5.2.2. Plumbing component design, selection, installation, and other considerations

[. . .]

4. **Faucets with flow restrictors.** Flow restrictors increase *water age* and can increase the *risk* of *microbial growth* if debris becomes trapped. Flow restrictors, such as those that reduce flow to 1 gpm or less, can significantly increase *water age* in uncirculated hot and cold supply piping, particularly where faucets are used infrequently.

[. . .]

7. **Expansion tanks.** Expansion tanks, including but not limited to pressure tanks, well tanks, and hydro-pneumatic tanks, should be designed, located, and oriented to minimize dirt accumulation, minimize heat gain, to minimize retained (stagnant) water, and to allow access for required maintenance.
8. **Maintenance access.** Plumbing components should be accessible for maintenance and replacement. Examples of plumbing components that should be accessible are water hammer arrestors and all strainers, check valves, balancing valves, *backflow* preventers, and internal strainers, such as those in electronic faucets and pressure regulating valves.

[. . .]

5.2.3. Competing Objectives

5.3. *Legionella* Control Measures

There are multiple physical, chemical, and operational *Legionella control measures* that can be applied together or individually to manage the physical and chemical conditions that facilitate intrusion, *growth*, and transmission of *Legionella*. Multiple *control measures* are often used in the same system. Available *control measures* include:

1. temperature *control*
2. *supplemental disinfection*/treatment
3. filtration
4.~~3.~~ flushing
5.~~4.~~ recirculation
~~5. filtration~~
6. cleaning and maintenance

Building design, use, occupancy, location, and other factors can vary significantly across buildings. The selection of *Legionella control measures* appropriate for any facility may be unique. Depending on the circumstances, the use of one or more *Legionella control measures* may be appropriate.

5.3.1. Temperature Control

Legionella survival and *growth* is temperature dependent. See Section 4.2.2.2 “Growth” and ~~Table~~ Figure 4.2.2.2 “Temperature Effects on Survival and *Growth* of *Legionella* in Laboratory Conditions”.

1. Storage water heaters and hot water storage tanks should be adjusted or maintained so they deliver water consistently at or above 140°F (60°C), unless other compensating *control measures* are used. ~~While~~ Because the water temperature in the storage tank ~~must be~~ is maintained at or above 140°F (60°C), measures should be taken to prevent scalding.

   Note 1: The temperature set point indicated by the water heater thermostat may be different than the temperature of the water within the heater and exiting the heater.

   Note 2: Maintaining outlet water temperature at 140°F (60°C) does not guarantee *Legionella control* in water heaters or hot water storage tanks, especially if there is significant accumulation of sediment, stratification or long residence time. To counter significant stratification or long residence time, an intra-tank circulator loop can be added to water heaters and storage tanks. If such a loop is needed, a pipe from the inlet of the intra-tank circulator should connect the hot water supply or outlet location near the top of the water heaters and storage tanks. A pipe from the outlet of the intra-tank circulator should connect to the location specified in the manufacturer’s installation instructions for connecting the return from the building hot water recirculation loop, taking care not to affect the building hot water return flow. If there are no such instructions, the outlet of the intra-tank circulator should connect to the lowest point on the water heaters and tanks. The pump and piping should be sized and operated as ~~required~~ needed to reduce *Legionella growth* in the water within the intra-tank circulation loop. A size often selected is a pump capable of one or two tank changes per hour. When a single intra-tank circulator is used to provide circulation for multiple water heaters and storage tanks, it should provide the same general water circulation as would be provided by individual intra-tank circulators.

2. Unless other compensating *control measures* are used, hot water should be maintained consistently at or above 120°F (49°C) throughout the hot water system, including water for delivery to the *points of use* and in the hot water return. Maintaining hot water ~~T~~temperatures at or above 120°F (49°C) at fixtures have been used successfully as a *Legionella control* method, however water temperatures must be consistently maintained above 120°F (49°C) between the water heater and the fixtures to assure a minimum of 120°F (49°C) at the fixture and in the pipes returning to the water heater. To prevent scalding, the water ~~Maximum allowable~~ temperatures at the *tap* may require additional *control* or adjustment at or near the *point of use* ~~to prevent scalding~~.

[. . .]

5.3.2. Supplemental disinfection

Maintaining a *disinfectant residual* throughout the *potable water system* helps to *control Legionella growth*. However, the use of *supplemental disinfection* alone does not assure the *control* of *Legionella*. Water received from a *water utility* may or may not contain a consistent, measurable *disinfectant residual*. Even when the level of *residual disinfectant* in the water entering the building is at the intended level and meets regulatory requirements, the building potable water system may be colonized by *Legionella* and ~~require~~ a *control measure*, such as *supplemental disinfection*, may be needed.

The building owner should consult with the *water utility* to determine the intended *disinfectant* level and should ~~verify~~ confirm the actual level coming into the building. Even if the water received does contain a consistent, measureable *disinfectant residual*, the *residual* may dissipate while in the plumbing, before reaching the *points of use*. The rate at which *disinfectants* decay varies from one *disinfectant* to another and is affected by a number of factors, including water quality, organic matter, time, pH, plumbing materials and water temperature. The higher the water temperature the faster the loss of *disinfectant*. In most cases, heating water for the hot water distribution system rapidly depletes any *disinfectant*. *Supplemental disinfection* is most often applied to heated potable water, but is sometimes applied to *control Legionella growth* ~~water~~ in ~~the~~ cold water distribution systems ~~sometimes requires treatment~~.

~~Because building design, use, occupancy, location and other factors can vary, the selection of *Legionella control measures* appropriate for any facility may be unique. No one plan or set of *control measures* is appropriate for all buildings.~~ No condition or combination of conditions should automatically trigger the use of *supplemental disinfection* without careful consideration. The following conditions are examples of circumstances ~~for which~~ where additional *control measures*, including *supplemental disinfection* ~~should~~ may be considered as part of an overall *water management program*:

[. . .]

6. Facilities with areas designated for treating or housing persons considered *at-risk* for Legionnaires' disease, such as those receiving treatment for burns or receiving~~,~~ chemotherapy for cancer, those receiving treatment associated with solid organ or ~~transplantation,~~ bone marrow transplantation, those with underlying diseases, such as cancer, renal disease, diabetes and chronic lung disease, those taking drugs that weaken the immune system, those otherwise ~~people that are~~ *immunocompromised*, ~~those taking drugs that weaken the immune system,~~ the elderly, and smokers.

5.3.2.1. *Supplemental Disinfection* Used to Treat Building Water Systems

[. . .]

To evaluate the available options, consult available scientific or technical evidence supporting and challenging the overall impact of the *supplemental disinfection* method on the *building water systems*, on the building occupants, and on building operation and personnel. Factors that should be considered when evaluating *supplemental disinfection* options include, but are not limited to:

1. What is the ~~amount of *disinfectant residual* in the~~ quality of the water supplied to the building, such as the amount of *disinfectant residual*, *microbial* activity, and the concentration and type of corrosion inhibitors?

[. . .]

5. What is the effectiveness of the *supplemental disinfection* method under the intended building water system use conditions? Use conditions that should be considered include, but are not limited to, water temperature, *water age*, and water chemistry parameters, such as alkalinity, hardness, pH, and the type and concentration~~,~~ ~~and type~~ of corrosion inhibitors ~~in the water supplied to the building~~.

[. . .]

10. What is the degree of complexity and technical skill necessary to ~~verify~~ confirm the intended *control limits* are being met, for example, the measurement of *disinfectant* concentration or water quality at the fixtures?

[. . .]

5.3.3. Physical barriers: ~~Screens and Filters~~Point-of-Use Barriers, Inline Barriers, and Point-of-Entry Devices

Point of entry filtration, screens, and other devices can be used to reduce sediment and nutrients in potable water supplied to the building, and *point-of-use* and inline filters can be used as barriers to water borne pathogens, including *Legionella*. *Point-of-use* filters are often used to provide a temporary pathogen barrier, but may also be deployed as a continuing *control measure*. However, the use of physical barriers alone does not assure the *control* of *Legionella*. The following conditions are examples of circumstances for which *point-of-use* physical barriers should be considered as part of an overall *water management program*:

1. Where there has been a case of *legionellosis* associated with *building water systems*
2. Where building water system samples have tested positive for *Legionella*
3. Facilities where hot and cold water temperatures recommended for *Legionella control* cannot be maintained reliably throughout the entire *potable building water system*
4. Facilities where there is not a consistent, measurable *disinfectant residual* in the water received at the building water service entrance
5. Facilities where there is not a consistent, measurable *disinfectant residual* at all hot and cold water *taps* after about one minute of flow
6. Facilities with areas designated for treating or housing persons considered *at-risk* for Legionnaires' disease, such as those receiving treatment for burns, chemotherapy for cancer, solid organ transplantation, bone marrow transplantation, those with underlying diseases, such as cancer, renal disease, diabetes and chronic lung disease, people that are *immunocompromised*, those taking drugs that weaken the immune system, the elderly, and smokers.

5.3.3.1. Point-of-use filters and inline physical barriers~~devices~~. A physical barrier to ~~environmental~~ transmission of *Legionella* from the *potable water system* is sometimes established by means of *point-of-use* (POU) filters. Additionally, POU filters are sometimes used for short term intervention in areas intended to serve *at-risk individuals*, for the purpose of preventing contaminants in the water from exiting the system. Inline physical barriers can be used to reduce *turbidity* or, depending on the pore size, can serve as a barrier to transmission of *Legionella* in water downstream of the inline barrier and to connected equipment and processes, such as endoscope reprocessing, ice making, and dialysis. POU *microbial* filters and inline physical barriers with an effective pore size of 0.2 microns or smaller and that are certified to ASTM Standard F838-15a, or equivalent, have been shown to prevent transmission of *Legionella*. POU filters and inline physical barriers should be installed, maintained, and replaced following the manufacturer's instructions. If the manufacturer's instructions are not followed, POU filters may ~~become fouled and support~~ fail and increase the *risk* of *microbial growth* in the building water system and may no longer prevent exposure to *Legionella*. Some filter media, such as activated carbon, deplete *disinfectant residuals*.

5.3.3.2. Point-of-entry devices. Physical removal of some contaminants from incoming water may be accomplished by means of point-of-entry (POE) devices such as screens, centrifugal separators, and filters. These devices typically have pore sizes far too large to remove *Legionella* bacteria, but can be beneficial for removing particulates and nutrients that can deplete *disinfectant residuals*, contribute to sediment accumulation and create conditions that are favorable for *Legionella growth*. POE devices ~~screens~~ are also useful in reducing the effects of water supply disruptions and pressure surges that can cause an increase in particulates and *turbidity* in water supplied to the building. POE devices should be installed, maintained, and replaced following the manufacturer's instructions. If the manufacturer's instructions are not followed, POE devices may fail and increase the *risk* of *microbial growth* in the building water system. ~~Filters may become fouled and support *microbial growth*.~~ Some filter media, such as activated carbon, ~~consume~~ deplete *disinfectant~~s~~ residuals*.

5.3.4. Routine Flushing

Routine flushing is the *control measure* most often used to help reduce *water age*.

Flushing replaces aging water, in which the level of *disinfectant residual* ~~is~~ declin~~ing~~es with residence time, with newer water; however, reducing *water age* alone does not assure the *control* of *Legionella*. Flushing also helps purge accumulated sediment, deposits 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. Effective flushing can take from a few minutes to many hours, depending on the size of the system, pipe and component size, flow rates, the total volume of water, accumulated sediment, and deposits to be flushed. When flushing, the practitioner should consider use of auxiliary drain valves to facilitate flow through areas of the *building water system* 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.

5.3.5. Hot Water Recirculation

Recirculation is frequently used to maintain consistent water temperatures throughout the building hot water system within a target range (See Section 5.3.1, "Temperature Control", Section 4.2.2.2 "Growth", and Table Figure 4.2.2.2 "Temperature Effects on Survival and *Growth* of *Legionella* in Laboratory Conditions"). In addition to maintaining target temperatures, recirculation helps prevent *water age* relative to uncirculated systems, especially in infrequently or inconsistently used portions of the system.

5.45.3.6 Routine Cleaning and Maintenance

1. Routine cleaning and maintenance of building water system components reduces conditions that are supportive of Legionella growth, such as the accumulation of sediment in water storage tanks andto remove biofilm, bacteria, scale, accumulated sediment, and other deposits are important *Legionella* control measures. However, routine cleaning and maintenance alone does not assure the control of *Legionella*. Examples of *building water systems components* that should be considered for periodic cleaning and maintenance include faucets, showers, water storage tanks, filters, water softeners, electronic faucets, local, and point-of-use mixing valves, water hammer arrestors, and non-flow through expansion tanks.

2. Backflow prevention devices should be installed and maintained in good working order, and should be tested by a qualified technician in compliance with local codes and the authority having jurisdiction.

3. Routine monitoring and repairs of water system equipment and components should be made in a timely manner to address conditions that may contribute to Legionella colonization of system components. However, cleaned components may be recolonized by Legionella that could still be present in the building water systems. Backflow prevention assemblies should be installed and maintained in good working order, and should be tested by a qualified technician in compliance with local codes and the authority having jurisdiction.

4. When turbidity at multiple outlets occurs, it is a visible indication of the increased particulates and potentially increased microbial levels that can result from a variety of water utility system events. consider flushing the building water system until water quality is restored. Examples of causes of turbidity in the water supplied to the building include changes to the water source, water distribution pressure loss and repressurization, water main breaks, water utility construction, and high water usage events such as hydrant flushing and firefighting. Following such a *turbidity* event, consider what, if any, action should be taken, such as flushing the building water system until water quality is restored, applying the guidance in Appendix C to determine is microbial testing is warranted, or if some other remedial action is warranted. Where turbidity events are frequent or the impact from the event is unacceptable, consider the use of point-of-entry devices such as screens and filters. The water utility providing water to the building should be requested to provide notification of any water pressurization event. Examples of the causes for persistent turbidity, when the water supplied to the building is not turbid, include local corrosion of equipment, components, and materials, such as in water pipes, water storage tanks, water heaters, etc.

5.4. Remedial Treatment

The determination of need for *remedial treatment* of potable water, and the selection of any particular treatment, is a complex subject. Improper analysis may result in the use of remedial *disinfectants* or treatments that are not necessary. Inappropriate selection or improper application of remedial *disinfectants* and treatments may be ineffective, may be harmful to building occupants, and may be damaging to building piping and to building water system components, controls, equipment, and fixtures.

Potable water systems colonized by *Legionella* sometimes require may need *remedial treatment*. Even when successful, *remedial treatment* is only a temporary measure. Recolonization is very likely to occur unless the underlying reasons for *Legionella* colonization are addressed, and a proper water management program is implemented.

If a decision is made to implement a remedial *disinfection* method for *Legionella control,* the use of a number of commercially available *disinfectants* and *disinfection* treatments for this purpose are described in the scientific literature. Examples include, but are not limited to, chlorine, chlorine dioxide, monochloramine, copper-silver ions, hydrogen peroxide, ozone, and peracetic acid. This guideline does not endorse or promote any particular *disinfectant*/treatment.

To evaluate the available options, consult available scientific or technical evidence supporting and challenging the *disinfection*'s overall impact on the *building water systems*, on the building occupants and on building operation and personnel. Factors that should be considered when evaluating remedial *disinfection*/treatment options include, but are not limited to:

1. Which systems ~~require~~ need *remedial treatment*: the hot water system, the cold water system, or both the hot and cold water systems?

[. . .]

10. What is the degree of complexity and technical skill necessary to ~~verify~~ confirm the intended *control limits* are being met, for example, the measurement of *disinfectant* concentration at the fixtures?

[. . .]

5.4.1. Chemical Shock

5.4.2. Thermal Shock

[. . .]

Legionella re-colonization levels may rebound to levels higher than pre-treatment. After water temperatures are restored, the surviving *Legionella* are likely to grow because of nutrients released by freshly killed microorganisms.[2,3] Water heaters that provide hot water to the *building water system* frequently are not capable of achieving, maintaining and delivering the volume of water at the temperature necessary to kill *Legionella* throughout the building hot water system. Even if the water heater is capable of providing adequate hot water, it may take extended periods of time and the very-high temperature water may not reach all portions of the system due to factors such as small pipe diameters, system orifices, low flow fixtures and *dead legs.*

5.5. References

1. Beer, K. et al. (2015). Surveillance for Waterborne Disease Outbreaks Associated with Drinking Water – United States, 2011-2012. *MMWR. Morbidity and Mortality Weekly Report*, *64*(31), 842-848.

2. Temmerman, R., Vervaeren, B., Noseda, B., Boon, N., and Verstraete, W. (2006). Necrotrophic Growth of *Legionella pneumophila*. *Applied and Environmental Microbiology*, *72*(6):4323-4328.~~et al. (2006);~~

3. Falkinham, J., Hilborn, E., Arduino, M., Pruden, A., & Edwards, M. (2015). Epidemiology and Ecology of Opportunistic Premise Plumbing Pathogens: *Legionella pneumophila, Mycobacterium avium,* and *Pseudomonas aeruginosa*. *Environmental Health Perspectives*, *123*(8), 749-758.

Modify Section 6 as shown. The remainder of Section 6 is unchanged.

6. ORNAMENTAL WATER FEATURES

[. . .]

6.1. System Description

[. . .]

Water features near sources of heat or in warm climates are more likely to contain water at a temperature within the range favorable to *Legionella growth* (77°F–113°F [25°C–45°C]). Intermittent operation may also create situations where water temperature increases in localized parts of the system. If a water feature is not drained and flushed after use, then the water should be circulated at least daily to maintain distribution of water treatment chemicals, even when the water feature is not being used.

Water features produce *aerosols* with droplets of various sizes, including sizes smaller than 5 microns that can be inhaled deeply into the lungs. Multiple cases and *outbreaks* of *legionellosis* have been associated with fountains that appeared to release little or no *aerosols*, such as small fountains with coarse sprays, cascading features and water walls. However, indoor water features release *aerosols* to a confined environment, where the *aerosols* are not readily diluted or dissipated. Outdoor water features release *aerosols* to an unconfined space, where they can more readily be diluted by fresh air and dissipated by wind.

~~Water features near sources of heat or in warm climates are more likely to contain water at a temperature within the range favorable to *Legionella growth* (25 - 45°C [77 - 113°F]). Intermittent operation may also create situations where water temperature increases in localized parts of the system. If a water feature is not drained and flushed after use, then the water should be circulated at least daily to maintain distribution of water treatment chemicals, even when the water feature is not being used.~~

Water features are subject to contamination from a wide variety of sources, including materials scrubbed from the air and returned to the feature's water by falling water droplets, by organic and inorganic materials dropped, thrown or blown into the fountain and by rust and other materials from the water feature structure, piping and components. Water evaporation concentrates these contaminants and if not cleaned and managed, these contaminants can result in scale accumulation and can support *microbial growth*, including *biofilms*. Exposure of surfaces to light can result in increased algae *growth*. Algae and *biofilm* can support *Legionella growth* in water feature pools~~, and~~ basins, ~~that are less than 1 meter (3.3 feet) deep~~ and on surfaces that may be wetted but not submerged or that may not be wetted continuously.

6.2. System Design/Engineering, Installation, Commissioning

6.3. Operation, Maintenance, and *Legionella* Control Measures

Proper operation and maintenance of a water feature is essential to managing the potential for *Legionella growth* and transmission. A *water management program (Program)*, such as the one contained in ANSI/ASHRAE Standard 188, *Legionellosis: Risk Management for Building Water Systems*[1], should be implemented. The *Program* should contain multiple *control measures* to manage the potential of *Legionella growth* and transmission. Such measures include operating the water feature to avoid elevated water temperature and to *control water age*, cleaning to remove accumulated sediments and *biofilms* and adding *biocides* on a regular basis to suppress *microbial growth*. The *control measures* used should be monitored to confirm they are being maintained within their *control limits*. Design elements, such as encasing the water feature in glass can help block *aerosol* transmission. Additional information is available in *Guidelines for the Control of Legionella in Ornamental Water Features*[2] ~~2005~~, published by the South Dakota Department of Health.

When used, *biocides* should be applied in a manner consistent with product's label and comply with the requirements of the *authority having jurisdiction*. See Appendix B for guidance on US regulations.

The following operation, maintenance and *control measures* are recommended for systems with volumes greater than 25 gallons (~~100~~ 95 liters):

[. . .]

The following recommendations are for water features that have a water volume less than or equal to 25 gallons (95 liters):

1. An *oxidizing biocide* should be manually added to the water to achieve an appropriate *residual*, such as 3 to 5 mg/L free chlorine *residual* for chlorine-based *biocides*, for at least one hour per day.
2. The water feature should be cleaned and disinfected as follows:
   ~~2.~~a. at least monthly or as recommended by the manufacturer when between 5 and 25 gallons (19 and 95 liters);~~.~~
   ~~3.~~b. Water features of less than 20 Liters (5-gal) water volume should be cleaned and disinfected at least weekly or as recommended by the manufacturer when less than 5 gallons (19 liters).
~~4.~~3. Water filters should be serviced and replaced following the manufacturer's recommendations or, in the absence of a manufacturer recommendation, at least monthly.
4. The water feature should be taken out of service if potentially affected parties cannot ~~verify~~ confirm systems are being maintained according to the manufacturer's instructions.
5. Routine microbial testing of bacteria, such as by the heterotrophic plate count (HPC) method or by a dip slide, is an indicator used to estimate microbial content in the water and should be performed when the water feature cannot be maintained consistently. (Note: Heterotrophic bacteria testing does not correlate with the presence or absence of Legionella.)

6.4. References

1. ANSI/ASHRAE Standard 188-2018, *Legionellosis: Risk Management for Building Water Systems*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

2. Legionella Risk Management, Inc. (2005). Guidelines for Control of *Legionella* in Ornamental Water Features. Legionella Risk Management, Inc., Chalfont, PA.

Modify Section 7 as shown. The remainder of Section 7 is unchanged.

7. SPAS

Note: Section 4 - Legionellosis and *Legionella* provides essential context for the practical information and guidance contained in this section. Users of this guideline are encouraged to review the information in Section 4 prior to implementing the guidance in Section 7.

Recreational spas open to the public that are not drained between uses have been recognized as a source of infection and disease resulting from waterborne pathogens, including *Pseudomonas aeruginosa*, *non-tuberculous mycobacteria (NTM)* and *Legionella*. Legionellosis *outbreaks* have frequently been traced to spas.

The water temperature in spas, baths, and whirlpools is are generally in the range of 90°F–104°F (32-40°C), with the maximum temperature based on bather comfort. These water temperatures are within the range most favorable to *Legionella growth* (77°F–113°F [25°C–45°C]) and favorable for *growth* of many other microorganisms. These water temperatures, along with water aeration and a high ratio of the surface area of the bather's body, relative to water volume, accelerate the loss of the *biocide residual*.

Spas operate with high-velocity water recirculation and air injection which create bubbles of varying size that rise to the water surface and then burst, creating a constant *aerosol*. Microorganisms, such as *Legionella* can be released from the water into the air, either via bubbles or *aerosol*. These bubbles and *aerosols* have water droplets of varying sizes, many less than 5 microns, that extend into the air above the water surface to a height of at least 1.5 feet (0.5 meters), well within the breathing zone of the bathers. The *aerosols* can then be carried much further distances by airflow. Indoor spas should be located in rooms with isolated air handlers and include dehumidifiers to maintain relative humidity below 60%, in order to reduce the probability of exposure to individuals outside the immediate spa location.

Spas have a relatively small volume of water per occupant (approximately 300 liters, compared to 50,000 liters in a typical swimming pool), so the bathing load can quickly introduce a variety of contaminants into the water, such as body oils, skin flakes, bacteria and fungi, suntan lotion, and other organic materials. In addition to serving as *microbial* nutrients, these organic materials can also increase in *biocide* demand, which reduces the *biocides'* ability to *control microbial growth*. In surveys of spas, *Legionella* has been found in isolated from as many as 33% of the spas sampled, primarily where the *biocide residual* levels were not adequately maintained.

Therapeutic spas typically are drained, cleaned and filled with fresh potable water between uses and therefore have a lower probability for *microbial growth*.

7.1. System Descriptions

7.2. System Design/Engineering, Installation, Commissioning

[. . .]

4. Routine draining and filling is required needed on a predetermined schedule or interval is recommended. Draining and filling should be designed to be simple and quick.

[. . .]

7. Dehumidification is required recommended to reduce the *aerosol* concentration in the room where a spa is in use.

[. . .]

7.3. System Operation and Maintenance (Routine)

Health *risks* associated with spas are significant. In many jurisdictions, public spas are subject to state and local regulations covering public swimming and bathing facilities. In jurisdictions without such regulations, public spas should comply with recommendations of local government agencies providing oversight. In jurisdictions without such regulations or local agencies, public spas should comply with the *CDC*'s Model Aquatic Health Code or the National Swimming Pool Foundation's *Pool & Spa Operator Handbook* Association of Pool and Spa Professionals' standard ANSI/APSP-11, *American National Standard for Water Quality in Public Pools and Spas*. These guidelines cover all areas of operation, including mechanical specifications and operational parameters such as flow rates, temperature, water chemistry and bacteriology.

7.3.1. Bather Load

7.3.2. Bather Health Restrictions

7.3.3. Filter Operation

Hygienic maintenance of spa filters is generally require more action than is required for more intensive than swimming pool filters because of the higher ratio of the number of bathers to the volume of water in the pool. Health codes typically include recommended flow rates for different filter types.

Filter maintenance should include regular back flushing to remove buildup of organic debris. The required frequency of back flushing is typically determined by manufacturer recommendations (flow-rate requirements) rather than by microbiological criteria. In general, daily back flushing may be required necessary during periods of heavy usage. If back washing is not maintained at the proper frequency, there is increased potential for poor backwashing due to caking of the media or channeling.

Filter cartridges should also be cleaned or replaced on a regular basis, typically once or twice weekly.

Filters are designed to collect sediment and have the potential for *biofilm* and bacteria *growth*. To reduce this potential, water containing the proper level of *disinfectant* should be circulated across the filter. Commercial spas should have constant water flow across the filter (24 hours per day). The system flow rate should not be reduced more than 25% lower than the minimum design requirement and only reduced when the spa is unoccupied. Non-commercial spas generally have lower bather loading, but still have the potential for *biofilm* and bacteria *growth* when *disinfectant* circulation stops when the spa is not in use. Spa operators should establish and maintain at least minimum levels of *disinfectant* in accordance with Table 7.4 prior to startup and during use.

7.4. *Legionella* Control

Below is a table showing some typically recommended *biocide residual control limits*.

TABLE 7.4 Typically Recommended Biocide Residual Control Limits

Biocide Control Measures	Typical Biocide Residual Control Limits
Free chlorine residual (mg/L)	3.0 – 5.0
Bromine (mg/L)	4.0 – 68.0
pH	7.2 – 7.8

Requirements specified by the *authority having jurisdiction* for the use and application of *biocides* should be followed. *Biocides* should be applied in a manner consistent with the product's label. See Appendix B for guidance on US regulations.

Maintaining the required *biocide residual* within the *control limits* is essential for controlling the *growth* of *Legionella* (and other bacteria) in spa water, so the *biocide residual* level should be measured frequently, as often as hourly during periods of heavy use. The best control is provided by automatic systems that continuously monitor *biocide residual* and add *biocide* as needed.

Several alternatives for spa treatment are currently available, including copper/silver ionization, ultraviolet light and ozone. While these treatments may *control Legionella* and other bacteria in pools and spas, there are insufficient data to support their recommendation. Use of alternative *biocides* in combination with chlorine or bromine may decrease chlorine or bromine demand. Pool and spa health regulations may require the use of chlorine or bromine, even if alternative *biocides* are used. Cyanuric acid and stabilized chlorine products should not be used in spas.

7.4.1. Microbial Testing

Regular *microbial testing* of spas can provide an important record of operating conditions and may alert operators of conditions indicating need for review and possible adjustments to the operation and treatment program. *Microbial testing* is not usually required by the *authorities having jurisdiction*. *Microbial* tests results often require up to 24 hours or longer and should only be used to confirm the effectiveness of *disinfection*. *Microbial testing* is not a replacement for frequent *testing* of the water chemistry, nor is it a replacement for routine maintenance. The most common *microbial* test to confirm overall *control* of a spa *disinfection* program is Heterotrophic Plate Count (HPC)~~, also called Total Heterotrophic Aerobic Bacteria (THAB)~~. (Note: ~~THAB~~ HPC does not directly correlate with the presence or absence of *Legionella*.) Listed below are some typical bacteria and bacteria limits useful in spa review.

1. Standard agar ~~Total~~ Heterotrophic ~~Aerobic Bacteria~~ plate count (~~THAB/~~HPC) (at 95°F [35°C]) - < 200 ~~CFU~~ organisms per mL (maximum)
2. Total coliforms - 2 organisms per 100 mL (maximum)
3. ~~Fecal coliforms - None allowable~~

3.~~4.~~ *Escherichia coli* - < 1 ~~CFU~~ organism per 100 mL

4.~~5.~~ *Pseudomonas aeruginosa* (at 41°C) - ~~None allowable~~< 1 organism per 100 mL

5.~~6.~~ *Legionella* ~~species~~ – See Table C5.1 in Appendix C: Microbial Testing for *Legionella*

Where *testing* for *Legionella*, see Appendix C: Microbial Testing for *Legionella* for guidance on proper sampling, handling, and shipping of *Legionella* test samples. HPC is not considered adequate for confirming levels of *Legionella*.

7.5. Routine Maintenance

7.6. Training and Record Keeping

7.7. Remedial Treatment (Non-routine)

When high bacterial counts occur, remove the spa from service and conduct shock *disinfection* with a *biocide* such as chlorine, maintaining 10 ppm free chlorine for 1 hour. When shock *disinfection* is completed, drain the water, clean spa surfaces, service filters, fill with fresh potable water and return the spa to the routine *biocide residual* level before use. If an *outbreak* or illness is suspected[1], remove the spa from service; discuss with the local public health agency; collect water samples as directed by the local public health agency; drain the spa; scrub all spa surfaces; replace filters or filter media; make need repairs; refill the spa; hyper-chlorinate using 20 ppm free chlorine (maintain a minimum of 20 ppm for 10 hours); flush the system, and recollect water samples as directed by the local public health agency. The spa should then be refilled with fresh potable water and the *biocide* level established in accordance with Table 7.4 prior to use. If an *outbreak* or illness was suspected, both *testing* to confirm the source of ~~perform~~ *Legionella* and *testing* before and after remediation to confirm potential source and elimination of *Legionella* is suggested.

Modify Section 8 as shown. The remainder of Section 8 is unchanged.

8. OPEN-CIRCUIT COOLING TOWERS, CLOSED-CIRCUIT COOLING TOWERS, AND EVAPORATIVE CONDENSERS

Note: Section 4 - Legionellosis and *Legionella* provides essential context for the practical information and guidance contained in this section. Users of this guideline are encouraged to review the information in Section 4 prior to implementing the guidance in Section 8.

Evaporative heat rejection systems use circulating water to efficiently cool chillers, heat pumps, compressors, condensers, heat exchangers, and other process devices. The heat transferred to the circulating water from process devices is rejected to the atmosphere through evaporation in open-circuit cooling towers, closed-circuit cooling towers, and evaporative condensers. The circulating water is continuously replenished with supply water.

Open-circuit cooling towers, closed-circuit cooling towers, and evaporative condensers are collectively referred to as evaporative heat rejection equipment, or often simply as cooling towers. Other components ~~equipment~~ in evaporative heat rejection systems includes pumps, valves, ~~and~~ water treatment devices, and possibly remote sumps/drop tanks.

~~Evaporative heat rejection systems have been linked to Legionnaires' disease.~~ *Growth* and transmission of *Legionella* in evaporative heat rejection systems is linked to the quality of the supply water and circulating water.

Issues associated with *Legionella* include contamination with bacteria and/or solids, have been associated with system design and maintenance practices, periods of intermittent operation, systems that are idle without draining, and periods when water treatment is stopped or is absent, and contamination of supply water.

8.1. Description of Systems

8.1.1. Open-Circuit Cooling Tower Systems

Principles of Operation. An open-circuit cooling tower cools water by evaporating a part of the water through direct contact with atmospheric air. Air movement through the tower is usually achieved by fans, although some large cooling towers rely on natural draft for air movement.

Open-circuit cooling towers associated with *building water systems* are typically used to reject waste heat from the condenser of chillers providing building air conditioning, as well as process equipment such as air compressors, surface condensers, cogeneration heat exchanges, etc. Water from the cooling tower is circulated to the chiller where it is heated and then returned to the cooling tower to be cooled (Figure 8.1.1).

Open-circuit cooling towers commonly use media, referred to as "fill", to improve contact between the water and the air. Louvers are often employed at the tower air inlet to keep water from splashing out of the water collection basin. Inertial stripping devices called *drift* eliminators are installed at the air discharge to minimize the escape of water droplets (*drift*) from the tower. The effectiveness of these *drift* eliminators can vary significantly based on design and physical condition. High efficiency *drift* eliminators designs are recommended and defined as achieving *drift* reduction equal to or less than 0.002% of the circulating water volume for counterflow equipment and equal to or less than 0.005% for crossflow equipment.

Building potable water is typically used to initially fill the system and as make-up water, although alternate water sources, such as reclaimed water and air conditioning condensate are increasingly used. As cooling tower water evaporates, mineral ions in the remaining water become more concentrated. This concentration of potentially scale-forming or corrosive ions is managed through a controlled *bleed*. Make-up water is added to replace water lost through evaporation, *drift*, and *bleed*, and other losses.

[. . .]

8.1.2. Closed-Circuit Cooling Tower Systems

[. . .]

Water System Volume. Most commonly, there is no external cooling water piping in these systems. Because the water is totally contained within the closed-circuit cooling tower unit, the volume of water is usually significantly lower than with open-circuit cooling tower systems. The smaller volume of water reduces the amount of treatment chemical required to operate these systems. If the closed-circuit cooling tower system includes external piping, remote sumps, equalizers, headers and other water-containing components, the water volume can be similar to open-circuit cooling towers, from an operating and treatment perspective.

8.2. Guidance

This section contains information on preplanning, design, operation, start-up, shut-down, commissioning, and remedial actions related to *legionellosis risk management* in evaporative heat rejection systems.

8.2.1. Design

Good design practices facilitate proper system maintenance and water treatment. It is important to maximize mass transport and minimize accumulation of water based solids, airborne contaminants and bio-matter. Design guidelines include:

[. . .]

8. When variable speed pumps are incorporated, the system should not be allowed to fall below the minimum flow rate recommended by the equipment manufacturer to maintain cleanliness. The minimum flow rate through heat exchangers, such as the chiller condenser, should not fall below 3 feet per second (0.90 meters per second) for extended periods of time to avoid deposition of contaminants.

[. . .]

8.2.2. Cooling Tower Siting

8.2.3. Temperature Strategies

8.2.4. Water Management Program

[. . .]

A properly designed *Program* utilizes both operational and water treatment methods. The *Program* should consider materials of construction, local water supply qualitychemistry, variations in supply water quality, operating environment, cooling system type, cooling system load, cooling system *risk* characterization, and industry standard performance metrics. The *Program* should provide confirmation that it is being implemented as designed (*verification*) and that it is effectively preventing minimizing fouling, controlling corrosion, *Legionella* and other bacteria, and *biofilm growth* in the system (*validation*). Establishing a *Program* requires an understanding of cooling water treatment and experience in developing such *Programs*.

[. . .]

8.2.4.1. Operational Methods

1. **Blowdown (Bleed-Off) Control:** *Control* of the *cycles of concentration* is required necessary to achieve water treatment objectives. Automated control systems should be employed.

   Note: The *cycles of concentration* should be calculated using a stable species in the recirculating water system that is not either increased or reduced due to scaling or water treatment protocols. Alternatively, the make-up water and *blowdown* volumes can be measured to calculate the *cycles of concentration*, which in this case would be the ratio of the make-up water volume to the *blowdown* volume.

2. **Filtration:** Depending on factors such as supply water quality, the location of the tower, the level of maintenance personnel available, and particle load, filtration can be of benefit on some cooling tower installations. Filtration should be properly sized and installed to reduce the level of suspended solids in the water. When selecting the type of filtration, consideration should be given to particle load, particle size as well as manpower availability. Proper maintenance of the filtration system is essential. The filtration system should be installed to ensure proper flow and movement of water in the tower basin to minimize accumulation of deposits in low flow zones. Properly designed and installed Bbasin sweepers piping and nozzles can improve the effectiveness of removing visible suspended solids and help minimize accumulation of deposits in low flow zones of the cooling tower basin. the water filtration system.

3. **System Cleaning:** Keeping the system clean helps reduce *microbial* populations by preventing the harboring of organisms inside crevices and deposits. The frequency of physical cleaning will vary depending on operational factors. An annual offline cleaning and *disinfection* is recommended as a minimum frequency.

8.2.4.2. Chemical Water Treatment Methods

8.2.4.2.1. Scale, Corrosion and Sediment Control:

1. Scale control programs are designed to maintain the solubility of scale forming impurities. This may can be achieved with careful *control* of pH or and the addition of scaling threshold-inhibitors, crystal modifying polymers, and polymeric dispersants.
2. Corrosion can be reduced by the addition of corrosion inhibitors selected for the site-specific system metallurgies and water quality. Understanding system metallurgy, flow velocity and water chemistry will help in the selection dictate the type of inhibitors. Use of a synergistic combination of inhibitors will can provide multi-metal protection of the cooling water system.
3. Dispersant polymers are used to inhibit particulates from adhering on system surfaces. Many scale and corrosion inhibitor formulations contain a dispersant as a component of the product. The amount and type of a dispersant polymer required is dependent on the available water quality, amount and type of dirt, oil, or other potential contaminants which may be material that is present.
4. An automated chemical feed system should be used to ensure that these additives are maintained within their target *control* range.

8.2.4.2.2. Microbial Control: The two primary components for microbiological *control* are *oxidizing biocides* and *non-oxidizing biocides*. Feed strategy should ensure intended *biocide* levels at all times, including standby periods (see Section 8.2.6, “System Standby and Shut-down”).

1. **Oxidizing biocides:** *Oxidizing biocides control microbial* population by their ability to oxidize organic matter. Oxidants break down *microbial* cell walls, penetrating the cell and *oxidizing* internal cellular structures. The relatively short half-life of *oxidizing biocides* may require multiple daily doses or automated dosing to maintain measurable *residuals* of free halogen throughout the day. While there are various *oxidizing biocides*, Tthe most commonly used *oxidizing biocides* for cooling water treatment are chlorine and bromine.
2. **Non-oxidizing biocides:** *Non-oxidizing biocides* function in a number of ways, including reacting with intracellular enzymes, solubilizing cell membranes, and precipitating essential proteins in *microbial* cell walls. These *biocides* for cooling water application include many organic compounds that are effective at specific concentrations for a specific period of contact time. The most commonly used *non-oxidizing biocides* include glutaraldehyde, dibromo-nitrilo-propionamide, isothiazolones and various organo sulphur compounds.

   In addition to *microbial control* agents (*biocides*), *dispersants* are also may be used to enhance the performance and increase the effectiveness of the *biocides* by maintaining deposit-free and clean surfaces helping minimize deposits and *biofilm* within the cooling system.

   The use and application of *Bbiocides* should follow the requirements for their use and application specified by the *authority having jurisdiction*. *Biocides* should be applied in a manner consistent with the product's label. See Appendix B for guidance on US regulations.

   In most some jurisdictions, *biocide* use is regulated and products must be registered. In many jurisdictions, an applicators license or certification is required for the person applying or company supplying the products.

8.2.4.3. Non-chemical and Physical Water Treatment Methods & Equipment:

Non-chemical and physical water treatment methods and equipment may be used in addition or as an are potential additions or alternatives to chemical programs for water treatment in certain cooling water loops. Integrating these alternative technologies into a *water management program* requires compliance with manufacturers' recommendations and instructions. More detailed information about individual technologies is available in the *2015 ASHRAE Handbook - HVAC Applications*. Such alternative technologies should be subject to the same confirmation that they effectively *control* the *hazardous conditions* (*validation*) as a chemical water treatment program.

8.2.5. Miscellaneous Guidelines

8.2.6. System Standby and Shut-down

Evaporative heat rejection systems may require a be "shut down", in whole or in part, for a variety of reasons such as: physical cleanings, system maintenance, low cooling load, redundant design or off season operation. Whenever a system is required to be offline, one of the following conditions will apply:

a. **Standby (Wet):** Whenever the system is shut down or out of service or when portions of the system are nonoperational for less than 5 days, without draining the water, the following actions should be taken:
   1. Maintain the system's water treatment program (*microbial*, corrosion and scale/sediment *control*), along with normal *monitoring* practices. When an automated *biocide* program is in use, adjustments to the feed program may be required necessary to ensure the *biocide* is added while the system is circulating, and not skipped once the system is in standby.
   2. Circulate water at least three times a week daily throughout the open loop of the closed-circuit cooling tower and the entire open-circuit cooling system, including any basin sweeping and filtration systems. This periodic circulation will help restore *control* of water treatment parameters and help *control* biological *growth*.

[. . .]

8.2.7. System Startup

Prior to returning an idle or wet stored a system in wet standby or dry shutdown to service, the manufacturer's recommendations and instructions for inspection and cleaning should be followed. If filtration or separators are present, the manufacturer's recommendations and instructions should be followed.

[. . .]

8.2.8. New System Commissioning

8.2.9. Online ~~Remedial Treatment/~~ and Offline ~~Emergency Cooling Water System~~Cleaning and Disinfection

The following online and offline cleaning and *disinfection* procedures may be utilized as part of a *water management program* contingency plan, typically as a tiered response, or as part of a routine system maintenance and operation schedule. The procedures below may be described with different terminology by other documents or *AHJs*. These procedures may require modification based on system operating requirements or limitations, system water volume or water availability, and wastewater treatment or discharge capabilities. Consult a water treatment professional for guidance on applying these procedures. Workers engaged in online and offline cleaning and *disinfection* should follow the guidance provided in Appendix D, "Guidance on Personal Protective Equipment for use when there is Risk of Exposure to Contaminated Aerosols." ~~When remedial online or offline disinfection actions are required, the cooling system should be considered as a whole. Mechanical cleaning of all components of the cooling system may need to be applied as practical.~~

8.2.9.1 Online Remedial Treatment

Online *remedial treatment* of a cooling water system may require the use of an alternate *biocide* or higher-than-usual concentrations of the existing *biocide*. The decision to use online *remedial treatment* may be determined by *microbial* test results as described in Section 8.3. In general, online *remedial treatment* includes the following steps:

1. Increase the dosage of the current *biocide(s)* or introduce a different *biocide*. *Biocides* may be applied as a one-time slug dose or at an elevated level for a defined period of time.
2. Continue routine water treatment.
3. Re-test according to your *water management program*.

~~8.2.9.1~~8.2.9.2 Online ~~Remedial Treatment~~ Disinfection

Online ~~remedial treatment~~ *disinfection* of a cooling water system~~s~~ typically requires the use of an *oxidizing biocide* at higher-than-usual concentrations. Online *disinfection* may be part of the system startup protocol or a routine system maintenance and operation schedule as called for in the *water management program*. The decision to use online *disinfection* may also be ~~driven~~ determined by *microbial* test~~ing~~ results as described in Section 8.3, "*Legionella* Testing", or when the procedure above is not effective. In general, online ~~remedial treatment~~ *disinfection* ~~should~~ includes the following steps:

1. Review current water treatment program (cleanliness, maintenance, *biocide* program).
~~1. Disengaging all water treatment components, including the conductivity sensor, pH sensor, ORP sensor, automated chemical feed systems and any other water treatment control sensor.~~
2. Confirm~~ing~~ where practical that the fill pack and *drift* eliminators are ~~clean~~ free of debris and in good working condition. ~~Fill should be free of debris.~~ If significant biomass or fouling is present, schedule an offline cleaning and *disinfection*.
~~4.~~3. Circulate ~~W~~water ~~should be circulated~~ through all ~~associated~~ system equipment, including any bypass or standby components. ~~If significant biomass or fouling is present, all associated system equipment should be physically (mechanically) or chemically cleaned.~~
~~5.~~4. If necessary, reduce the *cycles of concentration* to achieve and maintain a pH of less than 8.0 for chlorine-based *disinfectants* or less than 8.5 for bromine-based *disinfectants* as possible. ~~Lowering the system *cycles of concentration* to reduce system pH that improves the effectiveness of *oxidizing biocide* treatment, particularly chlorine.~~
5. Add~~ing~~ an *oxidizing biocide* sufficient to achieve a *biocide residual* of at least ~~>~~5.0 mg/L ~~of~~ as free ~~*biocide residual*~~ available oxidant and maintain~~ing~~ that level for a minimum of five~~one~~ hours.
~~4.~~6. Re-test according to your *water management program*.
~~7. Blowing down the system until the *biocide residual* level is 1.0 mg/L or lower.~~

8. ~~Re-engaging all water treatment components, including the conductivity sensor, pH sensor, ORP sensor, automated chemical feed systems and any other water treatment control sensor.~~
9. ~~Restoring routine treatment.~~

8.2.9.3 Offline Cleaning and Disinfection

Offline cleaning and *disinfection* of a cooling water system typically requires the use of an *oxidizing biocide* at higher-than-usual concentrations and mechanical cleaning of the system. Offline cleaning and *disinfection* may be part of the system startup protocol or a routine system maintenance and operation schedule as called for in the *water management program*. The decision to use offline cleaning and *disinfection* may be also determined by *microbial* test results as described in Section 8.3, or when other procedures described above are not effective. In general, offline cleaning and *disinfection* includes the following steps:

1. Review current water treatment program (cleanliness, maintenance, *biocide* program).
2. Remove heat load from the cooling system. Shut off fans associated with the cooling tower. Disengage all automated chemical feed and control equipment.
3. Shut off system *blowdown* and keep makeup water valves open and operating.
4. Close building air intake vents near the cooling tower, especially those downwind, until after the cleaning procedure is complete.
5. Circulate water through all system equipment including any bypass or standby components.
6. Add an *oxidizing biocide* sufficient to achieve a *biocide residual* of at least 10 mg/L as free available oxidant.
7. Add an appropriate *dispersant* and apply antifoam, if needed. Apply appropriate corrosion inhibitors.
8. If necessary, reduce the *cycles of concentration* to achieve and maintain a pH of less than 8.0 for chlorine-based *disinfectants* or less than 8.5 for bromine-based *disinfectants* as possible.
9. Maintain a free available oxidant *residual* of 5 mg/L for a minimum of five hours. Shorter contact times can be effective at higher concentrations.
10. Drain the system after the *disinfection* period to the sanitary sewer following all applicable rules, regulations, and permits that may be required by the *AHJ*.
11. Physically clean all reasonably accessible associated system equipment. Consideration should be given to all associated equipment, including cooling tower fill pack and *drift* eliminators, equalizer lines, remote sumps, basins, strainers, chillers, free cooling heat exchangers, and all system equipment including any bypass or standby components.
12. Refill the system and circulate water through all system equipment including any bypass or standby components.
13. Add an *oxidizing biocide* and maintain a free available oxidant *residual* of at least 10 mg/L for one hour.
14. Drain the system after the *disinfection* period to the sanitary sewer following all applicable rules, regulations, and permits that may be required by the *AHJ*.
15. Refill the system. Return all chemical feed and control equipment to normal operation, consider repassivation of system metallurgies and resume water treatment. Reopen any closed building air intake vents.
16. Retest according to your *water management program*.

~~8.2.9.2~~8.2.9.4 Offline Emergency ~~Cooling Water System~~ Cleaning and Disinfection

Offline emergency cleaning and *disinfection* of a cooling water system typically requires the use of an *oxidizing biocide* at higher-than-usual concentrations and mechanical cleaning of the system. ~~The following off-line remedial treatment procedure is based on United Kingdom HSG 274 and other governmental recommendations.~~ The decision to use offline emergency cleaning and *disinfection* may be determined by *microbial* test results as described in Section 8.3, when other procedures described above are not effective, or when there is a suspected association of disease with the cooling water system.~~It is typically used when there is a suspected association of disease with the cooling water system.~~ In general, offline emergency cleaning and *disinfection* includes the following steps: ~~This procedure may require modification based on system volume, water availability and wastewater treatment capabilities.~~

1. Review current water treatment program (cleanliness, maintenance, *biocide* program).

~~1.~~2. Remove heat load from the cooling system~~, if possible~~. Shut off fans associated with the cooling tower. Disengage all automated chemical feed and control equipment.

~~2. Shut off fans associated with the cooling equipment.~~

3. Shut off ~~the~~ system *blowdown*~~.~~ and ~~K~~keep makeup water valves open and operating.

4. Close building air intake vents in the vicinity of near the cooling tower, especially those downwind, until after the cleaning procedure is complete.

5. Circulate water through all system equipment, including any bypass or standby components.~~Continue to operate the recirculating water pumps.~~

6. Add an *oxidizing biocide* sufficient to achieve a *biocide residual* of at least ~~an initial level of >~~20 mg/L as free available oxidant. ~~of free halogen *residual*~~

7. Add an appropriate *dispersant* and apply antifoam, if needed. Apply appropriate corrosion inhibitors.

8. If necessary, reduce the *cycles of concentration* to achieve and maintain a pH of less than 8.0 for chlorine-based *disinfectants* or less than 8.5 for bromine-based *disinfectants*, as possible.

~~8.~~9. Maintain a free available oxidant *residual* of 10 mg/L for a minimum of 24 hours. Shorter contact times can be effective at higher concentrations. ~~for the specified time listed in Table 8.2.9. Add *biocide* as needed to maintain the appropriate free oxidant *residual* for the minimum time listed.~~

~~9. Monitor the system pH. Since the rate of oxidizing *disinfection* often slows at higher pH values, acid may be added, or the *cycles of concentration* can be reduced to achieve and maintain a pH of less than 8.0 for chlorine-based *disinfectants* or less than 8.5 for bromine-based *disinfectants*.~~

10. Drain the system after the *disinfection* period to the sanitary sewer, following all applicable rules, regulations, and permits~~, to a sanitary sewer~~ that may be required by the *AHJ*.

~~11. Refill the system and repeat steps 1 through 10, before continuing to step 12.~~

~~12. Inspect the system after the second drain-off. If a *biofilm* is evident, repeat steps 1 through 10 and refill the system until no *biofilm* is evident.~~

11. Physically clean all reasonably accessible associated system equipment. Consideration should be given to all associated equipment, including cooling tower fill pack, *drift* eliminators, equalizer lines, remote sumps, basins, strainers, chillers, free cooling heat exchangers, and all system equipment, including any bypass or standby components.~~When no *biofilm* is evident, mechanically clean the tower fill, tower supports, cell partitions, and sump. Workers engaged in tower cleaning should follow the guidance provided in Appendix D, "Guidance on Personal Protective Equipment for use when there is Risk of Exposure to Contaminated Aerosols".~~

12. Refill the system and circulate water through all system equipment including any bypass or standby components.

13. Add an *oxidizing biocide* and maintain a free available oxidant *residual* of at least 10 mg/L for one hour.

~~14. Refill and recharge the system to achieve a 5 mg/L *disinfectant residual*. Hold this *residual* for one hour and then drain the system until free of visible *turbidity*.~~

14. Drain the system after the *disinfection* period to the sanitary sewer following all applicable rules, regulations, and permits that may be required by the *AHJ*.

15. ~~and r~~Refill the system. Return all chemical feed and control equipment to normal operation, consider repassivation of system metallurgies, and resume water treatment.~~, then add the appropriate corrosion and deposit control chemicals, reestablish normal *disinfectant residuals* and put the cooling tower back into service.~~

~~15.~~16. Retest according to your *water management program*.

~~TABLE 8.2.9 MINIMUM CONCENTRATION LEVEL PER CIRCULATION TIME~~[2]

~~Minimum Circulation Time (Hours)~~	~~Minimum Continuous Free Oxidant Residual (mg/L)~~
~~5~~	~~5~~
~~2~~	~~25~~
~~1~~	~~50~~

8.3. *Legionella* Testing

Legionella testing can be used to confirm the *Program* is controlling *Legionella growth*. Trending of *Legionella* bacteria population through *testing* provides a direct indicator of the effectiveness of *Legionella control* activities. *Testing* is not a substitute for a *water management program*, but can be included as part of an analysis of potential *hazardous conditions*, and to ~~validate~~ confirm the efficacy of remediation methods. Decisions regarding whether to test for *Legionella,* determining *testing* frequency and interpretation of test results vary based on numerous site specific conditions, including, but not limited to supply water quality, equipment type, use patterns, environmental conditions, individuals served and other *risk* factors. See Appendix C: Microbial Testing for *Legionella*, for guidance on *Legionella testing* and circumstances where *Legionella testing* may be appropriate.

Based on remedial confirmation, further maintenance, including mechanical cleaning of other points within the system may be ~~required~~ necessary.

Modify Section 9 as shown. The remainder of Section 9 is unchanged.

9. DIRECT EVAPORATIVE AIR COOLERS, MISTERS (ATOMIZERS), AIR WASHERS, AND HUMIDIFIERS

[. . .]

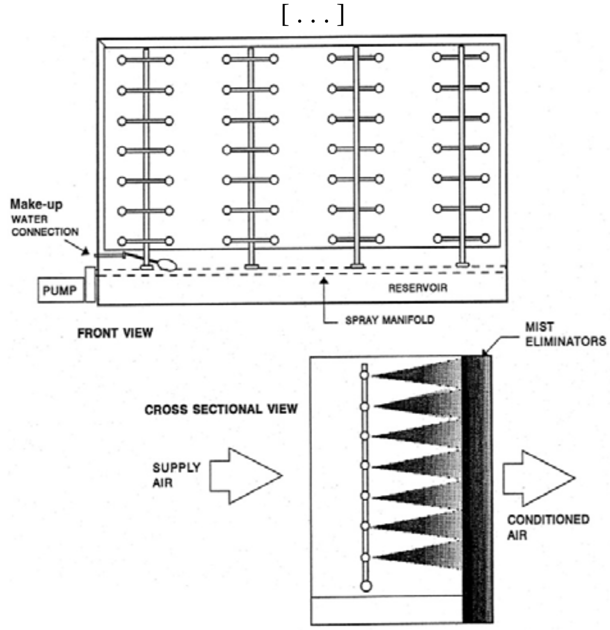


Figure 9b. Single bank air washer humidifier.

Note: For clinical use of adiabatic atomizing humidifiers, humidifier water should be treated according to the requirements of Section 6.6.3, "Adiabatic Atomizing Humidifier Requirements" of ANSI/ASHRAE/ASHE Standard 170, *Ventilation of Health Care Facilities.*

9.1. System Description

There are many different types and designs of equipment in the category "Direct evaporative air-cooling equipment and humidifiers". ~~Some types~~ Types that by design induce evaporation of water by generating small droplets or *aerosols* have been linked to cases of Legionnaires' disease.~~, while others have not been associated with cases of Legionnaires' disease.~~ Care should be taken with all types of evaporative air cooling and humidification equipment to avoid the possibility of transmission of *Legionella* bacteria.

9.1.1. Wetted Media

9.1.2. Air Washers

9.1.3. Misters

[. . .]

The use of a *biocide* registered for mister applications may be applied to *control microbial growth* within the system in accordance with the *AHJ*, the manufacturer's recommendations, and the materials of construction.

Note: Clinical equipment such as nebulation devices and ventilators should be rinsed and dried after use and filled only with sterile water. Devices should be cleaned between uses as directed by the manufacturer.

[. . .]

9.2. Fixed Equipment Siting

Evaporative air coolers/humidifiers should not be located near the outlet of a cooling tower, fluid cooler, evaporative condenser, kitchen exhaust, or any other source of organic contamination. Air filtration upstream of the evaporative air cooler/humidifier is recommended when particulate contamination is expected. If air filtration is located downstream of the equipment it must be a sufficient distance away to allow absorption of moisture into the air stream. For more information, see ANSI/ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*, Section 5.10, "Drain Pans" and Section 5.13, "Access for Inspection, Cleaning, and Maintenance", and ANSI/ASHRAE/ASHE Standard 170, *Ventilation of Health Care Facilities*, Section 6.3, "Outdoor Air Intakes and Exhaust Discharges".

Note: For clinical use of adiabatic atomizing humidifiers, humidifier water should be treated according to the requirements of Section 6.6.3, "Adiabatic Atomizing Humidifier Requirements" of ANSI/ASHRAE/ASHE Standard 170, *Ventilation of Health Care Facilities.*

9.3. Fixed Equipment System Operation, Routine Maintenance and Microbial Control

Evaporative air coolers/humidifiers, air washers, misters, and ancillary equipment should be regularly cleaned and maintained. Dead-end piping, low spots, and other areas where water may stagnate during shutdown should be eliminated. Water filters and air filters should be cleaned when appropriate based on service loading and manufacturer's recommendation.~~ as required.~~ In every case, a regular schedule for cleaning and flushing the entire system should be maintained.

[. . .]

Modify Section 10 as shown. The remainder of Section 10 is unchanged.

10. INDIRECT EVAPORATIVE AIR COOLERS

[. . .]

10.1. System Operation

[. . .]

The open loop recirculating water temperature in an IEC is dependent on the heat load and climate, similar to the recirculating loop temperature in evaporative heat rejection devices. ~~When operating, the recirculating water temperature in IEC systems is generally below the range favorable to *Legionella growth* (25-45°C [77-113°F]), because the water comes close to the wet-bulb temperature of the airstream to which it is exposed, which in most regions where these devices are used is well below 77°F (25°C).~~ In many cases, the recirculating water temperature will be below 77°F (25°C). However, the recirculating water temperature can be in a range favorable to *Legionella growth* (77–113°F [25–45°C]) during significant parts of the operating cycle. As such, the IEC should be treated as traditional evaporative heat rejection equipment. Refer to Section 8 for guidance on siting, *disinfection*, water *testing*, the need for mist eliminators, maintenance, etc.

[. . .]

10.2. Siting

Indirect evaporative air coolers should not be located near the outlet of a cooling tower, fluid cooler, evaporative condenser, kitchen exhaust, paint booth, incinerator, or any other source of organic matter. The open loop discharge of these devices should not be located near building air intakes, operable windows, etc. (Refer to Section 8.2.2 for guidance). For more information, see ANSI/ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*, Section 5.10, "Drain Pans" and Section 5.13, "Access for Inspection, Cleaning, and Maintenance" and ANSI/ASHRAE/ASHE 170, *Ventilation of Health Care Facilities*, Section 6.3, "Outdoor Air Intakes and Exhaust Discharges".

Modify Section 11 as shown. The remainder of Section 11 is unchanged.

11. COOLING COILS AND CONDENSATE COLLECTION

11.1. System Description

11.2. Siting

11.3. System Operation and Maintenance (Routine)

[. . .]

11.3.1. Treatment

UV *disinfection* can be an effective method for maintaining coils free of organic *growth*, however, UV *disinfection* alone is not a substitute for best practices for coil and condensate pan maintenance. For more information, refer to the 2015 ASHRAE Handbook, *HVAC Applications*: Chapter 8, "Health Care Facilities"; and Chapter 60, "Ultraviolet Air and Surface Treatment". *Biocide* treatment can be used to *control* slime in drain pans and to help prevent clogging of drains. *Biocide* use is not a substitute for proper drain design and cleaning. *Biocides* should be approved for this use by the *authority having jurisdiction*, and should be applied in compliance with the instructions on the manufacturer's label. See Appendix B for guidance on US regulations.

Modify Section 12 as shown. The remainder of Section 12 is unchanged.

12. OTHER BUILDING WATER SYSTEMS WHERE *LEGIONELLA* MAY GROW

Note: Section 4 - Legionellosis and *Legionella* provides essential context for the practical information and guidance contained in this section. Users of this guideline are encouraged to review the information in Section 4 prior to implementing the guidance in Section 12.

In the absence of *control*, *Legionella* can grow in almost any system or equipment containing non-sterile water at temperatures conducive to *Legionella growth* (See Section 4). When establishing a *water management program (Program)*, particularly where *at-risk individuals* may be exposed, evaluate all building systems and equipment that contain or utilize water, to determine under what conditions their use or disuse may result in *growth* and transmission of *Legionella* and then follow the principles provided in Guideline 12. The following are examples of systems and other locations where *Legionella* may grow:

1. Storage and use of recycled water (gray water, etc.)
2. Collection, storage, and use of rain water
3. Storage and use of ground water
4. Storage of water to supplement high demand or for emergency use
5. ~~Safety showers and eyewash stations~~

6.5. Lawn sprinklers and irrigation systems
7. Undrained water hoses, including hoses used for fire suppression
8.6. Solar water heating systems
7. Examples of other locations where *Legionella* may grow:
   a. Undrained water hoses, including hoses used for fire suppression
   b. Machine and metal working lubrication and coolant systems
   c. Safety showers and eyewash stations
   d. Spray washers
   e. Dental water units, including ultrasonic water scalers
   f. Medical devices, such as CPAP machines, bronchoscopes, heater-cooler units
   g. Ice machines
9. Machine and metal working lubrication and coolant systems
10. Spray washers
11. Dental water units, including ultrasonic water scalers

Modify Appendix C as shown. The remainder of Appendix C is unchanged.

APPENDIX A—BIBLIOGRAPHY

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Modify Appendix C as shown. The remainder of Appendix C is unchanged.

APPENDIX C—TESTING FOR *LEGIONELLA* IN BUILDING WATER SYSTEMS (ENVIRONMENTAL TESTING)

Note: Section 4 - Legionellosis and *Legionella* provides essential context for the practical information and guidance contained in this section. Users of this guideline are encouraged to review the information in Section 4 prior to implementing the guidance in Appendix C.

[. . .]

C1. SAMPLE SELECTION, COLLECTION, AND TRANSPORT

[. . .]

Criteria for determining the volume of a water sample collected for *Legionella testing* include the type of sample to be analyzed, such as potable, cooling tower or whirlpool spas, and the method of analysis, such as culture or PCR. For culture *testing*, potable water samples generally contains fewer *Legionella* bacteria than other types of samples, so collection of a larger volume of water is recommended in order to enable the laboratory to concentrate the sample before *testing*. Because the number of bacteria in *non-potable* water samples from open systems, such as cooling towers and whirlpool spas, is generally higher than in potable water samples, concentration of *non-potable* water samples by the laboratory prior to *testing* is not always necessary. As general guidance, a 250-mL sample volume for routine *monitoring* of water systems is sufficient, while a 1-liter sample volume is typically taken for investigative sampling such as during an *outbreak*. The laboratory should be ~~consulted for~~ told the reason for *testing*; for example, routine *testing* or case investigation. The laboratory can then provide specific recommendations about sample size for the water sample type.

[. . .]

C2. *LEGIONELLA* TESTING LABORATORIES

If a choice is made to test for *Legionella*, it is recommended that tests be conducted by a laboratory that is accredited by a regional, national, or international accrediting body, according to a nationally or internationally recognized standard that, at a minimum, requires the use of revision controlled standard operating procedures for *testing*, documentation of the performance characteristics of tests, periodic proficiency *testing* and periodic independent audits verifying compliance. An example of such a recognized standard is ISO/IEC 17025:2015. The routine method of *testing* for *Legionella* in *building water system* samples utilized should be included in the laboratory's scope of accreditation. It is recommended that the laboratory chosen is capable of detecting all members of genus *Legionella*, identifying *L. pneumophila* serogroup 1, and retaining isolates for further typing by public health authorities. If *testing* for a disease investigation, the laboratory should be able to determine the species of *Legionella*.

C3. *LEGIONELLA* TEST METHODS

If a decision is made to use *testing*, a variety of test methods may be used to evaluate the distribution of *Legionella* in *building water systems*. The selection of a suitable test method may depend on both the type of *building water system* tested and the reason for *testing*. For example, a method for detecting viable cells, such as culture *testing*, may be preferred when evaluating *Legionella growth* trends in a *building water system*, even though culture tests do not give immediate results ~~are not quickly available~~. In another example, when evaluating whether remediation of a *building water system* was successful, it may be more useful to use a test method with quick turnaround time, such as PCR *testing*. If a comprehensive examination of *building water systems* is needed, it may employ more than one test method. During an investigation, *CDC* and most other public health authorities recommend using a test method capable of detecting all species of *Legionella* and providing material for typing. This section discusses ~~advantages and limitations of the~~ most commonly used *Legionella* test methods and new variations on such methods. For routine *testing*,~~. C~~ consult with the *testing* laboratory to assist with selection of the most appropriate test method, proper sample collection and transportation and for explanation of test results and units. Any test method should be validated against a standard method by a third party to determine accuracy and precision (sensitivity and specificity).

C3.1. Culture

Culture is a broad term for procedures that involve growing bacteria on artificial media. Culture methods have historically been the most frequently used test methods to determine whether *Legionella* are detectable in a sample. the most frequently used test method to determine whether there are detectable levels of viable *Legionella* bacteria in a sample. Culture *testing* has advantages over other *microbial* test techniques, because it can discriminate between live and dead organisms. Traditional *CDC* and ISO culture-based *testing* is performed by placing a portion of the sample on a solid media plate and it can detect all *Legionella* species and serogroups, including those not previously recognized. Most laboratories use some variation of the US-CDC *Procedures for Recovery of Legionella from the Environment (2005)* or ISO 11731, *"Water Quality – Enumeration of Legionella"* culture methods (traditional methods), but details, such as sample volumes, plate types and resuspension methods procedures may differ between laboratories.[4, 5] The ability to detect reliably and accurately identify and count *Legionella* by traditional culture in a given sample is dependent on several factors, including, but not limited to, the method of collection and transport, sample processing methods procedures, and the skill, experience, and procedural rigor of the , and laboratoryexperience.[6,7] Some stressors can cause *Legionella* to enter a state where it can still cause disease, but is not detected by culture test methods. *Legionella* that enter this state are called viable but non-culturable (VBNC).

A study by the US-CDC Environmental *Legionella* Isolation Techniques Evaluation (ELITE) Program indicates that inter-laboratory identification and counting errors in *Legionella* culture-based methods may be high.[8] *Legionella* culture test results are highly dependent upon the skill, experience, and procedural rigor of the laboratory. Final results from culture tests typically are reported in colony forming units (CFU) per volume (milliliter or liter). The generally accepted reported limit of detection is about 10 CFU/mL, regardless of how much sample volume was is tested.[8] Emerging variations on culture-based methods that are not derived directly from US-*CDC* or ISO methods include, but are not limited to:

1. **Bacterial Enzyme.** Bacterial enzyme culture method detects *L. pneumophila* serogroups by using a specialized substrate in a liquid growth medium. Results are reported in Most Probable Number (MPN) per mL. The limit of detection is reported to be about 1 MPN/100 mL.[12,13,14]
2. **In-field Inoculation.** In-field inoculation method detects all *Legionella* species and serogroups, including those not previously recognized. It utilizes solid media secured on "dip-slides" (agar on a paddle) that are inoculated with (dipped in) the water sample in the field prior to shipping to a test laboratory for analysis.[6] Results are reported in CFU/mL. The generally accepted limit of detection is the same as traditional culture methods, about 10 CFU/mL.

Some stressors can cause *Legionella* to enter a state where it can still cause disease, but is not detected by culture test methods. *Legionella* that enters this state are called viable but non-culturable (VBNC).

Final results from culture tests typically are reported in colony-forming units (CFU) per volume (milliliter or liter) and All culture methods ultimately yield a pure isolate of *Legionella*. Final results from culture tests are available 7-14 days after samples are collected analyzed, depending on the level of detail requested. *Legionella* typically require at least three days incubation to grow enough for an analyst to detectColonies large enough to be visible to the naked eye are typically present within 3-4 days, so preliminary results may be available prior to 7 days.

C3.2. Polymerase Chain Reaction (PCR)

The most common non-culture methods used to evaluate environmental samples for *Legionella* are variations of PCR using *Legionella*-specific DNA or RNA templates. PCR holds the potential to detect all known *Legionella* species and forms, including dead and viable but non-culturable (VBNC) organisms, with a high degree of sensitivity and selectivity.[9,10] Results from PCR tests are typically reported in genomic units (GU) and can be available the same day the laboratory receives the sample. Genomic units (GU's) cannot be equated with CFU's. Currently, PCR methods are limited because viable organisms that may be able to cause infection, cannot be differentiated from non-viable, dead, *Legionella*. Other limitations of PCR include the inability to discriminate between strains, cross-reaction with non-*Legionella* bacteria, causing false positive results and chemicals in the sample that inhibit the PCR reagents. Although PCR results may be available in a matter of hours, the results should be interpreted with these limitations in mind. Notwithstanding these limitations, PCR *testing* is useful for negative screening of *microbial* samples for *Legionella*, especially when used in conjunction with culture methods.[11] Culture *testing* to determine the presence of viable *Legionella* can be performed following a positive PCR test result. Note that non-viable, dead *Legionella* may be present, even when there is an effective microbiological *control* program.

C3.3. Other Detection Methods

Emerging test methods may be performed by a laboratory or may be performed on-site. These methods include, but are not limited to, antibody-based methods. Detecting *Legionella* in environmental samples may utilize other methods such as antibodies, non-spread-plate culture, or bacterial enzyme detection. Unlike culture and PCR testing, sSuch methods typically may detect only a subset of *Legionella* species or serogroups. The main advantage to such methods is that they may be used in the field for a quick indication of system performance. These methods may report results in different units, such as most probable number (MPN)[12]. Consult with the *testing* laboratory or test method manufacturer regarding use of the reported units. Any test method should be validated against a standard method by a third party to determine accuracy and precision (sensitivity and specificity).

C4. INTERPRETATION OF TEST RESULTS

Test results represent the number of *Legionella* in the sample at the time the sample was tested, including any increases or decreases due to sample handling, preparation and transport and due to *testing* variability, etc. [6,7,8] There can also be considerable fluctuation in the concentration of *Legionella* between different sample locations within a *building water system* and fluctuations due to changes in building use patterns and seasonal conditions. Reporting the results of *Legionella testing* to the public or to environmental health authorities is not generally required when it is not linked to a case of disease., h However it is important to confirm reporting requirements with the *authority having jurisdiction*.

[. . .]

C5. RESPONSES TO *LEGIONELLA* TEST RESULTS

If results from *testing* for *Legionella* indicate that the *water management program (Program)* has not met the *Legionella control* objectives, then, based on the type of *Legionella* found (see Section 4.2), the concentration, and the extent of colonization, the number of calculated *Legionella* CFU/mL and, for cooling towers and evaporative heat exchangers, the number of samples with *Legionella* >10 CFU/mL* and for *potable water systems*, the number of samples with *Legionella* >1 CFU/mL* and whether the sample was collected from a central distribution location, implement the applicable clauses in C5a – gh:

a. Review the sample collection, handling and *testing* procedures to confirm that the results are not due to errors.
b. Confirm that system equipment is in good working order and functioning as intended.
c. Review records to confirm that the *Program* was implemented as designed.
d. Review assumptions about operating conditions, such as the physical and chemical characteristics of the water supplied to the building.
e. Re-evaluate fundamental aspects of the *Program*, including the analysis of *hazardous conditions*, cleaning and maintenance procedures, chemical treatment and other aspects of the *Program* that could affect results of *Legionella testing*.
f. If review or re-evaluation of the *Program* indicates deficiencies, adjust the *Program* as necessary.
g. After careful review, re-evaluation and possible adjustment of the *Program* (See C5a – f), consider whether *remedial treatment* is needed. In all cases, if the root causes of *Legionella growth* are not identified and controlled, *growth* of *Legionella* is likely to reoccur.
h. Following any adjustments of the *remedial treatments*, collection of representative retest samples to confirm the effectiveness of the response or remedial effort is recommended.

* CFU/ml concentration values assume *testing* utilizes spread plate culture methods and may not be directly applicable to other test results. For example, genomic units (GU) are not equivalent to colony forming units (CFU). Most Probable Number (MPN) and CFU are used interchangeably. Consult test provider's performance characteristics for conversion factors, if applicable.

Results of *testing* for *Legionella* have been interpreted based upon concentration, the extent of colonization and the type of *Legionella*. For instance, recovery of low concentrations of bacteria from several representative sites may indicate that *Legionella growth* in the *building water system* is not well controlled. Consideration should also be given to low concentrations of *Legionella* strains known to be more likely to cause disease, such as *L. pneumophila* serogroup 1, which may indicate a greater *risk* than equivalent concentrations of *Legionella* strains known to be less likely to cause disease. Whenever a case of disease is associated with a *building water system*, whether the association is only possible or is confirmed, *Program* confirmation activities (*verification* and *validation*) should be reviewed and the *Program* reevaluated and revised, if needed (see steps C5a - h~~g~~).

Legionella test results alone should never automatically trigger actions such as *remedial treatment*. Follow steps C5a through C5h before determining the appropriate response. ~~Actions should be taken only after careful review and reevaluation of the *Program* (see C5a - g).~~ Healthcare professionals may use *Legionella* test results to inform clinical practices, such as the type of disease screening performed.

Table C5.1 Performance Indicators for Water Management Programs for Potable Water Systems

Calculated *Legionella* (CFU/ml)	**Program Performance**	**Suggested Response**
≤1 or Not Detected*	*Legionella growth* appears well controlled.	Continue *Program*
>1*	Conditions may allow *Legionella growth*.	Implement the guidance in C5***
Trending of Test Results Over Time	**Program Performance**	**Suggested Response**
10 to 100 fold increase**	*Legionella growth* appears to be poorly controlled.	Implement the guidance in C5***
>100 fold increase**	*Legionella growth* appears to be uncontrolled.	Implement the guidance in C5***

* If test results are expressed in units other than CFU/mL, consult the testing laboratory or test manufacturer for the appropriate interpretation of results.~~CFU/ml concentration values assume *testing* utilizes spread plate culture methods and may not be directly applicable to other test results. For example, genomic units (GU) are not equivalent to colony forming units (CFU). Most Probable Number (MPN) and CFU are used interchangeably. Consult test provider's performance characteristics for conversion factors, if applicable.~~

** A 10 fold ~~increase~~ (1 Log ~~increase~~) increase in the number of *Legionella* previously detected, ~~for example, from 1 CFU/ml to 10 CFU/ml. A 100 fold increase (2 Log increase) in the number of *Legionella* previously detected, for example, from 1 CFU/ml to 100 CFU/ml.~~even when the increase results in values that, taken alone, indicate *Legionella growth* appears well controlled. An example of a 10 fold (1 Log) increase is from 1 CFU/mL to 10 CFU/mL. An example of a 100 fold (2 Log) increase is from 1 CFU/mL to 100 CFU/mL.

This table provides guidelines that may be used to evaluate the performance of Programs and provides responses to the *Legionella* test results. The information in this table does not necessarily correlate with health *risk* and is not predictive of disease. Results of *testing* for *Legionella* have been interpreted based upon concentration, the extent of colonization, and the type of *Legionella*.

*** In healthcare facilities where at-risk persons are housed or treated and where *Legionella growth* ~~is uncontrolled~~ does not appear well controlled, consider implementing measures from the healthcare facility's water management plan to protect patients from exposure to water *aerosols* while implementing the guidance in C5.

~~The water in some medical equipment may be tested as part of a Program. If *Legionella* test results are positive, the equipment should be decontaminated before use.~~

Table C5.2 Performance Indicators for Water Management Programs for Cooling Towers and Evaporative Heat Exchangers

Calculated *Legionella* (CFU/ml)	**Program Performance**	**Suggested Response**
≤10* or Not Detected	*Legionella growth* appears well controlled.	Continue *Program*
>10*	Conditions may allow *Legionella growth*.	Implement the guidance in C5
Trending of Test Results Over Time	**Program Performance**	**Suggested Response**
10 to 100 fold increase**	*Legionella growth* appears to be poorly controlled.	Implement the guidance in C5
>100 fold increase**	*Legionella growth* appears to be uncontrolled.	Implement the guidance in C5

* If test results are expressed in units other than CFU/mL, consult the testing laboratory or test manufacturer for the appropriate interpretation of results. ~~CFU/ML concentration values assume *testing* utilizes spread plate culture methods and may not be directly applicable to other test results. For example, genomic units (GU) are not equivalent to colony forming units (CFU). Most Probable Number (MPN) and CFU are used interchangeably. Consult test provider's performance characteristics for conversion factors, if applicable.~~

** A 10 fold (1 Log) increase in the number of *Legionella* previously detected, even when the increase results in values that, taken alone, indicate *Legionella growth* appears well controlled. An example of a 10 fold (1 Log) increase is from 1 CFU/mL to 10 CFU/mL. An example of a 100 fold (2 Log) increase is from 1 CFU/mL to 100 CFU/mL.~~** A 10 fold increase (1 Log increase) in the number of *Legionella* previously detected, for example, from 1 CFU/ml to 10 CFU/ml.~~

~~A 100 fold increase (2 Log increase) in the number of *Legionella* previously detected, for example, from 1 CFU/ml to 100 CFU/ml.~~

This table provides guidelines that may be used to evaluate the performance of Programs and provides responses to the *Legionella* test results. The information in this table does not necessarily correlate with health *risk* and is not predictive of disease. Results of *testing* for *Legionella* have been interpreted based upon concentration, the extent of colonization, and the type of *Legionella*.

APPENDIX C REFERENCES:

[. . .]

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