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Guidance on the recognition, evaluation, and control of *Legionella* colonization and amplification in common building water systems.

Recognition, Evaluation, and Control of ***Legionella*** in Building Water Systems

2nd edition

Edited by J. David Krause, PhD, MSPH, CIH; Deborah L. Jaeger, MS; and John P. Springston, MS, CIH, CSP, FAIHA

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Preface

As part of revising and updating the first edition, the authors solicited input from users of the guideline. AIHA staff distributed a survey to people who purchased the guideline's first edition and provided an email address. Recommendations and input from those who submitted responses were used to develop the second edition outline and content. The authors relied on the input of respondents to ensure the update captured, integrated, and addressed the most important issues for users of the guideline. The authors thank everyone who responded to the survey and the AIHA staff who managed and analyzed the survey responses.

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Background on *Legionella*

2.0 Background on *Legionella*

2.1 History

In the summer of 1976, the deaths of 29 people and illnesses of an additional 180 or more individuals were associated with the American Legion convention held at the Bellevue-Stratford Hotel in Philadelphia, Pennsylvania. Although the media is credited with naming the disease after the Legionnaires that it affected, it was the public health officials and microbiologists at the U.S. CDC who ultimately determined that the causative agent was *Legionella pneumophila*, an aerobic, Gram-negative rod-shaped bacteria common to freshwater environments, cooling towers, and other artificial water sources. As of the time of this writing, there are 62 known species of *Legionella*, half of which have been associated with human disease. *Legionella pneumophila* serogroup 1 causes most cases of Legionnaires' disease and is frequently detected in building water systems.

Despite all that has been learned about *Legionella* since 1976, incidence rates of Legionnaires' disease have been rising steadily since 2002. Estimates from the CDC indicate a nearly nine-fold increase of reported cases since 2000, with the number of reported cases rising almost every year. The most recent data available for all reported cases of legionellosis in 2018 indicate that almost 10,000 confirmed cases were reported in the United States. However, the true number of cases is almost assuredly much higher. Recently, a committee of experts for the National Academies of Sciences, Engineering, and Medicine (NAS) estimated that each year there are as many as 52,000 to 70,000 cases of disease in the United States. Some proposed explanations offered in the literature regarding the continued rise of Legionnaires' disease include the aging population, increased use of immunosuppressant drugs, and more comorbidities in persons, along with aging water distribution infrastructure, transforming building designs (such as greater complexity of building water systems), and emphasis on water conservation measures.

2.2 Bacterium and Disease

Legionella species have been found to cause several types of disease. The first is Legionnaires' disease, a potentially lethal infection typically resulting in severe pneumonia with fever, myalgia, and cough. The second is Pontiac fever, a flu-like illness with no pneumonia. Pontiac fever was first identified in 1968 in Pontiac, Michigan, when 95 of 100 employees in the Oakland County Health Department became sick. The problem was eventually traced to an evaporative condenser in the basement of the building, which was vented within six feet of the heating, ventilation, and air conditioning (HVAC) system fresh air intake. Legionnaires' disease is the more severe condition and can be debilitating and life-threatening, whereas Pontiac fever is an influenza-like illness that spontaneously resolves itself without medical treatment. *Legionella* species can also cause disease at sites outside of the lungs. Illnesses such as endocarditis, wound infections, joint infections, and graft infections have been associated with *Legionella* infection. These diseases are categorized as extrapulmonary legionellosis and are diagnosed when there is clinical evidence of disease at an extrapulmonary site and associated diagnostic testing indicates evidence of the presence of *Legionella* at that site. These illnesses are often grouped together as legionellosis, although Pontiac fever and extrapulmonary legionellosis are rarely reported or detected by current disease surveillance systems.

Legionnaires' disease is most commonly contracted from exposure to water aerosols, or small droplets of water, containing viable *Legionella*. Aspiration is also a mode of transmission, which is well documented in healthcare settings. Cases of Legionnaires' disease associated with suspected exposure to potting soil contaminated with *L. longbeachae* have also been reported. This recognized source has predominantly been described in Great Britain, Australia, and New Zealand, with a few reported cases in the United States. Although potting soil as a source of exposure is briefly described in this guideline, building water sources are the primary focus and most common source of exposure leading to Legionnaires' disease. *Legionella* amplification typically occurs in heated water sources but can also be found in unheated potable water and other indoor building water systems. *Legionella* amplification can occur in recirculated water sources, such as cooling towers, hot tubs and spas, decorative water features, and recirculating hot water

systems in large multistory buildings. Transmission of *Legionella* does not occur from person-to-person contact but rather from inhaling aerosols or aspirating water from colonized water sources. Legionnaires' disease is primarily a building-related illness.

Legionnaires' disease is a serious illness, with about one in ten community-acquired cases resulting in death and one in four people dying if they contract the illness while in a healthcare facility. The incubation period is commonly 2–10 days from the time of exposure to the bacterium, sometimes extending to 14 days. Risk factors for contracting Legionnaires' disease include age (i.e., 50 years or older), gender (males are at higher risk), being a current or former smoker, having chronic lung disease or a weakened immune system, or treatment with immunosuppressive medications such as corticosteroids.

2.3 Ecology

Legionella bacteria are naturally occurring in low levels in rivers, lakes, and streams. Water in natural or artificial sources can serve as amplification reservoirs for *Legionella* when suitable conditions for growth occur. Because it can survive routine water disinfection treatment, *Legionella* can be found at low concentrations in municipal water supplies. Municipal water is the source of *Legionella* in buildings, although federal and state regulations do not require testing for *Legionella* under the Safe Drinking Water Act. Water from natural sources (e.g., rivers and lakes) passes through municipal water treatment plants and into the distribution piping, delivering very low (and often undetectable) concentrations of *Legionella* bacteria into buildings. *Legionella* can also be introduced to water distribution lines from soil when a break occurs.

Once introduced to building water systems and cooling towers, the bacteria then travel to sites where conditions are favorable for colonization and amplification to occur. Examples of potential *Legionella* amplification sites in buildings include cooling towers, evaporative condensers, humidifiers, ice machines, carbon filters, water softeners, the potable water system (hot water heaters, hot and cold water pipes and premise plumbing distribution systems, shower heads, electronic faucets, faucet aerators), decorative fountains and other indoor/outdoor water features, nebulizers, mister reservoirs, hot tubs and spas, car washes, and industrial wastewater treatment plants.

Legionella bacteria thrive and are protected from harsh environmental conditions in biofilms that routinely develop within most water sources and distribution systems. Once a biofilm develops, it can be difficult to eradicate. Under normal use concentrations, most biocides only impact the exposed surface of the biofilm. As a result, even if desired biocide levels are achieved, they will not be effective in eliminating all *Legionella*.

Although *Legionella* do not form endospores, they are able to enter a viable but non-culturable (VBNC) state when exposed to certain chemical or environmental conditions. The VBNC state of stressed bacteria is a well-known phenomenon and is not specific to *Legionella*. Some of the conditions that have been reported to induce a VBNC state in bacteria include nutrient starvation, low temperatures, high salt concentration, low oxygen concentration, heavy metals, pipe material, and treatment with chemical disinfectants. This phenomenon makes it difficult to know whether chemical treatments have eradicated *Legionella* growth or simply driven it into a state that makes it undetectable by culture methods. Fortunately, however, *Legionella* bacteria in the VBNC state have not been found to cause disease until they have been "resuscitated" under favorable conditions.

Water temperature is a critical factor for *Legionella* to thrive in natural or artificial sources. The ideal temperatures for growth of *Legionella* are approximately 77–115°F (25–46°C), but it can survive at temperatures ranging from 32–145°F (0–63°C). *Legionella* has also been found to survive in water with pH ranging from 5.0–8.5 and dissolved oxygen concentration of 0.2–15 parts per million (ppm). Other utility and building-specific environmental conditions considered to encourage *Legionella* colonization (and thus increase the risk of human disease) include accumulated debris; scale and biofilm; stagnant water or low flow sections (also known as "dead legs") in the water distribution system; residual chlorine levels below 0.5 ppm; the presence of algae, amoebae, protozoa, and nutrients; and the type of plumbing materials used. Although chlorine levels are often cited as a potential indicator of risk, recent studies have not shown chlorine levels at or below 0.5 ppm to be predictive of the presence or absence of *Legionella* in building water systems. However, these levels do seem to be a risk factor. Because cooling towers and other building water systems may become colonized from their make-up water source, and they typically contain warm water and generate aerosols, it is important that such systems are well-maintained, periodically monitored, cleaned, properly treated with biocides, and periodically disinfected to prevent *Legionella* amplification and exposure.

2.4 Epidemiology

Inhaling water aerosols that contain *Legionella* is by far the most common route of transmission for Legionnaires' disease. Deposition of *Legionella* into the alveoli of the lung can lead to infection and development of pneumonia if the individual's immune system cannot fend off the bacteria. Legionnaires' disease can also be

acquired by aspirating drinking water and ice contaminated with *Legionella*, which can occur during dental procedures or when hospital patients chew on ice chips, for example. However, the aspiration exposure route is not believed to be a common route of exposure outside of healthcare settings. Inhaling aerosolized droplets is believed to be the primary source of exposure in both healthcare and community exposures. Currently, there is little evidence of person-to-person transmission of *Legionella*, aside from a single case report from Vila Franca de Xira, Portugal, in 2014. Other, less common routes of *Legionella* transmission have been documented, such as direct instillation via contaminated medical devices or wound infections.

For *Legionella* to cause Legionnaires' disease, a series of events—referred to as the chain of causa-

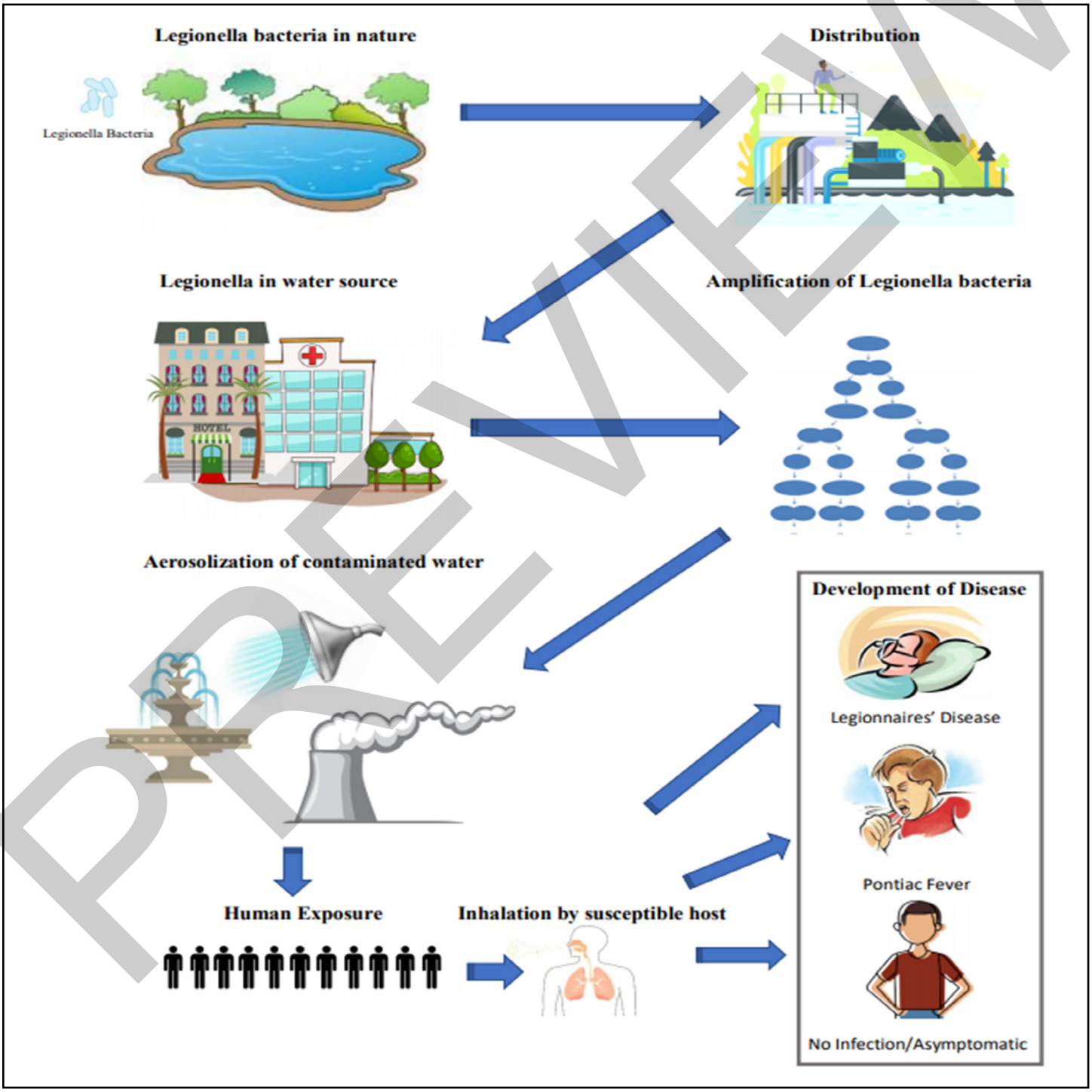

Figure 2.1: Legionnaires' disease chain of causation.

Chapter 4
Evaluating Prevention, Control, and Remediation Efforts

4.0 Prevention, Control, and Remediation

Prevention and control measures work together. Maintenance procedures and regimens, proactive testing for *Legionella*, water treatment, and follow-up in areas that have been previous sources of *Legionella* amplification together form a layered approach to preventing *Legionella* amplification in building water systems. Facilities and maintenance personnel should be aware of preventive efforts that aim to control *Legionella* growth in building water sources. A qualified water treatment professional, working together with building maintenance personnel and a Competent Professional, should be consulted in developing and implementing a building water system treatment program. A water management plan for a building will establish control locations, control measures, and corrective actions. These are reviewed and approved by the Water Management Program Team.

4.1 Preventive Measures

Regular maintenance of building water systems contributes to prevention of *Legionella* amplification. Routine maintenance procedures should include visual inspection of equipment, equipment cleaning, removing low-flow or stagnant water sources, temperature maintenance, and ensuring adequate disinfectant levels throughout the water system.

Routine equipment inspection and cleaning to remove scale, algae, sediment, and biofilm is important because these conditions encourage growth of *Legionella*, and the presence of these factors tends to decrease biocide effectiveness.

4.2 Water Treatment Measures

4.2.1 Mechanical Cleaning

The process of removing large amounts of debris, rust, scale, algae, and biofilm typically requires extraordinary efforts beyond normal, routine maintenance procedures. A combination of mechanical, steam, and pressure washing with chemical surfactants and decalcification agents is often necessary to remove debris. System components must often be disassembled to access areas that need to be cleaned.

Pressure washers and high-pressure steam cleaning washers are often used to dislodge and remove debris and scale from cooling towers and decorative fountains. Caution must be taken when using this approach because it can produce aerosols potentially containing high concentrations of *Legionella*. Whereas workers performing the cleaning may be protected with proper PPE, unprotected passersby and building occupants could also become exposed to these contaminated aerosols.

4.2.2 Thermal Treatment

Thermal treatment is no longer recommended for the remediation of premise plumbing or other water systems due to its frequency of failure and rapid return of *Legionella* growth. When performed, heat and flush involves raising the water heater tank temperature to 160°F (71°C) or higher and circulating (flushing) all hot water lines and outlets for at least 30 minutes. The time it takes to perform this procedure depends on the water temperature when it reaches the outlets, but it can be substantial. Thermal treatment provides only temporary results, is very labor intensive, and poses a scalding risk. Depending on the ambient temperatures, age of the hot water system, and size of the facility, it may be impractical or even impossible to achieve effective results. At best, only short-term improvements (from weeks to months) should be expected when using thermal treatment for *Legionella* control. Particular care needs to be taken when using this approach in public buildings, where the general population is at risk for scalding water temperatures. Fixtures will need to be tagged out during this procedure.

4.2.3 Chemical Treatment

Use of chemical disinfectants is a common treatment method to reduce viable *Legionella* concentrations in potable and non-potable water systems. Oxidizing agents (i.e., chlorine and bromine) have been shown to be effective at controlling *Legionella* levels in various water sources. Bromine is used in non-potable systems (such as cooling towers) and in bathing facilities, but not potable systems. Chlorination has also been an effective treatment in domestic water systems. Chlorine levels must be monitored. High chlorine levels are corro-

sive to cooling towers and plumbing systems, whereas levels that are too low do not effectively control *Legionella* growth. Bromine is often used in combination with chlorine. It is less corrosive to building equipment than chlorine. In addition to chlorine and bromine, a number of other chemical treatment methods are used for water treatment in potable and non-potable systems. Refer to Appendix 2 (Water Treatment Technologies) for a discussion of chemical disinfectants.

A water treatment specialist should always be consulted to help design and implement a water treatment protocol specific for the building water system. Many local authorities regulate water system disinfection as a pesticide application, requiring trained and licensed applicators who use only EPA-registered products. Depending on the scope and size of the water system being treated, local water authorities may need to be consulted prior to adding chemical disinfectants. If an automated system is installed to supplement municipal potable water disinfection, large systems may require review and permitting by regulating authorities.

4.2.4 Biofilm Control

Biofilms develop in water systems at the surface-water interface. Biofilms that develop within water storage and distribution systems can amplify and protect *Legionella* and other bacteria and can limit the effectiveness of routine and shock disinfection treatments. Once established, because of their structure and composition, biofilms are harmful and can be almost impossible to eradicate. Biofilms are complex, interrelated communities of microorganisms protected by a polysaccharide envelope, which both anchors the cells to surfaces and protects them from disinfectants and high temperature conditions. Biofilms develop when the surface provides a safe habitat and provides access to nutrients and free-floating microorganisms. Once they get large enough, portions of the biofilm can shed from the surface, releasing bacteria and seeding other areas of the water distribution system.

Several factors influence biofilm growth, usually by working together with no individual factor dominating. Controlling biofilms in distribution systems typically requires a maintenance program that includes regular line flushing and maintaining adequate levels of residual disinfectant. When dealing with established biofilms, the most commonly used disinfectant, chlorine, does not penetrate biofilms and sediments very well. Chlorine is also consumed by reacting with organic material. Monochloramine has been found to be more effective at controlling biofilm growth. Both chlorine and monochloramine have maximum contaminant levels (MCLs) established by the EPA to limit potential harmful effects.

4.3 Remediation Plan

The role of an industrial hygienist or other Competent Professional in designing the remediation of a *Legionella* amplification site or exposure source can vary according to the specific project or facility. Ideally, a team approach should be used that includes a Competent Professional with expertise in *Legionella*, along with facility engineers, managers, and water treatment experts. The team should then design and implement the remediation plan and include an integrated post-remediation verification testing component.

When there is evidence of *Legionella* amplification in building water sources, and disinfection steps more stringent than ordinary operating procedures are required, careful consideration should be given to the effects of the remediation plan to potentially exposed individuals, as well as possible negative impacts on the equipment. Accordingly, any remediation steps should be developed on a case-by-case basis, often in consultation with the equipment manufacturer.

An effective remediation plan involves using the most appropriate disinfection methods that have the greatest potential for success while minimizing adverse impacts on equipment, materials, and exposed individuals. Many disinfectants used to treat *Legionella* and disrupt biofilm habitats can be corrosive and cause water leaks or increase leaching of metals from plumbing fixtures into potable water systems. Other treatment systems that automatically inject disinfectants or bio-control agents into utility and potable water systems require continuous monitoring, adjustments, and ongoing maintenance. Monitoring for accelerated corrosion of components within the plumbing system using metal corrosion coupons is often performed to detect damage caused by some oxidizing disinfectants.

The plan should include remediation efforts based on *Legionella* sampling data and reliable and current information that has been collected about the water system.

4.4 Interim Measures and Remediation

In the event that *Legionella* amplification is detected in a building water system, or that one or more cases of Legionnaires' disease may be associated with recent exposure to a building water system, sampling for *Legionella* is recommended. Initiation of interim measures to prevent or minimize ongoing exposure and risk of disease is recommended while awaiting test results, which can take 10–14 days to become available. If public health officials detect a cluster or outbreak of legionellosis, especially in a healthcare or long-term care facility, they often mandate "water restrictions" until test results demonstrate that the suspected

Chapter 8
Legionella Guidelines, Standards, and Regulations

8.0 *Legionella* Guidelines, Standards, and Regulations

Industrial hygienists play an important role in educating building owners and operators about potential health effects associated with exposure to *Legionella* and providing information to assist them in minimizing and remediating *Legionella* contamination. Educational materials developed by the CDC and EPA, specifically for the public and clinicians, are readily available in the public domain. These fact sheets or brochures can be freely copied and distributed to building occupants and property owners. This chapter discusses regulations, guidelines, and standards that are applicable to a broad range of facilities. See Chapter 6 for a discussion on healthcare-specific standards, regulations, and guidelines.

8.1 Federal Regulations

No federal agency in the United States specifically regulates exposure to *Legionella*. The Occupational Safety and Health Administration (OSHA) General Duty Clause [Section 5(a)(1) of the Occupational Safety and Health Act of 1970] requires employers to furnish to each worker "employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm" to its workers. As such, OSHA may enforce the General Duty Clause where a workplace has a recognized, serious hazard, such as occupational exposure to *Legionella* in building water systems, for which there is no specific OSHA standard. Other OSHA standards and regulations that may apply to workplaces where there is the potential for *Legionella* contamination and exposure include the PPE standard (29 CFR 1910.132) and the Respiratory Protection standard (29 CFR 1910.134). Additionally, most chemicals used for cleaning and water system disinfection are considered hazardous, requiring additional precautions under the Hazard Communication standard (29 CFR 1910.1200).

Although not specifically designed to address *Legionella*, two U.S. Environmental Protection Agency (EPA) regulations are often applicable when controlling and remediating *Legionella* contamination in building water systems.

8.1.1 Safe Drinking Water Act

In 1974, the Safe Drinking Water Act (SDWA) was passed by Congress, with subsequent amendments in 1986 and 1996. The SDWA is the main federal law that ensures the quality of drinking water in the United States. Under SDWA, the EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards. The law requires the EPA to determine the level of contaminants (physical, chemical, biological, or radiological) in drinking water at which no adverse health effects are likely to occur. These non-enforceable health goals, which are based solely on possible health risks and exposure over a lifetime, are called maximum contaminant level goals (MCLGs). The SDWA applies to every public water system (PWS) in the United States. The SDWA does not cover private wells or apply to bottled water.

For many contaminants, the EPA has established enforceable MCLs, which take into account cost, benefits, and the ability of public water systems to detect and remove contaminants using suitable treatment technologies. For contaminants that have no economically or technically feasible and reliable method for measurement at particularly low concentrations, a treatment technique is prescribed rather than establishing an MCL. A treatment technique is an enforceable procedure or level of technological performance that public water systems must follow to ensure control of a contaminant. States may set more stringent MCLs or treatment technique levels for contaminants in drinking water than EPA does.

There is no specific MCL for *Legionella*. The current EPA stance is that, if *Giardia lamblia* and viruses are removed/inactivated in accordance with the treatment techniques in the surface water treatment rules, then *Legionella* will be adequately controlled as well.

8.1.2 Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the distribution, sale, and use of pesticides. All pesticides distributed or sold in the United States must be registered (licensed) by the EPA. Before EPA registers a pesticide under FIFRA,

the applicant must show, among other things, that using the pesticide, according to the manufacturer's specifications, "will not generally cause unreasonable adverse effects on the environment."

Pesticide products and devices that make antimicrobial claims of efficacy against *Legionella* are subject to certain EPA requirements. FIFRA defines a pesticide as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest." The term *pesticide* includes antimicrobials (e.g., sanitizers and disinfectants), in addition to various other substances used to control pests. Products that contain a substance or mixture of substances, and that make a pesticidal claim, must be registered by EPA prior to sale and distribution. For products that claim efficacy against a public health pest, an applicant must submit data demonstrating efficacy against that pest to obtain a registration.

Although devices are subject to certain EPA regulatory requirements, they do not need to be registered as pesticide products. Under FIFRA, a pesticide device is defined as an instrument or contrivance (without a chemical substance) that is used to destroy, repel, trap, or mitigate any pest such as insects, weeds, rodents, animals, birds, mold/mildew, bacteria, and viruses. A device is subject to the FIFRA prohibition against misbranding and must be produced in an EPA-registered establishment. To be considered a device, the item must not be sold or distributed with a substance or mixture of substances (e.g., chlorine, monochloramine, or copper or silver electrodes) in order to perform its intended pesticidal purpose. The manufacturer of a device with a label that makes pesticidal claims should generate and maintain data (i.e., efficacy data) that support those claims. Otherwise, the label could be considered misbranded if it makes false and misleading claims about the product and the manufacturer cannot produce data that support those claims.

8.2 Guidelines and Standards

Over the past 30-plus years, various governmental entities, trade associations, and professional societies have published voluntary guidelines and standards to assist professionals in the assessment, control, and remediation of *Legionella* in building water systems. Although some guidance documents contain numerical concentration limit recommendations for *Legionella* in different types of water systems (e.g., cooling towers, decorative water features, spas, potable water, etc.), consensus health-based guidelines do not currently exist. Environmental concentrations of *Legionella* alone cannot predict the probability of disease. Other factors, such as host susceptibility and exposure dose, also contribute to the likelihood of disease.

There is considerable disagreement regarding the practice of routine, proactive sampling of building water systems for *Legionella*. Until recently, with the exception of very limited circumstances (e.g., transplant units), the U.S. Centers for Disease Control and Prevention (CDC) did not recommend routine monitoring for *Legionella* in the absence of two or more confirmed cases of legionellosis. With the 2021 publication of the Routine Testing module of its *Legionella* Control Toolkit (see Section 8.2.3), CDC has expanded its guidance on the subject of routine testing. ASHRAE suggests environmental testing for *Legionella* to either evaluate water treatment effectiveness or determine a potential source of contamination after there have been reported cases of legionellosis. However, several other organizations and professional associations, including the World Health Organization, the U.S. Department of Veterans Affairs, and AIHA, recommend routine environmental testing for *Legionella*.

Table 8.1 lists various U.S. and International documents that provide guidance for the control of *Legionella* in building water systems.

8.2.1 Allegheny County Health Department

One of the earliest U.S. guidelines on *Legionella* control, entitled *Approaches to Prevention and Control of Legionella Infection in Allegheny County Health Care Facilities*, was published by the Allegheny County (Pennsylvania) Health Department in 1993. The guidelines recommended that all hospitals perform, at least yearly, an environmental survey of all hot water tanks and distal sites and that the survey include culture samples for *Legionella*. The guidelines specified the number of sites that should be sampled, depending on the number of patient beds in the hospital. If 30% or more of the distal sites tested positive for *Legionella*, then disinfection of the system was recommended. This risk assessment metric was later incorporated into the New York State Department of Health *Legionella* regulation of 2016 and validated in a 2021 report, which concluded that "In a well-maintained or well-treated premise water distribution system, ~30% or lower proportion of positive *Legionella* samples should occur. Anything above that cutoff is either very unlikely or not expected at all and indicates a problem in the water system."

Additionally, specialized testing of any patients with healthcare-acquired pneumonia for *Legionella* was recommended. Although the 30% positivity metric has been used to trigger remedial actions, it has **not** been demonstrated to be a predictive indicator of increased risk of Legionnaires' disease or disease outbreaks.

In 2014, Allegheny County Health Department published *Updated Guidelines for the Control of* Legio-

Table 8.1: Select *Legionella* Assessment or Remediation Voluntary Guidance for Industrial Hygienists

Organization	Title	Publication Date
Wisconsin Division of Health	Control of *Legionella* in Cooling Towers: Summary Guidelines	1987
Allegheny County Health Department	Approaches to Prevention and Control of *Legionella* Infection in Allegheny County Health Care Facilities	1993
	Updated Guidelines for the Control of *Legionella* in Western Pennsylvania	2014
National Environmental Health Forum (Australia)	Guidance for the Control of *Legionella*	1996
American Industrial Hygiene Association	Field Guide for the Determination of Biological Contaminants in Environmental Samples	1996
	Field Guide for the Determination of Biological Contaminants in Environmental Samples, 2nd ed.	2005
	Recognition, Evaluation, and Control of *Legionella* in Building Water Systems	2015
U.S. Department of Health and Human Services, Centers for Disease Control and Prevention	Transmission of Nosocomial Legionnaires' Disease	1997
	Guidelines for Preventing Opportunistic Infections Among Hematopoietic Stem Cell Transplant Recipients	2000
	Guidelines for Environmental Infection Control in Health-Care Facilities: Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee	2003
	Guidelines for Preventing Healthcare-Associated Pneumonia	2004
	Developing a Water Management Program to Reduce *Legionella* Growth and Spread in Buildings: A Practical Guide to Implementing Industry Standards	2017
U.S. Department of Labor, Occupational Safety and Health Administration	OSHA Technical Manual, Section III, Chapter 7: Legionnaires' Disease [archived document]	1999
U.S. Environmental Protection Agency, Office of Water	*Legionella*: Human Health Criteria Document	1999
	Technologies for *Legionella* Control in Premise Plumbing Systems: Scientific Literature Review	2016
American Society of Heating, Refrigerating and Air-Conditioning Engineers	ASHRAE Guideline 12-2000: Minimizing the Risk of Legionellosis Associated with Building Water Systems	2000
	ANSI/ASHRAE Standard 188-2021 Legionellosis: Risk Management for Building Water Systems	2021
	ASHRAE Guideline 12-2020: Managing the Risk of Legionellosis Associated with Building Water Systems	2020
Association of Water Technologies	*Legionella* 2000: An Update and Statement by the Association of Water Technologies	2000
	Legionella 2003: An Update and Statement by the Association of Water Technologies	2003
	Legionella 2019: A Position Statement and Guidance Document	2019
World Health Organization	Guidelines for Drinking-water Quality	2004
	Guidelines for Safe Recreational Water Environments	2006
	Guide to Ship Sanitation	2007
	Legionella and the Prevention of Legionellosis	2007
Public Works and Government Services Canada	MD 15161-2006: Control of *Legionella* in Mechanical Systems	2006
	MD 15161-2013: Control of *Legionella* in Mechanical Systems	2013
Cooling Technology Institute	Guideline WTB-184: Best Practices for Control of *Legionella*	2008
	Guideline 159: Practices to Reduce the Risk of Legionellosis from Evaporative Heat Rejection Equipment Systems	2020

Table 8.1: Select *Legionella* Assessment or Remediation Voluntary Guidance for Industrial Hygienists (continued)

Organization	Title	Publication Date
U.S. Department of Veterans Affairs	Prevention of *Legionella* Disease	2008
	Domestic Hot Water Temperature Limits for *Legionella* Prevention and Scald Control	2009
	Prevention of Healthcare-Associated *Legionella* Disease and Scald Injury from Potable Water Distribution Systems	2014
Health Protection Surveillance Centre (Ireland)	National Guidelines for the Control of Legionellosis in Ireland, 2009	2009
BSI	BS 8580 – Water Quality: Risk Assessments for *Legionella*	2010
	BS 8580-1:2019 - Water Quality: Risk Assessments for *Legionella* Control [Code of Practice]	2019
European Working Group for *Legionella* Infections	EWGLI Technical Guidelines for the Investigation, Control and Prevention of Travel Associated Legionnaires' Disease	2011
Ministry of Health (New Zealand)	The Prevention of Legionellosis in New Zealand: Guidelines for the Control of *Legionella* Bacteria	2011
Health and Safety Executive (England)	Legionnaires' Disease: Technical Guidance. Part 1: The Control of *Legionella* Bacteria in Evaporative Cooling Systems	2013
	Legionnaires' Disease: Technical Guidance. Part 2: The Control of *Legionella* Bacteria in Hot and Cold Water Systems [Interim Guidance Systems]	2013
	Legionnaires' Disease: Technical Guidance. Part 3: The Control of *Legionella* Bacteria in Other Risk Systems	2013
ASTM International	ASTM D5952-08(2015) Standard Guide for the Inspection of Water Systems for Legionella and the Investigation of Possible Outbreaks of Legionellosis (Legionnaires' Disease or Pontiac Fever)	2015
enHealth (Australia)	Guidelines for Legionella Control in the Operation and Maintenance of Water Distribution Systems in Health and Aged Care Facilities	2015
European Guidelines Working Group	European Technical Guidelines for the Prevention, Control and Investigation of Infections Caused by *Legionella* Species	2017
NSF International	Standard 453: Cooling Towers – Treatment, Operation, and Maintenance to Prevent Legionellosis	2017
Council of State and Territorial Epidemiologists	Revision to the Case Definition for National Legionellosis Surveillance	2019
National Academies of Science, Engineering, and Medicine	Management of *Legionella* in Water Systems	2020

nella *in Western Pennsylvania*. The updated guidelines broadened the scope to include other facilities that house or serve persons at high risk of legionellosis and address water sources beyond potable hot water systems. Additionally, a risk management approach has replaced the previous, more prescriptive recommendations related to environmental control of *Legionella*.

8.2.2 American Society of Heating, Refrigerating and Air-Conditioning Engineers

In 2000, ASHRAE published *Guideline 12-2000: Minimizing the Risk of Legionellosis Associated with Building Water Systems*. The guideline is intended for "designers, owners, operators, users, maintenance personnel, and equipment manufacturers" of nonresidential buildings and multifamily homes. It provides information and guidance on methods to control and minimize *Legionella* contamination in building water systems and to lessen the risk of occurrence of legionellosis. The document provides specific environmental and operational guidelines for a variety of different water systems where *Legionella* may be found, including potable and emergency water systems, heated spas, architectural fountains, and cooling towers. Although not a standard, ASHRAE Guideline 12-2000 is considered by many to be the first true standard of care document with regard to controlling *Legionella* in building water systems.

Appendix V
Legionella Considerations: Extended Building Closures and Safe Reopening

Refer to the following resources for a discussion of building closures and related *Legionella* considerations:

AIHA. COVID-19 Resource Center. Falls Church, VA: AIHA, 2020. https://www.aiha.org/public-resources/consumer-resources/aiha-covid-19-pandemic-efforts.

AIHA. *Guidance Document: Recovering from COVID-19 Building Closures*. Falls Church, VA: AIHA, 2020. https://aiha-assets.sfo2.digitaloceanspaces.com/AIHA/resources/Public-Resources/RecoveringFromCOVID-19BuildingClosures_GuidanceDocument.FINAL.pdf.

Centers for Disease Control and Prevention (CDC). Reopening Buildings After Prolonged Shutdown or Reduced Operation. Atlanta, GA: CDC. Last reviewed July 2021. https://www.cdc.gov/nceh/ehs/water/legionella/building-water-system.html

Recognition, Evaluation, and Control of *Legionella* in Building Water Systems, 2nd edition

Edited by J. David Krause, PhD, MSPH, CIH; Deborah L. Jaeger, MS; and John P. Springston, MS, CIH, CSP, FAIHA

This document is intended to provide guidance on recognition, evaluation, and control of *Legionella* colonization and amplification in common building water systems, both with and without any associated disease (legionellosis). This document expands upon information previously presented in two AIHA publications: *Field Guide for the Determination of Biological Contaminants in Environmental Samples*, 2nd edition and *Recognition, Evaluation, and Control of* Legionella *in Building Water Systems*.

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