Blue Earth Labs®

ASHRAE 188 – Legionellosis Risk Management

The Good, The Bad, and The Ugly:
What You Must Know to Prevent an Outbreak

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Overview

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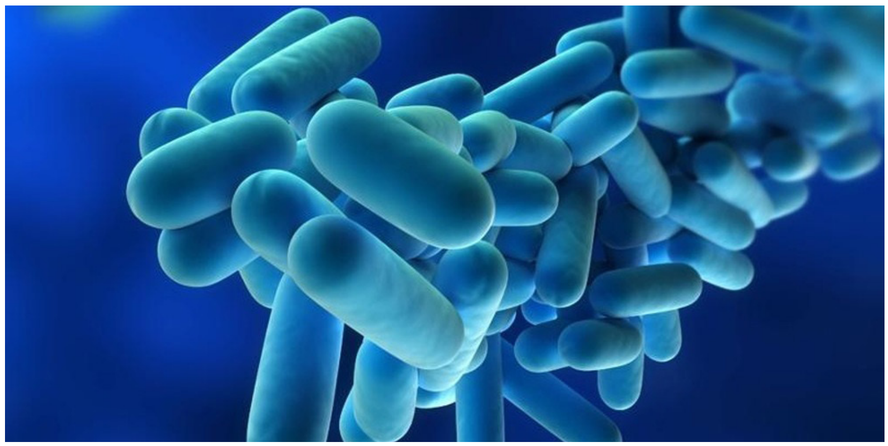
Introduction

The first recognized outbreak of Legionellosis was diagnosed in 1976 in Philadelphia, Pennsylvania, infecting 221 persons and causing 34 deaths. The Center for Disease Control estimates that in the U.S. alone, between 8,000 and 18,000 persons are hospitalized each year due to Legionnaires' Disease, and that due to underreporting, actual cases may be closer to 100,000. Most cases involve a severe form of pneumonia from Legionella, the bacterium responsible for Legionnaires' Disease, which thrives in warm, moist conditions such as those present in lungs.



Legionella pneumophila is a common strain of *Legionella* bacteria found in building water systems.

Not communicable from person to person, Legionnaires' Disease is contracted by breathing in mist or vapor that has been contaminated by Legionella. While Legionella occurs naturally in the environment, particularly in warm water, outbreaks typically are associated with contaminated building water sources such as cooling towers, pools, hot tubs, decorative fountains, and potable water systems. Basically, any water source that can be aerosolized into a mist should be considered a potential source for Legionellosis transmission. Furthermore, because it is a natural occurring bacterium, Legionella is often present in water systems, awaiting the right conditions for reproduction. These conditions can occur in the deposits – the scale and biofilm - that build up in any water system. Particularly in warm weather, these deposits can produce the ideal conditions allowing Legionella to thrive.

Many standard disinfection and flushing practices may remove the immediate concentration of Legionella, but do little to prevent recurring outbreaks because they don't effectively remove the deposits that still harbor the bacteria. Disruptive to building water system operations, these

Legionellosis Key Facts*

An estimated 8,000 to 18,000 people are hospitalized with Legionellosis each year in the U.S., and up to 30 percent of those cases prove to be fatal.

More than 90 percent of all cases go undetected, often misdiagnosed as common pneumonia, but with a mortality rate also thought to be in the 30 percent range.

80 percent of all cases are traced to potable water systems; 23 percent are hospitalacquired, and 77 percent are acquired in such settings as hotels, commercial and educational facilities, and industrial plants.

*Source: U.S. Centers for Disease Control

Legionnaires' disease may develop when people breathe in a mist or vapor (small droplets of water in the air) containing the bacteria. One example might be from breathing in droplets sprayed from a decorative fountain that has not been properly maintained (www.cdc.gov).

standard methods frequently involve shock chlorination, or elevated temperatures, neither of which is sustainable in a building water system as they make the water use by residents unpleasant or even dangerous. The alarming truth is that frequently Legionella programs are reactive, addressing an outbreak, rather than proactive, removing the deposits that allow the Legionella to reproduce and infect the system.

The severity of this disease, and therefore the liability and risk involved in NOT addressing the potential for contamination in building water systems, should not be underestimated. Even with treatment, those who survive may suffer long-term effects from the damage done to their lungs. A study of a 1999 Netherlands outbreak, which infected 318 patients resulting in the death of at least 32 persons, determined that long-term Health Related Quality of Life (HRQL) symptoms affected patients even a year and a half following the infection. These impairments included fatigue (75% of patients), neurologic symptoms (66%), and neuromuscular symptoms (63%) (Clinical Infectious Disease, 2002 Jul 1; 35(1) Lettinga KD, Verbon A, Nieuwkerk PT, Jonkers RE, Gersons BP, Prins JM, Spellman P). These long-term, and potentially life-long health impacts carry with them long-term and potentially life-long liabilities.

ASHRAE 188 seeks to establish standards that address the potential for contamination and encourage program development to manage risk.

ASHRAE, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, is committed to helping building designers and managers design and maintain building water systems that minimize these risks. In 2015, ASHRAE, in association with American National Standards Institute (ANSI) issued ANSI/ASHRAE Standard 118-2015, Legionellosis: Risk Management for Building Water Systems (ASHRAE 188-2015).

ASHRAE 188-2015 calls for a survey of buildings to determine if it has any of the "at risk" water system features, or if the building houses or treats residents who may be more susceptible to infection due to compromised immune function. In addition, ASHRAE 188-2015 identifies and establishes standards for managing risks in five types of water systems known to carry risk of Legionella contamination:

The key to preventing legionellosis in water systems (such as cooling towers, fountains of whirlpool spas) is the proper risk management program.

1. Potable Water Systems
2. Cooling Tower and Evaporative Condensers
3. Whirlpool Spas
4. Ornamental Fountains and Other Water Features
5. Aerosol-Generating Misters, Atomizers, Air Washers and Humidifiers

Section 7 of ASHRAE 188-2015 provides standards that are somewhat tailored to the individual characteristics of each of these five water systems.

General Requirements

Perhaps most important, ASHRAE 188-2015 Section 6, calls for the development of a comprehensive program that involves the following steps:

1. **PROGRAM TEAM:** Establish a Program Team responsible for evaluating the building water systems, and developing and implementing a monitoring and maintenance program to minimize the risk of contamination.
2. **WATER SYSTEM DESCRIPTION:** Requires a complete description, with system schematics and process flow diagrams, of all potable and non-potable water systems within the building.
3. **EVALUATION OF HAZARDS:** Analyze the water systems to determine where conditions susceptible to Legionella may occur and where control measures may be effectively applied.
4. **CONTROL MEASURES:** Establish locations for application of control measures to maintain systems within the control limits determined by the Program Team.
5. **MONITORING AND CORRECTIVE ACTION:** The Program Team will develop methods for monitoring the systems to determine if the control measures are effectively maintaining the system within the control limits, and take corrective action when necessary to maintain system within those limits.
6. **CONFIRMATION:** Develop a system to monitor the program to ensure implementation and to validate effectiveness.
7. **DOCUMENTATION:** Develop a documentation system to monitor compliance with the program to confirm communication and accountability.

First, The Good

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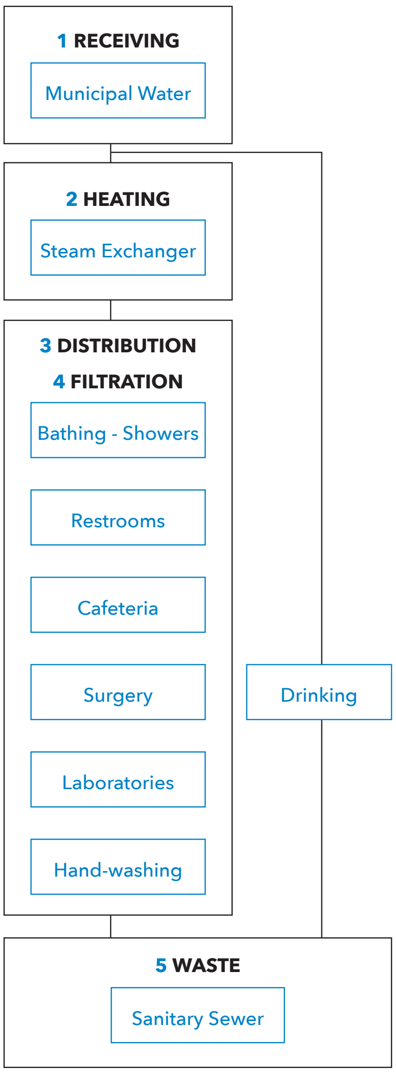
As the first guidance to address the need for an ongoing Legionellosis risk management program, ASHRAE 188-2015 can be an excellent planning and assessment tool for addressing risks within large public and institutional buildings.

1. **SYSTEMATIC APPROACH:** ASHRAE 188-2015 lays out a systematic process for developing a program for Legionellosis risk management. The standard's step-by-step approach guides building managers through the process, with team development, assessment, accountability, and communication.
2. **ASSESSMENT OF ALL BUILDING WATER SYSTEMS:** Development of complete schematics of all water systems within a building, not just the potable system, is major benefit of the standard. Comprehensive in scope and detailed in approach, ASHRAE 188-2015 helps assure that managers get the big picture as well as the details that will assist in thorough control and monitoring. Compliance with the standard will ensure that system schematics are up to date. Frequently building expansions or renovations involve modification of the water systems, modifications that may not be noted in the comprehensive system schematics. Lines may be added (or removed), connections altered, and the entire water system documentation becomes outdated and inaccurate. Compliance will assure that these modifications, past, present and future, are incorporated into the overall management plan.
3. **EVALUATION OF RISK POINTS:** The standard requires building utility managers to evaluate risk points, places where hazardous conditions might exist. Evaluating, visually confirming and documenting the entire water system can identify dead ends and places where water may stagnate, providing opportunity for deposits to build and develop colonies of Legionella bacteria.
4. **CONTROL LIMITS COMBINED WITH CONTROL MONITORING:** The program team must determine a method or methods for controlling the water system to maintain it within limits that discourage the proliferation of Legionella colonies. Monitoring is also an integral part of the standard, to ensure that the water systems are maintained within the control limits. Examples of control limits might be a range for temperature, disinfectant residual, or pH.


Building water system

SAMPLE SIMPLIFIED PROCESS FLOW DIAGRAM FOR POTABLE WATER SYSTEM



5. **ESTABLISHMENT OF CONTROL POINTS:** A control point is a place within the system where a corrective action can be applied and monitoring can be done to ensure that the system remains within limits. ASHRAE 188-2015 recommends not only identifying control points but developing corrective action plans, including equipment layouts and schematics, which will allow prompt action in the event that control limits are exceeded. Prompt action may prevent an outbreak.
6. **IMPLEMENTATION, DOCUMENTATION, AND COMMUNICATION:** As an ongoing program, the standard calls for verification of implementation and ongoing documentation and communication between the manager and the program team. These measures assure accountability. It also allows for evaluation and improvement of the program as well as providing proof of due diligence in maintaining the building's water systems.
7. **GUIDANCE FOR EACH TYPE OF WATER SYSTEM:** ASHRAE 188-2015 Section 7 includes requirements specifically for each type of building water system. These guidelines include special considerations for risk evaluation and development of a risk management plan tailored to each type of system.
8. **FLEXIBILITY:** While providing a framework and process, ASHRAE 188-2015 understands that buildings and their associated risks are varied and may be complex. This is not a prescriptive one-size-fits-all standard, but provides overarching guidance that points the way, while allowing the managers and program teams the flexibility to determine best how to meet the needs of their systems.
9. **NOT REGULATORY:** As of yet, adoption of the standard into legally binding regulation has not occurred. One notable exception is the adoption of Section 7.2 into emergency Legionella regulations by the New York State Department of Health following the July and August 2015 outbreak in New York City. This regulation addressed the cleaning, inspection and monitoring of cooling towers only.

Why is "not regulatory" a good point? Because it allows the building owner and managers the flexibility to address risk management on their own terms, developing their own programs without additional regulatory requirements that may not be applicable to their particular building, its systems or the occupants.

Now, The Bad

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Cooling towers are considered a risk factor for *Legionella* in building water systems.

ASHRAE 188-2015 is a broad and general standard with few enforceable provisions.

1. **PLAN ONLY AS GOOD AS THE EFFORT:** The risk management program will only be as good as the effort put into developing it. A building management team could go through the motions and develop a program that is technically in compliance with the provisions, but without follow up and continued diligence, risk from Legionellosis may not be reduced. An ineffective plan won't be proof of due diligence in the event of an outbreak.
2. **CONTROL POINTS – WHAT WORKS BEST?** While requiring the identification of control points, the standard does not explain what makes for an effective control point. The program team should consider ease of access, space for corrective action equipment, and sampling or instrumentation stations for monitoring. Whether the control point requires a sampling station or instrumentation will be determined by the type of control parameter, the control limit and the degree of sophistication desired for monitoring the control imit. Most important, any corrective action applied at the control point must be effective in addressing a potential outbreak. The corrective action should be able to circulate through the entire water system to address any Legionella colonies, particularly in dead end or stagnant areas. In the case of large systems, multiple control points may be required to monitor the system's condition effectively and to respond effectively to an outbreak.
3. **CONTROL PARAMETER AND CONTROL LIMITS – WHAT ARE YOU GOING TO MONITOR?** While setting up control points for monitoring and corrective action, ASHRAE 188-2015 does not provide specific examples of control parameters or limits for specific water systems. Control limit is only defined as "a maximum value, a minimum value of a range of values to which a chemical or physical parameter associated with a control measure must be monitored or maintained in order to reduce the occurrence of a hazardous condition to an acceptable level" (page 2-3). Likewise, a control measure is defined as a "disinfectant, heating, cooling, filtering, flushing, or other means, methods or procedures used to maintain the physical or chemical conditions of the water to within control limits" (page 3). ASHRAE 188-2015 does not define what those limits might be in order to be effective. These are not obvious decisions and for some systems, may actually be difficult to implement.

4 **NEW CONSTRUCTION OR EXISTING SYSTEM:** The standard does provide considerations for new construction but offers little guidance on how to retrofit existing systems to reduce risk.

5 **REACTIVE OR PREVENTATIVE?** The standard discusses how to respond to a potential outbreak, and how to know if you might be vulnerable to an outbreak early, but offers little in the way of recommending measures for actually preventing an outbreak. To be within the comfort tolerances of human residents or guests, the control limits, commonly used disinfectant concentrations or temperature, often are well within the ranges allowing for Legionella growth and reproduction.

Which brings us to....

The Ugly

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To understand the full complexity of Legionellosis prevention requires understanding the bacterial ecology and why it is so difficult to prevent growth in building water systems. To assist, ASHRAE has another standard guidance document, Minimizing the Risk of Legionellosis Associated with Building Water Systems (ASHRAE 12-2000) that provides excellent information on the ecology, proliferation (what ASHRAE terms amplification) and transmission of the bacteria. ASHRAE 188-2015 references ASHRAE 12-2000, but it bears emphasizing that to fully understand and minimize risk, building managers should become familiar with and implement the procedures of both documents.

Bottom line, Legionella require other microorganisms in order to live and reproduce. Conditions conducive to their growth include water temperatures between 77 and 108 oF (25 to 42 oC), biofilms that grow in deposits, sediments and scales within systems, and microorganisms such as amoebae or protozoans for host organisms. Unfortunately, these conditions are common within building water systems.

Moreover, the control parameters frequently applied are of limited effectiveness in removing the biofilms that protect and nourish the Legionella and their hosts.

1. **TEMPERATURE AS CONTROL PARAMETER:** Using heating as a control parameter is difficult as the range of temperatures that are tolerable for humans is also the range preferred by Legionella. ASHRAE 12-2000 recommends using temperature for a control parameter for hot water systems, maintaining them above 140 oF (60 oC). However, the temperature which causes pain in humans is generally between 106 and 108 oF (41 to 42 oC), and higher temperatures carry the risk of severe scalding. Monitoring mixing valves to modulate the temperature is critical to manage the risk inherent in this method of control. Of course, as soon as the temperatures are lowered to a comfortable level for guests and residents, the risk that any Legionella can proliferate is increased. High hot water temperatures will not prevent Legionella colonization in shower heads, where the temperatures must be reduced for comfort and safety.

   For other water systems, temperature is not a practical control parameter. For some water features such as spas and whirlpools, the temperature of these systems is actually optimal for the growth of Legionella and the host microbes. Cooling tower systems, like those implicated in the recent NYC outbreak, maintaining high temperatures is clearly not practical.

Corrective action using temperature requires raising the temperature to 160 to 170 oF (71 to 77 oC) combined with flushing. Clearly during these corrective actions, residents and guests could not use the water systems. Even more critical, there are no guarantees that flushing with hot water will remove the biofilms and deposits harboring the microorganisms infected by the Legionella. Flushing with hot water is often incapable of breaking down the biofilms for removal. Once the corrective action is complete, the Legionella and their host organisms would again continue to proliferate.

2 **DISINFECTION AS A CONTROL PARAMETER:** The most common disinfectant is chlorine, and most municipal water systems seek to maintain a chlorine residual of at least 1 mg/L throughout their system. However, due to the chlorine demand of residues and biofilms within the distribution system, frequently the water entering a building has little to no residual chlorine.

Moreover, as a control parameter, it is not clear what concentration of chlorine would be necessary. Legionella is notably resistant to chlorine, more than other microbes. The biofilms and deposits also provide protection to the Legionella and the host microbes, so that while the chlorine may disinfect the water, it does not penetrate the biofilms and both the microbes and the Legionella continue to multiply.

Disinfection, as a corrective action, requires high concentrations. For hot water systems, since the heat would drive off the chlorine, the applied dosage may be as high as 20 to 50 mg/L in order to achieve even the minimal 2 mg/L. Residents and guests frequently find concentrations higher than 2 mg/L unpalatable in drinking water and unpleasant for showers and other water features.

Again, the deposits and biofilms prevent the penetration of the chlorine, limiting long-term effectiveness. Once the residual dissipates, the Legionella and host microbes again flourish.

3 **BIOCIDES AS A CONTROL PARAMETER:** Biocides are often used to control microbial fouling and can be effective for some fouling situations. However, ASHRAE 12-2000 notes that “Protozoa are highly resistant to both oxidizing and non-oxidizing biocides; hence they must be controlled by limiting the microbial biofilms that serve to provide them nutrients” (page 9). Biocides have limited effectiveness in removing the biofilms.

Cooling tower cleaning

So clearly none of these common control parameters can assure that Legionella will be prevented at all times.

4 **CLEANING AS A CONTROL METHOD:** Following the outbreak of Legionnaires' disease in New York City (NYC) in July and August 2015, the City mandated more frequent inspection of the cooling towers. That outbreak, the largest in NYC's history, sickened more than 120 persons and resulted in 12 deaths. In addition to the inspections, NYC also mandated cleaning and disinfection of all cooling towers. The cooling towers in the Bronx were cleaned and disinfected first, as this was the borough impacted by the outbreak.

Despite these efforts, on September 28, NYC reported another outbreak. Unrelated to the first, this outbreak was in Morris Park, another Bronx neighborhood six miles from the site of the original outbreak. Eventually 13 more persons would be diagnosed as infected, with one dying from the disease. All cases reported onset dates before September 21st. Thirty-five cooling towers, all of which had been cleaned and disinfected since the July-August outbreak, were tested and 15 were positive for Legionella.

So what went wrong? While the latest outbreak is still under investigation, it is highly probable that the initial cleaning and disinfection failed to remove the biofilms in the towers. These biofilms were still viable habitats for the Legionella and their microbe hosts. With continued warm weather, the Legionella again flourished and eventually infected human hosts.

5 **REPORTING AND TESTING PROCEDURES TO CONFIRM LEGIONELLA LEAD TO DELAYS IN RESPONSE.** Once infected, a patient typically shows symptoms in two to 10 days. Tracking down the possible sources may take several more days. Once water samples are collected from potential sources, standard lab tests to confirm the presence of Legionella require up to 10 days for incubation. Meanwhile, additional persons may be infected.

In the interim, a building manager who suspects that a water system may be contaminated faces a number of difficult decisions. Do you notify residents and guests to the potential? Do you remove systems from service and begin corrective action prior to receiving results? Clearly a manager must err on the side of public health and safety, even if it is a false alarm, and despite the certainty of a devastating public relations nightmare. The liability of adopting a "wait for confirmation" attitude is simply too great.

Biofilm coating the sides of a kitchen drainpipe

Unfortunately, the methods and programs outlined under ASHRAE 188-2015 do little to shorten this time frame and may not provide early warning of contamination. The program, while a step in the right direction, remains predominately reactive rather than preventative. The control parameters may not alert the program team to the potential of an outbreak. Even if control limits are exceeded and corrective actions implemented, these may not be adequate to remove the Legionella from the system and eliminate the risk of infection except in the short term. Unless you remove the biofilms that naturally grow in the deposits within these water systems, the conditions remain favorable for Legionella and their microbial hosts.

To prevent an outbreak, remove the biofilm and deposits

As long as the biofilms and deposits remain intact within building water systems, the conditions are right for Legionella to thrive. An organic matrix holds these deposits and biofilms in place, acting as a "glue" that effectively shields the Legionella colonies from most corrective actions.

Blue Earth Labs® Clearitas® product line attacks the organic compounds holding the deposits and biofilms in place. Certified under NSF Standard 60, Clearitas is safe for drinking water applications and all building water systems.

The rate at which Clearitas removes these deposits is based on dosage and the type of deposits. High remediation doses will oxidize the deposits quickly, releasing them from building water structures, including piping and cooling tower systems, allowing them to be safely flushed out of the system. Once the scales, deposits, and biofilms are removed, lower dosages applied continuously prevent reformation of biofilms. Without a habitat for the microbes upon which Legionella depend, the bacteria simply cannot flourish, colonies will not form, and Legionnaires' disease can be effectively prevented.

Simple to use, application is often as simple as connecting a chemical metering pump and an injection nozzle into those control points identified under the ASHRAE 188-2015 program.

Preventative Action or Crisis Management – It is your choice!

Avoiding the devastating consequences of a Legionnaires' disease outbreak requires preventative action, not just monitoring and responding to a crisis. The risk to public health, and the subsequent damage to your business, is simply too high to gamble on reactive monitoring strategies and ineffective, short-term corrective actions.

The scientists and engineers of Blue Earth Labs can assist you in assessing your systems in accordance with ASHRAE 188-2015. Their knowledge and experience will provide a remediation and preventative maintenance plan that is custom tailored for your risk factors and building water systems. A continuous Clearitas preventative program will ensure that your water systems stay Legionella free.

The health of your clients and of your business deserves nothing less.

About

Blue Earth Labs develops advanced cleaning and water infrastructure maintenance solutions to assist municipal and commercial facilities in providing safe, clean water. We combine chemistry with commitment, innovation and expertise to make water safer. cleaner. better® for all living things. We have developed a chemical platform specifically engineered to extend the operational life and efficiency of any water processing, storage or distribution infrastructure. We clean your infrastructure and keep it clean by chemically removing organic and inorganic contaminants both online and off-line. Our products are being used in applications extending from municipal fresh water systems to municipal and commercial wastewater systems, manufacturing plants, healthcare facilities, food processing plants, cooling towers, hotels and restaurants and other commercial industries. Contact us to find out more about what we do.

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