> NSF Special Section: Designed to be Lead-Free

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The National Academy of Sciences Building in Washington, D.C.

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OUR COVER THIS MONTH

The National Academy of Sciences Building was constructed in 1924 as a meeting place for the brightest scholars to meet on matters of science and technology. During a major MEP upgrade, the building had solar thermal collectors installed on the roof, steam-to-hot water convertors and a full-service kitchen installed. The building is trending for a LEED Gold certification and has made the day-to-day operations significantly smoother. Photo by Maxwell MacKenzie.

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FEATURES

COLUMNS

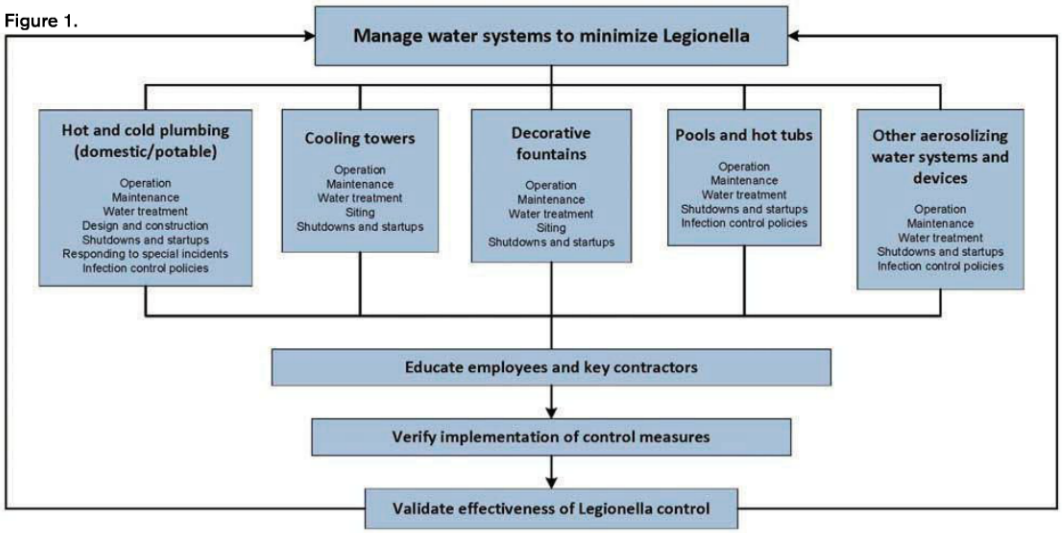
DEPARTMENTS

By Matthew R. Freije

The fine print

Legionella and water temperatures go hand-in-hand.

Figure 1.



Water temperature control is only one part of operating and maintaining plumbing systems to minimize Legionella and an even smaller part of a comprehensive Legionella management plan. This diagram is from the training course Water Temperatures and Legionella in Plumbing Systems. Courtesy of HC Info.

At first glance, guidelines may lead engineers and facility operators to conclude that controlling Legionella bacteria in plumbing systems can be accomplished long-term by simply raising water heater temperatures.

As with any solution that appears easy and cheap, it is important to check the fine print. For water temperatures and Legionella, the fine print includes the following:

Piece of the puzzle

1. Water temperatures are a small part of a big picture. The purpose of managing building water systems to minimize Legionella bacteria is to prevent Legionnaires' disease. A Legionella management plan must include preventive measures for all water systems that present a significant risk of Legionella growth and transmission, not just for plumbing systems. Minimizing Legionella bacteria within plumbing systems involves much more than water temperatures (see Figure 1).

Out in the wild

2. Water temperatures may affect Legionella bacteria differently in real plumbing systems than in piping loops set up for laboratory studies. Don't jump to conclusions based on Figure 2 on page 24.

In an actual hot water system, especially in large buildings, it can be difficult to keep the entire plumbing system at the target temperature even if the water heaters have the capacity to handle periods of highest demand. That can happen because water will cool down in sections where it is stagnant because of the design or infrequent use.

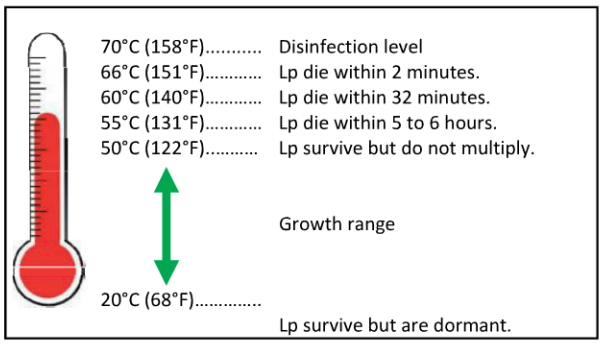
Even where the target temperature can be maintained, Legionella bacteria imbedded in scale or biofilm will not behave as shown in Figure 2. In a pot of water, Legionella will not multiply at temperatures above 50° C (122° F) and will die within about 32 minutes at 60° C (140° F). A large plumbing system is different – it is an entire ecosystem. Every plumbing system has biofilm within a short time after being filled with water.

Therefore, the effectiveness of water temperature management in controlling Legionella cannot be guaranteed and should not be assumed.

Hot, hot, hot

3. Regulations limit maximum hot water temperatures. Many government and industry organizations have recommended storing hot water above 60° C (140° F) and delivering it above 50° C (122° F) for Legionella control, including the American Society of Heating, Refrigerating and Air-Conditioning Engineers), the Centers for Disease Control and Prevention, Occupational Safety and Health Administration, (U.K.) Health and Safety

Figure 2.



The effect of water temperature on Legionella pneumophila (Lp) found by Sanden et. al. in a laboratory study (Sanden GN, Fields BS, Barbare JM, Feeley JC. 1989. "Viability of Legionella Pneumophila in Chlorine-free Water at Elevated Temperatures." Current Microbiology 18; 61-65). This diagram is from the training course "Water Temperatures and Legionella in Plumbing Systems." Courtesy of HC Info.

Executive, ASTM International and the World Health Organization.

The minimum temperature recommendations present a dilemma because of maximum temperature regulations and scalding risk. For example, the Joint Commission and most state health departments have set maximum temperature guidelines to protect against scalding in hospitals and nursing homes.

The 2009 Veterans Health Administration directive, "Domestic Hot Water Temperature Limits for Legionella Prevention and Scald Control," plainly states the dilemma: "It is not possible to maintain water temperatures at the outlet that prevent the growth of Legionella and simultaneously eliminate the possibility of scald injury in persons partially or fully insensitive to hot water temperature."

The big chill

4. Reducing the cold water temperature may be infeasible or impractical. Most of the same organizations (ASHRAE, ASTM, CDC, HSE, OSHA) that recommend high hot water temperatures also recommend keeping cold water at or below 20° C (68° F).

Water supplied to a building below 20° C (68° F) may pick up heat as it flows in pipes along sun-baked walls, in ceilings, in pipe chases, or because of hot water infiltration at janitor sinks, bedpan washers, shower valves or other cross connections. Some steps to minimize heat gain may be cost effective (e.g., adding insulation; adding check valves to prevent crossover).

However, if the required measures are impractical or infeasible (e.g., relocating pipes), or if the incoming water supply exceeds 20° C (68° F), as is the case in some parts of the U.S., then implementing other control measures (e.g., chemical disinfection) will be more practical than trying to reduce the incoming cold water temperatures.

Not a perfect fit

5. Mixing valves are not a one-size-fits-all solution. Mixing valves can be located just downstream of water heaters to reduce the temperature throughout the rest of the system and at showers and faucets to reduce the temperature just before use.

Setting hot water storage tanks or tank-type heaters at or above 60° C (140° F) is beneficial for Legionella control assuming, based on the tank size relative to hot water demand, water stays in the tanks long enough to be disinfected (Figure 2). Thermostatic mixing valves must be used downstream of the tank outlets to reduce the temperature to a no-scalding level.

If semi-instantaneous heat exchangers are used for water heating, setting them at 60° C (140° F) will be of little or no benefit for Legionella control if water will not be held at that temperature long enough to kill Legionella. Installing a mixing valve downstream of a semi-instantaneous heat exchanger could actually promote rather than hinder Legionella growth by adding surface area (for biofilm development) to the system.

However, mixing valves are typically installed not only (or even primarily) to kill Legionella within water heaters, but to deliver hot water within a more consistent and precise temperature range, which in some buildings could ultimately help with Legionella control.

System shock

6. Surprises occur. Delivering hot water within a specified temperature range is about more than water heater settings and mixing valves. It requires a comprehensive plumbing system operation and maintenance program. Target temperatures cannot be assumed because of stagnation, hot-cold crossover and other complexities that can affect temperatures at some outlets, so periodically checking temperatures is important.

Check cold water temperatures at the point of building entry to track the temperature of the incoming water supply at various times of the year. Also, check the temperatures at faucets to identify excessive heat gain between the point of entry and points of use.

Check water heater, hot water storage tank and thermostatic mixing valve gauges to make sure the temperatures are within the target range. Check the hot water return gauges and take readings at outlets to identify excessive temperature loss between the hot water supply and points of use.

The Legionella management plan should outline performance limits for water temperatures. If the limits are not met, investigate the problem and take appropriate corrective measures.

Water temperature management must be given its proper place within a building's Legionella prevention program – no more and no less. Target temperatures must be set thoughtfully, achieved safely and measured.

As with the entire management plan, the effectiveness of water temperature management in controlling Legionella cannot be guaranteed and must therefore be validated rather than assumed. pme

Matt Freije is the founder and president of HC Info. He earned an undergraduate degree in mechanical engineering from Purdue University and a graduate certificate in epidemiology and biostatistics from Drexel University. His consulting work has been focused on Legionella since 1995. His first book, "Legionellae Control in Health Care Facilities: A Guide for Minimizing Risk," has sold in more than 30 countries. Much of this article was excerpted from "Water Temperatures and Legionella in Plumbing Systems," an e-learning course written and narrated by Freije.