ASHRAE Guideline 12-2000

ASHRAE® STANDARD

Minimizing the Risk of Legionellosis Associated with Building Water Systems

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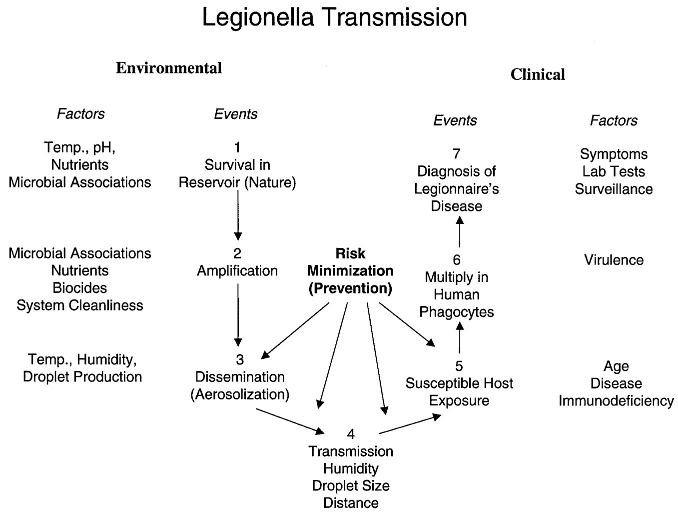

Figure 1 Legionella transmission. Adapted from Barbaree (1991)[3].

as possible in the disease's chain of transmission. The rationale for this is that if one preventive measure fails, others will be in place and act as fail-safe mechanisms. With this philosophy in mind, it may be desirable to design interventions to prevent transmission of Legionellosis at as many points as possible in the disease's chain of transmission. General concepts are presented so that readers may develop an understanding of the types of conditions that may allow amplification and transmission of *Legionella*.

A variety of aerosol-producing devices have been associated with outbreaks of Legionnaires' disease, including cooling towers,[4,5] evaporative condensers,[6,7] showers,[8,9] whirlpool spas,[10,11] humidifiers,[12] decorative fountains,[13,14] and a grocery store produce mister.[15] Aspiration of colonized drinking water into the lungs has been suggested as the mode of transmission in some cases of hospital-acquired Legionnaires' disease.[16-18]

Numerous investigations have demonstrated that cooling towers and evaporative condensers have served as the sources of *Legionella*-contaminated aerosols causing outbreaks of community- and hospital-acquired infection. Outbreak-associated transmission via cooling towers and evaporative condensers has been most commonly documented when those infected have been in close proximity to the contaminated devices; however, data from a few Legionnaires' disease outbreak investigations suggest that legionellae may be carried in cooling tower aerosols for distances of up to 3 kilometers (2 miles)[19] (this is regarded as requiring an unusual combination of climatic conditions). A number of outbreaks of Legionellosis associated with cooling towers and evaporative condensers have occurred after these devices have been restarted following a period of inactivity.[20,21]

Shower heads and tap faucets can produce aerosols containing legionellae in droplets of respirable size. Epidemiologic studies and air sampling conducted during outbreak investigations have established the role of aerosols produced by showers and tap faucets in disease transmission.[9] Aerosols produced by respiratory therapy equipment that have been filled or rinsed with contaminated potable water in hospitals have also caused disease transmission.[12,22]

Heated spa pools operate at temperatures conducive to bacterial growth. The aeration of spa pools can result in formation of potentially contaminated aerosols. A range of pathogenic microorganisms, including *Pseudomonas aeruginosa* and *L. pneumophila*, have been found in spa pools. Outbreaks of Legionellosis have occurred among bathers as well as people near colonized spas.[10,11]

A more complete and detailed description of the most common amplifiers associated with building water systems, including the treatment recommended to minimize the risk of Legionellosis, is found in Sections 4-10.

4. POTABLE AND EMERGENCY WATER SYSTEMS

4.1 Potable Water Systems

4.1.1 System Description. Potable water systems in buildings for this discussion start at the point where the water enters the building and end where it exits the piping at a faucet, showerhead, etc. The systems include all piping, hot water heaters, storage tanks, faucets, nozzles, and other distribution outlets.

4.1.2 System Operation. Factors associated with the plumbing system that may influence the growth of legionellae are as follows:

Chlorine concentration. Municipal potable water supplies are generally chlorinated to control the presence of microorganisms, historically to control microbes associated with sewage. The legionellae are more tolerant of chlorine than many other bacteria and may be present in small numbers in municipal water supplies.[23]

Temperature. Although legionellae have been recovered from cold water, the temperature range favorable for amplification is 25-42°C (77-108°F). The environment becomes more hostile as the temperature is moved from this range.

Design of plumbing system. Growth of legionellae may occur in portions of the system with infrequent use, in stagnant water, and in portions of the system with tepid temperatures. Growth may also occur in dead-end lines, attached hoses, shower nozzles, tap faucets, hot water tanks, and reservoirs.

Plumbing materials. Rubber washers and fittings, including water hammer arrestors and rubber hoses with spray attachments, have been shown to provide sites for growth of legionellae.[24] Organic compounds leached from plumbing materials may contribute to growth of heterotrophic bacteria, including legionellae.

4.1.3 Water Droplet Size. Contaminated potable water sources present the greatest risk when dispersed into the air in a very small droplet size (less than 5 micrometers) that can be inhaled deeply into the lungs. Actions that may generate small droplets are those that break up the water stream, i.e., shower nozzles, aerators, spray nozzles, water impacting on hard surfaces, and bubbles breaking up.

4.1.4 Nutrients. Both dead and living microorganisms, biofilms, and debris may provide nutrient sources for legionellae growth. When legionellae are found in plumbing systems, it is common to detect the microbes in the sediment in hot water tanks and in peripheral plumbing fixtures that accumulate sediment. Legionellae growth appears to be heaviest at the solid-liquid interface with the development of slime deposits.

4.1.5 Associated Cases of Legionnaires' Disease. Potable heated water systems are an important potential source of Legionellosis in all buildings and are of particular importance in hospitals, nursing homes, and other health care facilities.[25] Many reports link legionellae in hospital tap water to epidemics and clusters of nosocomial (hospital-acquired infection) Legionnaires' disease, often involving immunosuppressed patients.[26]

4.1.6 Recommended Treatment. Where practical in health care facilities, nursing homes, and other high-risk situations, cold water should be stored and distributed at temperatures below 20°C (68°F), while hot water should be stored above 60°C (140°F) and circulated with a minimum return temperature of 51°C (124°F). However, great care should be taken to avoid scalding problems. One method is to install preset thermostatic mixing valves. Where buildings cannot be retrofitted, periodically increasing the temperature to at least 66°C (150°F) or chlorination followed by flushing should be considered. Systems should be inspected annually to ensure that thermostats are functioning properly.

Where practical in other situations, hot water should be stored at temperatures of 49°C (120°F) or above.

Those hot or cold water systems that incorporate an elevated holding tank should be inspected and cleaned annually. Lids should fit closely to exclude foreign materials.

Detailed current plans for hot and cold water piping systems should be readily available. Hot water heaters and storage vessels for such systems should have a drainage facility at the lowest point, and the heating element should be located as close as possible to the bottom of the vessel to facilitate mixing and prevent water temperature stratification. In high-risk applications, insulated recirculation loops should be incorporated as a design feature. For all situations, the pipe runs should be as short as practical. Moreover, where recirculation is employed, the pipe runs should be insulated and long dead legs avoided. New shower systems in large buildings, hospitals, and nursing homes should be designed to permit mixing of hot and cold water near the showerhead. The warm water section of pipe between the control valve and showerhead should be self-draining.

Copper-silver ionization is a relatively new approach to controlling *Legionella* in hot water distribution systems and has been used successfully in a number of hospitals.[27-29] Electrolytically generated copper and silver ions build up in the hot water recirculating system to levels effective in eradicating *Legionella*, typically in the range of 0.2-0.8 mg/L copper and 0.02-0.08 mg/L silver. The optimal concentration of copper-silver ions for controlling *Legionella* in hot water is not known. A particular concentration may not be universally effective because of variables in water quality and system design. It is also important to note that the efficacy of copper-silver ions, like chlorine, is adversely affected by elevated pH.[30]

Where decontamination of hot water systems is necessary (typically due to implication of an outbreak of Legionellosis) the hot water temperature should be raised to 71-77°C (160-170°F) and maintained at that level while progressively flushing each outlet around the system. A minimum flush time of five minutes has been recommended by the Center for Disease Control Hospital Infection Control Practices Advisory Committee.[31] However, the optimal flush time is not known and longer flush times may be necessary. In the original report describing this method, multiple 30-minute flushes were required to significantly reduce *Legionella* colonization.[17] The number of outlets that can be flushed simultaneously will depend on the capacity of the water heater and the flow capability of the system. Local building and sanitary codes should be checked for any temperature limits of water discharged to the sewer. Appropriate safety procedures to prevent scalding are essential. When possible, flushing should be performed when the fewest building occupants are present (e.g., nights and weekends). For systems where thermal shock treatment is not possible, shock chlorination may provide an alternative.[32,33] However, there is less experience with this method of decontamination. Also, users should realize that the required levels of free chlorine residual can cause corrosion of metals. Chlorine should be added to achieve a free chlorine residual of at least 2 mg/L throughout the system. This may require chlorination of the water heater or tank to levels of 20 to 50 mg/L. The pH of the water should be maintained between 7.0 and 8.0. Each outlet should be flushed until the odor of chlorine is detected. The chlorine should remain in the system for a minimum of 2 hours (not to exceed 24 hours), after which the system should be thoroughly flushed.

Once the decontamination is complete, recolonization is likely to occur unless the proper temperatures are maintained, continuous supplemental chlorination is continued, or alternative approaches, such as the use of a silver/copper ionization device, are employed.

In high-risk applications, monthly removal of shower heads and tap aerators to clean out sediment and scale and to clean them in a chlorine bleach solution is recommended.

For potable water systems that were opened for repair or other construction or systems that were subjected to water pressure changes associated with construction (which may cause water to become brown and the concentration of *Legionella* to dramatically increase),[34] it is recommended that as a minimum the system be thoroughly flushed. High-temperature flushing or chlorination may be appropriate, and this judgement should be made on a job-specific basis. If only a portion of the system is involved, high-temperature flushing or chlorination may be used on only that portion of the system.

4.2 Emergency Water Systems—Safety Showers, Eye Wash Stations, and Fire Sprinkler Systems

4.2.1 System Description. All three of these systems are generally plumbed to the potable water system, have little or no flow with resulting stagnant conditions, and may reach temperatures warmer than ambient. Legionellae, heterotrophic bacteria, and amoebae have been cultured from these systems.[35] When the devices are used, aerosolization is expected.