ASHRAE Guideline 12-2000

ASHRAE STANDARD

Minimizing the Risk of Legionellosis Associated with Building Water Systems

Approved by the ASHRAE Standards Committee February 5, 2000; by the ASHRAE Board of Directors February 10, 2000.

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ISSN 1041-2336

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ASHRAE STANDARDS COMMITTEE 1999-2000

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Minimizing the Risk of Legionellosis Associated with Building Water Systems

1. PURPOSE

The purpose of this guideline is to provide information and guidance in order to minimize *Legionella* contamination in building water systems.

2. SCOPE

2.1 This guideline provides specific environmental and operational guidelines that will contribute to the safe operation of building water systems to minimize the risk of occurrence of Legionellosis.

2.2 This guideline is intended for use with nonresidential building systems (including but not limited to hotels, office buildings, hospitals and other health care facilities, assisted living facilities, schools and universities, commercial buildings, industrial buildings, etc.) and centralized systems in multifamily residential buildings (including but not limited to central heating/cooling systems, central domestic water systems, common area fountains, etc.). While not specifically intended for noncentralized or single-family residential building systems, some of the information may be useful for these systems.

2.3 This guideline is intended for the use of designers, installers, owners, operators, users, maintenance personnel, and equipment manufacturers.

3. ECOLOGY OF *LEGIONELLA*

3.1 Infection and Disease

The majority of Legionnaires' disease cases diagnosed and reported to the public health officials are sporadic (i.e., not occurring as part of a recognized outbreak).[1] Compared with outbreak-associated infection, much less is known about transmission of sporadic Legionellosis, although it is likely that transmission occurs by similar mechanisms. Exposure to legionellae in sporadic cases may occur in a variety of settings, including the home, the workplace, and public places visited during routine daily activities or during travel. The proportion of sporadic disease attributable to exposure in each of these settings and to various environmental sources is unknown.

Legionellae are bacteria. When legionellae are present in aquatic environments, the risk of transmission of infection to humans depends on the presence of several factors: conditions favorable for amplification of the organism, a mechanism of dissemination (e.g., aerosolization of colonized water), inoculation of the organism at a site where it is capable of causing infection, bacterial strain-specific virulence factors, and the susceptibility of the host. Over 40 species of *Legionella* have been identified; *L. pneumophila* appears to be the most virulent and is associated with approximately 90% of cases of Legionellosis. Most *L. pneumophila* infections are caused by serogroup 1; however, certain serogroup 1 strains may be more virulent. The risk of acquiring Legionnaires' disease is greater for older persons and for those who smoke tobacco or have chronic lung disease. Persons whose immune system is suppressed by certain drugs or by underlying medical conditions appear to be at particularly high risk.

3.2 Habitats

Legionellae bacteria are commonly present in natural and man-made aquatic environments. The organism is occasionally found in other sources, such as mud from streams and potting soils; however, the overall importance of nonaquatic environmental sources in human disease is not yet known. In natural water sources and municipal water systems, legionellae are generally present in very low or undetectable concentrations. However, under certain circumstances within man-made water systems, the concentration of organisms may increase markedly, a process termed "amplification." Conditions that are favorable for the amplification of legionellae growth include water temperatures of 25-42°C (77-108°F), stagnation, scale and sediment, biofilms, and the presence of amoebae. Legionellae infect and multiply within several species of free-living amoebae, as well as ciliated protozoa. The initial site of infection in humans with Legionnaires' disease is the pulmonary macrophage. These cells engulf legionellae, provide an intracellular environment that is remarkably similar to that within host protozoa, and allow for multiplication of the bacterium. Hence, legionellae may be considered protozonotic; i.e., they naturally infect free-living amoebae and incidentally infect the phagocytic cells within human lungs under certain circumstances. Although legionellae may be cultivated on special agar media in laboratory settings, growth in nature in the absence of protozoa and/or in the absence of complex microbial biofilms has not been demonstrated. Intracellular growth of legionellae within protozoa and/or within diverse microbial biofilms may be the primary means of proliferation.

There is an indication that growth of *Legionella* is influenced by certain materials. Natural rubbers, wood, and some plastics have been shown to support the amplification of *Legionella*, while other materials such as copper inhibit their growth.

Generally, *Legionella* thrive in diverse, complex microbial communities because they require nutrients and protection from the environment. Controlling the populations of protozoa and other microorganisms may be the best means of minimizing *Legionella*.[2]

3.3 Transmission of Legionnaires' Disease

Most data on the transmission of Legionnaires' disease are derived from investigations of disease outbreaks. These data suggest that, in most instances, transmission to humans occurs when water containing the organism is aerosolized in respirable droplets (1-5 micrometers in diameter) and inhaled by a susceptible host.

Prior to actual disease a number of events occur, some of which can be influenced by good engineering and maintenance practices. These events and prevention opportunities are outlined in Figure 1. The first event, survival in nature, is generally outside the scope of building engineering and management practices. The next three events—amplification, dissemination, and transmission—can be influenced by engineering design and maintenance practices. Subsequent events are influenced by the individual's health.

The most effective control for most diseases, including Legionellosis, is prevention of transmission at as many points

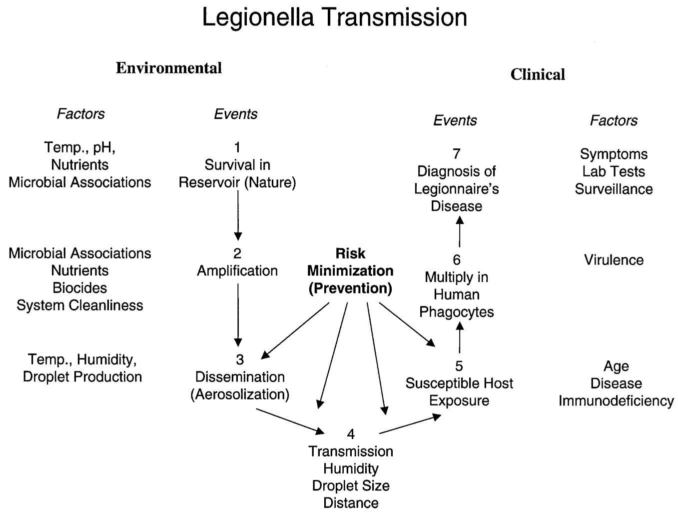

Figure 1 Legionella transmission. Adapted from Barbaree (1991)[3].

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.

4.2.2 Associated Cases of Legionnaires' Disease. Cases of Legionellosis resulting from exposure to these waters have not been documented.

4.2.3 Recommended Treatment. Safety shower and eye wash stations should be flushed at least monthly. In the case of fire sprinkler systems, it is recommended that fire-fighting personnel wear protective respiratory gear and that non-fire-fighting personnel exit the burning area. Appropriate precautions should be taken when checking the operation of fire sprinkler systems.

5. HEATED SPAS

5.1 System Description

Heated spas are small baths or pools used for relaxation (i.e., recreational), hygienic, or therapeutic purposes. Common features include warm water temperatures, (32-40°C/90-104°F) and the constant recirculation and agitation of the water through high-velocity jets and/or injection of air. While there is some confusion over the names used for each, the differences among the types of baths and pools are related mainly to size, purpose, material used, and equipment.

5.1.1 Whirlpool Spa (Spa, Hydrotherapy Pool). These are recreational baths or pools (public or private) holding more than one person and filled with warm turbulent water. The water is not replaced after each use but rather is filtered to remove particulates and chemically treated (typically with chlorine or bromine) to provide microbiological control. They may be located indoors or outdoors. Most smaller units are made from molded fiberglass, while larger in-ground varieties are generally made of gunite or concrete with a white plaster finish. They are generally circular in shape, always shallow (less than 1.3 m [52 in.]), and contain seats that allow occupants to submerge up to the chest or neck.

5.1.2 Hot Tub. These are traditionally deeper hot water baths or pools made of wood. Redwood is common, but they may also be made of cedar, mahogany, white oak, pine, or teak. Otherwise, the features and uses are similar to spas.

5.1.3 Whirlpool. This terminology has been traditionally used for the small therapeutic pools (often used in athletics) filled with warm, vigorously moving water, which may be small enough for treatment of a specific joint, such as a knee, ankle, or elbow. These pools are generally made of stainless steel and are emptied between uses.

5.1.4 Whirlpool Bath. These are small baths often found in bathrooms of hotel rooms or private residences. As such, they are used for both recreational and hygienic purposes. The baths are fitted with high-velocity water jets and/or air injection, but unlike whirlpool spas and hot tubs, the water is emptied after each use.

5.2 System Operation

Temperature. The water temperature in these spas, baths, and pools is generally in the range of 32-40°C (90-104°F), with the maximum temperature based on bather comfort. These warm temperatures are close to the optimum for the multiplication of *Legionella* and many other microorganisms. The warmer temperatures also accelerate the loss of the biocide.

Aerosol Production. Due to the operational features of the high-velocity water recirculation and air injection, a large number of bubbles of varying sizes rise to the water surface and burst. Microorganisms (e.g., *Legionella*) in the water can be released into the air via either bubbles or aerosol mist.

5.3 Water Droplet Size

This aerosol mist has water droplets of varying sizes (many less than 5 micrometers) and extends into the air to a height of at least 0.5 meters (1 1/2 ft) above the water surface (well within the breathing zone of the bathers). Under conditions of high relative humidity and air currents, the aerosol may also expose individuals outside the spa.

5.4 Nutrients

Due to the small volume of water per occupant (approximately 300 liters, compared to 10,000 liters in a typical swimming pool), the bathing load quickly contributes 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 nutrients, these organic materials can also cause an increase in chlorine (or bromine) demand, resulting in a reduction in free available halogen.

5.5 Associated Cases of Legionnaires' Disease

In surveys of whirlpool spas, legionellae have been isolated from as many as 33% of the spas sampled, but only in those spas where the disinfectant (chlorine or bromine) levels were not adequately maintained. Thus, it is generally presumed that outbreaks of Legionellosis from whirlpool spas are likely to be associated with spas that have similar deficiencies in their disinfectant levels.

It is universally recognized that water treatment criteria for spas (and swimming pools) should include disinfection against coliforms and other fecal pathogens (bacteria, viruses, and protozoa). In recent years, these types of recreational and therapeutic spas have been recognized as important sources of infection by other waterborne pathogens, including *Pseudomonas aeruginosa* and *Legionella* species. Several multiple-case outbreaks of Legionellosis (Legionnaires' disease and Pontiac fever) have been traced to spas and hot tubs, and fatalities have occurred.[10,36] No cases of Legionellosis have been traced to whirlpool baths.[10,11]

5.6 Recommended Treatment

5.6.1 Whirlpool Spas. Whirlpool spas are currently subject to state and local regulations related to public swimming and bathing facilities. These regulations may cover all areas of operation, including mechanical specifications, operational parameters (i.e., flow rate, temperature), water chemistry, and bacteriology. To minimize the occurrence of whirlpool-related infectious diseases (including Legionellosis), the following guidelines are relevant.

5.6.1.1 Bather Load. Clearly post and enforce the maximum number of occupants (0.93 m^2 [10 ft^2] of surface area per bather). Using this formula, a 2.5 meter (8 ft) diameter circular spa would have a maximum bather load of five at one time.

5.6.1.2 Bather Health Restrictions. Clearly post warnings on the increased health risk related to use by individuals who are immunocompromised or who have chronic lung disease.

5.6.1.3 Filter Operation. Hygienic maintenance of spa filters is more difficult than that of swimming pool filters because of the higher ratio of number of bathers to pool volume. Health codes consistently accept filter flow rates as follows:

High rate sand filters — 3.4-6.7 L/s per m^2
(5-10 gal/min per ft^2) of filter media
Diatomaceous earth filters — 1 L/s per m^2
(1.5 gal/min per ft^2) of filter media
Cartridge filters — 0.25 L/s per m^2
(0.375 gal/min per ft^2) of filter media

Maintenance of filters includes back flushing regularly to remove the buildup of organic debris. Determining the frequency of back flushing is currently based on manufacturer recommendations (flow-rate requirements) rather than microbiological criteria. As a general rule, daily back flushing may be required during periods of heavy usage. Filter cartridges should also be cleaned or replaced on a regular basis (once or twice weekly).

5.6.1.4 Water Chemistry. The American National Standards Institute and National Spa and Pool Institute (ANSI/NSPI) have established chemical standards related to pool disinfection. The standards are generally used as a basis for most state and local regulations and have been modified slightly by the Centers for Disease Control in their "Interim Recommendations to Minimize Transmission of Legionnaires Disease from Whirlpool Spas on Cruise Ships (1995)."[37]

	Minimum	Ideal Values	Maximum
Free chlorine (mg/L)	3.0	4.0-5.0	10.0
Combined chlorine (chloroamines) (mg/L)	None	None	0.2
Bromine (mg/L)	4.0	4.0-6.0	10.0
pH	7.2	7.4-7.6	7.8

The upper value of 10 mg/L (free chlorine or bromine) should not be considered a routine target maintenance level; however, this level is acceptable for relatively short durations.

The ideal values should be considered minimum values for control of *Legionella* because of the relative resistance of *Legionella* to halogens (compared to other bacteria and enteric viruses). Maintaining the required free available halogen level is **absolutely critical** for controlling the growth of bacteria (including *Legionella*) in the spa water. Thus, these parameters should be measured frequently, as often as hourly during periods of heavy use. Automatic systems that continuously monitor the free halogen and adjust as needed would offer the best control of the water chemistry. In addition, it would be desirable to install halogen level-dependent injector devices on both sides of the filter to ensure that adequate levels of biocide are maintained within the filter and within the water exiting the filter.

Several alternative or adjunctive nonhalogen water treatment procedures are currently being marketed, including copper/silver ion water treatment, iodinization treatment, ultraviolet light treatment, and ozonation. While any or all of these approaches may successfully control *Legionella* and other bacteria in pools and spas, there are insufficient data at the present time to recommend any major variation from current water treatment practices. This situation may change as additional data from laboratory and real-world studies become available.

5.6.1.5 Bacteriological Parameters. Regular testing of all spas can provide an important record of safe operating conditions and may alert operators of unsafe conditions when they occur. However, since bacteriological results require as much as 24 hours (or longer for *Legionella*) for results, they should be used only to spot-check or confirm the effectiveness of the disinfection system, not as a replacement for frequent testing of the water chemistry or routine maintenance. Where culturing for legionellae is to be done, see section 11 for input on proper sampling, handling, and shipping.

Standard agar plate count (35°C)-	200 cfu per mL (maximum)
Total coliforms-	2 organisms per 100 mL (maximum)
Fecal coliforms-	None allowable
Pseudomonas aeruginosa (41°C)-	None allowable
Legionella species-	None allowable

5.6.1.6 Routine Maintenance. Current ANSI/NSPI recommendations include taking the spa out of service at the end of each day in order to carry out a superhalogenation (i.e., shock disinfection) using 10 mg/L or 10 times the combined chlorine level, whichever is greater, for one to four hours. Due to the buildup of total dissolved solids and organic matter in the water, the spa water should also be replaced at least once a week (depending on the frequency of use). Daily water changes may be necessary under continuous conditions of high use. At the same time, the spa should be thoroughly cleaned, including a vigorous scrubbing of the spa surface, weirs, and skimming devices, in order to remove buildup of microbial biofilm. Conditions of high bacterial counts also require shock disinfection in order to achieve safe operating conditions, often coupled with changing the water, cleaning the spa, and maintenance of filters.

5.6.1.7 Training and Record Keeping. Training of maintenance personnel on all aspects of the safe operation of whirlpool spas should be mandatory. As part of this training, it should be emphasized that spas are not the same as swimming pools; thus, maintenance required for safe operation is very different. Maintenance personnel should also be trained to maintain good records of all water chemistry measurements, back flushing of filters, water changes, and spa cleaning. Results of samples sent to outside labs for bacteriological analysis should also be maintained. All records should be kept for a period of at least two years.

5.6.2 Whirlpool Baths. Since whirlpool baths are always filled with fresh potable tap water and drained at the end of each use, the recommendations for control of Legionellosis would fall initially under those guidelines developed for potable water systems.

6. ARCHITECTURAL FOUNTAINS AND WATERFALL SYSTEMS

6.1 System Description

In these systems, water is either sprayed in the air or cascades over a steep media such as rocks, and then it returns to the man-made pool. This guide is not intended to cover fountains in natural bodies of water or natural waterfalls.

6.2 System Operation

These systems are sometimes operated intermittently with on-time often scheduled only during certain time periods. Applications can include elaborate displays specifically intended to periodically attract large crowds in entertainment centers. Systems that are operated intermittently may encourage greater biocontamination.

6.2.0.1 Temperature. Because of the high temperature ranges needed for proliferation of legionellae bacteria, outdoor fountains and pools in hotter climates and indoor fountains and pools subject to sources of heat may be susceptible to becoming amplifiers. Temperature increases may be facilitated by heat from the pump/filter systems themselves. Intermittent operation may also create situations where temperature increases occur in limited parts of the system.

6.3 Water Droplet Size

These systems can produce droplets of various sizes and certainly have the potential to produce droplets less than 5 micrometers. Generally speaking, the legionellae risk increases as the rate of aerosol production increases.

6.4 Nutrients

Fountains are subject to contamination from a wide variety of sources, including materials scrubbed from the air and returned to the pool with the falling water droplets as well as organic and inorganic materials dropped, thrown, or blown into the pool.

Algae and bacteria are recognized as a particular problem in pools less than 1 meter (3 ft) deep. When used, filter systems are similar to the types used for swimming pools.

6.5 Associated Cases of Legionnaires' Disease

Several multiple-case outbreaks of Legionellosis have been associated with decorative fountains in public buildings, particularly hotels.[13,14] However, the true incidence of disease from these sources may be much higher due to the occurrence of isolated cases where no association with the building or the fountain was suspected.

6.6 Recommended Treatment

6.6.1 Design Considerations

- Drains or sumps should be situated at the lowest level of the pool, with no other local low points that are not served by drains or sumps.
- Provision for maintenance should be considered in the design stage. Access to pump(s) and filter(s) should be provided. Stagnant areas or areas that are difficult to clean should be avoided.

6.6.2 Maintenance

- Regular cleaning is recommended.
- Use of filters should be considered; however, systems with a small water volume may be drained and refilled with fresh water every few weeks in lieu of filtering.

6.6.3 Water Treatment

Microbial fouling control is important, especially where the conditions are such that there are significant periods of time when the temperature of the fountain water is in the range that is favorable for the amplification of legionellae growth (see 3.2). When biocidal treatment is employed for microbial fouling control, the biocide must be registered with the Environmental Protection Agency for use in decorative fountains. For further information on water treatment, see 7.6.2 of this guideline and the "Water Treatment" chapter in the Applications volume of the ASHRAE Handbook.

7. COOLING TOWERS INCLUDING FLUID COOLERS (CLOSED-CIRCUIT COOLING TOWERS) AND EVAPORATIVE CONDENSERS

7.1 Cooling Towers

7.1.1 System Description. A cooling tower is an evaporative heat transfer device in which atmospheric air cools warm water, with direct contact between the water and the air, by evaporating part of the water (see Figure 2). Air movement through such a tower is typically achieved by fans, although some large cooling towers rely on natural draft circulation of air. Cooling towers typically use some media, referred to as "fill," to achieve improved contact between the water and the cooling air.

7.1.2 System Operation. Cooling towers associated with building water systems are typically used for rejection of waste heat from the condenser of chillers providing air conditioning for a building. Water from the cooling tower is piped to the condenser where it is heated and then back to the cooling tower to be cooled.

7.1.2.1 Temperature. The typical temperature of the water in cooling towers ranges from 29°C (85°F) to 35°C (95°F) although temperatures can be above 49°C (120°F) and below 21°C (70°F) depending on system heat load, ambient temperature, and system operating strategy.

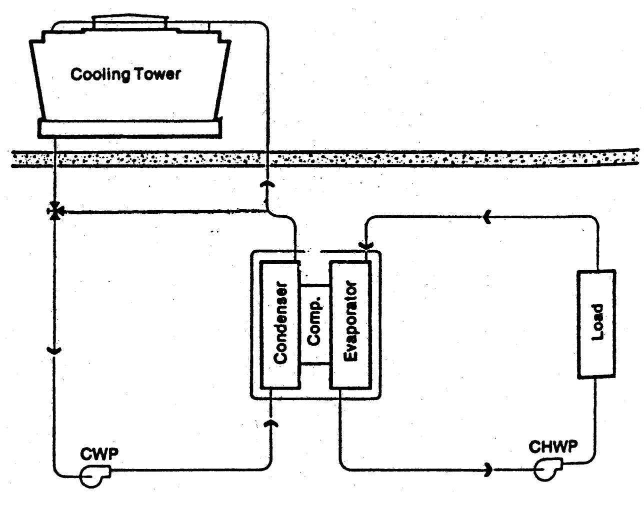

Figure 2 Typical cooling tower/chiller system.

7.1.2.2 Circulating Water System. Cold water piping from the cooling tower runs to one or more pump(s), then to the chiller condenser, where it is heated, and then back to the hot water distribution system in the cooling tower. Considerable variation in the piping arrangement occurs. Stagnant areas or dead legs may be difficult to clean or penetrate with biocides.

A significant volume of water may be contained in the piping system.

7.2 Closed-Circuit Cooling Towers and Evaporative Condensers

7.2.1 System Description. Closed-circuit cooling towers and evaporative condensers are also evaporative heat transfer devices. Both are similar to conventional cooling towers, but there is one very significant difference. The process fluid (either a liquid such as water, an ethylene glycol/water mixture, oil, etc., or a condensing refrigerant) does not directly contact the cooling air. Rather, the process fluid is contained inside a coil assembly (see Figure 3).

7.2.2 System Operation. Water is drawn from the basin and pumped to a spray distribution system over the coil assembly while the cooling air is blown or drawn over the coil by fans. Removal of heat is achieved by evaporating part of the water.

7.2.2.1 Temperature. Water temperature in closed-circuit cooling towers and evaporative condensers is similar to that in cooling towers.

7.2.2.2 Circulating Water System. Most commonly, there is no external piping in these systems. Because the water is totally contained within the unit, the volume of water is generally significantly less than with conventional cooling tower systems.

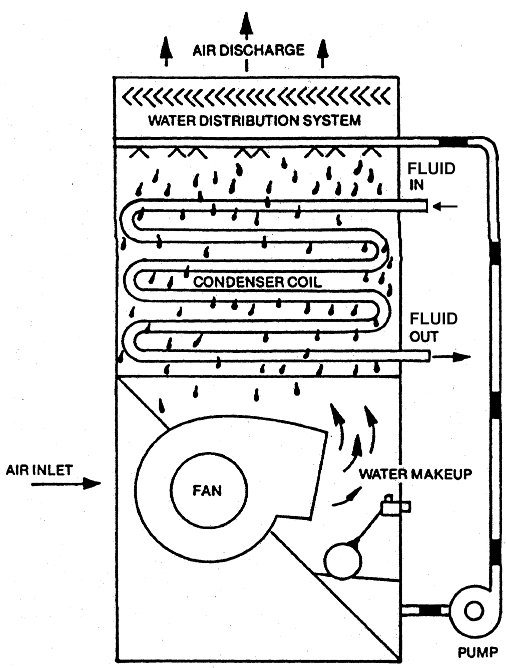

Figure 3 Typical closed-circuit cooling tower or evaporative condenser.

7.3 Water Droplet Size

Cooling towers and evaporative condensers incorporate inertial stripping devices called drift eliminators to remove water droplets generated within the unit. While the effectiveness of these eliminators can vary significantly with the design (new state-of-the-art eliminators are significantly more efficient than older designs) and the condition of the eliminators, it should be assumed that some water droplets in the size range of less than 5 micrometers leave the unit. In addition, some larger droplets leaving the unit may be reduced to 5 micrometers or less by evaporation.

7.4 Nutrients

Because cooling towers and evaporative condensers are highly effective air scrubbers and because they move large volumes of air, organic material and other debris can be accumulated. This material may serve as a nutrient source for legionellae growth. Diverse biofilms, which can support the growth of legionellae, may be present on heat exchanger surfaces, structural surfaces, sump surfaces, and other miscellaneous surfaces.

7.5 Associated Cases of Legionnaires' Disease

Evaporative heat rejection equipment such as cooling towers and evaporative condensers have been implicated in numerous outbreaks of Legionnaires' disease, and studies have shown that detectable levels of legionellae are present in many, if not most, such devices.[38-40]

7.6 Recommended Treatment

The key recommendations are that the system be maintained clean and that a biocidal treatment program be used. It is also recommended that the services of a qualified water treatment specialist be used to define and oversee the treatment.

7.6.1 System Maintenance. Keeping the system clean reduces the nutrients available for *Legionella* growth. Regular visual inspections should be made for general cleanliness. The cold water basin of the unit should be cleaned when any buildup of dirt, organic matter, or other debris is visible or found through sampling. Mechanical filtration may be used to help reduce these solids. Strainers, cartridge filters, sand filters, centrifugal-gravity-type separators and bag-type filters can be used to assist in removal of debris.

The drift eliminators should also be inspected regularly and cleaned if required or replaced if deteriorated or damaged.

Operation and maintenance records should include the following information:

- system schematic
- system water volume, with date and method of determination
- manufacturers' instructions for equipment operation
- regular water treatment procedures
- material safety data sheets for chemicals used (MSDS)
- names of persons responsible for system operation and shutdown
- dates of inspections and written results of inspections
- dates and nature of routine maintenance
- dates of equipment repairs or modifications with description of work done

7.6.2 Water Treatment. Water treatment provides a heat transfer fluid that allows equipment to function optimally. Objectives of water treatment for cooling water systems is to use water efficiently as well as to

- minimize microbial growth,
- minimize scale,
- minimize corrosion,
- minimize sediment/deposition of solids (organic or inorganic) on heat transfer surfaces.

An effective water treatment program should allow more efficient operation due to lower fouling, a longer system life due to decreased corrosion, and safer operation of the system due to reduced chances of microbial exposure to the public.

Control of scaling and corrosion is necessary in many water treatment programs. Scale such as calcium carbonate and/or other minerals containing silica, magnesium, and phosphate may precipitate onto heat exchanger and piping surfaces. Scaling can be minimized by use of inhibitors containing phosphonates, phosphates, and polymers to keep calcium and carbonate and other minerals in solution. Corrosion can be minimized by the use of inhibitors such as phosphate, azoles, molybdenum, and zinc. Scale and corrosion inhibitors are effective if microbial fouling and biofilm development are properly controlled. Microbial fouling can influence scaling and corrosion processes and can affect the performance of inhibitors. Microbial biofilms on surfaces can consume certain inhibitors (such as phosphates, phosphonates, and azoles), prevent access of inhibitors to surfaces, create localized oxygen-depleted zones, change the pH near surfaces, and accumulate or trap deposits onto surfaces.

Surfactants have also been used to minimize deposition on surfaces (particularly heat transfer surfaces). When used, the surfactant must be compatible with the scale and corrosion inhibitors as well as appropriate for the type of dirt, oil, or other material that is present.

Equally important to controlling scale and corrosion is keeping the system clean and free of sediment. Common sources of sediment include materials scrubbed from the air (dirt, leaves, paper, kitchen or other organic exhaust), precipitated solids (calcium, magnesium, carbonate silica), and corrosion products (rust). Microbes including bacteria, protozoa, algae, and (infrequently) fungi can grow in cooling systems and use the above materials as nutrients. Consequently, it is desirable to either prevent the entry of the material into the system or to remove it from the system.

Strategies to accomplish this include siting of the tower (relative to kitchen exhausts, etc.), scale and corrosion control, and filtration and/or separation.

Microbial fouling is controlled by the use of biocides, which are compounds selected for their ability to kill microbes while having relatively low toxicity for plants and animals. In the USA, the Environmental Protection Agency has regulatory authority for biocides and requires registration of all biocides. In addition, registration is required in each state where the biocide will be distributed. The data package submitted to the EPA includes efficacy data against a variety of microbes and toxicity data for animals. Much of the laboratory data are provided by the manufacturers of the individual biocides. Biocides must be used in accordance with the directions on the label.

There are two main groups of chemical biocides: oxidizers and nonoxidizers.

Oxidizing biocides include bromine, bromo-chlorohydantoin, chlorine, chlorine dioxide, iodine, isocyanurates, ozone, or other compounds with the ability to accept electrons from other compounds that serve as reducing agents. Oxidizing biocides can accelerate corrosion of metals if they are dosed at excessive concentrations. Halogen biocides (chlorine, bromine, and iodine) react with the protein in cell membranes to cause the protein to become dysfunctional, thus killing/ controlling the organism. Ozone and chlorine dioxide are believed to oxidize other components of the microbial cell.

Nonoxidizing biocides include many organic compounds registered with the EPA for cooling water applications, such as bromonitropropanediol, bromonitrostyrene, carbamates, decylthioethaneamine, dibromonitrilopropionamide, dodecylguanidine hydrochloride, glutaraldehyde, isothiazolones, methylene bisthiocyanate, quaternary phosphonium salts, and tris-hydroxymethylnitromethane. Quaternary ammonium compounds are sometimes used but were found to be ineffective against legionellae in a recent study.[41] These biocides function in a number of ways, including reacting with intracellular enzymes, solubilizing cell membranes, and precipitating essential proteins in microbial cell walls. Properly used, nonoxidizing biocides are effective for control of the microbial fouling process in cooling water systems.

Both oxidizers and nonoxidizers can undergo chemical reactions with materials in the water that decrease their effectiveness. Some biocides react with components of some scale and corrosion inhibitors to render both compounds less effective for their intended purpose. Selection of corrosion/scale inhibitors as well as the biocide requires a knowledge of water chemistry, a basic understanding of water microbiology, and specific information about the system (what the system is cooling, sources of contamination, etc.).

It is generally sound practice to regularly alternate the biocides used for a cooling water system to avoid the selection and growth of resistant strains of microbes. The alternating biocide approach has been emphasized with the rationale that the population that survives the biocide treatment one week is susceptible to the alternate biocide a week or two later. Alternating the dose and frequency of the same biocide is also used to achieve this goal.

Because *Legionella* are known to enter cooling water systems in the makeup water, it should be assumed that they are present in the water along with other bacteria, protozoans, and algae. Protozoa are highly resistant to both oxidizing and nonoxidizing biocides; hence they must be controlled by limiting the microbial biofilms that serve to provide them nutrients.[42]

For further information on the subject of water treatment, see the "Water Treatment" chapter in the Applications volume of the ASHRAE Handbook.

7.6.3 Cooling Tower System Shutdown and Start-Up Procedure[43]

Shutdown

When the system is to be shut down for a period of more than three days, it is recommended that the entire system (cooling tower, system piping, heat exchangers, etc.) be drained to waste. When draining the system is not practical during shutdowns of short duration, the stagnant cooling water must be pretreated with an appropriate biocide regimen before tower start-up.

Start-Up for Drained Systems

- Clean all debris, such as leaves and dirt, from the cooling tower.
- Fill the system with water. While operating the condensing water pump(s) and **prior to operating the cooling tower fans**, execute one of the two alternative biocidal treatment programs described below.
  (1) Treat with the biocide that had been used prior to shutdown. Utilize the services of the water treatment supplier. Maintain the maximum recommended biocide residual (for the specific biocide) for a sufficient period of time (residual and time will vary with the biocide) to bring the system under good biological control.
  (2) Treat the system with sodium hypochlorite to a level of 4 to 5 mg/L (ppm) **free** chlorine residual at a pH of 7.0 to 7.6. The chlorine residual must be held at 4 to 5 mg/L (ppm) for six hours, measurable with standard commercial water test kits.
- Once one of these two biocidal treatments has been successfully completed, the fan can be turned on and the system returned to service. Resume the standard water treatment program (including biocidal treatment).

Start-Up for Undrained (Stagnant) Systems

Remove accessible solid debris from the cooling tower sump and from any remote storage tank(s) that may be used.

- Perform one of the two biocide pretreatment procedures (described in "Start-Up for Drained Systems") directly to the cooling tower sump or remote storage tank. Do not circulate stagnant bulk cooling water over cooling tower fill or operate cooling tower fans during pretreatment.
- Stagnant cooling water may be circulated with the main cooling system pump(s) if tower fill is bypassed. Otherwise, add approved biocide directly to the bulk water source and mix with either manual or by sidestream flow methods. Take care to prevent the creation of aerosol spray from the stagnant cooling water from any point in the cooling water system.
- After biocidal pretreatment has been successfully completed, the cooling water should be circulated over the tower fill with fans off. When biocide residual is maintained at a satisfactory level for at least six hours, the cooling tower fans may be operated.

7.6.4 Emergency Decontamination of Wet-Type Heat Rejection Systems for *Legionella*. The Cooling Tower Institute has formulated an "Emergency Protocol" for decontaminating cooling towers and evaporative condensers using chlorine and dispersants.[44] However, this procedure must not be used routinely because it can be very corrosive and produce toxic fumes. This procedure has been adapted to include additional safety precautions and a 10 mg/L free residual chlorine level for 24 hours.[31]

7.6.5 Siting. In locating cooling towers and evaporative condensers, attention should be given to the following considerations.

- Locate as far as possible from fresh air intakes, including windows that can be opened.
- Do not locate in the immediate area of kitchen exhaust fans, plants, truck bays, or other sources of organic matter.
- Consider the direction of prevailing winds and do not locate upstream of outdoor public areas.
- Consider future construction, including nearby sites.

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

8.1 System Description

Direct evaporative air-cooling equipment and humidifiers cool and humidify air by direct contact with the water, either by wetted-surface materials (as in wetted media air coolers) or with a series of sprays (as in air washers and misters). These devices (see Figures 4 and 5) are used to control the temperature and humidity levels for commercial, industrial, and agricultural applications.

They utilize either once-through or recirculating water. Wetted media systems may include a pump, water distribution piping, and a sump to collect or hold water. A fan may be utilized to move air across the system and distribute evaporatively cooled and humidified air to the location being served. Concentration of contaminants in the water is limited by bleed off and quality of fresh water makeup.

8.1.1 Wetted Media. Wetted media devices utilize a porous substrate to provide an extended surface area for evaporation of water. Water is either circulated over the media or the media are rotated through a water bath. Since evaporation occurs from the surface of the media, no water droplets are produced. Mist eliminators are generally not necessary. These

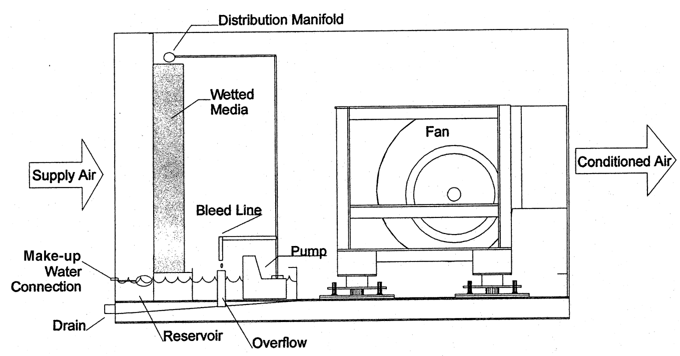

Figure 4 Direct evaporative air cooler/humidifier.

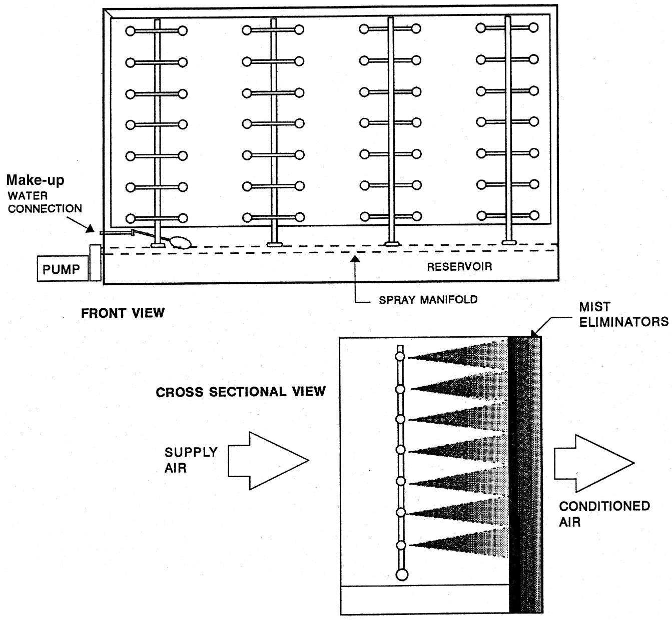

Figure 5 Single bank air washer humidifier.

devices utilize either once-through potable building water or are equipped with a recirculating system including a pump, automatic makeup water valve, a bleed-off/purge, and a positive draining reservoir.

8.1.2 Air Washers. Air washers utilize high-pressure nozzles to reduce water to small droplets for efficient evaporation. These systems have a chamber or casing containing one or more banks of spray nozzles and drift eliminators. Air washers contain a sump for collecting and holding excess spray water. The eliminator section removes entrained droplets of water from the air. Air washers also utilize either once-through potable building water or are equipped with a recirculating system including a pump, automatic makeup water valve, a bleed-off/purge, and a positive draining reservoir. The water may be chilled for additional cooling and/or dehumidification.

8.1.3 Misters. Misters produce an aerosol by use of ultrasonic devices, spinning disks, or spray nozzles. Normally these devices are supplied with fresh potable water directly from the building water systems; however, some systems contain a reservoir.

8.1.3.1 Heated Element and Steam-Type Humidifiers. Heated element and vapor-type humidifiers convert water to vapor that is discharged into the space being conditioned. Due to the elevated temperature and the fact that water droplets are not generated, these humidifiers are not considered a risk for the growth of *Legionella* during normal operation. However, if the humidifier is improperly installed, moisture may accumulate in the duct and lead to bacterial growth. During periods of time when equipment is not in use, all water should be drained from the system to avoid the possibility of bacterial growth.

8.2 System Operation

See 8.1.

It should be noted that due to process conditions, there may be periods of time when equipment is shut down. It is common practice to drain sumps when the units are not in use. In addition, a continuous bleed or purge cycle is usually employed to limit the buildup of solids and contaminants in the basin. High dilution rates remove bacteria, nutrients, and other contaminants before they are a problem. It is rare for growth of *Legionella* to occur under these conditions.

8.2.1 Water Temperature—Wetted Media Evaporative Air Coolers/Humidifiers and Air Washers. For wetted media evaporative air coolers/humidifiers and air washers, the recirculating water temperature approximates the wet-bulb temperature of the airstream to which it is exposed. Since the wet-bulb temperature in most regions where these devices are used is well below 25°C (77°F), the water tends to be maintained at temperatures below the Legionella growth temperature range of 25-42°C (77-108°F).

8.2.2 Water Temperature—Misters. For misters supplied directly from the building potable water system, the temperature would tend to be at the supply cold water temperature. If fed from a stagnant reservoir, or pipes exposed to heat, the temperature could increase. The temperature could exceed 25°C (77°F), which is favorable for amplification of legionellae.

8.2.3 Water Temperature—Air Washers. Air washer operating conditions are based on the requirements of the process; however, a standard operating temperature range for circulating water is 4-10°C (40-50°F). The normal operating portions of air washer systems tend to be maintained at temperatures below the *Legionella* growth temperature range of 25-42°C (77-108°F).

8.3 Water Droplet Size

8.3.1 Wetted Media. Wetted media equipment generally produces few droplets during operation. However, large droplets may form as a result of improper maintenance and uneven water or air distribution. The exact size of the droplets will vary with the condition of the wetted media and mist eliminators (where used), air velocity through the unit, and irrigation rate. It should be assumed that under extreme conditions droplets of less than 5 micrometers could be created.

8.3.2 Air Washers. The major causes of droplets being entrained into the airstream are fouled spray nozzles and damaged or dirty mist eliminators. Air washers can produce droplets of various sizes and certainly have the potential to produce droplets less than 5 micrometers in diameter.

8.3.3 Misters. These systems can product droplets of varying size and certainly have the potential to produce droplets less than 5 micrometers in diameter.

8.4 Nutrients

Because direct evaporative air coolers/humidifiers are efficient air scrubbers and move large volumes of air, organic matter and other debris can be accumulated. This may serve as a nutrient source for *Legionella* growth.

8.4.0.1 Wetted Media Evaporative Air Coolers/Humidifiers and Air Washers. Wetted media evaporative coolers/humidifiers and air washers have potential for growth where dirt, scale, or biological matter can accumulate. Most likely areas of such accumulation are collection troughs, mist eliminators, or water storage tanks.

8.4.1 Misters. Nutrient availability would be minimal when fed potable water directly from the building potable water system. If distribution piping and/or a holding reservoir is used, nutrients in the form of sediment and other debris may exist.

8.5 Recommended Treatment

8.5.1 All Systems. Regular inspection and maintenance of evaporative air coolers/humidifiers, air washers, misters, and ancillary equipment are recommended. Avoid dead-end piping, low spots, and other areas in the water distribution system where water may stagnate during shutdown.

Consider the use of photochemical ozone generators to control microbial concentrations in water in sumps and distribution piping. Water filters and air filters should be cleaned as required. The entire cooling water loop should be cleaned and flushed monthly.

8.5.2 Recirculating Systems. Proper sump water level or spray pressure must be maintained. Bleeding off or purging some of the water is the most practical means to minimize scale and nutrient accumulation. The bleed rate or purge depend on water quality (including hardness) and airborne contaminant level. Regular inspections should be made to ensure that the bleed rate or purge is adequate and is maintained. As an added precaution, sumps could be automatically drained during shutdown of the fan. When it is impractical to shut a system down for cleaning, it should be provided with a positive draining sump and easily accessible flush-out of the water distribution header so it can be flushed during operation. After flushing, dose the recirculating cooling water with a biocide approved by the EPA for such applications.

8.5.3 Air Washers. Use corrosion inhibitors to prevent corrosion of metals in the systems and formation of corrosion products. Control the level of suspended solids that can supply nutrients and growth areas for legionella. Finally, the microbiological activity should be controlled through the utilization of biocides approved by the EPA for such applications.

8.5.4 Wetted Media Evaporative Air Coolers/Humidifiers. Media located inside a large built-up air house may not dry completely during period of shutdown (i.e., weekends), resulting in stagnation. In order to dry out the media, pumps should be shut down prior to scheduled fan shutdowns. Smaller systems and those having the media located adjacent to inlet louvers normally dry sufficiently without assistance. For systems experiencing high contaminant loading, a flush-out cycle may be used that runs fresh water through the pad every 24 hours during a period of time when the system is not in operation. Media should be cleaned or replaced when necessary.

8.5.5 Misters. Never recirculate atomized water. Drain pipes and reservoir when equipment is not in use. For portable misters, drain and disinfect piping and reservoir regularly. Only sterile water should be added to the reservoir of portable humidifiers used in health care environments or in other areas where immunocompromised persons are likely to be exposed to the generated aerosols.

8.6 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. Filtration upstream of the evaporative air cooler/humidifier is recommended when particulate contamination is expected. Filtration downstream of the equipment must be a sufficient distance to allow absorption of moisture into the air stream.

8.7 Associated Cases of Legionnaires' Disease

There have been no known cases of Legionnaire's disease with air washers, wetted media evaporative air coolers/humidifiers, or steam humidifiers. A supermarket vegetable misting device using water from a holding tank was implicated in one outbreak of Legionnaires' Disease.[15] There is a documented case of Legionnaires' Disease that occurred in a hospital setting and resulted from aerosolized tap water from a humidifier.[12,22]

9. INDIRECT EVAPORATIVE AIR COOLERS

Indirect evaporative air coolers cool air in a heat exchanger, which transfers heat to a secondary airstream as shown in Figure 6. Although the primary air is cooled by the evaporatively cooled secondary air, no moisture is added to the primary air.

9.1 System Description

The heat exchanger is cooled by evaporation of water utilizing one of several methods:

1. direct wetting of the heat exchanger surface
2. cooling of secondary air utilizing evaporative cooling media
3. atomizing spray into secondary airstream or onto heat exchanger surface
4. cooling tower and coil.

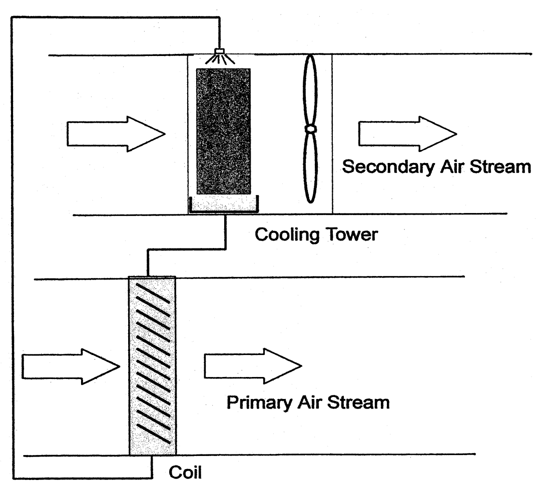

Figure 6 Indirect evaporative cooler.

9.2 System Operation

9.2.1 Temperature. The recirculated water temperature approximates the wet-bulb temperature of the secondary airstream. As is the case with direct evaporative air coolers, it is unlikely that the water temperature will exceed 25°C (77°F).

9.3 Water Droplet Size

Water droplet size will vary with exchanger type, condition of the media and mist eliminators (where used), air velocity through the unit, and other factors. Refer to the section of this guideline regarding specific exchanger type, i.e., cooling towers, misters, etc.

9.4 Nutrients

See 7.4 for equipment using a cooling tower to cool the secondary airstream and 8.4 for equipment using evaporative coolers or misters to cool the secondary airstream.

9.5 Recommended Treatment

See 7.6 for equipment using a cooling tower to cool the secondary airstream and 8.5 for equipment using evaporative coolers or misters to cool the secondary airstream.

9.6 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.

9.7 Associated Cases

There has been no positive association of Legionnaires' disease with indirect evaporative air coolers.

10. METALWORKING SYSTEMS

10.1 System Description

In these systems, metalworking fluids are applied to cutting surfaces for lubrication and to prevent overheating of both the machine tool and the machined part.

10.2 System Operation

Both oil-based and water-based fluids are used. A variety of such fluids are commercially available from many companies.

As a rule, microbial growth does not occur in oil-based products. However, water-based fluids do become contaminated by microorganisms.

10.2.1 Temperature. As the fluids cool the machine tool and machined part, they become heated and the ambient temperature of the fluid sumps ranges between 24° and 32°C (75°F and 90°F), permitting the growth of many pathogens including *Legionella* species.

10.3 Water Droplet Size

These systems can produce droplets of varying size depending on the specific machining operation and have the potential to produce droplets less than 5 micrometers in size.

10.4 Nutrients

These systems are typically open and subject to contamination from the air and surfaces that are being machined.

10.5 Associated Cases of Legionnaires' Disease

Metalworking systems have been implicated in the outbreak of Pontiac fever as well as acute respiratory syndrome and hypersensitivity pneumonitis.[45]

10.6 Recommended Treatment

Exposures from metalworking operations can be a serious potential health concern, the magnitude of which is not fully understood. Biocides are supplied with fluid concentrates, which are diluted when used and/or added to the fluid reservoir. However, the variety of fluids, microbial types, turnover rate, and metal operations makes successful dosing not always predictable. Selections of biocides should be based on fluids and microbes being treated.

It is recommended that care be taken to minimize contamination and to reduce exposure to machine operators until further information is available.

11. MONITORING FOR *LEGIONELLA*

Culturing for *Legionella* may be appropriate if carried out for a specific purpose, such as verifying the effectiveness of a water treatment protocol, tracing the source of an outbreak, evaluating the potential amplifier/transmission sources at a facility, verifying that the decomination procedures have been effective, or in health care facilities caring for patients with exceedingly high risk of developing Legionnaires' disease (e.g., organ transplant recipients).[46-48] Where culturing is performed, proper sampling, handling, and shipping methods should be used.[49]

However, except as discussed in 5.6.1.5, routine culturing of samples from building water systems may not be predictive of the risk of transmission for the following reasons.

1. Presence of the organism cannot be directly equated to the risk of infection. The bacterium is frequently present in water systems without being associated with known cases of disease.

2. Interpretation of the results of culturing of water is confounded by use of different bacteriologic methods in various laboratories, by variable culture results among sites sampled within a water system, and by fluctuations in the concentration of *Legionella* isolated from a single site.

3. The risk of illness following exposure to a given source is influenced by a number of factors other than the concentration of organisms in a sample. These factors include, but are not limited to, strain virulence, host susceptibility, and how efficiently the organisms are aerosolized to the small particle size required to reach the deep portion of the human lung and remain viable.

4. Test results only represent the counts at the time the sample was collected. A negative result from such a sample is likely to lead to a false sense of security because any amplifier can quickly become heavily colonized if it suffers neglect.

Testing is not a substitute for sound maintenance practices and water treatment.

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(This informative annex is not a part of this guideline and is for information purposes only.)

ANNEX A

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POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.