Guidelines for Control of Legionella in Ornamental Water Features

The purpose of this guideline is to provide legionella risk management information to owners and operators of ornamental water features including ornamental fountains in community settings. This guideline provides information regarding protocols for operating indoor and outdoor ornamental water features to control legionella growth and transmission.

Part 1 - Overview

Ornamental water features including ornamental fountains in community settings such as restaurants[1], hotels[2,3,4], offices and conference centers[5] have been associated with Legionnaires' disease outbreaks. Most reported outbreaks have been associated with indoor ornamental water features[1,2,3,5] but there has been at least one case documented related to an outdoor feature[4]. These outbreaks can result in serious illness and death.

As with cases related to mold, many insurance carriers do not cover costs associated with Legionnaires' disease outbreaks. While we don't often hear about Legionnaires' disease it is not uncommon; an estimated 15,000 cases of Legionnaires' disease occur in the U.S. annually and, according to CDC, less than 10% of them are diagnosed or reported[7]. We do not know what percentage of these estimated 13,000 undiagnosed cases are related to ornamental features.

This document details recommended operating procedures for ornamental water features and reviews the risk factors associated with these units. For more details on legionella, legionella growth and Legionnaires' disease, all those who own or operate ornamental water features in community settings should familiarize themselves with the most widely recognized U.S. guidelines on the subject, ASHRAE Standard "Minimizing the Risk of Legionellosis Associated with Building Water Systems"[8] and the OSHA Legionella Manual[9].

Healthcare facilities with ornamental features should comply with the ASHRAE and OSHA guidelines as well as the CDC Guidelines for Environmental Infection Control in Health-Care Facilities[10] and the JCAHO/ASHE joint guidelines titled Regulatory Advisory Waterborne Pathogens – Compliance with JCAHO requirements[11].

Those most susceptible to Legionnaires' disease are: elderly, transplant patients, heavy smokers and those with immune compromising illnesses such as AIDS, cancer, diabetes and chronic lung disease. Facilities operating ornamental water features in community settings should be aware that these highly susceptible individuals can be found in restaurants, hotels, office buildings and entertainment facilities. Additionally, about 20% of those who succumb to Legionnaires' disease have none of the identified risk factors.

The CDC Guidelines for Environmental Infection Control in Health-Care Facilities[9] states all healthcare facilities should "**Avoid placing decorative fountains and fish tanks in patient-care areas; ensure disinfection and fountain maintenance**." Healthcare facilities with patients susceptible to Legionnaires' disease should be cognizant of the inherent risk and liability associated with locating an ornamental water feature in any area which may be used, even as a thoroughfare, by those patients. Because of the significant risk associated with operating an ornamental feature in a healthcare facility, hospitals should implement the risk management plan for ornamental features then verify results by testing the feature water quarterly to insure legionella levels are consistently less than 1 cfu (colony forming unit). If testing verifies the desired levels are being consistently maintained then after one year, testing can be reduced to annually.

Part 2 - Legionella Growth Factors

This guideline will briefly review legionella growth and transmission as related to ornamental water features. An in depth review of legionella ecology can be found in Chapter 3 of the ASHRAE guidelines[8].

Source

Legionnaires' disease is caused by the waterborne bacteria legionella, which is found in most water sources, including municipal drinking water, at levels that are below standard detection limits and not harmful. Legionella can grow to dangerous levels in systems that store water, including ornamental water features.

For legionella to grow in an ornamental feature, the legionella bacteria must be present in the supply water or aerosolized legionella must enter the feature from another source. If the ornamental feature is indoors and the only makeup used is distilled or sterile water, the potential for legionella growth is reduced significantly. If the system used a water source that may have contained legionella, switching to sterile water will not eradicate legionella already in the system.

Temperature

Legionella require a certain temperature to multiply. Legionella will reproduce at temperatures between 20°C and 45°C and will grow rapidly between temperatures of 27°C and 40°C. In ornamental water features that do not follow protocols as outlined in this document, legionella can multiply to deadly levels at temperatures as low as 20°C.

As water evaporates, it releases heat and cools the remaining water in the feature. The amount of cooling is impacted by the relative humidity and amount of aerosolization. For features in air conditioned buildings with an average air temperature of 21°C and a low to moderate relative humidity the feature water temperature will typically be 18°C or lower. The temperature of outdoor features is impacted by daily weather conditions.

Equipment such as UV units, pumps and lights can elevate water temperature to levels significantly higher than 20°C. The amount of water temperature increase as a result of lighting is impacted by the type, location and wattage of the light, the shape of the feature, and the amount of watts in proportion to the water flow and system volume. Submerged light can add a tremendous amount of heat to the water overall or just in the area of the light. Submerged lighting has been present in all ornamental fountain outbreaks reported in the US. Where submerged lighting is used in a water feature, the risk management plan needs to be modified accordingly.

Remote Light focused on the feature will add a negligible amount of heat to the water for most features. A water wall feature (see description below) will absorb more heat from a remote light source than other types of features because of the wall's large surface area.

Source of Nutrients

Legionellae are parasitic bacteria that grow best in the presence of higher life forms including amoebae, protozoa and algae. Any water that is at all cloudy or dirty can be considered to have an extremely high concentration of bacteria and also higher life forms like amoebae as well.

Even clear water that is not properly maintained can readily grow legionella. The location and size of the feature can also be a factor in the source of nutrients. Large features can have debris dropped in them by passersby. Features in food areas have a potential of food or even oils entering the unit.

Filtration is an effective method to control solids including minerals and nutrients in the water. Filtration will not filter out legionella bacteria but by keeping the feature clean, filtration will minimize items that are needed for legionella habitat.

Biofilm

Biofilm, the slippery material found on wet surfaces, is where legionella typically grow best. Biofilm grows well on materials that are more porous such as plastic, stone and concrete. Nonporous materials such as copper, brass and stainless steel are less conducive to biofilm growth and much easier to keep clean. Biofilm can be cleaned easily from smooth surfaces but other surfaces such as uneven rocks or non-accessible surfaces such as plastic tubing are very difficult to clean.

Scale, the white chalky residue from calcium in the water, is also a good medium for biofilm growth. To keep features free of scale, water pretreatment by softeners, reverse osmosis, or pH control through acid feed is recommended. Also, scale control chemicals can be used by themselves or in conjunction with a pretreatment program.

For small features adding makeup by hand, distilled water is recommended. Distilled water is not the same as spring water. Spring water will contain minerals including calcium that add a spring like flavor to the water, while distilled water is pure H_2O with no minerals at all.

Another factor having a significant impact on biofilm growth is water flow. Flowing water will tend to minimize biofilm growth whereas stagnant water can facilitate quick biofilm growth. Fountains should be run a minimum of 6 hours a day to minimize biofilm growth; this will also minimize potential for mosquito larvae in outdoor fountains.

Materials

Organic materials provide nutrients for legionella growth. Materials such as rubber and fiber (paper) washers should not be used in ornamental features. Copper corrosion byproducts can have biocidal properties and can inhibit algae and legionella growth.

Part 3 - Legionella Transmission Factors

To cause disease, legionella must be aerosolized into small droplets approximately 1 to 5 microns in diameter and breathed into the lungs (human hair is less than 100 microns). When inhaled, droplets larger than 5 microns typically enter the stomach where legionella will have no impact.

Design

Ornamental feature design has a **major** impact on the amount of aerosol generated. Below is a summary of design factors and their impact on legionella growth.

- Flow Type - Ornamental features that spray or mist water will create much more aerosol than features which cascade water. Totally enclosed or mostly enclosed features such as a sea bubbler type will generate little if any aerosol. Ornamental feature flow types are reviewed on the next page.

- Surface Area - The amount of exposed surface area will impact the potential for biofilm growth, heat exposure and dirt accumulation. A fountain with a lot of surface area, such as many rocks, has a greater potential for biofilm growth and is more difficult to keep clean.

- Submerged Components - Biofilm and legionella will grow well in plastic tubing and places where dirt can accumulate. Units with no hidden or difficult to inspect and maintain components are easier to keep clean.

• Lighting - Submerged lighting has a **major impact** on the risk of Legionnaires' disease associated with ornamental features. All documented cases of Legionnaires' disease outbreaks related to ornamental features in the US had submerged lighting. LED and fiber optic light produces less heat than incandescent or halogen light sources.

• Drainage - The ability to drain a fountain from the lowest point in the system, below pumps and tubing, easily and quickly has an impact on maintenance of the unit.

Fountain Size

A small indoor feature may generate little aerosol which may only travel a few yards. A large exterior fountain can generate large volumes of aerosol that travels several city blocks. However, smaller indoor units not maintained properly can present a high risk. One outbreak, which resulted in death and illness, was caused by a feature that contained less than 20 gallons of water.

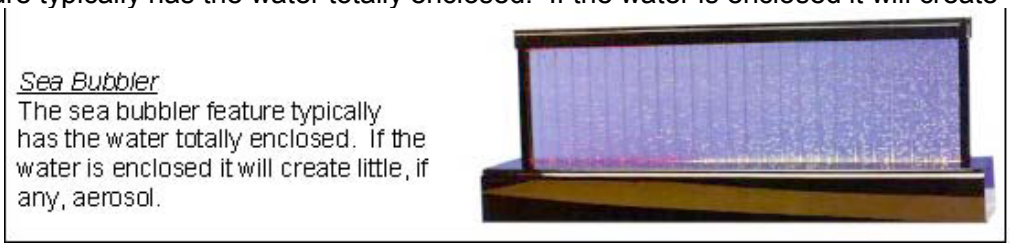
Location

Fountain location, to a smaller degree than other factors, impacts aerosol transmission. A fountain located in the corner of the room away from all air flow will have a much lower risk of transmitting an aerosol than one located in the air circulation path. The same holds for exterior ornamental features. An exterior fountain located on the side of the building protected from winds or in a location with little or no winds will have a much lower possibility of transmitting aerosols than one in an exposed or windy area.

Types of Ornamental Features

Sea Bubbler

The sea bubbler feature typically has the water totally enclosed. If the water is enclosed it will create little, if any, aerosol.



Cascade

A cascading fountain pumps water to the top of the feature then allows the water to cascade down to the sump over typically smooth surfaces that create very little aerosol. By design, the smooth peaceful flow of the water results in little aerosol generated.

Water Wall

A Water Wall feature operates like a Cascade fountain pumping the water to the top of the unit and allowing it to flow down over a smooth surface to the sump. Because of the fine sheeting of water created over a large surface area, there is the additional possibility of creating a small amount of aerosol.

Spray

The Spray fountain pumps water through a nozzle forcing a spray of water into the air. Water droplets fall by gravity back to the sump. This design will create a significantly larger amount of aerosol than any of the previously discussed units. A pulsing fountain is a type of Spray fountain that pulses water into the air. Pulsing fountains can create significantly more aerosol than a standard spray type fountain. Fine mists and high sprays will create more aerosol than coarse and low sprays. However, outbreaks have been associated with coarse, low sprays.

Mist

These ornamental features operate in the same fashion as table top humidifiers. The main difference between this unit and humidifiers is that humidifiers have a fan to circulate the mist into the room so that it quickly evaporates. These units allow the mist to stay around the unit for effect. The units by design create a very high amount of aerosol in proportion to their total volume.

Part 4 - Recommended Ornamental Fountain Operating Procedures

Regular maintenance including biocidal treatment will greatly reduce the risk of legionella growth. Recommended maintenance practices for indoor and outdoor units are reviewed on the next two pages. Ornamental features that by design or application are more of a risk, in particular indoor features with submerged lighting, features located in healthcare facilities, or features with water temperatures exceeding 70^{o}F require greater attention.

The most commonly used biocides in small ornamental features are ionized copper, halogens (chlorine and bromine), hydrogen peroxide and polyquat. For larger features there are many other options including ozone, peracetic acid, and chlorine dioxide to name a few. For more details on biocides, refer to the addendum to this document, "Water Treatment for Ornamental Features". This addendum will be updated regularly. Some municipal water systems[12] prohibit the use of copper in fountains and pools because of the impact it has on aquatic life.

Some ornamental feature manufacturers do not recommend using chlorine and instead recommend weekly cleaning of surfaces with a 50/50 solution of water and white vinegar followed by cleaning of the pump and tubing by pumping a 10% vinegar solution. Vinegar is a weak acid, a good cleaner and has mild disinfecting properties. This vinegar solution concentration will clean and also dissolve scale buildup. In applications where the manufacturer does not allow chlorine, other less reactive products such as hydrogen peroxide or polyquat, should be used (check with manufacturer).

Both ozone and UV, properly applied are very effective at killing all bacteria, viruses and algae. UV provides no residual disinfectant; it will only kill the bacteria that flow across it. UV will greatly reduce organic loading and result in much lower use of chlorine. UV may add some heat to the water. Ozone will provide an effective residual disinfectant. When using ozone indoors, insure the product is properly applied and the generator is installed to minimize risk of ozone leakage indoors. Even small amounts of ozone in the air can be harmful to lungs[13]. Biocides must be "EPA registered" for use in ornamental fountains as stated on the EPA label. If water is discharged to streams or surface runoff, it will require NPDES permitting as well.

When not in use for three or more days, features should be drained and cleaned or fed with a high chlorine level (5 ppm) prior to operation as stagnant water will impact legionella and biofilm growth. Legionella is a waterborne bacteria – no water, no legionella. For ornamental features that are left stagnant, the best thing to do is drain

them completely during those periods.

Some manufacturers recommend changing feature water if it becomes cloudy or has an odor. If water becomes cloudy or has an odor, there are significant amounts of bacteria in the water and excellent conditions for biofilm growth. Ornamental features in community settings should never be operated with cloudy or smelly water.

The level of disinfectant in swimming or wading pools is significantly higher than the levels recommended in this document. For ornamental features in community settings, the owner / operator is responsible to insure the unit is never used for public bathing. Features with other organic loading, such as ducks or geese, should take appropriate measures to control legionella as well as other pathogens.

Chart 1 - Indoor Ornamental Water Features

	Large (> 200 gal) & All hospital fountains	**Medium (less than 100 gallons)**	**Small (less than 5 gallons)**
Filtration	Filtration	Drain & clean monthly	Drain & clean weekly
Bacteria Control	Automatic control & feed of biocide. Maintain at least 0.5 ppm free chlorine (or equivalent) continuously	Manual or automatic biocide feed to maintain at least 0.5 ppm free chlorine (or equivalent) 6 hours a day.	Manual dosing once a day of liquid chlorine to develop 3 – 5 ppm free chlorine (or equivalent) for 1 hour.
Algae Control	Feed chlorine or algaecide as required to insure no algae or slime		
Slime Control	Spray slimy areas with a weak bleach solution and rinse		
Semi-Annual	Open & inspect filter	Open & inspect filter	
Annual	Drain, clean & inspect	Drain, clean & inspect	

Chart 2 - Outdoor Features

	Large (> 200 gal) & All hospital fountains	**Medium (less than 200 gallons)**	**Small (less than 25 gallons)**
Filtration	Filtration	Filtration	Drain water monthly.
Bacteria Control	Automatic control & feed of biocide. Maintain at least 0.5 ppm free chlorine (or equivalent) continuously	Manual or automatic biocide feed to maintain at least 0.5 ppm free chlorine (or equivalent) 6 hours a day.	Manual dosing once a day of liquid chlorine to develop 3 – 5 ppm free chlorine (or equivalent) for 1 hour.
Algae Control		Feed chlorine or algaecide as required to insure no algae or slime	
Slime Control		Spray slimy areas with a weak bleach solution and rinse	
Algae Control	Feed as required to insure no algae	Feed as required to insure no algae	Feed as required to insure no algae

Slime Control	Algaecide and biocide should control slime	Spray slimy areas with a weak bleach solution and rinse	Spray slimy areas with a weak bleach solution and rinse
Semi-Annual	Open & inspect filter	Open & inspect filter	
Annual	Drain, clean & inspect	Drain, clean & inspect	

The above protocols are for units with medium to low risk factors.

* Consider the indoor unit at a significantly higher risk if:

- Water temperature exceeds 21^{o}C. Temperature should be measured at the hottest area in the system and at the time of day when the water temperature is hottest.
- The unit is located, in a walkway to or near a hospital, extended care facility or retirement home.
- The unit is routinely stagnant.
- There is additional organic loading of the unit.
- The unit has submerged lighting.

Maintenance Log

Keep a Maintenance log for all ornamental features.

Daily Logs

Free chlorine or free bromine residual

- Collect water samples where chlorine level will be lowest such as a low flow area or a high temperature area and away from any source that may give higher chlorine such as near the chemical feed location or city water makeup.
- For small, manually dosed ornamental fountains, the reading should be taken one hour after dosing to insure the desired level of chlorine is maintained in the feature at least one hour a day.

Temperature

- Water temperature should be logged once a day when the chlorine sample is collected. As with chlorine, the water temperature should be obtained in the area of the fountain with the highest temperature.
- For features where the water temperature is constant, as with most indoor units, a change in water temperature may be an indicator of an equipment problem.
- For smaller indoor features with constant temperature weekly temperature logs are sufficient.

pH and alkalinity

- pH impacts the ability of chlorine and bromine to kill bacteria. pH should be kept at less than 8.5 for chlorine and less than 9.0 for bromine systems.
- For copper systems, pH should be maintained at less than 7.6 or as recommended by the manufacturer and less than 100 ppm total alkalinity. Above 7.6 (see manufacturers instructions) copper can precipitate from solution causing staining of the feature.

Visual Inspection

- Log daily visual inspection.

Weekly Logs

- If copper is used as a disinfectant, weekly testing and, in some cases, testing every two weeks may be sufficient.
- If using polyquat feed according to manufacturers recommendations and log additions.
- Log weekly cleaning of surface for debris, algae and scum

Monthly, Quarterly and Annual

Log all recommended manufacturer maintenance items including:

- Filter inspections
- Filter changes
- Filter media changes (minimum of once / year)
- Pump cleaning (typically every 3 to 4 months)
- Water changes – when water is changed all slime and dirt should be cleaned with a weak disinfectant. The sump as well as pump and piping or tubing should be rinsed with a disinfectant solution as well.

Part 5 – Summary

Ornamental water features properly designed and operated pose a lower risk than swimming pools for disease. However, poor design, maintenance and / or operating practices can produce catastrophic results. Those who own or operate ornamental features should incorporate at a minimum the following steps in their management plan:

1. Insure a competent person is responsible for maintaining the features. That person must be familiar with these guidelines as well as other pertinent guidelines including those listed in this document.

2. Have a written plan risk management plan that details operational practices to control waterborne pathogens including legionella.

3. Maintain a log of the treatment program results and all maintenance.

4. For larger units complete an assessment of the system and all components.

The risk management plan, maintenance log and treatment program may be very simple for a small unit and more complex for a larger unit. Below is a sample plan.

When testing legionella concentrations in ornamental features, action levels as recommended for domestic water in OSHA guidelines (APPENDIX III:7-3) should be used. Healthcare facilities should have less than 1 cfu/ml of legionella in their ornamental features. **Note: Legionella testing should never be used in place of a risk management plan. Legionella testing should only be used as a tool to assess the effectiveness of a risk management plan.**[9]

Risk Management Plan (for a small, moderate to low risk, indoor feature)

In the log book enter the date, action taken and initials of the person completing the task.

Daily Treatment

- Add chlorine daily at the end of the each day to develop at least 3 ppm free chlorine (or add polyquat as recommended weekly and 0.5 pm chlorine daily).
- Test chlorine levels three times a week one hour after chlorine is added. Add chlorine if level is below 3 ppm (or below 0.5 ppm if used with polyquat).

Weekly Cleaning

- Drain feature and clean with dilute chlorine solution (or 50% vinegar solution).
- Remove pump filter and clean.
- Circulate dilute chlorine, hydrogen peroxide or vinegar solution for 30 minutes
- Rinse and refill with distilled water (or use tap water and appropriate treatment).

Quarterly Inspection

- Check components including pump for proper operation.

Additional Actions

- If unit is to be down for 3 or more days, drain unit completely and let it sit dry. When ready to operate refill and add normal treatment.
- If unit water is allowed to sit stagnant for 3 or more days, unit should be drained completely and disinfected with 5 ppm chlorine circulated for 30 minutes then rinsed and refilled prior to operation.
- If water is cloudy or smelly perform disinfection step above.

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