

Preventing Legionella: Common Disinfection Techniques

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A spore colony insinuates itself into a building's water system and causes a mysterious wave of potentially life-threatening illness. It sounds like the stuff of TV dramas. But it is a real-world scenario in the case of waterborne pathogens, particularly the *Legionella* organism.

Legionella is commonly found in domestic drinking water systems, cooling towers, evaporative condensers and decorative fountains- a risky prospect given the potentially fatal Legionnaires' disease (LD) it can foster.

Legionella pneumophila is the specific strain of bacteria responsible for causing LD. This serious illness results in fatality rates ranging from 5% to 30% of all cases, according to the Centers for Disease Control and Prevention (CDC). Individuals with weak immune systems are most susceptible. Risk heightens for those middle-aged and older, for smokers, those with chronic lung disease and for those whose immune systems are suppressed by cancer, kidney failure, diabetes or AIDS.

Testing for *Legionella* bacteria is not required by law, which creates a wide disparity in reporting of medically-diagnosed Legionnaires' cases. An estimated 8,000 to 100,000 cases are contracted annually, including both confirmed cases and estimates from sources including the CDC, the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) and industry experts.

The organism is commonly found in water-cooled, heat transfer systems and domestic hot water systems. But it can only be transmitted to humans through airborne particles. Dispersal of *Legionella* through aerosol or misting of contaminated water leads to individual and sometimes widespread illness.

Sources of aerosol dispersal include showers, produce misters and cooling tower drift.

While cooling towers previously were considered the prime source of *Legionella* bacteria growth and dispersal, ongoing research finds domestic hot water systems are the more common source of *Legionella* colonization.

Growth of *Legionella* bacterial colonies often is supported by so-called "dead legs" in plumbing systems, which allow scale and bio build-up. Water temperatures also can play a role, with systems that mix hot and cold creating ideal *Legionella* growth environments.

There are several common techniques to disinfect water systems for *Legionella* organism control. Proven effectiveness varies. When determining disinfection methods, individual water system managers are encouraged to weigh effectiveness, implementation cost, potential for plumbing corrosion and environmental impact.



One of Earthwise Environmental's CWTs is joined by an engineer during a review of Legionella prevention tactics in front of a cooling tower at a major Bar-S Foods Co. meat processing facility in Lawton, OK.

Thermal/Heat & Flush

The heat & flush method involves heating water temperature to as high as 160F for up to 30 minutes to sterilize systems. This chemical-free method requires no additional equipment and is commonly used, particularly in hospital outbreak scenarios. However, it is labor intensive and can prove ineffective for long-term *Legionella* infestation management. It also can damage older pipes and create potential for scalding.

One example is found in the 2000 outbreak of LD at a 1,070-bed medical center in southern Taiwan. The hospital faced the largest outbreak reported in that country, with 33 definite and probable cases in the months from January through April, and a total of 81 suspected cases during an eight-month period, including January through April.

When *Legionella* testing was conducted at the hospital in March, 80% of distal sites in intensive care units (ICUs) and 50% of distal sites in patient wards were found positive for *Legionella*. Meanwhile, 55% of cooling tower samples tested positive.

As no specialized equipment is required for heat & flush disinfection it allows for immediate action in the case of a LD outbreak. Hospital management initiated a heat & flush disinfection plan that also included individual disinfection of all 1,241 of the hospital's faucets and showerheads. Two disinfections were initiated, in March 2000 and July 2000. The four wings of the hospital, along with accompanying patient wards, underwent heat & flush disinfection over an eight-week period (one section per week). The second heat & flush in July was performed in a two-day period.

The first disinfection eliminated *Legionella* spores from patient wards and reduced the colonization rate in ICUs from 80% to 25%. However on retesting two months later, colonization in patient wards had increased from 0% to 15% of the distal sites, and to 93% of distal sites in the ICUs.

Shock (Hyper) Chlorination

The Shock or Hyper Chlorination disinfection method involves injecting chlorine into the water distribution system. Initial shock chlorination levels approach 50ppm, and taper off to create a 2ppm to 5ppm chlorine cycle.

A concern with this method is that chlorine decomposes rapidly at elevated water temperatures, and *Legionella* re-colonization can occur in as little as one to two weeks during continuous chlorination following the shock.

The method also has proven highly corrosive to plumbing, which can be offset in part with silicate corrosion control. Use of chlorination also can create maintenance challenges, including chemical storage. In addition, exposure to the chlorine byproduct Trihalomethane (THMs) is linked to several types of cancer, creating risk for facility employees handling stored chemicals or implementing disinfection.

Chlorine Dioxide

Chlorine dioxide (ClO₂) is approved by the EPA for use as a potable water disinfectant

under CFR Par 141-National Primary Drinking Water Regulation and has successfully been used for many years in Europe.

ClO₂ is a gas generated by either chemical or electrolytic means. While the methods of production vary, most involve the use of an acid and chlorite donor. ClO₂ is a powerful oxidant and kills *Legionella* and other bacteria through the oxidative disruption of cellular processes. The ClO₂ is distributed as a gas throughout the water distribution system.

ClO₂ readily decomposes in drinking water and residuals decrease as water system temperatures rise, making this treatment approach difficult in hot water systems. ClO₂ is also corrosive to plumbing infrastructure and creates byproducts including chlorate and chlorite. Testing for the chlorite portion of the molecule is required to stay within EPA maximum limits, and the test is difficult to field administer.

Copper-Silver Ionization

The most recent advance in the fight against *Legionella* is copper-silver ionization. This disinfection method dissolves and distributes small amounts of copper and silver ions throughout water systems to eradicate bacteria. Installation of a continuous eradication metallic ion unit is required. Typically this method is highly effective in eliminating *Legionella*, particularly in recirculation hot water systems, according to Janet F. Stout, PhD, University of Pittsburgh special pathogens

laboratory director and an international expert on waterborne pathogens.

Stout is leading a team investigation of the bacteria-inhibiting effects of copper-silver ionization systems and chlorine dioxide. Tracking of the first 16 hospitals to use copper-silver ionization for *Legionella* disinfection found the method effective over a 10-year span, reports Stout. Prior to copper-silver ion equipment installation, all 16 of the hospitals reported hospital-acquired LD, and 75% had previously attempted use of disinfection methods including thermal/heat & flush, ultraviolet light and hyper chlorination.

The 16 hospitals are of similar size, with a mean average of 435 beds. Each hospital also experienced confirmed patient cases of hospital-acquired LD. Hospitals were surveyed in 1995 and 2000 to document system hospital experience with system maintenance, *Legionella* contamination rates within the water system and occurrence of hospital-acquired LD.

By 2000, ionization systems had been in place from five to 11 years. Prior to installation, 47% of the hospitals reported that more than 30% of distal water sites tested positive for *Legionella*. Post-installation, in 1995, 50% of hospitals reported zero positive results, with 47% reporting 0% in 2000. Within the entire group of 16 hospitals implementing ionization disinfection, Stout's research shows that zero cases of hospital-acquired LD have occurred since 1995.

Earthwise Environmental Case Study: Hospital Central Plant

One of the largest teaching hospitals in Illinois is also home to a central plant with 7,000 tons of cooling tower capacity and a 100,000 gallon central chilled water loop. The hospital's discovery of positive *Legionella* counts in its cooling tower system and excessive corrosion in its chilled water system required immediate intervention.

The Earthwise Environmental engineering survey and inspection process found leaking chemical feed stations and insufficient biocide feeds, as well as the absence of a proper *Legionella* control program.

Further inspection found the chilled loop system running at a corrosive pH of 5.5 with over 100+ PPM of dissolved iron. Neither a filter changing program nor any corrosion coupon studies were in place.

Earthwise created and instituted solutions to the central plant's challenges that served to: reduce the hospital's liability from hazardous

chemicals and potential *Legionella*; provide labor savings; create increased energy efficiency; and ensure long-term protection of equipment.

Specific Solutions:


Cooling Tower

- Custom design of new feed and control system
- Initiation of dual *Legionella*-specific biocide program and testing
- Computer-based 24/7 monitoring and control capability
- Weekly service visits

Chilled Loop

- Developed a custom-formulated product to raise and buffer pH to 9.0
- Instituted a "Step-down" filter approach from 25-10-5 micron in three months
- Switched to silica-based corrosion inhibitor for multi-metal protection

Favorable Outcomes:

- Reduced the hospital's liability and environmental impact from hazardous chemicals use and storage
- Proactive *Legionella* control has consistently led to 0 positive results, insuring the safety of the hospital employees and patients
- Installation of a "real time" 24/7 online monitoring system reduced staff labor hours and provides instant information on water conditions throughout the plant
- Insuring long-term protection of the chilled piping system eliminates need for costly capital replacement
- Reduction of labor hours for filter changes
- Cleaner heat transfer surfaces resulted in increased efficiencies and lower energy costs. 

Next Steps

There are no blanket remedies for *Legionella* eradication programs. There are a number of issues to take into account when evaluating the best technology for disinfection. The decision is best left up to the facility team evaluating the effectiveness and ultimate costs of various available technologies.

A cost evaluation by University of Pittsburgh Medical Center's St. Margaret Hospital compares quarterly thermal/heat & flush eradication with continuous eradication metallic ion unit. The 250-bed acute care and teaching hospital has a 2,000-gallon domestic hot water system. At the time of the evaluation, heat & flush costs including labor, lab fees and an increase in water heating needs totaled nearly \$82,000 annually (based on a quarterly program). Meanwhile, the metallic ion unit purchase and installation carried a one-time cost of \$60,000, provided continuous eradication and created only ancillary annual maintenance costs for cleaning, de-mineralizing and diode replacement.

Stout's study represents the final step in experts' proposed evaluation processes of disinfection systems. These include:

- 1) Demonstrated ability of *Legionella* eradication with laboratory assays (in vitro)
- 2) Anecdotal experiences in individual hospital Legionnaire's outbreak prevention
- 3) Controlled studies in individual hospitals
- 4) Validation from multiple hospitals over prolonged time period

According to Stout, "copper-silver ionization is now the only disinfection modality to fulfill all four evaluation criteria." Thus far, the first three of four steps are documented for thermal/heat & flush, hyper chlorination and chlorine dioxide.

Experts recommend a complete mechanical and system evaluation of plant operations, from sampling to data analysis, to determine the best fit of technology, products and services. When a chemical approach is decided, specialists should work closely with chemical manufacturers and clients to determine the custom blend that best meets clients' water treatment needs. 🌱



The Earthwise Environmental team inspects an ammonia evaporative condenser at the Lawton, OK meat processing facility.

About Earthwise Environmental

The Midwest's Leader in Water Safety, Conservation

Long before Al Gore's environmental film scored an Oscar and "green" became urban chic, Earthwise Environmental was working to make water safer and to conserve the Earth's most precious resource.

"We exceed industry best-practices to ensure that water management products are developed, manufactured, distributed, used and disposed of in a safe and environmentally responsible manner," says Robert S. Miller, founder and president of Earthwise Environmental.

Earthwise Environmental designs and implements water management solutions for hospitals, schools, hotels, food processing plants, light industrial and commercial building applications. With five Certified Water Technologists (CWTs) on the team—more than any other water treatment company in Illinois—Earthwise Environmental is the Midwest's leader at providing safe, environmentally-sound water management solutions. Its staff has more than 120 years of combined experience.

The CWT credential from the Association of Water Technologies was established to provide the water treatment industry with a designation representing a level of knowledge, extensive professional experience and education in all aspects of water treatment and technology. Certification requires technologists to have a minimum of five years experience in the water treatment industry. They must pass a written exam, submit the CWT application and references, receive approval from the certification committee and sign a code of ethics.

Watersystems, cooling towers and evaporative condensers are breeding grounds for *Legionella*. Cooling programs developed by Earthwise Environmental reflect the biocide selection necessary for suppressing the *Legionella* organism. Last year, to make building operations professionals more aware of how they can safeguard their buildings from serious problems, Earthwise co-hosted an environmental conference on air quality, mold and LD.

The company's collaboration with the industry's leaders in *Legionella* organism testing make Earthwise Environmental the nation's premier resource in the fight against LD, exceeding new industry standards set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

LEED the Way

The push for LEED certification makes water use a critical bottom-line issue for industrial and commercial users. It impacts the health of employees and visitors and the efficiency of tower equipment and personnel. Earthwise Environmental solutions cut capital costs by safeguarding the efficiency of plant equipment and preventing production downtime, Miller notes.

Implementation of an Earthwise Water efficiency program can reduce water and sewer costs by as much as 30% and save energy, chemical and maintenance expenses. Reduced liability from hazardous chemicals results in further reductions of labor, capital replacement and energy costs.

Earthwise Environmental partners with leaders in industrial hygiene, safety and environmental services to evaluate and implement new water- and energy-saving technologies. In 1997, Earthwise was the first water management company in the Midwest to introduce drumless technology—eliminating the need for chemical drums and hazardous chemical storage. Earthwise beta-testing of several non-chemical water treatment devices is underway by the company, and hold future promise to reduce water consumption and eliminate all chemistries from customer facilities.

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