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LEGIONELLA 2003:
An Update and Statement by the
Association of Water Technologies
(AWT)

(Approved by AWT Board of Directors, June 2003)



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(Note: Correction to data table on Page 11 was made 7-6-2006)

Legionella 2003: Update and AWT Statement

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Forward

The Association of Water Technologies (AWT) is a not-for-profit, international trade association founded to serve the interests of regional water treatment companies and to advance the technologies of safe, sound and responsible water treatment practice. AWT provides education and training, public awareness, networking, research, industry standards and resource support. Association activities are directed towards promoting the growth and development of member firms and advancing the arts and sciences of the water treatment industry.

Since the initial outbreak in 1976 that led to the discovery and identification of Legionnaires' disease, much has been discovered about the bacteria (*Legionella*) that causes the disease and the disease itself. This includes how Legionnaires' disease is contracted and how to minimize risk of disease contraction, as well as effective medical treatments for Legionnaires' disease. However, guidelines for "100%" disease prevention and control remain at large, as well as any uniform consensus on the routine testing (monitoring) for *Legionella* in the water systems that may harbor the bacteria. Existing guidelines and statements, however, do provide substantial direction and information that can be adopted to effectively control and minimize legionellosis.

This document is a comprehensive update of collective information and data available from numerous research, investigative, and authoritative sources on *Legionella* and legionellosis. These include the CDC (Centers for Disease Control and Prevention), OSHA (Occupational Safety and Health Administration), WHO (World Health Organization), EPA (Environmental Protection Agency), various state public health agencies, as well as associated technical trade organizations and recognized *Legionella* experts and commercial entities. Due to the multi-disciplined, technical and medical nature of the subject, this document is directed at summarizing and presenting *Legionella* in an up-to-date, informative, and useful format to the water treatment professional and end-user, as well as for the general public. Extensive references are cited that may provide more detailed and in-depth information on legionellosis and related topics to benefit those with more specific interest and application or decision making needs.

LEGIONELLA 2003:
An Update and Statement by the
Association of Water Technologies

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Figure 1: Cultured *Legionella* (bottom view) from Biofilm (top view); AWT Analyst, 1997.

I. Background: Discovery of Legionnaires' Disease & *Legionella*

Legionnaires' disease (LD) acquired its name from the media reference given to a mysterious pneumonia-like illness that afflicted numerous attendees of an American Legion convention in Philadelphia at the Bellevue-Stratford Hotel during July of 1976. An outbreak of illnesses occurred presenting Pennsylvania Department of Public Health officials with a recorded 221 cases of a strange respiratory illness contracted by convention (hotel) attendees and by some hotel pedestrians. Symptoms included high fever, chills, muscle pain, headache and eventual development of a dry cough with difficulty in breathing. Some patients developed patchy lesions in their lungs representative of severe pneumonia. More than two-thirds of the patients required hospitalization and 34 eventually died.

Investigation of the outbreak by the Centers for Disease Control and Prevention (Atlanta, GA) led to the eventual discovery of the causative agent, a bacterium, in January of 1977. The bacterium was subsequently named *Legionella pneumophila* (pneumophila is Greek for lung-loving). It was determined that neither the bacterium nor the disease was new and that *Legionella* bacteria have been around and causing disease for many years. When reexamined, the CDC found *Legionella* bacteria in fifty-year old (archived) tissue samples of unsolved and similar-illness cases. So, Legionnaires' disease was not a new disease discovered in 1976 – just an old one that was finally recognized and named.

II. Background: Terms, Definitions, & General Facts

Legionella is the name for the genus of bacteria. Legionellae (the plural, referring to more than one *Legionella* bacterium) are aerobic, non-spore forming, rod-shaped, typically flagellated, gram-negative bacteria. They are common to aquatic, especially warm water, environments and some soils. There are 43 or more identified species of *Legionella*, with more than half being linked to human disease. Some *Legionella* species are made up of multiple **serogroups**, with over 60 serogroups presently identified for the genus. Many of the species serogroups are further differentiated into numbers of **subtypes**.

Legionellosis is the collective term describing any illness caused by exposure to the bacterial pathogen *Legionella*. Legionnaires' disease and Pontiac fever are the two most common types of legionellosis, with Legionnaires' disease being the more serious and primary one of focus. It is an environmental disease – with the causative agent (*Legionella*) transmitted from an environmental source (water or soil) to a host. It is not transmitted from person to person – thus, it is not a communicable disease.

Legionella pneumophila (Lp) is one species of *Legionella* – and is the causative species to more than 90% of legionellosis cases. More than 70% of these cases are attributed to one serogroup of the more than 15 Lp serogroups – *Legionella pneumophila* serogroup 1 (Lp-1). As it turns out, Lp-1 is the most common isolate recovered from environmental samples. Within Lp-1 are more than 50 subtypes that can be identified by phenotypic or molecular typing methods. Serogroups and subtypes appear to differ as to their particular degree of virulence.

Legionnaires' disease (LD) is an acute bacterial infection of the lower respiratory tract, i.e., a bacterial pneumonia. The disease is a potentially fatal, multi-system respiratory illness with an average mortality rate of 15-20%. Fortunately, it is selective in attack and infects only 2-5% of those appropriately exposed to the bacteria.

- **LD is a serious illness and not rare.** *Legionella* bacteria are among the top three causes of sporadic, community-acquired pneumonias. *American Society for Microbiology News* (61:621) (1995) reported that 15-30% of patients admitted to intensive care units with pneumonia had legionellosis. It is also the cause of many hospital-acquired (nosocomial) cases of pneumonia. Many LD cases go undiagnosed because the disease is difficult to distinguish from other forms of pneumonia – unless specifically targeted. Even when detected, it often goes unreported to the public health authority, especially if cases are sporadic (one or two-case incidents) and not associated with an outbreak investigation. The under-detecting and under-reporting of LD makes its incidence difficult to estimate and why such figures vary widely. The CDC has estimated that the disease infects 10,000 - 15,000 persons annually in the US. OSHA estimates that over 25,000 cases of the illness occur each year, causing more than 4,000 deaths. Still, others estimate as many as 100,000 annual cases.

- **LD Exposure** is most likely to occur via:
 1. **Inhalation:** of aerosols, fine sprays, mists or other microscopic droplets of water (or soil) contaminated with *Legionella* – providing direct access into the lungs; and/or
 2. **Aspiration:** such as may occur when choking or spontaneously during the drinking, ingesting, swallowing process – allows oral fluids and/or particles to by-pass natural gag reflexes and enter into the respiratory tract and lungs instead of the esophagus and stomach.
- **LD Sources** may include almost any warm water system or device (man-made or natural) that disseminates water, particularly as aerosols, sprays or mists and provides favorable conditions for *Legionella* growth and amplification. A notable source of *Legionella* today, contrary to the long association and thinking that cooling towers are the only significant source for LD, is the domestic (potable water) plumbing system. These systems in large buildings and/or complexes including, but not limited to, hotels, institutions and health care facilities have been commonly linked to occurrences and transmission of LD. Current data suggest that cooling towers and evaporative condensers, while still potential LD sources, may be an overemphasized modal of disease transmission. Other LD sources include: various heat-rejection devices, humidifiers, showerheads, faucets, whirlpool baths and spas, hot springs, respiratory therapy equipment, and even misting machines found in grocery store produce sections.
- **LD Susceptibility** is an important factor in disease contraction. The greatest host susceptibility to *Legionella* is found in the elderly and those with suppressed or compromised immune or respiratory systems. This includes: heavy smokers, alcoholics, HIV patients, cancer, bone marrow or organ-transplant patients, and others with lung or respiratory diseases. Underlying disease and advanced age also contribute to a significantly higher risk of mortality with LD. The most **common** risk factor found in LD patients is heavy cigarette smoking, along with chronic lung disease. Bone marrow and organ transplants represent the most **intense** risk factor, since the medicines used to protect new organ transplants also compromise the body's immune defenses against infection. Patients taking corticosteroid medicines are also at risk.
- **LD Symptoms** may include:
 - ▶ High Fever, Chills, Headache, Muscle Pain (Flu-like symptoms),
 - ▶ Dry Cough and Difficulty in Breathing,
 - ▶ Diarrhea and/or Vomiting, and
 - ▶ Confusion and Delirium
- **LD Incubation period** is 2-10 days. This is the time it takes, after exposure, before symptoms of the illness appear. For several days, the patient may have flu-like symptoms and feel tired and weak. Most patients who are admitted to a hospital develop high fever, often greater than 39.5°C (103°F). A cough can be the first sign of a lung infection and may be sufficiently severe to cause sputum production (mucous with saliva). Gastrointestinal symptoms are seen in approximately 40% of patients, with diarrhea the leading symptom. Many patients have nausea, vomiting, and stomach discomfort. Other common symptoms include headaches, muscle aches, chest pain, and shortness of breath.
- **LD Treatment** requires the use of antibiotics. However, many antibiotics effective

against other bacterial pneumonias are ineffective against *Legionella* as they do not act to penetrate the pulmonary cells (alveolar macrophages) where infectious *Legionella* thrive. Fortunately, there are several newer antibiotics that are effective on *Legionella*. The two most potent classes of these antibiotics are the **macrolides**, such as azithromycin, and the **quinolones**, including ciprofloxacin, levofloxacin, moxifloxacin, gemifloxacin and trovofloxacin. Other agents that have proven effective against LD include tetracycline, doxycycline, minocycline and trimethoprim-sulfamethoxazole. Erythromycin, the former antibiotic of choice, has been replaced by these more effective and less toxic antibiotics.

When LD patients are treated with appropriate antibiotics near the onset of disease, the outcome is usually excellent, especially if there is no underlying illness compromising the immune system. For patients with compromised immune systems, including transplant recipients, any delay of appropriate treatment can result in complications, prolonged hospitalization, and death.

After successful treatment and hospital discharge, many patients will still experience fatigue, loss of energy, and difficulty concentrating. These symptoms may last for several months. Complete recovery within one year is usually the rule. Patients who were cigarette smokers should consider discontinuing smoking.

Pontiac fever is a much milder, non-pneumonic, flu-like illness caused by *Legionella* species. Cases of Pontiac fever have been linked to *L. pneumophila*, *L. feellie* and *L. anisa*. It attacks indiscriminately; uniformly infecting 90% to 95% of those exposed and has a shorter incubation period (than LD) of 1 to 3 days. Complete recovery usually occurs in 2 to 5 days without medical attention.

Because the contraction of Legionnaires' disease (LD) represents a much more serious condition than Pontiac fever, this paper's information focus will be on LD and Legionella pneumophila (as well as other species of Legionella) that cause it.

III. *Legionella*: Infectious Growth, Transmission & Host Susceptibility

Legionella are common warm water microorganisms. They are primarily found in surface waters (lakes, ponds, rivers and streams) but can also be found in ground water sources, including some soils (*Legionella long-beachae*). *Legionella* tend to grow in biofilm or slime on the surfaces of lakes, rivers and streams – and can easily adapt to conditions within water distribution systems.

The ecology of *Legionella* is particularly interesting and is important to its ability to persist in the environment, as well as infect man. *Legionella* are **protozoonotic** – in that they live, reproduce and survive within certain free-living amoebae and ciliated protozoa as facultative intracellular parasites. In this relationship, the protozoa are obligate cellular hosts in which *Legionella* replicate and thrive, as well as gain protection from harsh, natural or man-made, environmental conditions.

Chlorination, UV irradiation and chemical biocides all offer temporary means by which laboratory and planktonic *Legionella* can be eradicated from a water source. However, the majority of *Legionella* do not exist as free-swimming (planktonic) bacteria. Instead they reside, well-protected, inside protozoan hosts and in the matrix of biofilm. Eventually, they are released from their hosts in the form of small vesicles that may contain hundreds or a thousand or more legionellae per vesicle. In terms of survival, the amoeba-grown bacteria are better able to withstand their aquatic environment and may be more virulent. This adaptation and **endosymbiotic** relationship with amoebae and other protozoa allows *Legionella*, among other things, to survive typical potable water chlorination (disinfection) and appear in many finished water supplies to homes, buildings and industry.

Thus, the mere presence of *Legionella* does not, in and of itself, result in disease. It is only when *Legionella* are able to 1) amplify (increase in population density), 2) present certain virulent factors and 3) gain transmission into the lungs of susceptible human hosts that they can cause LD infections.

- ***Legionella* must have certain strain-specific virulence factors to cause disease.** They must also be present in sufficient quantity to cause infection. One gene (rtxA) is involved in the ability of *Legionella* to enter and cause toxic effects within host cells (Cirillo, S.L., et al., 2001).
- **A susceptible host must inhale or otherwise aspirate (choke into their lungs) water or particulates colonized with a sufficient quantity of virulent *Legionella*.** If these *Legionella*-contaminated droplets are of respirable size (<5.0 micron), the *Legionella* can reach the deepest (alveolar) parts of the lung. There they are engulfed by pulmonary macrophages intending to defend the body against invading bacteria. However, instead of being destroyed (digested) by phagocytosis, the *Legionella* survive and actually grow (amplify) within the macrophages – as they do environmentally within amoebae and other protozoa. At their optimum (human body) temperature for growth, the *Legionella* amplify to eventually cause cellular lysis (rupture) of the macrophage cells. This soon overwhelms the host's immune system and promulgates the disease.

- **The dose of *Legionella pneumophila* (or other species of *Legionella*) required to infect humans is not known.** It is most probably influenced by host susceptibility.

Growth & Amplification of *Legionella*: In order to better understand *Legionella*, its potential to cause disease and how to better control *Legionella* in water systems, we must understand the conditions that promote *Legionella* growth and amplification. Major factors include:

1. Stagnant water conditions and/or system design configurations that produce stagnation, such as side-arm and dead-leg piping;
2. Warm water temperatures between 20 and 50°C (68 to 122°F);
3. Optimal growth is at temperatures between 35 and 45°C (95 to 113°F);
4. Bulk water pH in the range of 5.0 to 8.5;
5. Sediment, scale, deposits, biofilm – support not only *Legionella* growth, but also that of the very important supporting microbiota for *Legionella*;
6. Microbiota, including algae and many bacteria that supply essential nutrients for growth of *Legionella*;
7. Certain amoebae and other protozoa that harbor *Legionella* as endosymbionts – allowing them to thrive, resist harsh environmental conditions (including biocides) and to significantly amplify.

Many different types of water systems can serve as *Legionella* amplifiers and (aerosol) disseminators, and have been associated with LD. They include:

- Domestic Hot Water Systems (tap faucets, showerheads, sprayers),
- Cooling Towers and Evaporative Condensers,
- Spas and Whirlpools (on display or otherwise in use),
- Humidifiers,
- Decorative Fountains,
- Supermarket Reservoir Mistifiers,
- Respiratory Therapy Equipment,
- Water fountains,
- Hot Springs (Waterfalls), and
- Dental Hygiene Equipment.*

* **Note:** as a potable water disseminator, should be considered a potential source of LD, however, it is not known to have been linked by direct subtyping to a known case of LD – although a great deal of media attention was given to a California dentist who died of LD a few years ago.

Accordingly, due care and concern should be exercised in the operation and maintenance of these and other type water disseminating devices or systems as to their potential to harbor, amplify and transmit *Legionella* and to the potential health risk they pose to at-risk individuals.

Transmission of *Legionella*: After growth and amplification of *Legionella* to potentially

infectious levels, the next requirement in the chain of disease causation is to achieve transmission of the bacteria (in) to a susceptible host. A widely accepted theory for the disease transmission of *Legionella* is that the organism is aerosolized (in water) from a water-disseminating system or device and is inhaled as tiny (micro) water-droplets, containing the bacterium, and gain entry into the lungs. However, another well documented mode of transmission that effectively gets bacteria into the lungs is “**aspiration**” – and evidence suggests that it may be the more common mode for *Legionella* transmission than previously considered.

Aspiration is a “choking process” that can occur during drinking, swallowing or clearing-the-throat and during respiratory therapy. Aspiration is a common way that bacteria enter lungs and cause pneumonia. As it occurs, secretions or fluids in the mouth can get past the choking (gag) reflex and instead of going into the esophagus and stomach, enter the respiratory tract and reach the lungs. Normally, there are protective mechanisms to prevent aspiration, however, these mechanisms can be defective in patients who smoke or have lung disease. According to some present studies, aspiration does appear to be a mode of *Legionella* transmission.

It would neither be safe nor correct to (so simply) state that “You can not get Legionnaires’ disease from drinking water containing *Legionella*!”

IV. Domestic Plumbing (Potable Water) Systems & Legionnaires' Disease

Legionnaires' disease is an environmental disease and an environmental issue, with safety and health responsibilities to be addressed by many. *Legionella* occur naturally in aquatic habitats and are routinely recovered from municipal water supplies. Low levels of *Legionella* in municipal water may seed industrial potable water, cooling water and process water networks. *Legionella* may colonize and amplify in hot water tanks, humidifiers, water-disseminating devices, cooling towers, ice machines, deadlegs in distribution systems and other areas where microorganisms are able to flourish. Cooling towers captured a lot of initial attention and regard to being a significant (possible) reservoir of *Legionella* and LD health concern. Equal attention and regard, if not more so by some experts, is now appropriately given to the domestic (potable) hot and cold water plumbing system as a significant (possible) reservoir of *Legionella* and LD health concern.

Evaporative cooling systems were initially implicated as the source of *Legionella* in nosocomial Legionellosis outbreaks. And early on, these systems and cooling towers in general became the "official source and reservoir" of Legionnaires' disease. This was unfortunate and proved problematic to cooling tower owners, manufacturers and to the water treatment industry as a whole, for they were subsequently expected to be the ones responsible to "take care of" *Legionella*. Eventually, epidemiological investigations showed that potable water systems can be a significant source of *Legionella*. While the larger, headline-grabbing, LD outbreaks are usually associated with cooling towers, information from the United Kingdom (U.K.), Health and Safety Executive, shows that the vast majority of LD cases are sporadic and from sources other than cooling towers. As well, the Centers for Disease Control and Prevention indicate the vast majority of LD cases go unreported and undetected. In studies conducted by Hodgson and Casey in 1998, several thousand samples collected from a variety of sources showed:

***Legionella* Colonization Frequencies:** (Hodgson & Casey study, 1998)

- ▶ Cooling Towers 6.26%
- ▶ Potable Water Distribution Systems 7.01%
- ▶ Hot Water Heaters 12.03%

While water treatment specialists more typically deal with the non-potable water systems that they chemically treat, i.e., cooling towers, evaporative condensers and other heat-transfer associated water systems, they should also be knowledgeable concerning *Legionella* in domestic plumbing systems.

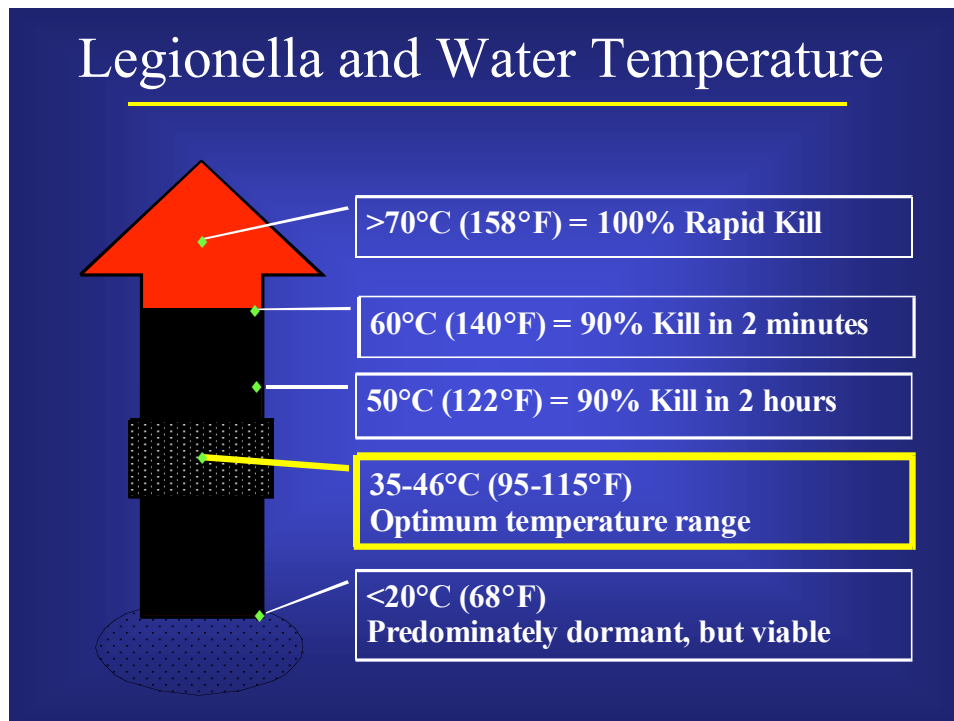
The Domestic Plumbing System & *Legionella*: The domestic (potable) water plumbing system can harbor *Legionella*, provide *Legionella* with favorable growth and amplification conditions, and has many outlets (taps, shower heads, etc.) to disseminate aerosols that may transmit LD. These systems are an integral part of most buildings, commercial and otherwise, large complexes, including hospitals and other health care facilities, as well as industry in general. Plumbing systems were first implicated in a nosocomial (acquired during a hospital stay) case of Legionnaires' disease in 1980. Since then, plumbing systems have been associated with numerous outbreaks of LD. The United Kingdom reported 19 of 20 hospital LD outbreaks, from 1980 to 1992, to be from plumbing systems.

In addition, cases of LD have also been attributed to plumbing systems in nursing homes, workplaces, and private residences. Domestic plumbing systems are thus a major source of concern for LD contraction, particularly within the health-care industry.

Hot-water systems are perfect breeding habitats for *Legionella*, as well as other bacteria that grow in biofilm. *Legionella* can flourish in hot-water tanks, especially in the bottom where warm zones develop beneath accumulated scale and sediment. The complexities of hot-water piping present an even greater problem than tanks alone. Biofilm and scale that form in valves, fittings and on pipe walls not only amplifies further bacterial growth, but also protects the bacteria “within” from hot water and chemical disinfectants. Deadlegs (unused piping) create additional problems because bacteria grow well in stagnant water conditions.

Temperature is an Important Factor: Consider temperature in the proliferation (and control) of *Legionella*. **Figure 2** illustrates several key temperatures for *Legionella*. The most important range to consider from the chart is the growth temperature range. Although growth has been recorded between 20°C and 45°C (68°F and 113°F), the optimum amplification range is a narrower band of 30°C to 40°C (86°F to 104°F). Above 45°C (113°F) *Legionella* is killed with time, and at 50°C (122°F) it may take up to two hours to attain a 90% kill. Below 20°C (68°F) *Legionella* is largely dormant, though some low level amplification may occur within the vacuole of the protozoan host organism.

Figure 2: Legionella and Water Temperature



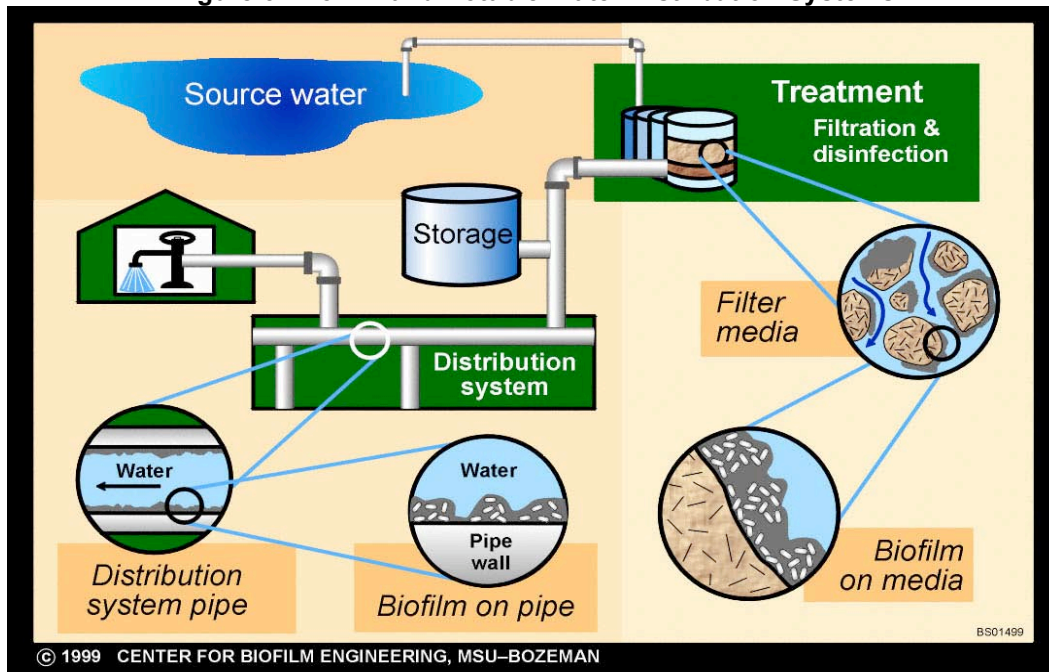
Note: Figure 2 is courtesy of Southeastern Laboratories, Inc. *Legionella* training material presentations.

The temperature data in **Figure 2** certainly suggests that the operation of potable or domestic hot water systems be at temperatures as high as possible. However, practicality has to consider the risk of scalding injury and energy conservation requirements.

It should be emphasized that temperature data (as in **Figure 2**) is usually based on laboratory studies and is not from actual system (piping) studies. As well, it must be emphasized that **the** system temperature is rarely one temperature (uniform) throughout the entire system. Thus, it should not be implied that maintaining potable water systems above 50°C (122°F) guarantees *Legionella* control – practical experience has proven otherwise. In actual plumbing systems, especially the larger and/or more complex piping systems, *Legionella* can survive at even higher temperatures due to biofilm, deadlegs, and other complexities. Accordingly, system temperature should not be relied upon for *Legionella* control (alone) without routine sampling also indicating control.

Disinfection of Domestic Plumbing Systems: Public (municipal) water systems are required to be disinfected at their points of distribution to conform to existing federal standards for bacterial disinfection. However, the federal standards are based upon the absence of Coliform bacteria counts and do not include any specific testing requirements for *Legionella*. Following disinfection, municipal water supplies generally travel miles before points of use. During this course, disinfectant residuals diminish and there is increasing exposure to potentially biofilm-contaminated piping.

Figure 3: Biofilm and Potable Water Distribution Systems



Note: Figure 3 is courtesy of the Montana State University – Bozeman Center for Biofilm Engineering.

Treatment Technologies: There are a variety of methods used to disinfect potable water systems at their point of use. The following is a summary of those most commonly considered and an over view of their technology, as well as their associated advantages, disadvantages and current regulatory considerations.

1. Heat-and-flush (heat shock): This method is a thermal eradication process and involves raising hot water tank temperatures to greater than 140°F (60°C), preferably to greater than 150°F (66°C), and circulating (flushing) through all outlets for up to 30 minutes. The flush time required will depend on the temperature of the water when it reaches the outlets.

► Summary: Thermal eradication provides temporary results; it is very labor-intensive, presents scalding risks, has associated high energy costs, is difficult to achieve complete effectiveness and, at best, provides only short-term (weeks to months) effectiveness.

2. Chlorination: For remedial or temporary disinfection, chlorine is added to water tanks at levels much higher (20–50 mg/l free chlorine) than normal for potable water and flushed throughout the system. For continuous disinfection, flow-adjusted injectors are installed to release chlorine at a drinkable concentration (1–2 mg/l free chlorine) throughout the domestic water system. However, it has been shown that *Legionella* suspended in chlorine demand-free water, pH 7.4, containing 2.5 mg/l free chlorine can survive 10 minutes incubation (Gilpin, et al. 1985 – see references).

► Summary: Shock chlorination (high levels) provides temporary results, but is also very corrosive to copper and steel piping, produces potentially carcinogenic disinfection by-products (DBPs), including trihalomethanes (THMs) and haloacetic acids, when reacted with organics, and provides short-term residual effect.

► Summary: Continuous chlorination (1–2 ppm free) is minimally effective against biofilm, not proven highly effective on *Legionella*, and may pose corrosion, odor or taste problems. *(Unacceptable taste and odor problems generally restrict its use above 2 mg/l. Chlorine, as Cl₂, is regulated under the EPA National Primary Drinking Water Regulations (NPDWRs) as a disinfectant at a maximum contaminant level (MCL) of 4 mg/l. Its recognized disinfection byproducts, total trihalomethanes and haloacetic acids are regulated at MCLs of 0.10 and 0.060 mg/l respectively.)*

3. Ultraviolet (UV) Radiation: UV is a point-source disinfection method and no chemical residual is produced or carried throughout the system. Light in the ultraviolet (UV) spectrum range of 250 to 280 nm is microbiocidal due to its action on the nucleic acid structure of DNA. UV sterilizers (lamps) installed on water lines operate to kill *Legionella* as water flows through the unit. Sufficient energy and residence time are required to adequately irradiate the water column to an effective kill level. Suspended solids will scatter UV and dissipate UV energy. Scaling of the UV lens will interfere with light intensity and energy.

► Summary: UV systems provide point-of-use rapid kill and sterilization, they have no residual effect throughout the system or if unit is shut off and would not be effective in decontaminating systems already infested with *Legionella* and biofilm, they have energy cost and operational considerations and require clean (<60 ppm suspended solids) water.

4. Ozonation: Ozone is dissolved into the point of use water system to achieve a dose of about 1 to 2 ppm. Ideally, this is done with a generator that produces ozone in proportion to the water flow rather than a generator that produces ozone at a constant rate regardless of demand. Since ozone is a very strong oxidizer, it is an excellent microbicide and proven effective at low concentrations. However, it can damage piping and since it has an extremely short half-life, it is virtually impossible to maintain any significant residual throughout a dynamic water system.

► Summary: Ozone generation has significant equipment cost as well as maintenance and operational cost considerations, disinfectant residuals are difficult to distribute or achieve throughout the system and has minimal impact on biofilm or non-planktonic *Legionella* in dynamic or complex water systems.

5. Copper-silver ionization: Flow-through ionization chambers containing copper-silver electrodes are installed on hot-water lines. As electrical current is applied to the electrodes, positively charged copper and silver ions are released into the hot-water system. The combination of these two metals provides a significant synergism of antimicrobial activity. The positive ions bond to negative bacterial (cell wall) sites, disrupting membrane structures and lead to cellular death. Systems in which the water has scaling potential and/or pH levels above 8.0 are problematic due to scaling electrodes and precipitating copper – both of which lend to significantly reduced effectiveness.

► Summary: Effective treatment with long-term residual effectiveness when off and has a relatively moderate yearly cost of treatment; however, initial capital expense is high and pH higher than 8.0 and scaling water may limit effectiveness and increase operational maintenance and cost; not used to treat the cold water supply, which can be a source of *Legionella* amplification; local restrictions on copper and/or silver discharge may limit use or effectiveness and the potential for galvanic corrosion on steel exists. (*Copper is regulated under the EPA NPDWRs as a contaminant at an MCL of 1.3 mg/l with silver listed as a secondary (NSDWRs) contaminant at 0.10 mg/l.*)

6. Chlorine Dioxide: Chlorine dioxide is a highly reactive gas that readily dissolves in water and remains a true gas in solution. It does not significantly hydrolyze in water, thus it retains biocidal activity over a broad pH range. Its primary mode of action is oxidation, however: **a)** it does not react with naturally occurring organic compounds to form THMs, **b)** is non-reactive with ammonia and most nitrogen-containing compounds, and **c)** is less aggressive to copper and steel than chlorine. It has viracidal and sporacidal activity and has been shown to be efficacious on *Legionella*, as well as effective in biofilm. For most practical water treatment disinfection purposes, it must be generated on-site for subsequent use. Prior to the newer electrochemical methodologies of generation today, on-site generation of chlorine dioxide was considered objectionable due to the necessity to intimately handle the hazardous chemical reactants. The packaged systems for chlorine dioxide production available today have eliminated this major objection.

► Summary: Chlorine dioxide is an effective treatment for *Legionella* and biofilm at levels as low as 0.2 mg/l with minimal objections; however, it must be generated on-site and treatment cost may be a consideration. (Chlorine dioxide, as ClO₂, is regulated under EPA NPDWRs as a disinfectant at an MCL of 0.8 mg/l. Chlorite, a disinfection byproduct, is regulated at an MCL of 1.0 mg/l.)

Note on Monochloramine: The use of monochloramine as a biocide in municipal water systems has proven more effective than chlorine and is currently in use by 25% of municipalities. It is more stable than chlorine and produces fewer disinfection byproducts (DBPs). In addition, field epidemiologic data correlates well with reductions of *Legionella* in potable water systems treated with monochloramine (*Chapter 79, ASM Press book on Legionella, 2002*). (*Chloramines, as Cl₂, are regulated as an EPA NPDWRs disinfectant at an MCL of 4 mg/l.*)

Note on EPA Drinking Water Standards: The National Primary Drinking Water Regulations (NPDWR) are legally enforceable standards that apply to public drinking water systems. These standards protect public health by limiting the levels of contaminants in drinking water. The National Secondary Drinking Water Regulations (NSDWR) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor or color) in drinking water. The EPA recommends secondary standards to water systems, but does not require the systems to comply. State Departments of Environmental Resources (or Protection) are responsible to enforce the primary standards and may choose to adopt secondary standards as enforceable. The applicability of these standards to point of entry (POE) or point of use (POU) treatment technologies in non-public water systems (e.g., healthcare facilities using a municipal water supply) is an unresolved issue and should be considered when evaluating treatment options. At present, states are taking various approaches to non public drinking water distribution systems within facilities. These range from no involvement at all to full requirement of the use of products certified under ANSI standards. Some states require their non-public water systems applying treatment technologies to comply with a variety of regulations including permitting and other reporting requirements. These regulations do not apply to process, cooling towers, or other non-potable water systems. Facilities should certainly evaluate their state requirements when considering treatment technologies.

Along with any disinfection methods of treatment used, the following are recommendations and sound practices to help manage and reduce the incidence of *Legionella* contamination within domestic plumbing (hot and cold) water systems:

- Reduce deadlegs (stagnant lines and stubs) in the system,
- Clean and inspect hot water tanks regularly – annually as a minimum,
- Continually run hot water circulation pumps – avoid recycling to mixing valves only,
- Store hot water at a minimum temperature of 60°C (140°F) and deliver to the taps at a minimum temperature of 50°C (122°F),
- Store and distribute the cold domestic water below 20°C (68°F) – if not possible, then consider monitoring for *Legionella* and using a disinfection system if *Legionella* are not under control,
- Flush the entire water system on a regular basis,
- Consider routine potable water treatments – including the use of approved biocides.

V. Cooling Towers: Water Treatment & Legionnaires' Disease

Cooling towers and evaporative condensers have the potential to develop infectious concentrations of *Legionella*. These systems can provide the favorable conditions for the growth and amplification of many microorganisms, including *Legionella*. Tower drift (water loss) becomes the mist or aerosol that can transmit potentially infectious *Legionella*. The evaporative (cooling) process causes makeup waterborne constituents, as well as system water constituents, to concentrate (i.e., remain in the tower loop according to cycles of concentration). The recirculating water's retention (residence) time in the water loop allows for increased growth and reproduction of organisms. Warm water temperatures, along with the presence of corrosion by-products, other deposits and sediment debris, further promote biofilm and provide *Legionella* an ideal environment for growth and amplification.

Water Chemistry & System Maintenance should be well controlled in these systems. The chemical treatment objectives of any prudent water treatment program are to reduce corrosion, deposits, and microbiological fouling. These same practices will also significantly contribute to the control of *Legionella* growth and amplification. Cooling tower systems associated with ineffective water treatment practices and/or neglect certainly present a greater likelihood of harboring potentially infectious *Legionella*. However, high (even infectious) levels of *Legionella* have been found in otherwise well-maintained and operated tower systems. Testing performed on 1336 cooling tower samples from routinely maintained tower systems (Gilpin, et al., 1995) showed that *Legionella* was not found to be ubiquitous in such systems: 46% of the samples had no detectable *Legionella*, 90% of the samples had less than or equal to 200 morphologically intact *Legionella*/ml and only 3% had counts exceeding 1000 morphologically intact *Legionella*/ml.

► **Biocide Treatments** play a major role in microbiological control programs, including the control of *Legionella*. However, biocide treatments do not generally target specific microbial organisms, nor are they 100% efficacious. In the case of *Legionella* control, it must be stressed that the efficacy of any specific biocide can only be determined by testing for the presence of *Legionella* in the field under actual operating conditions. Environmental *Legionella* cannot be reproduced in the laboratory from culture-grown organisms. Therefore, laboratory trials should not be relied upon exclusively for proof of a biocide's efficacy against *Legionella*. In addition, Total Bacterial Counts (TBC) of a cooling water system should not be relied upon for any definitive correlation to *Legionella* counts, control or disease risk. Legionnaires' disease has been associated with systems where the total bacterial count was very low, yet *Legionella* counts high. Systems have also been found to have very high total bacterial counts, yet very low and even zero *Legionella* counts.

► **Biodispersants** play an important role in microbiological control programs, particularly against *Legionella*. These chemicals act to loosen microbial deposits (slime, sludges, etc.) and promote system cleanliness. Biodispersants promote biocide penetration of biofilm and enhance the effectiveness of biocides. Biofilm is often seen as the slime layer on surfaces in contact with water. *Legionella* flourish within biofilm since it is nutrient-rich and contains a diverse population of microbiota, including amoebae and other protozoa. As opposed to being freely suspended (planktonic) in the bulk water, biofilm *Legionella* and *Legionella* within protozoa are protected from concentrations of biocide and/or other environmental conditions that would otherwise kill or inhibit them.

Biodispersants should not be used alone in microbiological or *Legionella* control programs without also using biocides. In their various modes of action, biodispersants may loosen and free large amounts of biofilm related bacteria (including *Legionella*) into the bulk water. These bacteria may be viable and (now in the bulk water) have the potential to be transmitted from the tower and pose an LD health risk. Biodispersants are meant to supplement and enhance the performance of biocides, not replace or serve as an alternate to the use of biocide.

Cooling Tower Disinfection for the purpose of *Legionella* control and disease prevention is generally recommended as:

- Maintenance actions for startup, post lay-up or regularly scheduled tower cleaning;
- Corrective prevention and control actions following system (tower) *Legionella* sampling with elevated counts; and
- Required actions following a confirmed or suspected system LD case.

The following is an abbreviation of the emergency cooling tower disinfection method described by the Centers for Disease Control and Prevention (CDC), 1997. This procedure is usually used if there is suspicion that the tower may have been the source of exposure for a case of Legionnaires' disease. The complete methodology should be previewed for a full understanding of the CDC procedure. It should be noted, however, that most cooling tower and water treatment experts differ with respect to the chlorine levels recommended and the routine frequency of using this type disinfection, due to the corrosive (damage) potential of chlorine to system materials of construction. Guidelines established by ASHRAE (2000) and by CTI (the Cooling Technology Institute) (1996) should also be consulted.

1. Shut off the cooling tower fans;
2. Keep makeup water valves open and the circulation pumps operating;
3. Close outdoor air intake vents located within 30 meters of the cooling tower;
4. Achieve an initial free residual chlorine (FRC) of at least 50 mg/L;
5. Add a dispersant to tower water within 15 minutes of chlorine addition, then maintain 10 mg/L FRC for 24 hours;
6. Drain and refill the system, then repeat steps 4 and 5 at least once to remove all visible algae-like film;
7. Using a brush and water hose, thoroughly clean all water-contact areas, including the basin, sump, fill, spray nozzles, and fittings;
8. Circulate 10 mg/L FRC for one hour, then flush the system until free of all sediment;
9. Refill the system with clean water and return to service.

Note: It is generally recommended today that dispersant-chlorination (only) disinfection procedures for *Legionella* also include a final step maximum dosing (per EPA label) of a nonoxidizing antimicrobial combination – either a synergistic combination in one product or two separately applied products.

VI. Cooling Towers and *Legionella*: Objectives and Guidelines

Cooling Tower *Legionella* Objectives – Minimizing Counts & Transmission

Because of the potential for any cooling tower to harbor, amplify and to disseminate *Legionella*, control measures need to be considered for all cooling tower and evaporative condenser operations. *Legionella* control measures should encompass two objectives:

1. Minimizing *Legionella* Counts in Cooling Towers: Practically keeping *Legionella* below detectable levels in every cooling tower system at all times is not feasible and should not be expected. However, practices and precautions to **minimize** *Legionella* in cooling towers are reasonable and should be an ongoing control effort. Many of the measures that are generally recommended for *Legionella* control in cooling towers are also recommended for the efficient operation and proper maintenance of a cooling tower system and include:

- Proper Design
- Periodic Cleaning
- Regular Maintenance
- Effective Water Treatment

In combination, these measures generally minimize *Legionella* counts in a tower, but cannot be expected to eliminate them entirely in every system. Even properly maintained and operated cooling towers have been found to have high *Legionella* counts.

2. Minimizing *Legionella* Transmission from Cooling Towers to People: Minimizing transmission from the tower to a host is the second responsible measure in reducing risk of LD, again recognizing that there are no guarantees to keeping a tower system 100% *Legionella*-free. The following considerations should be made:

- Minimize Tower Drift with proper and well maintained eliminators
- Locate Tower to keep drift from air intake pathways to potential hosts
- Locate Tower to keep outside sources of plant life or nutrients from entry
- Use of appropriate masks or respirators by workers or others subject to drift

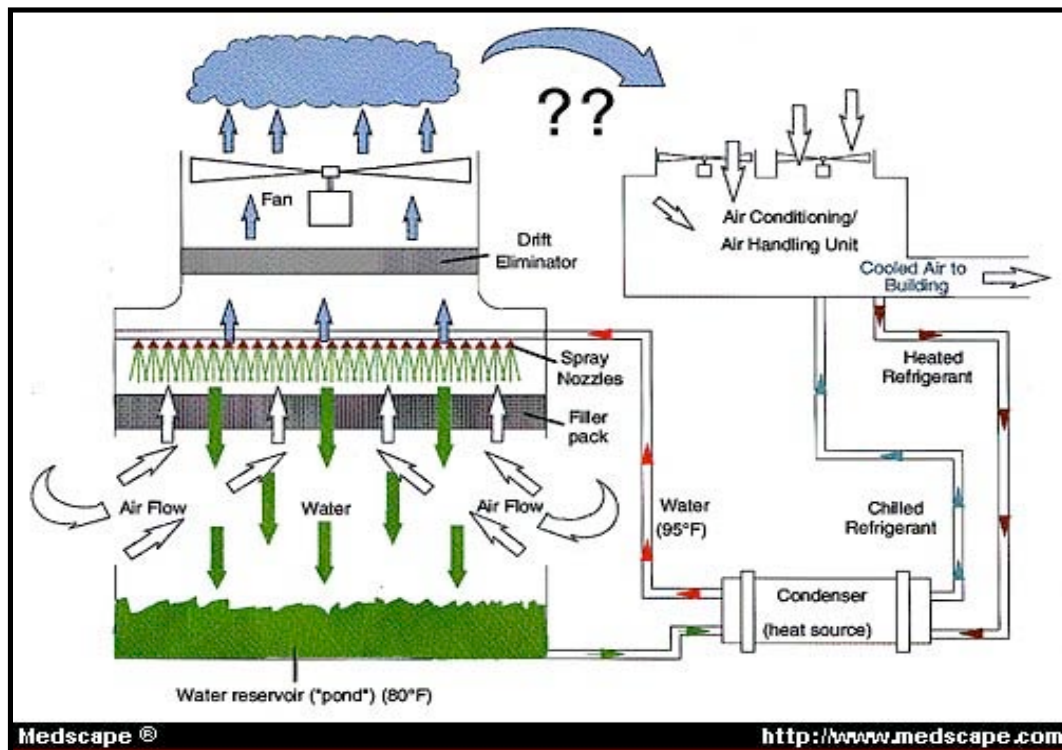
Design Guidelines for Cooling Towers and Evaporative Condensers should take the following into consideration to minimize *Legionella* counts in the tower and minimize transmission of *Legionella* from tower to people:

1. Tower location should consider prevailing winds and proximities with respect to people populations (particularly at-risk populations), building air intakes and surrounding units.
2. Tower location should consider prevailing winds and proximities which could introduce bacterial nutrient sources into the tower (kitchen exhausts, industrial processes, etc.).
3. Shield or cover cold-water basins, distribution decking, and other wet surfaces from sunlight to prevent algae growth in biofilms.
4. Materials of construction should be smooth and non-porous.
5. Water distribution piping should: a) be as simple as possible – avoiding deadlegs, stagnant lines and loops that are difficult to drain, b) promote effective flow through the entire system – utilizing equalization lines when necessary.
6. Towers should be easily accessible for inspection, sampling, cleaning and disinfecting.

7. The system should be designed to be completely drained or pumped out.
8. Provisions should be made to effectively dose, monitor and control a water treatment program, including: a) inhibitor and biocide/s chemical injection, b) water sampling, c) corrosion coupon sampling, and d) effective bleed and control points.
9. High efficiency drift eliminators should be used and maintained.
10. Filtered water, treated with trace (or greater) halogen residual, should be used as tower make-up.
11. Multiple-cell tower basins should be designed such that each cell and basin can be isolated, while the other cells remain in operation.
12. The tower system's total operating volume should be known for proper chemical dosing, particularly that of biocide and dispersant treatments.

Figure 4 shows the physical and mechanical relationship of a cooling tower to its associated HVAC equipment and the potential transmission of *Legionella* within the system to an office or other facility building air supply. It should be clear from this graphic why many of the cooling tower design and operational recommendations are made with respect to *Legionella* control and minimizing the risks of LD transmission.

Figure 4: HVAC and *Legionella* Transmission



Note: Figure 4 is courtesy of Medscape® at <http://www.medscape.com>

Operational Guidelines for Cooling Towers and Evaporative Condensers should take the following into consideration to minimize *Legionella* counts in the tower and minimize transmission of *Legionella* from tower to people:

1. Clean tower and disinfect before start-up, especially new system start-up, and after any long shutdown period (greater than 2 to 4 weeks).
2. Treat water for control of corrosion, scale, fouling and microorganisms.
3. Establish a maintenance plan and log all activities, including the chemical treatment program's dosages, services and results.
4. Maintain all drift (mist) eliminators in efficient and proper operating condition as well as the operations of fans that affect drift productions.
5. If deadlegs in the piping system exist and cannot be removed, blow them down regularly – particularly after biocide treatments and cleanings.
6. Exercise all valves in the system periodically by opening and closing them fully.
7. Clean the basin when slime, algae, or dirt are visible.
8. Blow down direct free cooling (chilled water) risers weekly.
9. Thoroughly flush and clean the entire system at least once (preferably twice) a year – and include an oxidizing disinfection before and after each cleaning.
10. Where a cooling tower is out of use, it should be drained and kept dry.

How Much Halogen? Many, including OSHA and CTI, recommend continuous feed of chlorine or bromine to effect control of *Legionella* in cooling tower systems. However, there is not a consensus recommendation on the (free) halogen level to maintain in these systems. The OSHA Technical Manual states that maintaining less than 1.0 mg/L free chlorine or bromine (with continuous feed) may not be enough to control *Legionella*, while more than 1 mg/L may be corrosive. CTI recommends 0.5 to 1.0 mg/L free halogen.

A realistic approach would be to establish a free halogen level based on an evaluation of the “technical specifics” for each system, and include the following considerations:

- System materials of construction and sensitivity to oxidant corrosion or attack,
- Water chemistry (indices) and corrosion potential for the system,
- Corrosion control history, if not new, for the system,
- Corrosion monitoring program in place,
- Microbiological and other fouling potential for the system (process or HVAC),
- Microbiological control history, if not new, for the system,
- Technical capabilities of the corrosion control product/s (program),
- Technical capabilities of the alternate microbiological control product/s (program), and

- A *Legionella* risk assessment of the system to include:
 - ▶ Design, maintenance & operation,
 - ▶ Proximity of “at-risk” host populations,
 - ▶ If *Legionella* testing is done, and
 - ▶ History of *Legionella* control

Accordingly: Systems where *Legionella* risk and/or history are great (bad) may opt for the higher free halogen levels (1-2 mg/L, or more), even if corrosion potential or failures may be higher than desirable.

And: Systems with less tolerance for corrosion failures and having a low *Legionella* risk assessment would operate at the lower free halogen levels (0.5-1 mg/L).

The ability to monitor corrosion and/or *Legionella* control provides additional tools to determine and “fine-tune” what free halogen levels work best to achieve treatment and protection objectives.

Finally, if corrosion control is a must, yet unacceptable with the free halogen levels needed for *Legionella* control, then an alternative *Legionella* control program should be designed. Chlorine dioxide, a proven biocide effective against *Legionella* without posing the corrosion problems associated with halogen biocides, could be considered. Using multiple non-oxidizing biocides, along with biodispersants, at their maximum allowable dosages may be considered, although there is generally increased treatment costs associated with such programs.

VII. Sampling and Testing for *Legionella*: A Proactive Decision

Legionella Testing -- Logic: Sampling and testing for *Legionella* can be useful in helping assess risks and in determining whether or not preventive and corrective measures are working. Having an action plan based on results of *Legionella* sampling can alert you to increased risks and whether or not disinfection procedures should be implemented. Not sampling tells you nothing about a system – until a case of LD occurs. With those quite logical and simple statements made, it may be assumed that *Legionella* sampling should be and is routine for any monitored system. Such is not the case.

Legionella Testing – Issues: *Legionella* experts have debated the issue of routine sampling and testing for years. The CDC advocates sampling after LD has been found (suspected or confirmed) so as to locate the source of *Legionella* and take remedial action. They do not encourage sampling in the absence of suspected or confirmed LD cases. Other experts disagree with this and advocate a more proactive approach of conducting periodic sampling (so-called “routine sampling”) even if no cases of LD have been detected or suspected.

Some of the current facts and understanding of *Legionella* and LD that continue to support any real consensus from being achieved amongst the experts include the following:

- There is no specific infectious density known for *Legionella* or a clearly established correlation between test culture or direct fluorescent antibody (DFA) test results of *Legionella* and risk of contamination.
- *Legionella* is frequently present in water supplies without causing disease, so routine testing and obtaining positive test results do not mean LD will occur. It may even produce a false sense of alarm and lead to costly corrective actions being undertaken. On the other hand, obtaining negative results does not assure that LD cannot occur and may provide a false sense of security that leads to relaxation of prevention measures. J. Brown (et al., 2001) noted that Australia has a protocol requirement for immediate cooling tower decontamination when *Legionella* counts reach a certain level. However, towers directly linked to LD cases were found to have *Legionella* counts below the protocol action level.
- Interpretation of results in routine *Legionella* sampling is still questionable due to:
 - ▶ Different bacteriologic methods used amongst laboratories,
 - ▶ Variable results between culture and direct fluorescent antibody methods,
 - ▶ Variable culture results from differing sites within the same system, and
 - ▶ Variations in the counts of *Legionella* isolated from a single site.

In addition, potentially infectious *Legionella* in some water samples may not grow on the microbiological medium specifically formulated to grow *Legionella*.

- The risk of illness following exposure to a given *Legionella* source is influenced by a number of variables and factors other than just the concentration of organisms in a sample. Host susceptibility, *Legionella* strain virulence, and efficiency of *Legionella* transmission (to host) are integral to LD risks and disease progress.

- Routine testing may present ambiguous (legal) liability issues: testing and getting positive results may establish a legal liability if a disease case occurs; yet the testing may prevent negligence charges from applying. On the other hand, not testing in the face of risk or other factors may support negligence and guilt in defending a responsible LD case.

(Cases to note: In 1997 OSHA fined a Cincinnati, OH injection molding facility following an investigation of three LD cases with no deaths. The fine was based on the General Duty Clause that requires employers to maintain a workplace free from recognized hazards. However, in 1998, following an investigation of LD cases with a death at a Baltimore, MD injection molding facility, the Maryland Department of Occupational Safety and Health Administration (MOSH) did not fine the employer. In the Maryland case, it was decided that plant management had taken proactive steps to reduce risk of LD among employees. The Maryland company had a good water treatment program and took immediate action to reduce the possibility of more cases of Legionnaires' disease.)

Legionella Testing is a Proactive Choice: There is no risk for LD if there is no *Legionella*. The only (practical) way to know if you have *Legionella* is to test for it. Since the risk of LD depends upon *Legionella* being present, those in favor of routine sampling maintain testing is logical, necessary and a proactive choice. The same reasoning applies, that, if you are taking measures to minimize *Legionella* in water, then you should periodically check *Legionella* levels to be sure that preventive measures are working. Although sometimes inconclusive, the results of sampling can at other times provide life-saving information.

Most experts do agree, including those that do not favor routine sampling, that there should be a consideration to sample any system that presents significant LD risk and/or exposure potential. Final consideration would be based on a thorough review and risk assessment of the system and its operating particulars. Specific risk assessment data would include: makeup and system water characteristics, system design and operational data, fouling history and potential, potential host populations and susceptibility, and LD case history.

Legionella Sampling: The most important consideration in *Legionella* sampling (testing) is to select a laboratory that has significant experience in culturing and testing samples for *Legionella*. There are specific sample collection procedures, preparation criteria and shipping requirements that should be followed and will be provided by a competent testing firm. They are beyond the scope of this document but, in general, include instructions for: sample type (swab or water), sample size and container requirements, sterile collection (chlorine neutralization) procedures, un-refrigerated shipping and time requirements, etc.

Legionella Test Results, Interpretations & Action Plans: The following excerpt is by J. R. Watson, Ph.D., *Legionella Update – 2000*, Microbiological Consultation Services, Inc.:

“Although small numbers of *Legionella bacteria* probably pose a very low risk to healthy individuals, corrective action should be kept in mind whenever legionellae are isolated from a water sample. Although the scientific community cannot agree on what number of *Legionella bacteria* is acceptable, we believe colony counts, as expressed in colony forming units (cfu) per ml of water, can be used as a loose guide for deciding when to implement corrective action. *Legionella pneumophila* colony counts for cooling tower specimens may be interpreted as follows:

- **>100 cfu/ml = large number of *Legionella* bacteria.**
- **10-100 cfu/ml = moderate number of *Legionella* bacteria.**
- **<10 cfu/ml = small number of *Legionella* bacteria.”**

The significance of *Legionella* laboratory test results and subsequent formulation of action plans to apply to systems monitored for *Legionella* is still somewhat at question. Again, this is where the scientific community simply does not yet have a definitive consensus. However, there is a general consensus that some sort of guideline should be used versus none at all. The following various guidelines and action plans are provided as a resource to such an end:

1. The OSHA Technical Manual offers the following guidelines to use when interpreting *Legionella* analyses for cooling tower and potable water systems. The guidelines may be used to assess the effectiveness of water system maintenance and *Legionella* control. These guidelines are based on limited data and are subject to change. They are intended to apply only to water systems being used by healthy individuals and are not necessarily protective for persons who are immunocompromised.

The levels requiring action vary for the source of exposure based on the assumption that some routes or exposure result in a greater dose to the lung. For this reason, humidifiers and similar devices such as misters and evaporative condensers, which produce an aerosol mist that can be directly inhaled, should be controlled to lower levels. Remember that these numbers are only guidelines, and the goal is zero detectable *Legionella* in a water source. Levels of *Legionella* equal to or greater than the values in the table constitute a need for action, as described below.

► **Action 1:** Prompt cleaning and/or biocide treatment of the system.

► **Action 2:** Immediate cleaning and/or biocide treatment. Take prompt steps to prevent employee exposure.

Action	Colony Forming Units (CFU) of <i>Legionella</i> per milliliter		
	Cooling tower	Domestic water	Humidifier
1	100	10	1
2	1,000	100	10

[From OSHA Technical Manual (Section III: Chapter 7, Legionnaires' Disease), which was adapted from George K. Morris, PhD, and Brian G. Shelton, Pathcon Technical Bulletin 1.3, *Legionella* in Environmental Samples: Hazard Analysis and Suggested Remedial Actions, June 1991]

2. Richard W. Gilpin, Ph.D., and GTS *Legionella* Water Testing Lab provides the following remedial action criteria as an attachment to all their *Legionella* test reports. The units of measure are from their Direct Florescent Antibody (DFA) epifluorescence microscopy and represent total numbers of morphologically intact *Legionella* observed.

► **<10-20/ml:** This is the most common test result and does not require remedial action. Retest in a month to check for evidence of increasing numbers of *Legionella*.

► **30-190/ml:** This is the second most common test result. A decision to disinfect the tower should be made by considering the numbers of *Legionella*, location of the tower, and the type of employee, patient, or visitor population. The tower’s proximity to pedestrian traffic, building air intakes, open windows and doors should also be considered. If tower is disinfected, retest after disinfection to make sure the procedure was successful. Review and revise the biocide treatment program currently in use. If the tower is not disinfected, retest within a few weeks to check for evidence of increasing numbers of *Legionella*.

► **200-1,000+/ml:** Least likely test result, but may be reached quickly from a previously lower level. Result represents a public health concern and disinfection of the tower is indicated. If the count is >1,000/ml, take immediate action. Retest after disinfection to make sure the procedure was successful. Review and revise the biocide treatment program currently in use. Retest within a few weeks to check for evidence of increasing numbers of *Legionella*.

3. A common cooling tower *Legionella* testing and action plan is seen in Figure 5. It represents a composite compilation of various AWT member Water Treatment Company *Legionella* action plans for cooling tower operations. The frequency of tower sampling for *Legionella* varies widely amongst the programs (i.e., monthly, quarterly, semi-annually to annually) and is generally determined from specific site and system LD risk assessments.

Figure 5: General Cooling Tower *Legionella* Testing Action Plan

Legionella Testing Action Plan			
Cooling Tower Legionella Count, cfu/ml (Colony Forming Units per milliliter)			
<u>>0-10</u>	<u>>10-100</u>	<u>>100-1,000</u>	<u>>1,000</u>
a.	b.	c.	d.
<u>ACTION PLAN:</u>			
a. Increase biocide addition/s.			
b. Increase biocides; review program; retest till <10.			
c. Disinfect/clean within 30 days; review program.			
d. Disinfect/clean within 7 days; review program.			

Note: Figure 5 is courtesy of Southeastern Laboratories, Inc. *Legionella* training material presentations.

VIII. Health Care Facilities – A Special LD Risk Environment

Table 1: Hospital Surveys for <i>Legionella</i> Contamination of Water Distribution Systems				
Reference	Location	Hospitals	% With <i>Legionella</i>	Isolate
HMSO	United Kingdom	40	70%	<i>L pneumophila</i> , serogroup 1
Alary	Quebec	84	68%	<i>L pneumophila</i> , serogroups 1-8
Vickers	Western Pennsylvania	15	60%	<i>L pneumophila</i> , serogroups 1-6
Patterson	United Kingdom	69	55%	<i>L pneumophila</i> , <i>Legionella</i> species
Marrie	Nova Scotia	39	23%	<i>L pneumophila</i> , <i>Legionella longbeachae</i>
Liu	United Kingdom	17	12%	<i>L pneumophila</i> , serogroups 1,4,6

Note: Table 1 was excerpted and adapted from "Resolving the Controversy on Environmental Cultures for *Legionella*: A Modest Proposal" by Victor L. Yu. Infect Control Hosp Epidemiol 1998;19:893-897. Cooling tower samples are not included in the data.

Health Care Facilities and JCAHO: Potable water plumbing systems present a favorable habitat for *Legionella* and pose an associated LD risk to the susceptible host populations within the healthcare community. Thus, there is a major emphasis on the risk assessment, control and management of these systems and their associated water disseminating equipment or systems in health care facilities. In accordance with this concern, the Joint Commission for the Accreditation of Healthcare Organizations (JCAHO) issued a new standard that became effective January 1, 2001. This standard, numbered EC 1.7, requires all JCAHO accredited facilities to have a management program to **"reduce the potential for organizational-acquired illness."** It holds the health care facility responsible for **"managing pathogenic biological agents in cooling towers, domestic hot water, and other aerosolizing water systems"** – i.e., *Legionella* among others.

The American Society for Healthcare Engineering (ASHE) has recommended in their technical reports on managing waterborne pathogens, per JCAHO EC 1.7, that health care facilities conduct a risk assessment of their potential sources of *Legionella* and develop a management plan for maintenance and operation of their water systems.

Health Care Facility – Risk Assessment & Management Plans: JCAHO surveyors now clearly expect health care facility managers to have a risk assessment and management plan in place to comply with JCAHO's EC 1.7 standard. Following is an outline from the ASHE web site on what a facility manager should be doing to comply with EC 1.7 and what JCAHO inspectors are looking for:

Step 1: Risk Assessment

- ▶ Work with the Infection Control Practitioner to assess the clinical risk of the patient population to identify and review:
 - The treatment and care areas for patients at greatest risk,
 - Any cases or current history of infections resulting from water borne pathogens, including legionellosis.
- ▶ Assess the environmental risk from potential amplification factors such as:
 - Domestic hot water systems
 - Design (i.e. dead legs and low flow conditions)
 - Operation (i.e. water temperature)
 - Maintenance (i.e. flushing and cleaning of hot water tanks)
- ▶ Assess cooling and humidifying systems, which produce aerosols:
 - Design (i.e. drift eliminators)
 - Operation (i.e. sterile water in room humidifiers)
 - Maintenance (i.e. cleaning cooling towers and use of an effective biocide)

Step 2: Risk Mitigation

- ▶ If susceptible patients are identified, work with the Infection Control Practitioner to determine what aerosolizing systems are present in that patient's environment (i.e. showers) and limit their access to these systems.

Step 3: Operational Management of Risk

- ▶ Develop a management plan as a result of the assessment (step 1) that includes standard operating procedures (SOP's) for maintenance and operation of water systems.
- ▶ Develop a system to document and log findings as a result of these SOP's such as temperatures, blow down of hot water tanks, cooling tower inspections, etc.
- ▶ Include in these SOP's a maintenance and audit program for any systems that are currently installed to limit *Legionella* amplification in aerosolizing systems such as cooling towers and/or potable water treatment systems (e.g. copper-silver or chlorine dioxide).
- ▶ Inspect cooling towers/evaporative coolers to ensure that they are in proper condition and operate as designed.

Step 4: Remediation (if required)

- ▶ Work with the organization based Infection Control and Safety committee to establish a contingency plan for water system decontamination to be implemented if Infection Control identifies an outbreak of Legionellosis and corrective steps are needed.

IX. Legionella Information – On the Internet

Much information, both international and multi-disciplined, on *Legionella* and Legionnaires' disease is accessible via the Internet. The following Internet sites (addresses) are listed as a resource to additional information on *Legionella*. The list is certainly not all-inclusive, but does provide an excellent collection of top sites on the subject matter and from which other sites are linked and/or accessible via Internet search engines:

<http://www.ashrae.org> ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc.) web site: where you can download their latest position and guideline papers on Legionellosis.

<http://www.awt.org> Association of Water Technologies (AWT) web site: where you can download their latest *Legionella* update and position statements.

<http://www.cdc.gov> CDC (The Centers for Disease Control and Prevention) web site: where you can search and get their latest guidelines and information on LD.

<http://www.cti.org> Cooling Technology Institute (CTI), formerly the Cooling Tower Institute, web site: where you can download their latest position papers on *Legionella*.

<http://www.dhmh.state.md.us/html/legionella.htm> State of Maryland Department of Health & Mental Hygiene web site: get their special LD "*Report of the Maryland Scientific Working Group to Study Legionella in Water Systems in Healthcare Institutions*" (June 14, 2000).

<http://www.hcinfo.com> HC Information Resources web site: provides publications, consulting services, seminars and training related to *Legionella* and other waterborne pathogens – comply with JCAHO EC 1.7. Some info is free, others have fees.

<http://www.legionella.com> GTS web site: a *Legionella* testing firm in business since 1981, where you can get their *Legionella* facts, publications, info sheets and services.

<http://www.legionella.org> The Pittsburgh VA HealthCare System's dedicated *Legionella* site with access to leading *Legionella* experts and LD information.

<http://www.osha.gov> OSHA home page: where you can search and get OSHA LD information, including their latest manual (Section III, Chapter 7) on LD.

<http://pathcon.com> PathCon Laboratories, a *Legionella* and indoor air quality testing firm, microbiological and investigative LD expertise – get their *Legionella* Technical Bulletins.

X. AWT Position Statement – *Legionella* & Legionellosis

The Association of Water Technologies makes the following recognition and position statements regarding Legionnaires' disease, water treatment and related practices of water treatment specialists. They are based on the significant and prevailing information from ASHRAE, CDC, CTI, EPA, OSHA, the medical community, leading experts and other authoritative agencies that study, investigate and deal with *Legionella* and Legionellosis.

1. AWT recognizes the potential hazard for *Legionella* contamination in cooling towers and evaporative condensers, as well as other water systems and water disseminating devices or equipment that may or may not be a part of water treatment programs.

2. AWT supports that prudent operational and water treatment practices for cooling towers, evaporative condensers and other recirculating water systems, are consistent with reducing *Legionella* contamination within them and include:

- Corrosion, scale and deposit control programs that promote operational efficiency and system cleanliness and reduce microorganism-breeding areas.
- Dispersant, biodispersant and antifoulant programs that reduce biofilm, sludge, debris and dirt accumulations – that further reduce microorganism-breeding areas.
- Biocide programs, including oxidizing and non-oxidizing treatments that are applied according to proper labeling, to control microbiological growth and proliferation.
- Maintaining best available mist elimination technology in evaporative systems and eliminating or minimizing stagnant (dead-leg) zones and areas.
- A minimum annual (twice annual preferred) thorough wash-out and cleaning of cooling towers and evaporative condenser cooling water systems - including an oxidizing disinfection before and after each cleaning.

3. AWT supports that the microbiology and environmental ecology of *Legionella* includes many variables that determine organism virulence and survival, disease transmission and contraction, and human host susceptibility. And, even prudently applied water treatment programs cannot guarantee 100% *Legionella* eradication or disease prevention.

4. AWT supports the sampling and testing for *Legionella* in cooling towers, evaporative condensers and other water systems appropriately **risk-assessed and evaluated** to pose disease risk. Specifically targeted systems include those that have a likelihood of harboring *Legionella* and/or pose an increased risk of transmission to populations of at-risk hosts. Monitoring for *Legionella* within a facility may also be appropriate or required to:

- Verify the effectiveness of water treatment protocols,
- Evaluate potential LD transmission sources,
- Verify the effectiveness of *Legionella* decontamination procedures,
- Test within certain healthcare facilities that have patients at high risk for LD.

5. AWT supports that *Legionella* sampling and testing should be **considered** for all potential *Legionella*-source water systems. An ultimate decision to test or not should be determined and based upon an assessment and review of the specific water system (site and operations) for LD risks. This includes having an understanding of relevant facts on *Legionella* sampling and testing, *Legionella* and Legionnaires' disease, and having an action plan for test results. Accordingly, AWT does not recommend the **routine** sampling and testing of all systems without appropriate assessments.

6. AWT will continue to investigate and evaluate, as well as promote and report, the latest findings, research and technologies relevant to the control of *Legionella* and the prevention of Legionnaires' disease. This includes independent research, as well as liaison and joint exchanges with government agencies, other organizations, associations, and related professional entities.

7. AWT, as a Responsible Care® Partner Association, further commits to sharing with the water treatment industry, the health care community and industry at large, as well as the general public, any relevant information gathered and produced from their resources addressing *Legionella* and Legionellosis.

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Legionella Position Paper Review Quiz

The questions for the quiz may be answered by reading and understanding the AWT Position Paper Legionella 2003. The correct answers are derived from that paper and any disputed answers will be referred back to that paper for justification. An 80% correct score must be achieved for credit for this review.

1. Legionnaires' Disease was named in what year?
 - a) 1926
 - b) 1976
 - c) 1980
 - d) 1992

2. What is an acute bacterial infection of the lower respiratory tract?
 - a) Legionella
 - b) Legionellosis
 - c) Legionella pneumophila
 - d) Legionnaires' Disease

3. Legionnaires' Disease infects approximately what percentage of those appropriately exposed to the bacteria?
 - a) 2-5%
 - b) 15-20%
 - c) 20-30%
 - d) 70%

4. After successful treatment and hospital discharge, complete recovery from Legionnaires' Disease is within what time frame?
 - a) 1-3 Days
 - b) 2-5 Days
 - c) 1 Year
 - d) The patient never fully recovers

5. The optimal growth for Legionella is between what temperatures?
 - a) 20-50 degrees F
 - b) 95-113 degrees F
 - c) Greater than 150 degrees F
 - d) Less than 20 degrees F

6. Legionella is transmitted to an acceptable host by which widely accepted method?
 - a) Being around an infected person
 - b) Shaking Hands
 - c) Aspiration
 - d) Touching

7. According to a 1998 Hodgson and Casey study, what system was most likely to transmit Legionella?
 - a) Cooling Towers
 - b) Potable Water Distribution Systems
 - c) Hot Water Heaters
 - d) Chilled Water Systems

8. Legionella is largely dormant at what temperature?
 - a) 20-50 degrees F
 - b) 95-113 degrees F
 - c) Greater than 150 degrees F
 - d) Less than 20 degrees C(68degrees F)

9. Ultraviolet Radiation provides disinfection in what spectrum range?
 - a) 0-100 nm
 - b) 100-250 nm
 - c) 250-280 nm
 - d) 280-350 nm

10. Chlorine dioxide is an effective treatment against Legionella and biofilms at what level?
 - a) .2mg/l
 - b) .8 mg/l
 - c) 1.0 mg/l
 - d) Greater than 5 mg/l

11. To disinfect a cooling tower, what Free Residual Chlorine (FRC) levels must be maintained?
 - a) 2mg/l
 - b) 8 mg/l
 - c) 10 mg/l
 - d) Achieve 50 mg/l FRC, maintain 10 mg/l FRC for 24 hours

12. To minimize the Legionella counts in the tower and minimize the transmission risk from the tower to people, one should;
 - a) Keep people away from the tower
 - b) Treat the system properly for scale, corrosion, fouling, and microorganisms
 - c) Keep the tower full at all times, even when not in use
 - d) Keep dead leg valves closed

13. OSHA and CTI recommend continuous Halogen feeding to control Legionella. What level is recommended?
 - a) .5 - 1.0 mg/l
 - b) .1 - .2 mg/l
 - c) greater than 1.0 mg/l
 - d) Halogens are not recommended at all

14. Legionella is reported in what units?
- CFUs
 - PPM
 - mg/l
 - Colonies per liter
15. Which is the most common test result and requires no remedial action?
- <10 – 20 cfu/ml
 - 30 -190 cfu/ml
 - 200 – 1000 cfu/ml
 - > 1000 cfu/ml
16. Which is the second most common result? Customer must make a decision to disinfect the tower.
- <10 – 20 cfu/ml
 - 30 -190 cfu/ml
 - 200 – 1000 cfu/ml
 - > 1000 cfu/ml
17. According to the Legionella Testing Action Plan, which action is recommended at levels of ≤ 10 cfu/ml?
- Increase biocide addition/s
 - Increase biocides; review program; retest until <10 cfu/ml achieved
 - Disinfect/clean within 30 days; review program
 - Disinfect/clean within 7 days; review program
18. According to the Legionella Testing Action Plan, which action is recommended at levels of >10 – 100 cfu/ml?
- Increase biocide addition/s
 - Increase biocides; review program; retest until <10 cfu/ml is achieved
 - Disinfect/clean within 30 days; review program
 - Disinfect/clean within 7 days; review program
19. According to the Legionella Testing Action Plan, which action is recommended at levels of >100 – 1000 cfu/ml?
- Increase biocide addition/s
 - Increase biocides; review program; retest until <10 cfu/ml is achieved
 - Disinfect/clean within 30 days; review program
 - Disinfect/clean within 7 days; review program
20. According to the Legionella Testing Action Plan, which action is recommended at levels of >1000 cfu/ml?
- Increase biocide addition/s
 - Increase biocides; review program; retest
 - Disinfect/clean within 30 days; review program
 - Disinfect/clean within 7 days; review program