Legionella: An Update & Statement by AWT

I. Background: The Discovery of Legionnaires= Disease & Legionella

Legionnaires= disease (LD) acquired its name by way of media reference to a mysterious pneumonia-like illness that befell many attendees of an American Legion Pennsylvania State Convention held at the Philadelphia Bellevue-Stratford Hotel in July of 1976. An outbreak occurred presenting Pennsylvania Department of Public Health officials with a recorded 221 cases of a strange respiratory illness contracted by the convention and other hotel attendees. Symptoms included high fever, chills, headaches, muscle pain (flu-like symptoms) and eventually development of a dry cough and difficulty in breathing. A third of the patients developed diarrhea and/or vomiting and half of the patients became confused and/or delirious. Some patients developed patchy lesions in their lungs representative of a severe pneumonia. More than two-thirds of the patients required hospitalization and 34 died.

The CDC (Centers for Disease Control and Prevention) in Atlanta, Georgia was called to help investigate the outbreak. Their investigations eventually lead to the discovery of the causative agent, a bacterium, in January of 1977. The bacterium was subsequently named Legionella pneumophila. While it was the outbreak in 1976 that gave the disease its name and led to the identification and naming of the causative bacteria, neither was new. Legionella bacteria have been around and causing disease for many years. The CDC reexamined fifty-year old archived and unsolved, similar-illness tissue samples and found Legionella bacteria. So, Legionnaires' disease was not a 'new disease' discovered in 1976 -- just an old one, finally recognized and named.

II. Background: Terms, Definitions, & General Facts

Legionella is the named genus of gram-negative, rod-shaped, aerobic bacteria that are very common to aquatic, especially warm water, environments. The plural, referring to more than one Legionella organism, is **legionellae**. There are some 39 identified species of Legionella, with over half of them being linked to human diseases. Some species are made up of more than one **serogroup**, with over 60 serogroups presently identified for the genus. Many serogroups are further differentiated into numerous **subtypes**.

Legionellosis is any illness caused by exposure to Legionella. The exposure primarily occurs when a person inhales aerosols, fine sprays, or other microscopic droplets of water contaminated by Legionella microorganisms. Cooling towers, evaporative condensers, heat-rejection devices, humidifiers, showerheads, faucets, whirlpool baths and spas, respiratory therapy equipment, even misting machines in grocery store produce sections, have been identified as sources of Legionella in outbreak investigations. **Legionnaires' disease** and **Pontiac fever** are the two most common types of legionellosis.

Legionella pneumophila (Lp) is the named species of Legionella causative to over 90% of legionellosis cases. More than 70% of these cases are attributed to a single of its 14 serogroups: Legionella pneumophila serogroup 1 (Lp-1). Within Lp-1 are at least 50 further subtypes. Lp serogroups and subtypes appear to differ in their degree of virulence. Lp-1 is the most common isolate recovered from environmental samples.

Legionnaires= disease (LD) is a potentially fatal, multi-system respiratory illness, accompanied with pneumonia. It attacks some 2-5% of those exposed (representing those most susceptible) and has an average mortality rate of approximately 15-20%. Factors influencing susceptibility include the elderly and those with suppressed or compromised immune or respiratory systems, such as: heavy smokers, alcoholics, HIV patients, cancer or organ-transplant patients, and others with lung or respiratory diseases. Underlying disease and advanced age are not only risk factors for acquiring LD, but also for dying from the illness. It incubates in human hosts within 2-10 days of exposure and will not abate without medication. When diagnosed and treated early, the disease responds well to the antibiotic erythromycin or many of the newer macrolide antibiotics.

LD is an environmental disease. The causative agent (Legionella) is transmitted from an environmental source (water) to a person. This differentiates it from communicable diseases, which are transmitted from person to person.

LD is a common and serious illness. It is not rare. Legionella bacteria are among the top three causes of sporadic, community-acquired pneumonia. It is also the cause of many hospital-acquired (nosocomial) cases of pneumonia. Many cases of LD go undiagnosed, as it is difficult to distinguish from other forms of pneumonia, unless specifically targeted. Even

when detected, they often go unreported to the public health authority, especially if cases are sporadic (a one or two case incident) and not associated with an outbreak investigation. This under-detecting and under-reporting of the disease makes its incidence difficult to estimate and, consequently, figures vary widely. The CDC has estimated that the disease infects 10,000 to 15,000 persons annually in the United States. OSHA estimates that over 25,000 cases of the illness occur each year and cause more than 4000 deaths. Still others have estimated as many as 100,000 annual cases.

Pontiac fever is a much milder, non-pneumonia, flu-like illness caused by Legionella pneumophila. It attacks 90-95% of those exposed, indiscriminately, and has a short incubation period of 1-3 days. Complete recovery usually occurs in 2-5 days without medical attention.

Because the contraction of Legionnaires= disease represents a much more serious condition than that of Pontiac fever, our information focus will be on this disease and Legionella pneumophila that causes it.

III. Legionella: Infectious Growth, Transmission & Host Susceptibility

Legionella pneumophila is a very common, said to be ubiquitous, organism. It is capable of being present in appreciable numbers in almost all ground and surface water sources. Legionellae tend to grow in biofilms or slime on the surfaces of lakes, rivers and streams -- and within water distribution systems.
Legionellae live within biofilms and uniquely within certain amoeba and protozoa, as endosymbionts. This allows them, among other things, to survive typical potable water chlorination (disinfection) and thus appear in many finished water supplies to homes and industry. Therefore, it is obvious that the mere presence of legionellae does not, in itself, result in infectious disease. However, it is when legionellae are allowed to amplify or increase in population density, and thus virulence probability, that they can become infectious -- when transmitted to a susceptible human host.

1) The legionellae must have sufficient virulence factors to cause disease. The virulent legionellae must be present in sufficient quantity to cause an infection.

2) The dose of Legionella pneumophila required to infect humans is not known. It is, however, most probably influenced by host susceptibility**.**

3) The susceptible host must inhale a transmitted aerosol containing the legionellae. The legionellae “vesicles” or transmission form must be less than 5 micrometers in size in order to reach the deepest (alveolar) parts of the lungs to cause infection, which is a result of overwhelming the host’s immune (defense) system.

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

X Stagnant water conditions and/or system design configurations that produce stagnation, such as side-arm and dead-leg piping.

X Warm water temperatures between 20-50 CE (68-122 FE)
Optimal growth is at temperatures between 35-46 CE (95-115 FE)

X A pH range generally between 5.0 to 8.5

X Sediment, scale, deposits, biofilms - support not only Legionella growth, but also that of the very important supporting microbiota for Legionella.

X Microbiota including algae and many bacteria that supply essential nutrients for growth of Legionella.

X Certain amoebae and other protozoan harbor Legionella as endosymbionts -- allowing them to thrive, resist harsh environmental conditions (including biocides) and to significantly amplify.

Transmission of Legionella: After growth and amplification of legionellae to potentially infectious densities, the next requirement in the chain of disease causation is to present the legionellae in an aerosol (water-mist) form. The primary transmission mode of Legionnaires= disease then becomes the subsequent inhalation of such an aerosol providing entry of the Legionella organisms deep into the human respiratory tract.

Several different type water systems can serve as legionellae amplifiers and (aerosol) disseminators, and thus have been associated with Legionnaires' disease. They include:

X Cooling Towers and Evaporative Condensers
X Domestic Hot Water Systems (tap faucets, showerheads, sprayers)
X Spas and Whirlpools (on display or otherwise)
X Humidifiers
X Decorative Fountains
X Supermarket Reservoir Misters
X Respiratory therapy equipment
X Dental hygiene equipment

Awareness should exist and precautions taken whenever such devices are in use, as to their potential to harbor and transmit legionellae and the health risk they pose to individuals.

IV. Domestic Plumbing, Hot-Water Systems & Legionnaires= Disease:

Cooling towers were implicated as the source of Legionella in the 1976 outbreak -- and for many years were thusly designated and generally assumed to be the "official reservoir" and source of Legionnaires' disease. This was unfortunate and became extremely problematic to the cooling tower water treatment industry, which was subsequently looked upon to be the ones to "take care" of Legionella. Some water treaters didn't help their cause by making claims to be able to do just that with "their" products and "their" water treatment programs!

We have now come to recognize Legionnaires' disease for what it is – an environmental disease and an environmental issue. Our raw waters are its source and it finds reservoir in many water systems. Cooling towers are but one type system - and not the major one. That distinction belongs to the domestic water (hot water and other) plumbing system.

Domestic plumbing systems, which may serve as makeup to cooling towers, do serve our buildings, commercial and otherwise, and our hospitals and other care facilities. These systems were first implicated in a nosocomial (acquired during a hospital stay) case of Legionnaires' disease in 1980. Since then, they have been associated with numerous outbreaks of legionellosis. The United Kingdom reported 19 of 20 hospital Legionnaires' outbreaks, from 1980 to 1992, to be from their plumbing systems. Cases of Legionnaires' disease have also been attributed to plumbing systems in nursing homes, workplaces, and private residences.

Hot-water systems are perfect breeding habitats for legionella, as well as other bacteria that form biofilms. Legionella can flourish in a hot-water tank, especially in the bottom warm zones that can develop with accumulated scale and sediment. The complexities of hot-water piping presents an even greater problem than tanks, because biofilm and scale that form in their valves and fittings and on the pipe walls not only feed bacteria but also protect them from hot water and chemical disinfectants. Dead-legs (unused piping) create additional problems because bacteria grow well in stagnant water.

V. Cooling Towers: Water Treatment & Legionnaires= Disease

Cooling towers and evaporative condensers do have the potential for developing infectious concentrations of legionellae. Cooling tower drift (water loss) creates the mist or aerosol that can transmit the disease. In addition, the cooling tower can provide many of the conditions for the growth and amplification of microorganisms. The evaporative (cooling) process causes all

makeup waterborne constituents, as well as system water constituents, to concentrate - i.e., remain in the tower loop according to cycles of concentration. The residence time in the water loop allows time for growth and reproduction of organisms. With warm water temperatures and the presence of deposits and sediment debris, further growth and amplification of legionellae can be promoted.

Water quality and system maintenance should be well controlled in these systems. The chemical treatment objectives of any prudent water treatment program are to maintain corrosion, deposit, and microbiological control. Effecting such also diminishes Legionella growth and amplification. Cooling tower systems associated with ineffective cooling water treatment practices and/or neglect certainly represent a greater potential for harboring potentially infectious Legionella. However, high (even infectious) levels of Legionella have been found in otherwise well-maintained and operated tower systems.

Biocide Treatments play an important role in microbiological control programs, including those for Legionella. However, biocide treatments do not "target" specific microbiological 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 legionellae in the field under actual operating conditions. Environmental legionellae cannot be reproduced in the lab from culture-grown organisms. Therefore, laboratory trail testing should not be relied upon exclusively for sole proof of a biocide's efficacy against legionellae.

Total Bacterial Counts (TBC) of a cooling water system should not be relied upon for any definitive correlation with legionellae counts, control or LD risk. Legionnaires' disease has been associated and legionellae counts found high in systems that had very low total bacterial counts. There have also been systems with high total bacterial counts, yet low or negative legionellae numbers.

Cooling Tower Disinfection for purposes of Legionella control and prevention is generally recommended as: (1) a maintenance action for startup, post lay-up or regular scheduled tower cleaning, (2) a corrective prevention and control action following tower Legionella sampling with high results, or (3) a required action following a confirmed or suspected system related LD occurrence.

The following is an abbreviation of the method outlined by the CDC. It should be noted, however, that most cooling tower and water treatment experts differ with respect to the chlorine levels recommended and routine frequency of using this type disinfection, due to the corrosive damage potential to system metallurgy. The guidelines established by CTI and ASHRAE should also be considered.

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 ppm;
5. Add a dispersant to tower water within 15 minutes of chlorine addition, then maintain 10 ppm 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 ppm FRC for one hour, then flush the system until free of all sediment;
9. Refill the system with clean water and return to service.

VI. Cooling Towers: Minimizing Legionella Counts & Transmission

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

1) Minimization of Cooling Tower Legionella Counts:

While keeping Legionella below detectable levels in every tower system is nearly impossible and should not be expected, attempting to **minimize** Legionella in cooling towers is 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 tower systems. They include: proper design, cleaning, maintenance and water treatment. Combined, they generally minimize Legionella counts in a tower, but cannot be expected to eliminate them entirely in every system. Even some properly maintained and operated cooling towers have been found to have high Legionella counts.

2) Minimization of Legionella Transmission from Cooling Tower to People:

Minimizing transmission from the tower to a host is the second responsible measure to reduce the risk of disease, especially with the realization there are no guarantees to keeping a tower system Legionella-free. In this regard, the following considerations should be made: minimizing tower drift (aerosol sprays) with proper and well maintained eliminators, tower location to keep tower drift (aerosol sprays) from building or other air intake pathways to possible hosts, tower location to keep outside sources of plant life or nutrients from entry to the tower system, and utilization of appropriate facial mask (filters) for workers or others subject to tower drift (aerosol sprays).

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 legionellae from tower to people:

- The tower's location should consider prevailing winds and proximities with respect to people populations, building air intakes and surrounding units.

- The tower's location should consider prevailing winds and proximities with respect to nutrient sources (kitchen exhausts, plants) getting into the tower.

- Shield or cover the cold-water basin, distribution deck, and other wet surfaces from sunlight to prevent algae growth.

- Materials of construction should be smooth and non-porous.

- Water distribution piping should be as simple as possible and avoid dead-legs and difficult to drain loops.

- Towers should be accessible with an ease of access for inspection, sampling, cleaning and disinfecting.

- The system should be designed for complete draining or pump out.

- Provisions should be made to facilitate a water treatment program, including: chemical injection, sampling, corrosion coupon sampling, bleed and drain points.

- High efficiency drift eliminators should be used and maintained.

- Treated water, filtered with trace halogen residual or greater, should be used as tower make-up.

- Multiple-cell tower basins should be designed such that each cell and basin can be isolated, while the other cells remain in operation.

- The tower system's total operating volume should be known for proper chemical dosing, particularly that of biocide and dispersant treatments.

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 legionellae from tower to people:

- Clean tower and disinfect before start-up, especially new system start-up, and after any long shutdown period (greater than 2-4 weeks).

- Treat water for control of corrosion, scale, fouling and microorganisms.

- Establish a maintenance plan.

- Maintain all drift (mist) eliminators in proper operation form as well as fan operations that affect drift productions.

- If dead-legs in the piping system cannot be removed, blow them down regularly, particularly after biocide treatments and cleanings.

- Exercise all valves in the system periodically by opening and closing them fully.

- Clean the basin when slime, algae, or dirt are visible.

- Blow down chilled water risers weekly on systems using direct free cooling.

- Thoroughly flush and clean the entire system on an annual minimum basis (2X preferred) - to include an oxidizing disinfection before and after cleaning.

VII. Sampling / Testing for Legionella: The Big Debate

Water sampling 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, obviously tells you nothing about your programs, until a case of Legionnaires' disease (LD) occurs. The foregoing sounds quite logical and simple, and an assumption that Legionella sampling should be routine for any monitored system. Such is not the case!

Legionella experts have debated the issue of sampling and routine testing for years. The Centers for Disease Control and Prevention (CDC) advocates sampling after LD has been found (confirmed) so as to locate the source of legionellae that caused it and take remedial action. They do not encourage sampling in the absence of 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.

What has stood in the path of any real consensus being achieved amongst the experts are the following current facts and understanding of Legionella and LD:

- There is no specific infectious density known for Legionella or clearly established correlation between test culture results of Legionella and risk of contamination;

- Legionella is frequently present in water supplies without causing disease, so routine

testing and getting a positive count does not mean LD will occur and may even produce a false sense of alarm and lead to costly corrective actions being undertaken. On the other hand getting negative results does not assure that LD cannot occur and may even provide a false sense of security and lead to relaxation of preventive maintenance.

- Interpretation of results in routine Legionella sampling is still questionable due to: the use of different bacteriologic methods amongst laboratories; variable culture results from differing sites within the same system; and variations in the counts of legionellae isolated from a single site.

- The risk of illness following exposure to a given Legionella source is influenced by a number of other variables and factors than just the concentration of organisms in a sample, including: host susceptibility, Legionella strain virulence, and efficiency of legionellae transmission (to host).

- Routine testing is also a double-edged liability sword: testing and getting positive results may establish a legal liability, if a disease case occurs; alternately having done testing may also prevent negligence charges from sticking. Also, with the presence of other factors, not having done testing may make you guilty in the face of defending a responsible LD case.

Those in favor of routine sampling believe that since the risk of Legionnaires' disease is greater when there are high levels of legionellae in water, it makes sense to take measures that will minimize legionellae in water and to check legionellae levels periodically to make sure the preventive measures are working. They contend that sampling results, although sometimes inconclusive, may at other times provide life-saving information.

Most experts, however, including those in the anti-sampling group, would agree that there should be a **consideration** to do sampling based on a thorough review of the facts on a site (system) specific basis.

VIII. Legionella Is 'DIGITAL':

The amount of information on Legionella and Legionnaires' disease that is available to us all is enormous! This can probably be said about any subject if you have access to the World Wide Web or Internet. This section (with the captivating 'Title') is a special "Digital Reference" section for seeking that extra information on Legionella.

The following list is far from comprehensive, much less complete, but is an excellent list and starting point for getting incredible amounts of information on Legionella and Legionnaires' disease – directly, or going to related links from these sites:

http://www.hcinfo.com An excellent 'dedicated to Legionella' site. Articles from noted experts and authorities on Legionella covering ALL issues are available for viewing and or download. Many are free; others have very modest charges. A MUST VISIT SITE!

http://www.osha.org OSHA's home page where you can search and get to legionella information, including their latest 40+ page document on Legionella.

http://www.cdc.org The Centers for Disease Control and Prevention (CDC) home page where you can search and get their latest guidelines and information on Legionella.

http://www.ashrae.org American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) home page – download their position papers on Legionellosis.

http://www.cti.org Cooling Technology Institute (CTI), formerly the Cooling Tower Institute, home page – download their position papers on Legionella.

http://pathcon.com PathCon Laboratories, a leading laboratory specializing in Legionella testing, investigations and expertise – get their Legionella Technical Bulletins.

IX. AWT Position Statement – Legionnaires' Disease:

The Association of Water Technologies makes the following position statement/s with regard to Legionnaires' disease and the practices of water treaters and their water treatment programs. It is based on the significant and prevailing information from CDC, OSHA, EPA, the medical community, leading experts and other authoritative agencies that study, deal with, and investigate Legionella.

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

2. AWT recognizes that prudent operational and water treatment practices for cooling towers, evaporative condensers and other cooling 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 breading areas.

- Dispersant and antifoulant programs to reduce biofilm, sludge, debris, and dirt accumulations - further reducing microorganism breading areas.

- Biocide programs, including oxidizing and non-oxidizing treatments used in accordance with proper labeling, to control the growth and over accumulation of microorganisms.

- Maintaining best available mist elimination technology in evaporative systems and eliminating or minimizing stagnant (dead-leg) zones and areas.

- Minimal annual (2X preferred) thorough mechanical cleaning of cooling water systems - to include an oxidizing disinfection before and after cleaning.

3. AWT recognizes that, due to the microbiological and environmental ecology of Legionella, including the many variables associated with transmission and contraction of legionellosis, even prudently applied water treatment programs cannot guarantee 100% Legionella eradication or legionellosis prevention.

4. AWT recognizes the value of Legionella testing for **targeted systems**, i.e., those representing an increased risk of Legionella within the system or those representing an increased risk of transmission to a population of susceptible hosts.

5. AWT recognizes that Legionella testing should be **considered** for all relevant systems, with a final decision to test based on an assessment and review of the specific site (system), including an understanding of the relevant facts on Legionella, Legionella sampling and Legionnaires' disease. AWT, however, does not recommend the **routine** testing of all systems.

6. AWT will continue to study, promote and report the latest findings, research and technologies relevant to the control and prevention of Legionella and legionellosis. This includes, but is not limited to, liaison and cooperative exchanges with other professional organizations, associations and related entities for the common purpose.

7. AWT's *Responsible Care Program* further commits to sharing with our industrial neighbors and the general public the information we have available from our extensive resources addressing Legionella and Legionellosis.