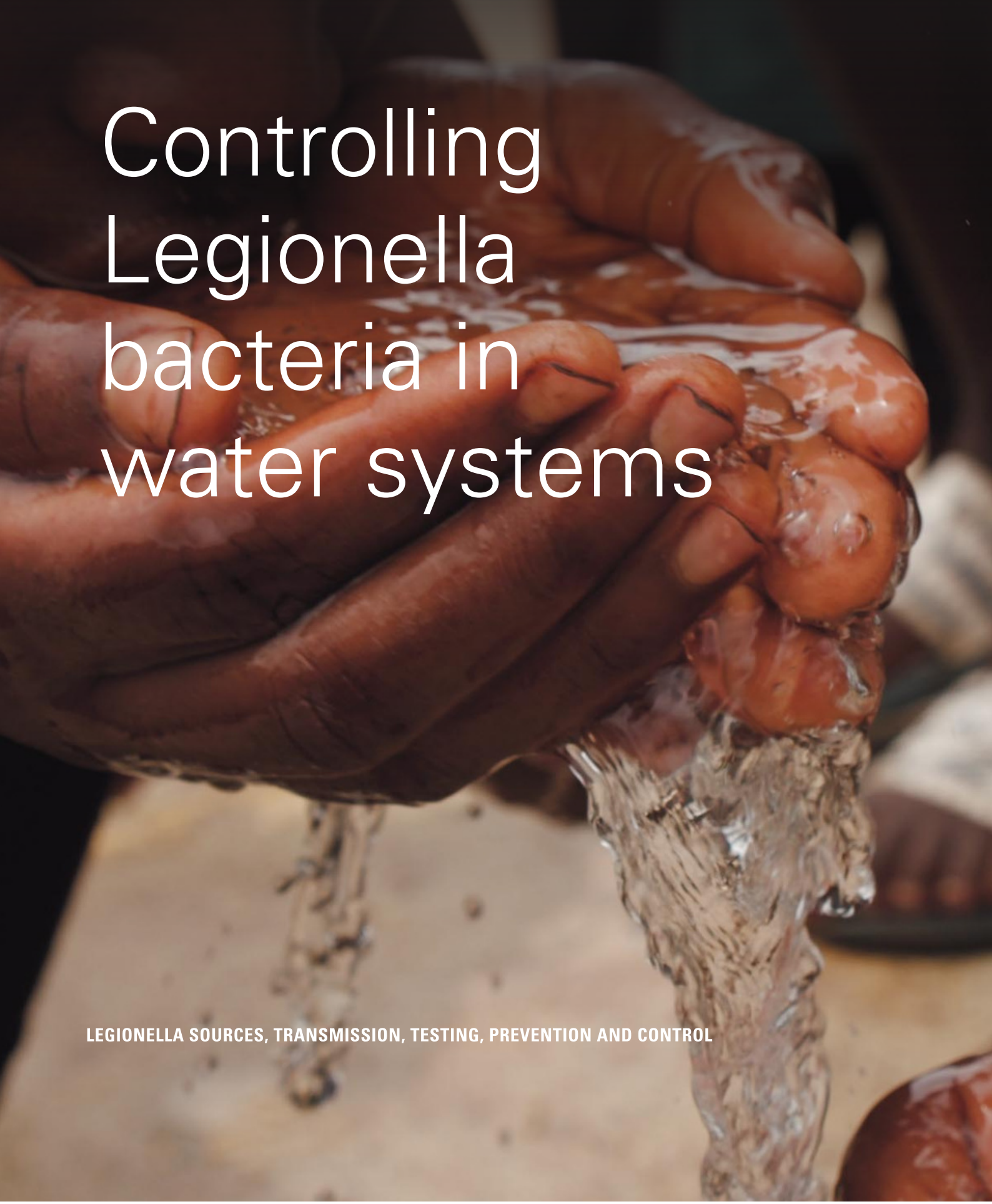

Controlling Legionella bacteria in water systems

LEGIONELLA SOURCES, TRANSMISSION, TESTING, PREVENTION AND CONTROL

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Legionella is a genus of pathogenic Gram-negative bacteria that includes the species L. pneumophila, causing legionellosis (all illnesses caused by Legionella) including a pneumonia-type illness called Legionnaires' disease and a mild flu-like illness called Pontiac fever.

Everyone expects and wants water to be safe and clean. However, this becomes challenging as underground water, water holding units and water distribution systems age or stagnate. In these circumstances, they often become contaminated with waterborne pathogens, particularly if drinking water systems are allowed to mix with sewage and industrial waste water.

One such waterborne pathogen is Legionella pneumophila which can proliferate to harmful levels in poorly managed water systems, and human exposure to contaminated water aerosols can result in legionellosis, which is a collective term for a group of diseases associated with Legionella bacteria.

Published studies have shown legionellosis has a fatality rate of 28% from hospital (nosocomial) acquired infections. During outbreaks it ranges from 5% to 30% and approaches 50% for nosocomial infections. Hence it necessitates action to control the spread of Legionella spp.[7]

INTRODUCTION

Legionellosis is a collection of infections that emerged in the second half of the 20th century, and are caused by Legionella pneumophila and related bacteria known as Legionella species, or spp. The severity of legionellosis varies from mild febrile illness (Pontiac fever) to a potentially fatal form of pneumonia (Legionnaires' disease) that can affect anyone, but principally affects those who are susceptible due to age, illness, immunosuppression and other risk factors, such as smoking.

Legionella is an important pathogen in health-care acquired (nosocomial) pneumonia, particularly in immunocompromised patients. Legionella spp. can also cause community-acquired pneumonia, which has a high rate of hospital admission if not treated early. Legionnaires' disease is recognized as a major form of travel-associated pneumonia, and about 20% of the cases of legionellosis detected in Europe are considered to be related to travel; these cases present a particular set of problems because of difficulties in identifying the source of infection. Although Legionella is a well recognized problem in developed nations, data are scarce from developing countries. Since risk environments and susceptible populations are found worldwide, it is likely that the problem of Legionella is under-appreciated in developing countries.[1,2]

Legionnaires' disease is usually spread by the inhalation of aerosolized water and/or dust from soil contaminated with the Legionella bacteria

LEGIONELLA

Legionella is a waterborne, pathogenic gram-negative bacterium that includes the species L. pneumophila, found in both potable and non-potable water systems causing Legionellosis and the deadly Legionnaire's Disease.

The first recognized outbreak of Legionnaires' disease was found in 1976. It is a severe, often lethal, form of pneumonia. Each year, an estimated 10,000 to 18,000 people are infected with the Legionella bacteria in the United States.[2]

It is not uncommon for patients with Legionnaires' disease to be admitted to the intensive care unit. Some will suffer long-term impaired health-related quality of life. A study of outbreak survivors showed persistence of fatigue (75%), neurologic symptoms (66%) and neuromuscular symptoms (63%) in the months following a diagnosis of Legionnaires' Disease.[2]

SOURCES

Legionella is a type of bacterium found naturally in freshwater environments, like groundwater, lakes and streams. It can become a health concern when it grows and spreads in human-made building water systems like:

- Showerheads and sink faucets.
- Cooling towers (structures that contain water sprays and a fan as part of centralized cooling systems for building or industrial processes).
- Hot tubs that aren't drained after each use.
- Decorative fountains and water features.
- Hot water tanks and heaters.
- Large plumbing systems.
- Spa pools, dental units and air conditioning units.

Home and car air-conditioning units do not use water to cool the air, so they are not a risk for Legionella growth. [1,2]

TRANSMISSION

Legionnaires' disease is not transmitted from person to person. Rarely, it has been transmitted by direct contact between contaminated water and surgical wounds. Legionella bacteria grow best at warm temperatures in wet environments and thrives at temperatures between 25°C and 45°C (77°F and 113°F), with an optimum temperature of 35 °C (95 °F). Temperatures above 60°C (140 °F) will kill Legionellae in around 2-4 minutes. Typical areas where temperatures allow the bacteria to thrive include domestic hot and cold water tanks, cooling towers, and evaporative condensers, and large air conditioning systems, such as those commonly found in hotels and large office buildings.

Although the first known outbreak was in Philadelphia, Pennsylvania, cases of legionellosis have occurred throughout the world. The disease may also be transmitted from contaminated aerosols generated in hot tubs if the disinfection and maintenance program is not followed rigorously. Freshwater ponds, creeks, and ornamental fountains are potential sources of Legionella.

The disease is particularly associated with hotels, fountains, cruise ships, and hospitals with complex potable water systems and cooling systems. L.pneumophila also thrives in aquatic systems in a symbiotic relationship as intracellular parasites of water-dwelling protozoa, such as amoebae. Amoebae are often part of bio-films, and once Legionella have inoculated amoebae, they are protected within a bio-film, they are particularly difficult to destroy. [4]

MECHANISM

Legionella bacteria enter the lung either by aspiration of contaminated water or inhalation of aerosolized contaminated water or soil. In the lung, the bacteria are consumed by macrophages, a type of white blood cell, inside of which the Legionella bacteria multiply causing the death of the macrophage. Once the macrophage dies, the bacteria are released from the dead cell to infect other macrophages. Virulent strains of Legionella kill macrophages by blocking the fusion of phagosomes with lysosomes inside the host cell; normally the bacteria are contained inside the phagosome, which merges with a lysosome, allowing enzymes and other chemicals to break down the invading bacteria.[4]

SYMPTOMS AND HEALTH EFFECTS

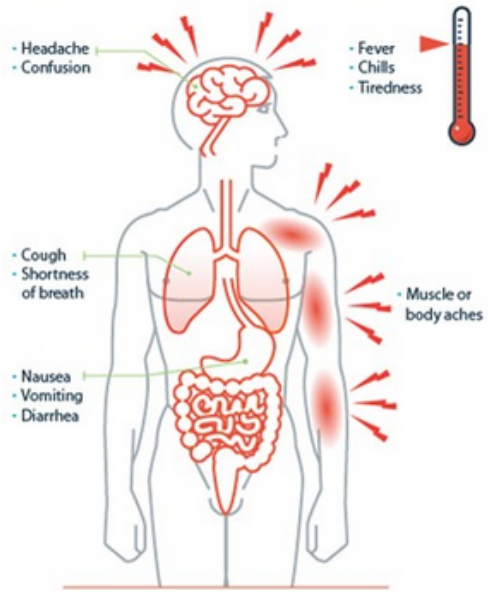
For several days, the patient may feel tired and weak. Most patients who are admitted to the hospital develop a high fever, often greater than 39.5°C (103°F). Cough can be the first sign of a lung infection. The cough may be sufficiently severe to cause sputum production (coughed up mucous). Gastrointestinal stomach symptoms are common with diarrhea being the most distinctive symptom. Many patients have nausea, vomiting, and stomach discomfort. Other common symptoms include headaches, muscle aches, chest pain, and shortness of breath which are also seen in Covid-19.

The non-pneumonic forms (such as Pontiac Fever) are acute, self-limiting influenza-like illnesses, usually lasting 2–5 days. The incubation period varies from a few hours to 48 hours. The main symptoms are fever, chills, headache, malaise and muscle pain (myalgia). No deaths are associated with this type of infection.[1,2]

Legionnaires' disease, the pneumonic form, has an incubation period of 2 to 10 days (but up to 16 days has also been recorded in some outbreaks). Initially, symptoms are fever, loss of appetite, headache, malaise and lethargy. Some patients may also have muscle pain and diarrhea.

Initially there might be a mild cough, but as many as 50% of patients can present phlegm. Blood-streaked phlegm or hemoptysis occurs in about one-third of the patients. The severity of disease ranges from a mild cough to a rapidly fatal pneumonia. Death occurs through progressive pneumonia with respiratory failure and/or shock and multi-organ failure.[1,2]

Untreated Legionnaires' disease usually worsens during the first week. In common with other risk factors causing severe pneumonia, the most frequent complications of Legionellosis are respiratory failure, shock, acute kidney and multi-organ failure. Recovery always requires antibiotic treatment, and is usually complete, after several weeks or months. In rare occasions, severe progressive pneumonia or ineffective treatment for pneumonia can result in brain sequelae and gangrene of limbs and extremities.[1,2] The death rate as a result of Legionnaires' disease depends on the severity of the disease, the appropriateness of initial anti-microbial treatment, the setting where Legionella was acquired, and host factors (for example, the disease is usually more serious in patients with immuno-suppression). The death rate may be as high as 40–80% in untreated immuno-suppressed patients and can be reduced to 5–30% through appropriate case management and depending on the severity of the clinical signs and symptoms. Overall the death rate is usually within the range of 5–10%.[1,2]



CONTROL AND PREVENTIVE MEASURES

The non-pneumonic form of infection is self-limiting and does not require medical interventions, including antibiotic treatment while patients with Legionnaires' disease always require antibiotic treatment following diagnosis. Although it is not always possible to eradicate the source of infection, it is possible to reduce the risks substantially. Prevention of Legionnaires' disease depends on applying control measures to artificial (human-made) water systems to minimize the growth of Legionella bacteria and dissemination of contaminated water aerosols.

These measures include good maintenance of devices, including regular cleaning and disinfection and applying other physical (temperature) or chemical measures (biocide) to minimize growth.

Some examples are:

- the regular maintenance, cleaning and disinfection of cooling towers together with frequent or continuous addition of biocides;
- installation of drift eliminators to reduce dissemination of aerosols from cooling towers;
- maintaining an adequate level of a biocide such as chlorine in a spa pool along with a complete drain and clean of the whole system at least weekly;
- keeping hot and cold water systems clean and either keeping the hot water above 50 °C (which requires water leaving the heating unit to be at or above 60 °C) and the cold below 20 °C or alternatively treating them with a suitable biocide to limit growth, particularly in hospitals and other health care settings, and aged-care facilities;
- reducing stagnation by ensuring water systems are fit for their intended use and flushing unused taps in buildings on a weekly basis.
- water management plans (WMP) can be implemented by authorities who are responsible for the building's safety or water system safety. These plans must be specific to the building or water system, and should result in the introduction and regular monitoring of control measures against identified risks, including Legionella.

Applying such controls will greatly reduce the risk of Legionella contamination and prevent the occurrence of sporadic cases and outbreaks. Extra precautions may be required for water and ice provided to highly susceptible patients in hospitals including those at risk of aspiration (for example, ice machines can be a source of Legionella and should not be used in buildings with highly susceptible patients). Control and prevention measures must be accompanied by proper vigilance on the part of general practitioners and community health services for the detection of cases. [2]

SGS TESTING SERVICES

Accurate identification of Legionella is important, because timely and appropriate therapy is the key to improving patient outcomes. Proactively managing the risk of Legionella bacteria in cooling towers and water systems is more cost effective than responding to an outbreak retroactively.

SGS environmental services performs a variety of chemical and microbiological testing, including testing for Legionella spp. in a range of water sources.

LEGIONELLA DETECTION BY CULTURE METHOD

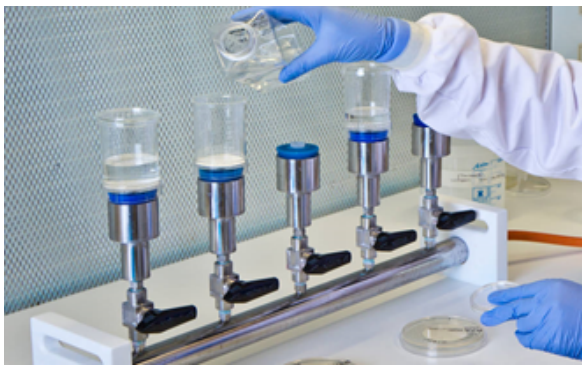
The Legionella culture method by ISO 11731 is the traditional approach for detecting and enumerating the Legionella colonies on BCGYE agar. The culture method takes ten to twelve days to complete, which is a loss of valuable time.

LEGIONELLA DETECTION BY RT-PCR METHOD

The polymerase chain reaction (PCR) is a molecular technique that provides an extremely powerful screening tool for the rapid detection of Legionella in environmental samples, within few hours. The protocol starts with DNA extraction from water sample followed by RT-PCR assay run. Although it doesn't distinguish between living and dead cells, moderate to high populations of Legionella detected by RT-PCR are usually indicative of an existing or potential problem in the future. Since the method does not determine viability of the Legionella bacteria, the RT-PCR screen must be considered as presumptive and requires further confirmation via conventional culture techniques

The 'gold standard' for Legionella specific testing is done using a culture method. However, due to the long incubation period (7-14 days), recent research has focused on using molecular techniques, such as quantitative polymerase chain reaction (qPCR), to provide faster and more accurate results.

S.NO.	PARAMETERS	METHOD	TURN AROUND TIME	SAMPLE QUANTITY
1	Legionella spp.	RT-PCR	24 - 48 hrs	1 L
		ISO 11731	10 - 12 days	1 L



SGS EXTENDED SERVICES

Incidents of Legionnaire's disease has steadily risen over the years. To help reduce this trend, in 2015 the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) developed a standard which provides guidance on minimum Legionella risk management requirements .

Monitoring requirements consist of routine microbial monitoring and general microbial monitoring (ie. 2nd Generation ATP, heterotrophic plate counts (HPC), dip slides) for risk identification and quarterly Legionella specific testing.
To help our customers for the early detection of legionella in water system SGS India provides onfield testing by using Luminultra's 2nd Generation ATP. LuminUltra's 2nd Generation ATP can provide a 'canary in a coal mine' when it comes to Legionella monitoring, a true leading indicator of potential Legionella issues.
ATP is a molecule that is present in all living cells, so its concentration in a sample can provide a direct indication of its total microbial content.

The advantages are:

- ATP provides a measurement in minutes this allows for a much faster response time if a microbial risk is identified. Since corrective actions can be taken days earlier, the cost of remediation may be reduced as the microbes will not be allowed to further proliferate while waiting for test results.
- ATP quantifies all living organisms while HPC only quantifies heterotrophic bacteria. Quantifying all organisms gives a better indication of microbial risk.
- ATP can be done on site with a portable kit while HPC must be done in a laboratory.
- LuminUltra's 2nd Generation ATP testing is used to evaluate the efficacy of several biocide treatment approaches. All ATP measurements are performed within two hours of sampling. Controls are also included to verify that measurements are not affected by residual biocide or other sample components. In this particular case, testing is completed using the QGA test kit, which specifically measures cellular ATP (cATP), which is contained only within living cells.

Through routine monitoring of critical locations, operators are able to rapidly detect microbiological growth and implement preventive actions, thereby preventing conditions that could require the cooling towers and production process to be shut down. [5]

SGS EXTENDED SERVICES

TABLE 1:Through routine monitoring of critical locations, operators are able to rapidly detect microbiological growth and implement preventive actions, thereby preventing conditions that could require the cooling towers and production process to be shut down. [5]

REGULATORY AUTHORITY	TEST FREQUENCY	LEGIONELLA CONCENTRATION (CFU/mL)	REMEDIATION
NYC	No Data	No Data	No Data
NYS	Every 90 days first year, annually thereafter	<30% positive results of sites tested >30% positive results of sites tested	Mention WMP Immediate short term control levels Retest, Persistent >30% result-institute long term control level.
AIHA	2x/year	1-9 10-100 >100	Continue monitoring and review WMP ID Infection source and online disinfection ID Infection source and online disinfection
OSHA	Not stated	10-99 >100	Online disinfection Online disinfection
PW & GSC Canada	2x/year	1-100 LP sg 2-15 1-10 LP sg 1 >100 LP sg 2-15 >10 LP sg 1	Online disinfection within 48 hrs Online disinfection within 48 hrs Online disinfection within 48 hrs Online disinfection within 48 hrs
HSE UK	Start Monthly and adjust as per test results.	>0.1, <0.1, <50% positivity >0.1, <0.1, <50% positivity >1.0	Review WMP Review WMP and consider disinfection Review WMP and consider disinfection
MSS France	No data	>1.0 >0.1 >0.025	Action required in non health care facilities Action required in health care facilities Action required in health care facilities with severly immunocompromised patients
DVGW Germany	No data	1	No Data
VROM Holland	No data	0.1	No Data
Australia & NewZealand	No data	No Data	No Data

NYS: Protection Against Legionella (2016)
AIHA:American Industrial Hygiene Association. Recognition and control of Legionella in Building Water System (2015)
OSHA:Occupational Safety and Health Administration,Technical Manual,Legionnaires' disease,Section-III, Chapter-7
PW & GSC Canada: Public Work and Government Services Canada. Control of Legionella in Mechanical System, Mechanical Design 15161 (2013)
HSE UK: Health & Safety Executive UK.Legionnaires' disease. Control of Legionella bacteria in Water Systems, Approved code of practice and Guidance (2009)
MSS France: Ministere de la Sante et des Solidarites (2005)
DVGW Germany: Deutscher Verein Gas und Wasserfatches, W551,2004
VROM Holland: The Netherlands Ministry of Housing, Modelbeheersplan Legionellapreentire in Liedingwater Distribution No. 16827 (2002)

SGS EXTENDED SERVICES

TABLE 2: Legionella Control Programs: Cooling Towers and Evaporative Condensers[6]

REGULATORY AUTHORITY	TEST FREQUENCY	LEGIONELLA CONCENTRATION (CFU/mL)	REMEDIATION
NYC	All system start up and evry 90 days thereafter.	<10	Maintain water chemistry and biocide levels.
		≥10 -<100	Online disinfection within 24 hours. Retest.
		≥100 -<1000	Online disinfection within 24 hours. Retest. Review WMP.
		≥1000	Online disinfection within 24 hours.
			Offline disinfection within 48 hours. Retest.
			Notify DOH within 24 hours of results.
NYS	All system start up and evry 90 days thereafter.	<20	Maintain water chemistry and biocide levels.
		≥ 20 -<1000	Online disinfection immediately. Retest. Review WMP.
		≥1000	Online disinfection immediately. Retest. Review WMP. Any retest >1000 offline disinfection immediately.
AIHA	Monthly	10 - 99	Review WMP and retest until <10 CFU/ml.
		100 - 1000	Review WMP and conduct an online disinfection until consistently <10 CFU/mL.
		≥1000	Review WMP and conduct an online disinfection until consistently <10 CFU/mL.
OSHA	Not Stated	100 - 999	Online disinfection.
		>1000	Offline disinfection.
PW & GSC Canada	Every 2 Months	1000- 10,000 non-Lp	Online disinfection within 48 hrs.
		1-100 Lp sg 2-15	Online disinfection within 48 hrs.
		1-10 Lp sg 1	Online disinfection within 48 hrs.
		>1000 non-Lp	Offline disinfection immediately.
		>100 Lp sg 2-15	Offline disinfection immediately.
		>10 Lp sg 1	Offline disinfection immediately.
HSE UK	Quaterly	0.1-1.0	Review WMP and resample.
		≥1.0	Review WMP, resample and disinfect.
MSS France	No data	No data	No data
DVGW Germany	No data	No data	No data
Holland	No data	No data	No data
AS/NZS 366.3 Australia & NewZealand	Quaterly	10-99	Online disinfection and add biodispersant.Retest 3-7 days.
		10 -1000	Online disinfection and add biocide. Retest 3-7 days.
		>1000	Offline disinfection and add biocide. Retest 3-7 days.

NYC: Chapter 8 (Cooling Towers) of Title 24 of the rules of the city of NewYork (2015)
NYS: Protection Against Legionella (2016)
AIHA: American Industrial Hygiene Association. Recognition and control of Legionella in Building Water System (2015)
OSHA: Occupational Safety and Health Administration,Technical Manual,Legionnaires' disease,Section-III, Chapter-7
PW & GSC Canada: Public Work and Government Services Canada. Control of Legionella in Mechanical System, Mechanical Design 15161 (2013)
HSE UK: Health & Safety Executive UK.Legionnaires' disease. Control of Legionella bacteria in Water Systems,Approved code of practice and Guidance (2009)
AS/NZS 366.3 Australia and New Zealand AS/NZS 366.3 Code of practice, Prevention and control of Legionnaires' Disease (2010)

SAMPLE COLLECTION

Depending on the reason for sampling, the sample may be taken as a first flush (i.e. no disinfection). This is appropriate for most occasions and will represent the worst case. After disinfection, the sample will be taken from a running outlet representing the circulating system.

For surviving, Legionella require moist environments. Sampling for Legionella spp. typically involves collecting water samples from potential sources. Collection sites range from taps and faucets to water storage reservoirs. It is important not to flush water outlets before taking a sample for Legionella analysis because the end section of the water system may be a contaminated site.

Common locations where Legionella can be found are cooling towers, evaporative condensers, fluid coolers that use evaporation to dissipate heat and, domestic hot water systems with water heaters that operate below 60°C (140°F) and deliver water to taps below 50°C (122°F). In case of investigations, for potable water collect 250 ml of water for routine monitoring and if possible larger volumes or several samples for isolate recovery.[3]

TRANSPORTATION

Samples must be shipped to the testing laboratory within 24 hours from sampling. Shipping temperatures should be kept between 2°C - 18°C. During hot weather it is recommended to add cold packs or ice in a cooler containing the sample containers.

All samples should be transported to the laboratory in dark, insulated containers to protect them from extreme temperatures and from light.[3]

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FAST FACTS

- Legionella can cause Legionnaires' disease, Pontiac fever, and, more rarely, extrapulmonary infections, collectively known as legionellosis.
- Scientists named the bacterium after an outbreak in Philadelphia in 1976. During that outbreak, many people who went to an American Legion convention got sick with pneumonia (lung infection).
- Health departments reported nearly 10,000 cases of Legionnaires' disease in the United States in 2018. However, because Legionnaires' disease is likely underdiagnosed, this number may underestimate the true incidence.
- About one in 10 people who gets sick from Legionnaires' disease will die.
- People can get Legionnaires' disease or Pontiac fever when they breathe in small
- droplets of water in the air that contains Legionella, this is known as aerosol.
- In general, people do not spread Legionnaires' disease to other people. However, this may be possible under rare circumstances.
- Legionella occurs naturally in fresh water environments, like lakes and streams. It can become a health concern when it grows and spreads in human-made building water systems.
- Regular monitoring of water for Legionella in various water systems is key to preventing infection.[1,2,3]

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