



***Legionella* Control in Cooling Towers, Evaporative Condensers, and Indirect Evaporative Coolers**

TECHNICAL INFORMATION PAPER No. 55-066-0617

PURPOSE. The steady increase of cases of Legionellosis (diseases caused by *Legionella* bacteria) demonstrates the need for proactive *Legionella* control programs for building water systems. Cooling towers and similar devices have often been the source of serious outbreaks, including ones located on Army installations. This TIP provides *guidance* for installations and building managers for minimizing the risk of legionellosis outbreaks by controlling *Legionella* bacteria in spray-type cooling units and their water circulation systems used in large building air conditioning systems. This TIP supplements the guidance provided in reference a.

BACKGROUND.

a. *Legionella* bacteria are the cause of Legionnaire's disease and Pontiac fever, diseases that are collectively known as legionellosis. *Legionella* is widespread in the environment and is commonly found at low levels in water, including rivers, streams, lakes, and treated municipal water; it is also widespread in building water systems that support air conditioning. There is currently no defined infectious level for ingestion, and *Legionella* is not considered to be a significant health hazard at low levels in water. However, the risk increases when the bacteria are allowed to grow and multiply ("amplification") and the contaminated water is then released in a respirable mist that is inhaled by a susceptible person. See the APHC Fact Sheet "Legionella Bacteria" (reference b) for more information.

b. Legionellosis is an increasing concern in the United States because the number of diagnosed cases continues to rise, and many cases are believed to remain undiagnosed. To counter this trend, state regulations for managing *Legionella* risks are likely to continue to become more and more stringent. For example, New York has recently mandated that all cooling towers and evaporative condensers be registered with the state, inspected, sampled for *Legionella*, cleaned and decontaminated if necessary, and certified. The operators must then develop and implement a management program for each unit that is designed to prevent the growth of *Legionella*.

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c. Conditions favoring the amplification of *Legionella* are—

- Water temperatures between 68° Fahrenheit (F) and 113° F.
- The presence of sediment, scale, rust, or biofilms (thin slimy films of microorganisms that adhere to surfaces) that can harbor *Legionella*.
- Stagnant or seldom changed water.
- Low residual levels of biocides, such as chlorine at below 0.5 parts per million (ppm).
- Level of acidity in the water (pH) between 6.5 and 8.5.

d. Cooling towers, evaporative condensers, and indirect evaporative air-cooling equipment are common elements of large building air conditioning systems. They all rely on the cooling effect of the evaporation of sprayed water to remove heat from process water used to cool buildings or to cool air directly.

- Open-circuit cooling towers evaporate a small fraction of the process water to cool the remainder.
- Closed-circuit cooling towers (fluid coolers) spray water on coils through which the process water (or water/glycol mixture) is circulated.
- Evaporative condensers spray water on coils through which a refrigerant is circulated in order to condense it.
- Indirect evaporative coolers spray water on air ducts to cool the air.

e. Water sprays can generate “drift” or respirable mists that can travel considerable distances. Units should have drift eliminators, which are baffle systems designed to trap most respirable water droplets. Many designs use a fill packing to improve cooling performance by increasing contact surface area and time.

[Note: Other building water systems can provide reservoirs for *Legionella* amplification. Some of the referenced documents describe them and provide instructions on how to identify and manage them. Army medical treatment facilities are required to have a program to minimize risks from pathogens in order to maintain accreditation by The Joint Commission. The APHC Industrial Hygiene Program Management Division provides model Utility System Management Plans in Environment of Care Management Plans at: <http://phc.amedd.army.mil/topics/workplacehealth/ms/Pages/BestPracticesToolkit.aspx>.]

LEGIONELLA CONTROL PROGRAM FOR COOLING TOWERS, EVAPORATIVE CONDENSERS, AND INDIRECT EVAPORATIVE COOLERS.

a. General. Many elements of a *Legionella* control program (LCP) are good routine operating and maintenance (O&M) procedures that are likely to already be included in standing operating procedures (SOPs). For example, eliminating sediment, scale, and

biofilms and repairing broken or faulty components will maintain the maximum cooling performance of the units as well as helping to control *Legionella*. The APHC recommends that building managers build upon this program as part of an overall Water Management Program to control *Legionella* in installation buildings.

b. Policy and Guidance Documents. The Department of the Army (DA) mandates compliance with Occupational Safety and Health Administration (OSHA) standards and consensus standards such as those developed by the American National Standard Institute (ANSI®) and the American Society of Heating, Air-conditioning, and Refrigeration Engineers (ASHRAE®). The ANSI/ASHRAE Standard 188-2015 (reference c) describes program requirements for *Legionella* control in building water systems and is considered by the Centers for Disease Control and Prevention (CDC) to be the current industry standard. The CDC Practical Guide (reference d) is based on the standard. The OSHA Technical Guide (reference e) provides a required protocol for cleaning and disinfection after a legionellosis outbreak. Other useful references (f through j) are listed above.

c. Steps in developing and implementing the LCP.

1. Establish a team that may include—

- Building owners and managers.
- Maintenance personnel.
- Industrial hygienist.
- Environmental health specialist.
- Safety officer.
- Local U.S. Army Corps of Engineers office.
- Equipment and chemical suppliers.
- Water treatment consultants.
- Laboratory.
- State and local health officials.

2. Gather information—

- Obtain applicable state and local regulations.
- Collect reference documents.
- Develop an inventory of all cooling towers and evaporative coolers, including manufacturer, model number, and serial number.
- Develop a verbal description and flow diagram for each circulating water system.

- Examine the circulating water system for deadlegs (sections of pipe where water is stagnant or seldom flushed out), and determine whether there are provisions to flush them.
- Ensure that all manufacturers' O&M manuals are available, are reviewed, and recommendations are incorporated into SOPs.
- Review the results of previous inspections and measurements.
- Evaluate the potential for mists from units to be entrained in the air entering buildings. Record distances from the unit to building openings and ventilation intakes.
- Identify new and unusual conditions that may create a *Legionella* hazard, such as construction activities and water main breaks.

3. Review and update O&M SOPs as needed to incorporate routine control measures, determine control points where the systems are to be monitored, determine acceptable control limits, and establish monitoring schedules that include—

- Visual inspections.
- Routine biological sampling as described below.
- Routine testing for pH and biocide residuals with appropriate test kits.
- Chemical additives: biocide, biodispersant, pH control, antifoaming agent, anti-rusting agent.
- Shutdown, annual cleaning, and startup procedures.

4. Develop and implement a health and safety plan for performing routine inspections and O&M—

- Identify and include, as appropriate, requirements for personal protective equipment such as hard hats and safety boots, hearing protection, splash and dermal protection against chemical additives, confined spaces, and lock out/tag out.

5. Develop a contingency response plan including—

- Procedures to be followed if control limits are out of the acceptable range.
- Procedures to be followed if there are known or suspected cases of legionellosis associated with any unit.
- Directions issued by national, regional, and local health authorities.
- Procedures for testing for *Legionella* in the event of known or suspected cases.
- Procedures for emergency disinfection.

6. Develop a plan for review of new or replacement equipment siting that addresses the following items—

- Accessibility requirements for O&M and inspections according to manufacturer's guidelines.
- Potential for air to discharge into occupied spaces, trafficable areas, pedestrian thoroughfares, outside air intakes, or other building openings.
- Potential for contamination from building systems to be drawn into the equipment.

7. Recordkeeping—

- Maintain written documentation of all aspects of the program.
- Enter sampling results in Defense Occupational and Environmental Health Readiness System [DOEHRS].

PROCEDURES FOR THE LCP. See Appendix.

BIOLOGICAL SAMPLING METHODS.

a. Dipslide Testing. Dipslide testing is used to routinely evaluate the total levels of living microorganisms in cooling water systems. A slide with a nutrient coating is dipped into a sample of the water and then incubated. The number of colony forming units per milliliter (CFU/mL) is counted and may be used as a basis for remedial actions if needed. While dipslide testing can provide a general impression of whether conditions in the water system favor the amplification of *Legionella*, it cannot confirm its presence or absence.

b. Methods for Identification of *Legionella*.

(1) The standard sampling and analytical method for *Legionella* is culturing on agar plates according to International Organization for Standards (ISO) 11731:1998 (reference k). Culturing may develop other microorganisms that obscure the identification of *Legionella*, and some *Legionella* cells may develop into a viable form that cannot be cultured. Confirmation methods for its presence in cultures may produce a high rate of false negatives. Culturing is still considered the “gold standard” for *Legionella* detection, however.

(2) An alternative method is quantitative polymerase chain reaction (qPCR). The qPCR, which is based on the amplification of a specific DNA sequence from the bacterium, is quicker and more sensitive than culturing. The qPCR can distinguish among different strains of the bacteria, which may be useful in identifying the source of a

disease outbreak. Potential drawbacks include some of the DNA that is amplified may come from dead cells, and other material in the sample may inhibit DNA amplification.

c. **Sample Collection and Analysis.** Collect and submit water samples as recommended by CDC (reference I) and the laboratory performing the analysis, including the recommended number of field blanks. To ensure reliable results, the laboratory should be a member of the CDC Environmental *Legionella* Isolation Techniques Evaluation (ELITE) Program. Members are listed at:

<https://wwwn.cdc.gov/elite/Public/MemberList.aspx>.

d. **Interpreting Results.** Sample test results only provides a snapshot of the presence of microorganisms or *Legionella* at one location, at one point in time. They do not represent the potential for disease and should not be used to predict the rate of growth in either well-maintained or neglected water systems. Sampling and testing are, therefore, not a substitute for proper *Legionella* control procedures. However, sampling results do provide a basis for confirming low levels and adequate control measures on one hand, and determining the need for response measures for unacceptable levels, and indicate whether or not bacterial growth is getting out of control.

CONTROL LIMITS FOR *LEGIONELLA* AND RESPONSES.

For the circulating water systems discussed in this TIP, results of *Legionella* testing should be interpreted as follows:

< 10 CFU/mL – **GREEN** - No significant presence of *Legionella*

- Continue with routine inspections and O&M.

10-99 CFU/mL – **AMBER** - Acceptable but elevated levels of *Legionella*

- Verify water treatment operation and parameters and increase biocide levels.
- Review cleaning and chemical additive program to determine if changes are needed.
- Retest until levels are GREEN.

100-1,000 CFU/mL – **RED 2** – Possible amplification

- Perform routine cleaning and disinfection within 30 days.
- Review cleaning and chemical additive program to determine if changes are needed.
- Remediate any identified potential site of amplification.
- Repeat and re-test until levels are GREEN.

>1,000 CFU/mL – **RED 1** –Confirmed amplification

- If no associated case of *Legionella* is suspected, perform routine cleaning and disinfection within 7 days.
- If an associated case is suspected, follow the emergency decontamination procedure described above.
- Review cleaning and scale control program to determine if changes are needed.
- Remediate any identified potential site of amplification.
- Repeat and retest until levels are GREEN.

REFERENCES.

a. U.S. Army Corps of Engineers. Engineer Manual (EM) 200-1-13, Environmental Quality: Minimizing the Risk of Legionellosis Associated with Building Water Systems on Army Installations, 30 Sep 16.

http://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_200-1-13.pdf?ver=2016-09-23-140847-227

b. APHC. Fact Sheet 13-019-0814, “Legionella Bacteria.”

http://phc.amedd.army.mil/PHC%20Resource%20Library/Legionella_Bacteria_FS_13-019-0814.pdf

c. ASHRAE. Standard 188-2015, Legionellosis: Risk Management for Building Water Systems.

http://www.techstreet.com/ashrae/standards/ashrae-188-2015?product_id=1897561

d. CDC. 2016. Developing a Water Management Program to Reduce *Legionella* Growth and Spread in Buildings: A Practical Guide to Implementing Industry Standards.

<http://www.cdc.gov/legionella/downloads/toolkit.pdf>

e. OSHA. OSHA Technical Manual, Appendix III: 7-5. Water Treatment Protocols for Facilities That Have Experienced a Legionnaires' Outbreak.

https://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_7.html#app_iii:7_5

f. Public Works and Government Services Canada. MD 15161-2013, Control of Legionella in Mechanical Systems.

<http://www.tpsgc-pwgsc.gc.ca/biens-property/documents/legionella-eng.pdf>

g. ASHRAE Guideline 12-2000, Minimizing the Risk of Legionellosis Associated With Building Water Systems.

http://www.techstreet.com/ashrae/standards/guideline-12-2000-minimizing-the-risk-of-legionellosis-associated-with-building-water-systems?product_id=232891

Errata sheet is available free online:

http://www.techstreet.com/ashrae/standards/ashrae-guideline-12-2000-errata-english-version?product_id=1759026

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<http://www.cti.org/downloads/WTP-148.pdf>

i. ASTM International. ASTM D5952-08(2015), Standard Guide for the Inspection of Water Systems for Legionella and the Investigation of Possible Outbreaks of Legionellosis (Legionnaires' Disease or Pontiac Fever).

<http://www.astm.org/Standards/D5952.htm>

j. Kerbel, W. et al. (Eds). 2015. Recognition, Evaluation, and Control of Legionella in Building Water Systems. AIHA, Fairfax, VA.

<https://www.aiha.org/marketplace/Pages/Product-Detail.aspx?productid={C15EB533-DFF4-E411-A28B-005056B20848}>

k. ISO. ISO 11731:1998, Water quality – Detection and Enumeration of *Legionella*.

http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=19653

l. CDC. 2005. Procedures for Recovery of Legionella from the Environment.

<http://www.cdc.gov/legionella/health-depts/inv-tools-cluster/lab-inv-tools/procedures-manual.pdf>

FOR MORE INFORMATION.

For more information, or for questions and comments on this TIP, please contact the Industrial Hygiene Field Services Division at (410) 436-3118, DSN 584-3118.

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APPENDIX. PROCEDURES FOR THE LCP

a. Inspections and monitoring.

1. Exterior inspection (weekly if feasible, but at least monthly, with unit running):

- Inspect the exterior of the unit for cleanliness and deterioration.
- Look for sediment, scale, biofilm, corrosion, and water leaks.
- Look for pools of water and small droplets emerging from the unit that may indicate excessive drift.
- Inspect the water treatment system for proper operation and adequate supply of chemicals.
- Collect a water sample monthly for dip testing.

2. Full inspection (quarterly, with power off):

- Inspect both the exterior and interior of the unit.
- Look for missing, misaligned, clogged, or broken spray nozzles.
- Examine the louvers and drift eliminators for damage, fouling, and improper positioning.
- Inspect the fill material for deterioration and fouling.
- Inspect water basins for damage.
- Measure pH and biocide residuals.
- Sample the reservoir for *Legionella*.

3. Annual inspection:

- Clean and repair units as needed. Replace deteriorated or missing components. Replace deadlegs with circulating lines or install provisions to allow frequent flushing.

b. Shutdown and Startup Procedure.

- Drain any system that is to be shut down for more than 3 days, or plan to pretreat water with biocide before restarting it.
- Before startup, perform routine cleaning and disinfection.

c. Routine Cleaning and Disinfection Procedure.

- Use additives such as detergent and non-foaming agents.

- Circulate water through the system for at least 1 hour.
- Switch off equipment, and drain the system.
- Thoroughly clean the internal shell, fill material, and sump to remove all debris.
- Refill with clean water.
- Dose with biocide, and circulate water for at least 1 hour.
- Clean strainers, water nozzles, and fittings.
- Clean or replace filters.
- Drain and refill with water and treat with biocides.

d. Emergency Response Procedure for Suspected Associated *Legionella* Cases (reference e). [NOTE: The instructions below are based on the use of a halogenated biocide. If another type of biocide is used, follow the manufacturer's recommendations.]

- Notify health officials.
- Collect at least three water samples for *Legionella* identification as recommended below, including samples from the incoming makeup water supply, water from the basin of the unit most distant from the makeup point, and recirculated water at its point of return to the unit.
- Close building air intakes in the vicinity until cleaning is completed and verified.
- Remove heat loads from the cooling system to the extent possible.
- Shut off fans associated with the cooling equipment.
- Shut off the system blowdown; keep makeup valves open.
- Continue to operate recirculating water pumps.
- Add sufficient biocide to reach a level of 50-ppm free residual halogen.
- Add an appropriate biodispersant (and antifoaming agent if needed),
- Maintain at least 10-ppm free residual halogen for 24 hours, testing and adding more biocide as needed.
- Monitor the system pH, and treat to achieve a pH of less than 8.0 (chlorine biocides) or 8.5 (bromine biocides).
- Drain the system to a sanitary sewer, dehalogenating the water if required by a discharge permit.
- Refill the system, and repeat the steps above, starting with the addition of biocide.
- Inspect the system, and repeat if a biofilm is present.
- Mechanically clean the unit while wearing eye protection and a half-face respirator with high-efficiency particulate air [HEPA] filters.
- Refill and add biocide to achieve a 10-ppm free halogen residual, hold for 1 hour, and drain system until the discharged water is free of turbidity.
- Refill and recharge the system to reestablish normal biocide residuals; put unit back into service.
- Resample as above for *Legionella*, weekly for the first month, every 2 weeks for the next 2 months, and monthly for the next 3 months.