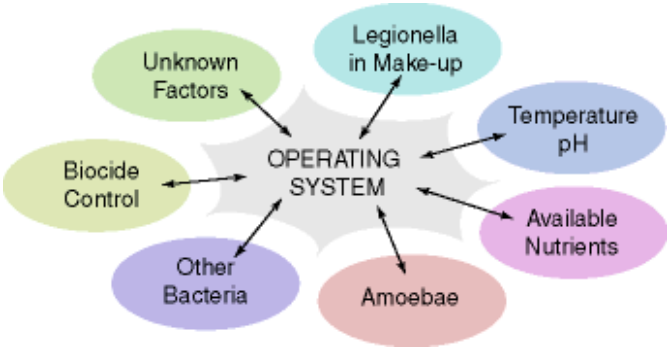
Legionnaires' Disease

Section II: What water systems in workplaces are potential sources of Legionnaires' disease bacteria (LDB)?

The primary sources of exposure to contaminated water in commercial and industrial facilities are water-cooled, heat transfer systems such as cooling towers or fluid coolers, and warm water sources such as domestic hot-water systems.



Operating Systems: Use the following modules to review maintenance, sampling protocol, treatment, and design considerations of each operating system.

- Section II:A. Cooling Towers, Evaporative Condensers, and Fluid Coolers
- Section II:B. Humidifiers and Misters
- Section II:C. Domestic Water Systems
- Section II:D. HVAC Systems
- Section II:E. Water Sampling Guidelines: This module provides sampling guidelines, sampling protocols, sample transportation, and monitoring and analysis procedures that *apply to all operating systems*.

Health Care Facilities and LDB:

- **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."

- **The American Society for Healthcare Engineering (ASHE)** recommends that health care facilities conduct a risk assessment of potential sources of LDB and develop a management plan for maintenance and operation of water systems.

Legionnaires' disease Bacteria LDB) Colonization Frequencies:

In studies conducted by Hodgson and Casey in 1998, several thousand samples collected from a variety of sources showed:

Cooling Towers	**6.3%**
Potable Water Distribution Systems	**12.0%**
Hot Water Heaters	**7.0%**

More Information...

Legionnaires' Disease

Disease Recognition | Potential Disease Sources | Investigation Protocol | Outbreak Response | Facts and FAQs

Section II:A. Cooling Towers, Evaporative Condensers, and Fluid Coolers

Cooling towers, evaporative condensers, and fluid coolers use a fan to move air through a recirculated water system. This allows a considerable amount of water vapor and sometimes droplets to be introduced into the surroundings, despite the presence of drift eliminators designed to limit droplet release. This water may be in the ideal temperature range for Legionnaires' disease bacteria (LDB) growth, 20°-50°C (68°-122°F). Good maintenance is necessary, both to control LDB growth and for effective operation.

Control Strategy:

How do these systems operate?

^TOP

Cooling towers, evaporative condensers, and fluid coolers reject heat from system fluids through evaporation.

- **Cooling towers** remove heat from condenser water via direct-contact evaporation in a cool air stream. This cooled water circulates through the condenser side of a mechanical refrigeration unit to absorb heat.
- **Evaporative condensers** operate similarly to cooling towers, except that the refrigerant condenser coils are inside the wet air stream and water passing over the coils directly cools the refrigerant.
- **Fluid coolers** reject heat from industrial processes, for example, computer-room air conditioners, etc. Like evaporative condensers, fluid coolers have heat-exchanger coils directly in the wet air stream.

Fig. 1: Condenser water pipes used in a cooling tower for heat reduction

What to consider in the system design

^TOP

Important design features include easy access or easily disassembled components to allow cleaning of internal parts including the packing (fill). The following features should be considered in the system design:

- Enclosure of the system will prevent drift of water vapor.
- Design features that minimize the spray generated by these systems are desirable.
- System design should recognize the value of operating with low sump-water temperatures.
- Each sump should be equipped with a "bleed," and make-up water should be supplied to reduce the concentration of dissolved solids.
- **High-efficiency drift eliminators are essential for all cooling towers**
    - Older systems can usually be retrofitted with high-efficiency models.
    - A well-designed and well-fitted drift eliminator can greatly reduce water loss and potential for exposure.

How to maintain these systems

^TOP

The system should be properly monitored and maintained according to manufacturers' recommendations to prevent buildup of scale, sediment, and bio-fouling. Visual inspection and periodic maintenance of the system are the best ways to control growth of LDB and related organisms. Measurements of water quality such as total bacterial counts, total dissolved solids, and pH have not proven to be good indicators of LDB levels in cooling towers.

Biocides:

- Add chemical biocides to control LDB growth. Obtain information on appropriate biocide selection and use from equipment manufacturers or from companies experienced with the particular system used.
- High concentrations of organic matter and dissolved solids in the water will reduce the effectiveness of any biocidal agent.
- Additional information (App II:A-1) on biocides is also available.

Temperature:

- Maintain sump water at a low temperature (20°C, 68°F) to control LDB growth.
- Sump-water temperatures depend on tower design, heat load, flow rate, and ambient dry-bulb and wet-bulb temperatures.
- Under ideal conditions, sump-water temperatures in evaporative devices approach the ambient wet-bulb temperature, and may be low enough to limit LDB amplification.

fig. 2: Remote cooling tower sump

Frequency of cleaning:

- Clean and disinfect cooling towers quarterly or at least twice a year if the unit is not used year round. Do this before initial start-up at the beginning of the cooling season and after shut-down in the fall.
- Systems with heavy bio-fouling or high levels (>100 colony forming units per milliliter, CFU/mL) of LDB may require additional cleaning. Also see Section II:E. Water Sampling Guidelines.
- Any system that has been out of service for an extended period should be cleaned and disinfected.
- New systems require cleaning and disinfecting because construction material residue can contribute to LDB growth.

Acceptable cleaning procedures are outlined as follows:

Fig. 3: Clean and disinfect per system schedule

- Inspect equipment monthly.
- Drain and clean quarterly or at least twice a year if the unit is not used year round.
- Treat circulating water for control of microorganisms, scale, and corrosion. This should include systematic use of biocides and rust inhibitors, preferably supplied by continuous feed.
- Monthly microbiologic analysis is needed to ensure control of biological contamination.

Recordkeeping:

- Document operations and maintenance in a log book. Log books should list dates of inspections and cleanings, water-quality test results, LDB outbreak investigations, and maintenance.
- Maintain an up-to-date description of the operating system (which includes all components cooled by the system) and details of the make-up water to the system.
- Written procedures for proper operation and maintenance of the system should indicate the use of scale and corrosion inhibitors and antifoaming agents. Written records of biocide or chlorine use should be readily available.

How often to test these systems for LDB following identification of contamination

^TOP

Outbreak Protocol:

After a contaminated system has been treated, sampling can be used to verify the effectiveness of the treatment. Subsequent testing of cooling-system water at the following intervals can verify that there is no significant re-growth of LDB:

1. Test weekly for the first month after return to operation.
2. Test every two weeks for the next two months.
3. Test monthly for the next three months.

How to collect water samples

^TOP

Water Sampling Protocol: Sampling information specific to cooling towers, evaporative condensers, and fluid coolers is provided below. For more information about water sampling, please refer to Section II:E. Water Sampling Guidelines.

Fig. 4: Taking a water sample from a storage tank

- Collect water samples before starting decontamination and at other times identified above.
- Sample the incoming (make-up) water supply to the cooling tower, evaporative condenser, or fluid cooler.
- Sample any storage tanks or reservoirs in the system such as chilled-water return tanks or header tanks.

- Sample the basin or sump of the cooling tower at a location distant from the incoming make-up water.
- Sample the water returning from the circulation system at the point of entry to the tower.
- If a biocide is used, follow the manufacturer's instructions for proper neutralization.

Interpretations Guidelines:

- The OSHA suggested guideline for LDB concentration in cooling towers, evaporative condensers, and fluid coolers is less than 10 CFU per milliliter.
    - If LDB concentrations are below 10 CFU per milliliter and no LDB were detected in swab or other samples, no further monitoring for LDB is necessary. Continue the maintenance program as long as the system is in use.
    - If water concentrations exceed 10 CFU per milliliter or LDB were detected in other samples, take steps to identify the source of contamination or amplification and treat the system. See How to treat a contaminated water system.
        - Sample the water system monthly until the source of contamination is identified and adequately treated. Once LDB concentrations remain below 10 CFU for a three-month period, sampling may be stopped.

How to treat a contaminated water system

^TOP

Please note: Collect water samples before starting decontamination and after completion.

1. Clean and disinfect the entire cooling system, including attached chillers and/or storage tanks (sumps) as follows:
    - Shut off the cooling tower fans.
    - Keep makeup water valves open and the circulation pumps operating.
    - Close outdoor air intake vents located within 30 meters of the cooling tower.
    - "Shock" treat cooling tower water at 50 mg/L free residual chlorine.
    - Add dispersant.
    - Maintain 10 mg/L chlorine for 24 hours.
    - Drain system.
    - Refill and repeat the previous four steps once.
    - Inspect system for visual evidence of bio-film. If found, repeat the first four steps again.
    - Perform mechanical cleaning (cooling tower design may require modified procedures).
    - Refill system, bring chlorine to 10 mg/L, and circulate for one hour.
    - Flush system.
    - Refill with clean water in accordance with an effective water treatment program; the unit is now ready to be returned to service.
2. Identify and eliminate all water leaks into the cooling water system
3. Sample the cooling water for analysis of CFU of *L. pneumophila*
    - The unit may be put into service provided the medical monitoring program has been implemented.
    - If sample culture results indicate detectable levels of *L. pneumophila,* repeat chlorination and resample the water.

Addition information:

- CDC Procedure for Cleaning Cooling Towers and Related Equipment
- Legionella 2003: An Update and Statement by the Association of Water Technologies (AWT).

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Section II:B. Humidifiers and Misters

Many HVAC systems supply humidified air to building occupants to maintain comfort. Improperly maintained humidifiers can be both amplifiers and disseminators of a variety of bioaerosols. However, the cool temperatures in HVAC systems generally are not conducive to growth of Legionnaires' disease bacteria (LDB).

Control Strategy:

- How do these systems operate?
- How to maintain humidifiers and misters
- How to test humidifiers and misters for LDB following identification of contamination
- How to collect water samples
- How to treat a contaminated water system

How do these systems operate?

^TOP

- **Atomizing humidifiers** use mechanical devices or pneumatic air to create a water mist that evaporates into the air stream. A contaminate-free water source is essential.
- **Heated pan humidifiers** use a heat source to evaporate water from a pan open to the air stream but do not create water mists. Intermittent use of the device coupled with a warm pan of water may support microbial growth. Contaminate-free water is essential.
- **Direct steam-type humidifiers** inject boiler-generated steam directly into the air stream. These systems do not create water mists and normally operate above 70°C (158°F), that is a temperature at which LDB cannot survive.

How do I maintain humidifiers and misters?

^TOP

Cold-water humidifiers require rigorous maintenance to ensure that the water source does not contribute to potential problems.

- Because humidifiers discharge water vapor or droplets into HVAC air distribution systems, inspect them for standing water and treat according to the HVAC Air Distribution System protocol as follows:
  - Inspect the entire air distribution system (including return and exhaust systems) for visual evidence of water accumulation.

- Eliminate all water leaks and remove any standing water found in the system. Replace or eliminate any water-damaged insulation in the system.
- After cleaning or disinfecting humidifiers and misters, operate the HVAC system using 100 percent outside air for eight hours before returning the building to normal operation.

- An adequate maintenance program should be in effect to reduce the growth of LDB.
- Water storage temperatures should be above or below the 20° - 50°C (68° - 122°F) range, and the system must be kept clean.
- Cold-water humidifiers in HVAC systems must be connected to a potable domestic water source and provided with a drain line to remove excess water.

Note: Stand-alone, console-type humidifiers that recirculate water for humidification should not be used because the water in these systems becomes contaminated with micro-organisms rapidly. These stand-alone units have been linked to an outbreak of Legionnaires' disease in a hospital. Ideally, HVAC humidifiers should use steam injection systems that reduce potential microbial contamination.

How to test humidifiers and misters for LDB following identification of contamination

^TOP

Outbreak Protocol:

When water sampling has identified LDB contamination and the treatment protocol has been successfully completed, return the humidifier to operation and test the unit's water system to detect recontamination according to the schedule below:

1. Weekly for the first month.
2. Every two weeks for the next two months.
3. Monthly for the next three months. If no contamination is detected after three months, end the monitoring program but continue the maintenance procedures as long as the humidifier is in use.

How do I collect water samples?

^TOP

Water Sampling Protocol: Sampling information specific to humidifiers and misters is provided below. For more information about water sampling, please refer to Section II:E. Water Sampling Guidelines.

- Collect water samples before starting decontamination and at other times identified above.
- Sample the incoming water supply if the plumbing provides access.
- Sample water reservoirs.
- If a biocide is used, follow the manufacturer's instructions for proper neutralization.

Interpretation Guidelines:

- The suggested OSHA guideline for LDB in humidifier water systems is less than 1 colony forming unit per milliliter, CFU/mL.
  - If LDB concentration are below 1 CFU per milliliter and no LDB were detected in swab or other samples, no further monitoring for LDB is necessary. Continue the maintenance program as long as the system is in use.
  - If detectable concentration of culturable LDB are measured in water or other samples, take

steps to identify the source of contamination or amplification and treat the system. See How to treat a contaminated water system.

- Sample the water system monthly until the source of contamination is identified and adequately treated. Once LDB levels remain undetectable for a three-month period, sampling may be stopped.

How to treat a contaminated water system

^TOP

Where water in humidifiers has been sampled and shown to contain measurable LDB or where such water is assumed to be contaminated with LDB based on epidemiological evidence, use the following protocol:

- Disinfect water in piping or reservoirs feeding the humidifier with chlorine or other effective biocide.
- Sample the humidifier water to ensure the LDB are eliminated. See Section II:E. Water Sampling Guidelines.
- Before using the humidifier, flush the piping or reservoir thoroughly to remove biocides.

Additional information (App II:A-1) on biocides is also available.

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Section II:C. Domestic Water Systems

Domestic water systems are designed to provide cold or heated water for washing, cleaning, consumption, etc. The term "domestic" applies to all non-process water used for lavatories, showers, drinking fountains, etc., in commercial, residential, and industrial settings. These systems usually include a boiler or heater, a recirculating piping system, and pipes terminating in taps and fixtures. Operating temperatures vary depending on system design, energy conservation programs, and intended use of the water.

- Section II:C-1. Domestic Hot-Water Systems
- Section II:C-2. Domestic Cold-Water Systems
- Tepid Water Systems

OSHA Recommends that you identify all parts of domestic water systems that may contribute to the amplification of Legionnaires' disease bacteria (LDB):

- Parts Identification

Tepid Water Systems

^TOP

Warm or tepid water systems that dilute domestic hot water from a water heater with cold water upstream from the outlet are not recommended.

- Warm water left in these lines is at ideal temperatures for growth of LDB.
- Localized mixing at the source to temper very hot water is more acceptable.
- Another alternative is "instantaneous" point-of-delivery heating of water using individual steam heating systems at each outlet.

Parts Identification

^TOP

Many variables can contribute to the growth of LDB in domestic water systems. Review the following system components to reduce and eliminate LDB amplification:

- Identify all parts of the domestic water systems where water may stagnate such as "dead legs" (sections of piping or plumbing that have been altered or capped such that water cannot flow through them) or storage tanks that are not frequently used.

Fig. 1: Backflow preventer

- Remove dead legs along with unused equipment and water lines from the system.
- Eliminate or minimize the use of rubber, plastic and silicone gaskets in the plumbing system. These materials may serve as growth substrates for LDB.
- Identify and test the integrity of all backflow preventers (to assure protection of domestic water from cross-contamination with process water) through a building code-approved method.

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Section II:C-1. Domestic Hot-Water Systems

Legionnaires' disease has been associated with domestic hot-water systems in a number of outbreaks. Large water heaters like those used in hospital or industrial settings frequently contain cool zones near the base where cold water enters and scale and sediment accumulate.

Control Strategy:

- How to maintain a hot-water system
- What to consider in the system design
- How often to test hot-water systems for LDB following identification of contamination
- How to collect hot-water samples
- How to treat a contaminated hot-water system

How to maintain a hot-water system

^TOP

Properly maintaining a hot-water system includes being aware of the following.

fig.1: Recirculating pump

Conditions that promote growth:

- **Scale and sediment** supply the environment needed for growth of Legionnaires' disease bacteria (LDB) and other microorganisms.
- **Dead legs** and non-recirculated plumbing lines that allow hot water to stagnate also provide areas for growth of the organism.
- **Temperatures** maintained below 60°C (140°F) encourage growth of LDB and other microorganisms.

Temperature:

- Maintain domestic water heaters at 60°C (140°F) and water delivered at the faucet at a minimum of 50°C (122°F). Where these temperatures cannot be maintained, control LDB growth with a safe and effective alternative method. Also see What to consider in the system design.
- Proper insulation of hot-water lines and heat tracing of lines can help maintain distribution and delivery temperatures at 50°C (122°F).
- If potential for scalding exists, employ appropriate fail-safe scald-protection.

System Controls:

- Run recirculation pumps continuously and exclude them from energy conservation measures.
- Eliminate or minimize the use of rubber, plastic and silicone gaskets in the plumbing system. These materials may serve as growth substrates for LDB. Frequent flushing of these lines also reduces growth.
- Identify and test the integrity of all backflow preventers (to ensure protection of domestic water from cross-contamination with process water) through a building code-approved method.

Biocides:

- Hot-water tanks should be drained periodically to remove scale and sediment.
- Periodically chlorinate the system at the tank to produce 10 ppm free residual chlorine and flush all taps until a distinct odor of chlorine is evident as a means of control. The tank must be thoroughly rinsed to remove excess chlorine before reuse.
    - In-line chlorinators can be installed in the hot water line; however, chlorine is quite corrosive and will shorten the service life of metal plumbing.
    - Control of the pH in the range of 6.8 - 7.0 is extremely important to ensure that there is adequate residual chlorine in the system.
- Additional information (App II:A-1) on biocides is also available.

Alternative Controls:
Please note: ozone and ultraviolet treatments are short-lived in their effectiveness and do not provide residual disinfection, as does continuous chlorination.

- Metal ions, such as copper or silver, in solution have a biocidal effect.
- Ozonization injects ozone into the water, killing microorganisms.
- Ultraviolet (UV) radiation also kills microorganisms.
    - Commercial, in-line UV systems are effective and can be installed on incoming water lines or on recirculating systems.
    - Scale buildup on the UV lamp surface can rapidly reduce light intensity and requires frequent maintenance to ensure effective operation.

What to consider in the system design

^TOP

- Water systems designed to recirculate water and minimize dead legs will reduce stagnation.
- Pressure-independent, thermostatic mixing valves at delivery points can reduce delivery temperatures.
- Point-of-use water heaters can eliminate stagnation of hot water in infrequently used lines.
- Eliminate dead legs when possible, or install heat tracing to maintain 50°C (122°F) in the lines.

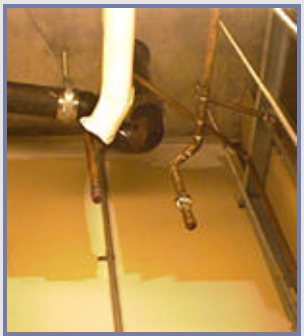


fig.2: Avoid points of stagnation.

How often to test hot-water systems for LDB following identification of contamination

^TOP

Outbreak Protocol:

Test the domestic hot- or warm-water system for LDB on the following schedule to ensure that recontamination has not occurred:

1. Weekly for the first month after resumption of operation.
2. Every two weeks for the next two months.
3. Monthly for the next three months.

How to collect hot-water samples

^TOP

Collect water samples to determine potential contamination as outlined above. ***Please Note: It is important not to flush a hot-water outlet before taking a sample because the end section of the water system may be a source of contamination.***

fig.3: Sampling from an electric water heater

Water Sampling Protocol: Sampling information specific to hot-water systems is provided below. For more information about water sampling, please refer to Section II:E. Water Sampling Guidelines.

- Sample the incoming water supply if the plumbing provides access.
- Sample hot and tepid water tanks and reservoirs.
- Sample faucets and showerheads throughout the facility, for example, those nearest, intermediate, and most distant from water heaters, storage tanks, and connections with municipal water supplies.
- If a biocide is used, follow the manufacturer's instructions for proper neutralization.

Interpretation Guidelines:

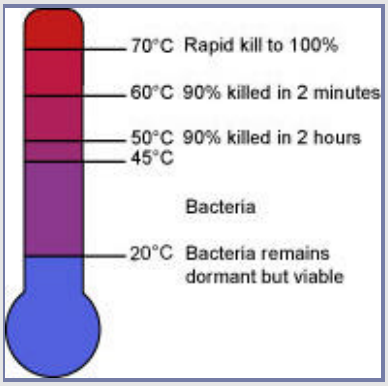
- The OSHA suggested guideline for LDB in domestic hot- and tepid-water systems is less than 10 CFU per milliliter.
  - If LDB concentrations are below 10 CFU per milliliter and no LDB were detected in swab or other samples, no further monitoring for LDB is necessary. Continue the maintenance program as long as the system is in use.
  - If water concentrations exceed 10 CFU per milliliter or LDB were detected in other samples, take steps to identify the source of contamination or amplification and treat the system. See How to treat a contaminated water system.
    - Sample the water system monthly until the source of contamination is identified and adequately treated. Once LDB concentrations remain below 10 CFU for a tree-month period, sampling may be stopped.

How to treat a contaminated hot-water system

^TOP

Use the treatment procedure below to treat all hot-water systems that have either been tested and found to contain detectable levels of LDB or are assumed to be contaminated based on epidemiological evidence.

- Disinfect the system using an effective chemical, thermal, or other treatment method. For example:
    - Pasteurize the hot water system by heating the water to at least 70°C (158°F) and maintain this temperature during the flushing period. While maintaining the temperature at 70°C (158°F), continuously flush each faucet on the system with hot water for 5-20 minutes.
    - Use an accepted chemical disinfectant such as chlorine or an acceptable biocide treatment to clean the system. Thoroughly flush the system after treatment to remove all traces of the corrosive and possibly toxic chemicals.
    - Follow any other technique that has demonstrated effectiveness and safety.



- After treatment, sample the hot water from each storage tank. If LDB are detected, re-treat and re-sample the water system. If no measurable levels are found and all other potential sources have also been addressed, proceed with follow-up testing as outlined above.

For additional information about treatment technologies, see Legionella 2003: An Update and Statement by the Association of Water Technologies (AWT).

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Section II:C-2. Domestic Cold-Water Systems

Domestic cold-water systems are not a major site for Legionnaires' disease bacteria (LDB) growth. However, elevated levels of LDB have been measured in ice machines in hospitals. Cold-water lines near heat sources in the units are believed to have allowed the bacteria to multiply. Dental water lines have been recognized as sources of water contaminated with high concentrations of microorganisms including LDB. However, an increased risk of disease among dental staff or patients has not been demonstrated.

Control Strategy:

- Which cold-water systems have been recognized as a source of LDB contamination?
- How to maintain a cold-water system
- How often to test cold-water systems for LDB following identification of contamination
- How to collect cold-water samples
- How to treat contaminated cold-water system

Which cold-water systems have been recognized as a source of LDB contamination?

^TOP

- **Ice machines** in hospitals supplied by cold-water lines near heat sources that promote LDB growth.
- **Water tanks** that allow water to remain uncirculated for long periods also can promote bacterial growth.
- **Cross-contamination** of a domestic cold-water system with another system should always be suspected of promoting bacterial growth.

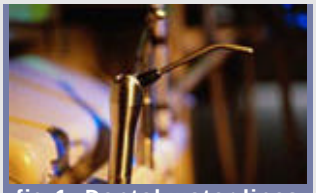

fig.1: Dental water lines may be a source of contamination

- **Emergency water systems** such as fire sprinkling systems, safety showers, and eye wash stations are other domestic cold-water sources from which LDB have been cultured. These systems experience little water flow and can be subject to periods of elevated temperatures. In addition, operation of these devices will aerosolize water. For these reasons, emergency water systems should be considered potential sources of LDB, although no documented cases of legionellosis have been associated with these sources.
- **Operating conditions for dental water lines** are especially appropriate for LDB proliferation because the water is stagnant a majority of the time, the narrow plastic tubing encourages bio-film formation, and the water temperature is usually 20°C (68° F) or higher -- some systems maintain water at 37°C (98°F).
  - Filtration of water at the point of use with replaceable, in-line, Food and Drug Administration (FDA) approved, 0.22-micrometer pore size filters is recommended for minimizing risk to patients and staff in dental facilities.

How do I maintain a cold-water system? ^TOP

Maintaining cold-water lines below 68°F (20°C) will limit the potential for bacterial growth. Other methods to consider include the following:

fig.2: Flush safety showers monthly.

- Maintain residual chlorine levels as per local authorities recommendation.
- Eliminate "dead leg" sections or frequently flush taps to drain stagnant areas to limit growth of the organism.
- Eliminate or design stagnant tanks to reduce storage time to one day or less.
- Cover cold-water lines to prevent contamination and protect them from temperature extremes.
- Protect all connections to process water with a plumbing code-approved device such as a back-flow preventer or air gap.
- Flush safety showers and emergency eye wash stations at least once a month.

How often to test cold-water systems for LDB following identification of contamination? ^TOP

Outbreak Protocol:

When treatment steps are successfully completed, return the water system to normal operation but test it for LDB according to the following schedule:

1. Weekly for the first month after resumption of operation.
2. Every two weeks for the next two months.
3. Monthly for the next three months.
4. If tests fail, repeat the disinfection procedure and restart the test program.

How do I collect cold-water samples? ^TOP

Collect water samples to determine potential contamination, as outlined above. Note: It is important not to flush the outlet before taking a sample because the end section of the water system may be a source of contamination.

Water Sampling Protocol: Sampling information specific to cold-water systems is provided below. For more information about water sampling, please refer to Section II:E. Water Sampling Guidelines.

- Sample the incoming water supply if the plumbing provides access.
- Sample cold water tanks and reservoirs if any.
- Sample faucets and showerheads throughout the facility, for example, those nearest, intermediate, and most distant from storage tanks and connections with municipal water supplies.
- If a biocide is used, follow the manufacturer's instructions for proper neutralization.

Interpretation Guidelines:

- The OSHA suggested guideline for LDB in domestic cold-water systems is less than 10 CFU per milliliter.
    - If LDB concentrations are below 10 CFU per milliliter and no LDB were detected in swab or other samples, no further monitoring for LDB is necessary. Continue the maintenance program as long as the system is in use.
    - If water concentrations exceed 10 CFU per milliliter or LDB were detected in other samples, take steps to identify the source of contamination or amplification and treat the system
      See How to treat a contaminated water system.
        - Sample the water system monthly until the source of contamination is identified and adequately treated. Once LDB concentrations remain below 10 CFU for a tree-month period, sampling may be stopped.

How to treat a contaminated cold-water system

^TOP

Cold-water systems have no provision for heating water, therefore, disinfection cannot be by heat treatment. The treatment procedure below should be used if cold-water systems are shown to contain measurable LDB or are assumed to be contaminated based on epidemiological evidence.

fig.4: Flush cold-water outlets.

1. Clean then disinfect all cold water systems including storage tanks, drinking fountains, water lines, and water outlets, as follows:
    - Use an accepted chemical disinfectant such as chlorine or other acceptable biocide and follow the manufacturer's instructions.
    - Use other technology that has been shown to be safe and effective.
2. If the cold-water lines have significant contamination, hyper-chlorination can eradicate LDB.
    - Raise the level of free chlorine to 20-50 mg/L and maintain this concentration for one hour at 50 mg/L or for two hours at 20 mg/L.
    - Faucets are then allowed to run until the odor of chlorine is present, and the water is allowed to remain for approximately two hours.
3. Flush all cold-water outlets and fountains for four minutes to remove disinfectant, at least twelve hours before re-use.

Disease Recognition | Source and Control | Water Sampling Guidelines | Investigation Protocol
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Legionnaires' Disease

Section II:D. Heating, Ventilating, and Air Conditioning (HVAC) Systems

Legionnaires' disease bacteria (LDB) cannot survive without water, and a properly operated, well-maintained HVAC system is unlikely to be a source of problems unless water contaminated with the bacteria enters the system. Air conditioning units without humidifiers have not been identified as sources of LDB. For a Legionnaires' disease outbreak to be linked directly with the HVAC system, LDB-contaminated water must enter the system, be aerosolized, and be delivered to building occupants.

Control Strategy:

What to consider in the system design

^TOP

Operate and maintain all HVAC equipment as originally designed, and maintain it so that it can perform as designed. Test all HVAC equipment periodically to ensure that it is performing as designed. Consider the following issues when designing HVAC systems; most apply to all types of microbial contamination:

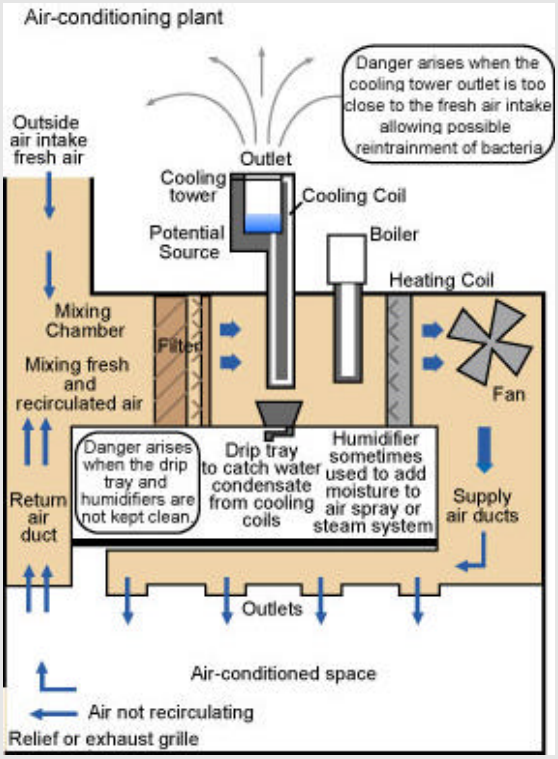
- Minimize use of water reservoirs, sumps, and pans.
- Provide a way to drain water sumps when not in use, such as, an electric solenoid valve on the sump drain.
- Provide a "bleed" for water sumps so that dissolved solids do not form sediments in the sump.
- Slope collection pans and drain sumps from the bottom so that all the water can drain out and allow the pan to dry.
- Locate HVAC fresh-air intakes so that they do not draw the mist from a cooling tower, evaporative condenser, or fluid cooler into the system. When evaluating this path, consider:
  - Prevailing wind direction and velocity.
  - Building effects such as low-pressure zones on leeward sides of buildings and on roof.
  - Architectural screen walls.
  - Distance from tower to intake.

- Design indirect evaporative cooling systems with the knowledge that the failure of the heat exchanger will allow wet systems to mix with the air-distribution systems.
- Do not use raw steam from the central heating boiler to humidify air because it contains corrosion inhibitors and anti-scaling chemicals.
- Atomizing humidifiers must have contaminant-free water.

How to maintain a HVAC system

^TOP

Inspect the entire air distribution system (including return and exhaust systems) for visual evidence of water accumulation.



- Properly drain all sumps and permanently drain inactive sumps to prevent accumulation of sediments.
  - If an HVAC sump is used during the hours when a building is occupied, drain the sump during unoccupied hours.
- Maintenance failures can produce stagnant water that can become an ideal environment for LDB growth if sufficiently warm (such as heated by sunlight).

To effectively control contamination, be aware of the conditions that may promote growth and distribute LDB:

- **External sources** may emit contaminated aerosolized water that is drawn into a system's fresh-air intake. Consider the following:
  - Fresh-air intake airways, typically concrete plenums located at grade level, supplying fresh air to air handlers in the basement or lower levels of buildings can collect organic material (such as leaves and dirt).
  - Aerosols from spray irrigation.
  - Open windows.
- **Internal sources** may provide contaminated aerosolized water that is then disseminated by the air-distribution system. Consider the following:
  - HVAC system humidifiers are potential sources of aerosol exposure if contaminated with LDB. See Section II:B. Humidifiers and Misters.
  - Direct evaporative air coolers with sprays or misters used as humidifiers include sumps, which may stagnate when not in use.
  - Indirect evaporative air cooling systems using water coils may develop a leak that may inject cooling tower water directly into the supply air stream.
  - Air-to-air heat exchangers may develop leaks, which may allow the wet air stream to mix with supply air and cause problems if the wet air stream is contaminated with LDB.
  - Wet evaporative coolers, slinger air coolers, and rotary air coolers with improperly operated and maintained systems that use warm, stagnant sump water may be potential sources of LDB.

- Residential humidifiers, such as free-standing or portable units, often contain sumps that are frequently contaminated with LDB.
- Computer room air conditioners may contain a humidifier sump filled with contaminated water.
- Improperly drained condenser pans may produce tepid conditions that can encourage microbial and fungal growth.

Should HVAC systems be sampled?

^TOP

LDB can live only in water. Therefore, if ducts are dry, they cannot serve as a source of LDB.

- Note: There is no reliable way to detect nonviable LDB in the air.
- For additional information, see Section II:B. Humidifiers and Misters: Sampling Protocol, and Section II:E. Water Sampling Guidelines: Monitoring.

How to treat a contaminated system

^TOP

In the event LDB is detected, follow these steps for treatment:

- Eliminate all water leaks and remove any standing water found in the system to ensure future drainage.
- Replace or eliminate any water-damaged insulation in the system.
- Operate the HVAC system using 100 percent outside air for eight hours before returning the building to normal operation.
- When the building is returned to normal operation, keep outside-air supply rates as high as possible for one month. At a minimum, the outdoor air requirements of ASHRAE Ventilation Standard 62-2001 must be met.

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Legionnaires' Disease

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Section II:E. Water Sampling Guidelines

Water sampling is critical to determining whether Legionnaires' disease bacteria (LDB) are present and at what levels. To ensure accurate detection, proper methods must be used when collecting and transporting samples. A number of analytical techniques are available for detection of LDB. These vary in their sensitivity, specificity, and turnaround time. Depending on individual circumstances, one or more of these methods may be preferable for a given workplace or system.

Physical Survey

^TOP

Fig. 1: Site assessment

Site Assessment: Estimate the size of the building and the number of water services in the facility during the initial walk-through. During the inspection, determine the number of samples needed and arrange with the appropriate laboratory for supply and shipment of sterile sampling containers and swabs and for the analysis of samples. Obtain or prepare a simple schematic diagram of the water services. Note the following features:

- The location of the incoming municipal or private water supply.
- The location of storage tanks, water treatment systems, and pumps.
- The location of water heaters and boilers.
- The type of fittings used in the system such as taps, showers, valves, and the pipe-work material.
- The location of all cooling towers, evaporative condensers, and fluid coolers.
- The location and type of all systems served by the cooling tower water including sump tanks, condensers, and indirect evaporative cooling coils in air-handling units.
- The location of any evaporative cooling systems or humidifiers.
- The location of ornamental fountains, whirlpools, eye washes, safety showers, or other water sources within or near the facility.

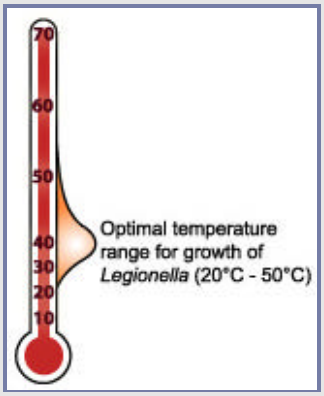
Water Route Inspection: Trace the route of the service from the point of entry of the water supply.

- Note the condition of pipes, jointing methods used, insulation, sources of heat, and the kind of insulation in water storage tanks.

- Note any disconnected fittings, "dead legs," and cross-connections with other services. Once you have identified these features, take water samples from:

    - The incoming water supply
    - Each storage tank and water heater
    - A representative number of faucets for each of the hot and cold water systems in the facility
    - All cooling towers, evaporative condensers, humidifiers, spas, showers, and other aerosol-generating sources.
    - The water entering or leaving any other type of fitting or piece of equipment under particular suspicion

Conditions That Promote Growth: LDB is widely distributed in water systems. Under ideal conditions, the bacterium is capable of multiplication within domestic water systems. Low, even non-detectable, levels of the organism can colonize a water source and grow to high concentrations. ***Note: It is important to remember that any water system can be a source of bacteria if the water in it is subjected to conditions that promote growth of the LDB.***



- Water conditions that tend to promote the growth of LDB include:
    - Stagnation
    - Warm water temperatures between 20° and 50°C (68° and 122°F)
    - pH between 5.0 and 8.5
    - Sediment that tends to promote growth of commensal micro flora
        - Microorganisms such as algae, flavobacteria, and *Pseudomonas,* which supply essential nutrients for growth of LDB, or protozoa that harbor the organism such as amoebae
- Water systems that frequently provide optimal conditions for growth of LDB include:
    - Cooling towers, evaporative condensers, and fluid coolers that use water evaporation to reject heat. These include many industrial processes that use water to remove excess heat.
    - Domestic hot-water systems with water heaters that operate below 60°C (140°F) and deliver water to taps below 50°C (122°F).
    - Poorly maintained humidifiers and decorative fountains that create a water spray and use water at temperatures favorable to growth.
    - Spas and whirlpools with aeration.
    - Dental water lines, which are frequently maintained at temperature above 20°C (68°F) and sometimes as warm as 37°C (98.6°F) for patient comfort.
    - Possibly other systems such as stagnant water in fire sprinkler systems or warm water for eye washes or safety showers.

Other Sources: It is important not to overlook any potential water sources in the building such as:

- Water to ice machines
- Plastic injection molding equipment
- Metal working fluids
- Hot springs (waterfalls)
- Respiratory therapy equipment
- Supermarket reservoir misters

Fig. 2: Note all potential water source

Water Sampling Protocol

^TOP

Respiratory Protection: Wear appropriate respiratory protection during the examination of water systems if a significant potential exists for exposure to high concentrations of contaminated aerosols. For example, wear a respirator while inspecting and collecting water samples near an aerosol generating water source, such as an operating spray humidifier, water mister, fountain, or shower, in a facility where there is a confirmed outbreak.

Fig. 3: Use respiratory protection when appropriate.

- Respirators should be in the form of a half-face respirator (fig. 3) equipped with a HEPA or similar filter capable of effectively collecting particles of 1-micrometer.

Sample Collection: ***Please Note: It is important not to flush water outlets before taking a sample because the end section of the water system may be a contaminated site.***

Fig. 4: Measure water temperature

- Collect 250 milliliter to 1 Liter of water in sterile polypropylene containers with a sufficient type and amount of neutralizer for any disinfectant agent in the water system. For example, sodium thiosulfate is used to neutralize residual chlorine and other halogens. Water samples high in copper or zinc and wastewater samples high in heavy metals can be treated with a chelating agent that will reduce metal toxicity. Contact the biocide manufacturer for instructions on appropriate neutralization to prevent continuation of bactericidal action during sample transit.
- Collect swab samples using pre-packaged sterile swabs in their own containers or small sterile glass or polypropylene bottles.

Sample Analysis:

- Submit the water samples to a laboratory that is certified for microbial water analysis and experienced in LDB detection using culture methods that measure colony forming units (CFU) of LDB per milliliter of water.
    - The microbiological laboratory that will analyze the samples should be able to provide sampling supplies or recommend commercial sources. Many commercially available collection bottles for drinking water samples contain sodium thiosulfate.

Source of Supply Water Sampling:

- Detectable levels of LDB in a water system may indicate contamination of the source water supply. The concentration of LDB in the source water represents the maximum allowable level in the system.

Measurement of Water Temperature:

- Measure the temperature of the sampled water (place the thermometer in the water stream flowing from an outlet valve or faucet, not in the sample container, or use an infrared thermometer) (fig.4).
- When measuring temperature from faucets, showers, fountains, etc., record the initial water temperature. Allow the water to run and measure the temperature every two minutes until the temperature stabilizes.
- Record the initial and final water temperatures and the time needed for the water temperature to stabilize.
    - Compare the initial and final water temperatures with the set temperature. Temperatures in cold-water systems should be maintained at a sufficiently low temperature (20°C, 68°F, or lower) to minimize bacterial growth. Temperature in hot-water systems should be maintained at a sufficiently high temperature (60°C, 140°F, or higher).
    - Sanitize the thermometer with isopropyl alcohol before measuring the temperature of each

sample to avoid cross-contamination of the samples.

Collection of Pre- and Post-flush Samples:

- Collect a 250-mL to 1-Liter 'pre-flush" sample of the first water drawn from bottom drains and outlet valves of storage tanks, sumps, and water heaters as will as faucets and showerheads.
- Allow the water to run until the temperature stabilizes and collect a second "post-flush" sample when the water temperature is constant.

Collection of Swab and Material Samples:

- Swab areas where there is scale build up (pre-wet the swabs with water taken form the sampling site).
- Collect samples of sludge, slime, or sediment with swabs or in sterile containers.

Sample Transportation

^TOP

Sample Preparation:

- Wrap vinyl tape clockwise around the neck of each bottle to hold its screw cap firmly in place and seal the interface between the cap and the bottle.
- Wrap absorbent paper around bottles, and place the bottles in a sealable (zip-lock) plastic bag.
- Place the sealed plastic bag in an insulated container (Styrofoam chest or box).

Fig. 5: Samples should be protected and shipped quickly.

Storage:

- Samples should be protected from temperature extremes such as sunlight or other external heat or cold sources during transport and storage, for example, temperatures below 3°C (37°F) and above 30 °C (86 °F).
- Samples should be stored at room temperature (20° ± 5°C, 68°F) and processed within two days.

Shipping:

- Ship samples to the testing laboratory using overnight mail.
- Make arrangements for weekend receipt when shipping on a Friday.

Monitoring

^TOP

Air: Air samples collected on special culture plates with an Andersen-type sampler rarely demonstrate the presence of LDB in the air.

- Negative results are frequent because of the difficulty in maintaining viability of the organism on the culture plates.
- Air sampling for LDB is strongly discouraged as a means of measuring potential exposure, because of the high likelihood of false-negative results.

Water: Analysis of water samples from a source suspected of LDB contamination

is a valuable means of identifying potential sources of the bacterium.

- A microbiological laboratory certified for microbial water analysis and experienced in LDB detection can determine the number of organisms present in colony forming units (CFU) per volume of water and can identify the different serogroups of *L. pneumophila* well as other species of *Legionella*.

Fig. 6: Water samples are the best means of source identification.

Microbiological Analysis

^TOP

Cultured Samples: Water samples are cultured on a buffered charcoal yeast extract (BCYE) culture growth medium.

Fig. 7: Cultured samples can identify specific serogroups.

- Preliminary culture results typically require three to five days for confirmation from the time of submission.
  - Confirmation of culture results may take additional time because some LDB take 10 to 14 days to form visible colonies.
  - Hold primary plates for a minimum of 14 days before reporting them negative.
- Selective isolation processes can reduce overgrowth by other microorganisms and can aid in the determination of LDB.
- Analyze cultured samples to identify specific serogroups. There is strong evidence of a casual link when the same serogroup and subtype of an organism is isolated from a patient and a water source.

Direct Fluorescence Antibody (DFA): The number of organisms in a water sample can also be determined via direct fluorescence antibody (DFA) conjugate tests that stain the organism with a fluorescent dye.

- This test is unable to distinguish between live and dead bacteria and may have some cross-reactivity with other bacteria.
- Use caution in interpreting the results of DFA tests since the potential exists for both false-positive and -negative results.
- Sample results can be available in one or two days.

DNA Amplification: A relatively new method for rapid, specific detection of LDB in water employs a polymerase chain reaction (PCR) process to amplify and then detect portions of DNA unique to LDB.

- This method may produce results in one day.
- Preliminary evidence indicates that PCR sensitivity and specificity are comparable to those of cell culture, which can take 3 to 14 days to obtain results.
- Further testing may lead to acceptance of this technique as the method of choice for monitoring water sources for contamination.

Test Results:

- Make the results of all water monitoring tests available to building occupants when excessive levels of LDB are found. Visitors and employees have rights to sampling results as per OSHA Standard 1910.1020(a).

Additional information (App I:A) on serogroups and subtypes is also available.

For more information on culture techniques, see Centers for Disease Control and Prevention (CDC): Water Sampling Strategies and Culture Techniques for Detecting Legionellae.

Sampling Guidelines

^TOP

OSHA Guidelines:

- Use the following suggested guidelines seen in Table 1. to assess the effectiveness of water system maintenance and to interpret sampling results. 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 people who are immuno-compromised.

Table 1. Colony forming units (CFU) of LDB per milliliter

Action	Cooling tower/Evaporative Condenser	Potable water	Humidifiers and Misters
1	100	10	1
2	1,000	100	10

The levels requiring action vary for the source of exposure, based on the assumption that some routes of exposure result in a greater dose to the lung. For this reason humidifiers and similar devices (such as misters and evaporative condensers) produce aerosol mists and, therefore, need to be controlled to lower levels than cooling towers and domestic water supplies to minimize the risk of inhalation. Levels of LDB equal to or greater than the values in the table constitute a need for action, as described below:

Action 1

- Cleaning followed by biocide treatment of the system, if appropriate.

Action 2

- Cleaning and or biocide treatment.
- Take immediate steps to prevent employee exposure.

**Remember that these numbers are only suggested guidelines, and the goal is zero detectable LDB in a water source.

[Adapted from George K. Morris and Brian G. Shelton, PathCon Technical Bulletin 1.5, p-2, *Legionella* Bacteria in Environmental Samples: Hazard Analysis and Suggested Remedial Actions, June 1998, Pathogen Control Associates, 270 Scientific Dr., Suite 3, Norcross, GA 30092]

Association of Water Technologies (AWT) Guidelines:

- The action plan seen in Table 2. represents a composite compilation of various AWT member Water Treatment Company LDB actions plans for cooling tower operations. The frequency of tower sampling for LDB varies widely amongst the programs and is generally determined from specific site and system Legionnaires' disease risk assessments.

Table 2. Cooling Tower Legionella Count, colony forming units (CFU) per milliliter			
>0-10	**>10-100**	**>100-1000**	**>1000**
a.	b.	c.	d.
a. Increase biocide addition/s. b. Increase biocides; review program; retest till <10. c. Disinfect and clean within 30 days; review program. d. Disinfect and clean within 7 days; review program.			
For additional information, see Legionella 2003: An Update and Statement by the Association of Water Technologies (AWT).			

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