TECHNICAL MANUAL

Oregon OSHA

Section III
(previously Section II of Oregon OSHA's Technical Manual)

HEALTH HAZARDS

CHAPTER 1: POLYMER MATRIX MATERIALS: ADVANCED COMPOSITES

CHAPTER 2: INDOOR AIR QUALITY INVESTIGATIONS

CHAPTER 3: VENTILATION INVESTIGATIONS

CHAPTER 4: HEAT STRESS

CHAPTER 5: NOISE

CHAPTER 6: LASER HAZARDS

CHAPTER 7: LEGIONNAIR'S DISEASE

*All information within this section and chapter has been reproduced from the Oregon OSHA Technical Manual (circa 1996) unless otherwise stated within the "**Chapter Revision Information**", located at the beginning of each chapter.*

SECTION III: CHAPTER 7

LEGIONNAIRES' DISEASE

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Chapter Revision Information:

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- *In June 2014, the chapter's multilevel listing format was modified from an alphanumeric system to a roman numeral system.*

SECTION III: CHAPTER 7

LEGIONNAIRES' DISEASE

TABLE OF CONTENTS

I. INTRODUCTION 5
II. DISEASE RECOGNITION 5
A. Causative Agent 5
B. Symptoms 5
C. Incidence 6
D. Risk Factors 6
E. Diagnosis 6
F. Transmission 8
III. SOURCE IDENTIFICATION 8
A. Conditions that Promote Growth 8
B. Common Sources of Contaminated Water 9
C. Monitoring 9
D. Microbiological Analysis of Water Samples 10
E. Interpretation of Sample Results 10
IV. INVESTIGATION PROTOCOL 11
A. Community Health Concerns 11
B. Types of Investigations 11
C. Level-One Investigation 12
D. Level-Two Investigation 14
V. CONTROLS 16
A. General Discussion 16
B. Cooling Towers, Evaporative Condensers, and Fluid Coolers 16
C. Domestic Hot-Water Systems 19
D. Domestic Cold-Water Systems 20
E. HVAC Systems 21
VI. BIBLIOGRAPHY 23

TABLE OF CONTENTS (CONTINUED)

LIST OF APPDENENDICES

APPENDIX: 7-1	Employee Awareness Program	25
APPENDIX: 7-2	Physical Survey and Water Sampling Protocol	33
APPENDIX: 7-3	Water Sampling Guidelines	36
APPENDIX: 7-4	Legionnaires' Disease Case Identification	37
APPENDIX: 7-5	Water Treatment Protocols for Facilities That Have Experienced a Legionnaires' Outbreak	45

I. Introduction

This chapter provides information to assist industrial hygienists in the assessment of work sites for potential Legionnaires' disease. It provides information on disease recognition, investigation procedures to identify probable water sources, and control strategies. The primary focus of this document is on the control and prevention of contaminated water sources, not on case identification, an area of expertise primarily exercised by local health departments frequently in conjunction with the Centers for Disease Control and Prevention (CDC) in Atlanta. Appendices include details on conducting an employee awareness program, water sampling protocols and guidelines for acceptable levels of the organism in water, procedures for identifying new cases of the disease, and water treatment and control strategies for facilities where an outbreak has occurred.

II. Disease Recognition

A. Causative Agent

Legionella pneumophila was first identified in 1977 by the CDC as the cause of an outbreak of pneumonia that caused 34 deaths at a 1976 American Legion Convention in Philadelphia. *L. pneumophila* had undoubtedly caused previous pneumonia outbreaks, but the organism's slow growth and special growth requirements prevented earlier discovery.

The diseases produced by *Legionella* are called ***legionellosis***. More than 34 species of Legionella have been identified, and more than 20 linked with human diseases. *L. pneumophila* causes the pneumonia known as Legionnaires' disease and the flu-like Pontiac fever. *L. pneumophila* has also been implicated in wound infections, pericarditis, and endocarditis without the presence of pneumonia. Because the majority of legionello-sis is caused by *L. pneumophila*, this chapter will deal exclusively with that organism. Cases where other species of *Legionella* are involved in disease require actions similar to those to control Legionnaires' disease.

The *L. pneumophila* bacteria are gram-negative rods that exist in a number of distinguishable serogroups. Each serogroup contains further subtypes that have different surface structures on the cell membrane and can be distinguished by special tests. Evidence indicates that some *Legionella* serogroups are more virulent than others. *L. pneumophila* serogroup 1 is the most frequently identified form of the bacterium isolated from patients with Legionnaires' disease, although other serogroups and subtypes of the bacterium are frequently isolated from water sources. Serogroups 4 and 6 are the next most frequently linked with disease.

B. Symptoms

Legionnaires' disease has an incubation period of 2 to 10 days. Severity ranges from a mild cough and low fever to rapidly progressive pneumonia and coma. Early symptoms include malaise, muscle aches, and slight headache. Later symptoms include high fever (up to 105^{o}F), a dry cough, and shortness of breath. Gastrointestinal symptoms including vomiting, diarrhea, nausea, and abdominal pain are common. The disease is treated with erythromycin or a combination of erythromycin and rifampin.

Pontiac fever is a nonpneumonia, flu-like disease associated with, and likely caused by, the *Legionella* bacterium. This disease has an "attack rate" of 90% or higher among those exposed, and a short incubation period, 1-3 days. Complete recovery usually occurs in 2-5 days without medical intervention. The factors that cause the same organism to produce two illnesses with major differences in attack rate and severity are not known.

C. Incidence

In the U.S., Legionnaire's disease is considered to be fairly common and serious, and the *Legionella* organism is one of the top three causes of sporadic, community-acquired pneumonia. Because it is difficult to distinguish this disease from other forms of pneumonia, many cases go unreported. Approximately 1,000 cases are reported annually to the CDC, but it is estimated that over 25,000 cases of the illness occur each year and cause more than 4,000 deaths.

D. Risk Factors

Legionnaires' disease is frequently characterized as an "opportunistic" disease that most frequently attacks individuals who have an underlying illness or weakened immune system. The most susceptible include persons who are elderly, smokers, and immunosuppressed. Individuals with chronic obstructive pulmonary disease (COPD), organ transplant patients, and persons taking corticosteroid therapy are also at elevated risk. The attack rate for the average population is approximately 5% or less. The fatality rate is similar to that of other forms of pneumonia, approximately 15%.

E. Diagnosis

CDC guidelines define two types of cases of Legionelloses, **probable** and **confirmed**. A **probable** case of Legionnaire's disease is a person who experienced an illness clinically compatible with Legionnaire's and has a single antibody titer of 256 or higher (discussed below), and can be associated with a population of individuals who have experienced confirmed cases of the disease (outbreak). A **confirmed** case of *Legionella* requires a physician's diagnosis of pneumonia based on a chest x-ray and positive laboratory test results. A laboratory test is necessary for confirmation because the symptoms and x-ray evidence of Legionnaires' disease resemble those of other types of pneumonia. Various methods are used to confirm the presence of the disease.

1. CULTURE OF THE ORGANISM

The definitive laboratory method of confirming the presence of the disease is by culturing viable cells of *Legionella* from sputum, bronchial washing, or autopsy on special media. Further identification of the cultured cells will identify the species and serogroup. Special tests may determine subtype of certain isolates. The sensitivity of this test to detect the disease is reported to be about 70%.

2. URINE ANTIGEN TEST

The detection of antigen from *L. pneumophila* in the urine is considered a reliable measure of the disease. These antigenic materials may include *L. pneumophila* cells or portions of cells in the urine during and after the disease. The presence of antigen in the urine is a strong indicator of the disease, and a patient may have a positive response for several months following the disease. The sensitivity of this test is limited because the only commercially available urinary antigen test detects only serogroup 1 forms of *L. pneumophila*. The CDC recommends only the radioimmunoassay (RIA) test because the latex antigen (LA) test has a high false-positive rate. Fortunately, 80-90% of the clinically diagnosed cases are caused by serogroup 1. The absence of a positive urinary test is not proof that a patient did not have Legionnaires' disease, but merely indicates the absence of antigen in the urine at the time of the test.

3. DIRECT FLUORESCENT ANTIBODY (DFA) STAINING

Direct fluorescent antibody staining of lung aspirates can detect *L. pneumophila*. However, this test is frequently negative during the initial stages of the disease because few organisms are present in the aspirate or sputum. This test also requires an antigen-specific reagent. There are a multitude of serogroups and subtypes of *L. pneumophila*, and a test will be negative if the exact antigen-specific reagent is not included.

4. SEROLOGY (ANTIBODY TITERS)

An increase in the antibody level in the serum of infected persons occurs several weeks after the onset of the disease. A fourfold increase in the antibody titer coupled with a physician's diagnosis of pneumonia is considered a reliable indicator of disease. This is measured by comparing the antibody level 4 to 8 weeks after onset (convalescent titer) to an initial (acute) titer at the beginning of the disease. Pontiac fever also produces an elevated antibody titer, but the flu-like symptoms of this disease do not match those of Legionnaires' disease.

Frequently only a convalescent titer has been measured from individuals who had symptoms of the disease. For situations in which these cases are associated with an outbreak of Legionnaires' disease, a single titer of 256 to 1 or higher is generally used as a presumptive indication of disease (probable case). Antibody strength is determined by the number of dilutions of serum which elicit a positive antibody response. The reciprocal value of the number of dilutions is the antibody titer. For example, an antibody titer of 256 means a positive antibody test of the patients’ s serum following serial dilutions of 1:2, then 1:4, then 1:16, etc., until the 1:256 dilution point is reached.

The indirect fluorescent antibody (IFA) test is the accepted diagnostic tool for demonstrating *L. pneumophilia* exposure. Another widely used test of antibody response is the enzyme-linked immunosorbent assay method (ELISA). CDC believes that direct comparison of results between IFA and ELISA is not reliable because there are insufficient data to compare the two. The ELISA method has gained wide medical acceptance as a useful means of demonstrating exposure to *Legionella*.

F. Transmission

The likelihood of contracting Legionnaires' disease is related to the level of contamination in the water source, the susceptibility of the person exposed, and the intensity of exposure to the contaminated water. Disease transmission usually occurs via *inhalation* of an aerosol of water contaminated with the organism. *Aspiration* of contaminated water into the lungs may also cause the disease. In the Philadelphia Legionnaires' disease outbreak, the hotel's cooling tower was identified as the likely source of the disease, although domestic water sources were not evaluated.

The disease has been associated with domestic hot-water systems in a number of outbreaks. In many instances it has been difficult to identify a likely source for aerosolization of the suspected water source. Although transmission of the disease other than through direct inhalation of aerosols may occur, the mechanisms are not clearly understood. The organism requires water, and the disease cannot occur in the absence of a contaminated water source. There is no evidence that the disease can be transmitted from one person to another.

III. Source Identification

A. Conditions That Promote Growth

L. pneumophila bacteria are widely distributed in water systems. They tend to grow in biofilms or slime on the surfaces of lakes, rivers and streams, and they are not eradicated by the chlorination used to purify domestic water systems. Low and even nondetectable levels of the organism can colonize a water source and grow to high concentrations under the right conditions.

Conditions that promote growth of the organism include heat, sediment, scale, and supporting (commensal) microflora in water. Common water organisms including algae, amoebae, and other bacteria appear to amplify *Legionella* growth by providing nutrients or harboring the organism. Because of its ability to remain viable in domestic water systems, it is capable of rapid multiplication under the proper conditions.

Water conditions that tend to promote the growth of *Legionella* include:

- stagnation;
- temperatures between 20^{o} and 50^{o}C (68^{o} -122^{o} F) (The optimal growth range is 35^{o} -46^{o} C [95^{o} -115^{o} F].);
- pH between 5.0 and 8.5;
- sediment that tends to promote growth of commensal microflora; and
- micro-organisms including algae, flavobac-teria, and *Pseudomonas*, which supply essential nutrients for growth of *Legionella* or harbor the organism (amoebae, protozoa).

B. Common Sources of Contaminated Water

Water sources that frequently provide optimal conditions for growth of the organisms include:

- cooling towers, evaporative condensers, and fluid coolers that use 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).
- humidifiers and decorative fountains that create a water spray and use water at temperatures favorable to growth;
- spas and whirlpools;
- 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; and
- other sources including stagnant water in fire sprinkler systems and warm water for eye washes and safety showers.

Water stored below 20 ° C (68 ° F) is generally not a source for amplified *L. pneumophila* levels. However, high levels of bacteria have been measured in the water supplying ice machines. The source of amplification in this case was thought to be heat from the condenser coil of the ice maker to the cold water supply. However, no cases of Legionnaires' disease have been linked to consumption of ice made from contaminated water.

C. Monitoring

1. AIR

An air sample applied to special culture plates by an Andersen-type sampler sometimes demonstrates the presence of the organism in the air. However, negative results are frequent because of the difficulty in maintaining viability of the organism on the culture plates. Air sampling for *Legionella* is **strongly *not* recommended** as a means of measuring potential exposure because of the high likelihood of false negatives.

2. WATER

Analysis of water samples from a source suspected of being contaminated with *L. pneumophila* is a valuable means of identifying potential sources of the disease. A qualified microbiological laboratory experienced in *Legionella* detection can determine the number of organisms present in colony forming units (CFU) per volume of water and can identify the different serogroups of *Legionella pneumophila* in the sample. Appendix III:7-2 provides details on the collection, storage, and shipping of water samples.

D. Microbiological Analysis of Water Samples

1. CULTURED SAMPLES

Water samples are cultured on special buffered charcoal yeast extract (BCYE) culture media. Selective isolation processes to eliminate other microbial overgrowth can determine the number of CFU of L. pneumophila per milliliter of water. This process of growth and isolation is time-consuming, and results typically require 7-14 days from the time of submission.

Cultured samples can also be analyzed to identify specific serogroups. Matching the same serogroup and subtype of organism in the patient as found in a water source is considered strong evidence of an associated link.

2. DIRECT FLORESCENCE ANTIBODY (DFA)

The number of organisms in a water sample can also be determined via direct florescence 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 also have some cross-reactivity with other bacteria. Sample results can be available in one or two days, and this method can be useful in screening water samples. Use caution, however, in interpreting the results since the potential exists for both false positive and negative results.

3. DNA AMPLIFICATION

A relatively new method for rapid, specific detection of the organism in water employs a polymerase chain reaction (PCR) process to amplify and then detect portions of DNA unique to L. pneumophila. This method can produce results in 1 day, and preliminary evidence indicates that its sensitivity and specificity are comparable to those of cell culture, which can take 10-14 days to obtain results. Further testing may lead to acceptance of this technique as the method of choice for monitoring water sources for contamination.

E. Interpretation of Sample Results

The probability of infection with L. pneumophila is a function both of the intensity of the exposure dose and the level of host susceptibility. Because total eradication of Legionella may not be possible, an acceptable control strategy is to minimize the number of organisms present in a water source. Ample evidence indicates that Legionella levels are readily controllable. A survey of over 1,000 cooling towers indicates that approximately 60% contained nondetectable levels of L. pneumophila when measured by DFA analysis for the number of organisms per milliliter of water (detection limit is 10 bacteria per milliliter of water). In another survey of 663 cooling towers, 57% contained Legionella that were not detected when measured by culture (detection limit less than 1 CFU/mL).

Other studies of domestic hot-water sources indicate that although the organism is common, especially in large hot-water systems, practical control measures can limit the potential for amplification. A private consulting firm and microbiological laboratory, PathCon Inc., Norcross, Georgia, has introduced suggested guidelines for control of the organism based on the number of

CFU of L. pneumophila per milliliter of water (Appendix III:7-3). These guidelines vary depending on the water source, a recognition by the authors that dose is related both to the potential for exposure and to concentration. For example, recommended exposure limits for contaminated water from a humidifier, which would involve direct exposure to an aerosol are lower than for a cooling tower where the opportunity for exposure is normally less. Work operations such as maintenance on cooling towers may involve direct exposure to cooling tower mist, and precautions to minimize exposure are always necessary. The authors recognize that these guidelines are based on limited data, but they represent the best available information and must suffice until the dose effect of L. pneumophila is better understood.

IV. Investigation Protocol

A. Community Health Concerns

It is important to remember that an outbreak of Legionnaires' disease among workers may have its origin in the community and may not be related to the work environment. A Legionnaires' outbreak is both an occupational and a public-health concern, and the investigation may include local public health departments and the Centers for Disease Control (CDC). To minimize employee risk and maximize the effectiveness of effort, close coordination among OSHA, other public agencies, and the employer is imperative.

B. Types of Investigations

The course of action chosen during an investigation of a facility should be based on the degree of certainty that the site is the source of a reported illness. For this reason, two investigation protocols are based on differing levels of suspected risk for exposure to Legionella. It is important to remember that these procedures are provided only to assist in the investigation of potential Legionnaires' cases. Individual circumstances may require changes in the investigation. All cases require sound professional judgment in deciding the appropriate course of action.

A **level-one** investigation may be initiated when there is a probable basis for suspecting that workplace water sources are contaminated with Legionella, or when there is information that one case of Legionnaires' disease may exist.

A **level-two** investigation should be conducted when more then one possible case of Legionnaires' disease has been reported at a facility.

If two or more cases of the disease can be attributed to a work site, assume that a Legionnaires' disease outbreak has occurred. If evidence indicates that the outbreak is still in progress (that is, at least one of the cases has occurred in the last 30 days), prompt actions should be undertaken to provide maximum protection to employees and eliminate the hazard. Appendix III:7-5 includes examples of actions required to control water sources where an outbreak has occurred.

Both investigations follow the same general pattern and include a preliminary opening conference, a walk-through of the facility to conduct a physical assessment of the water systems,

a more detailed examination of the systems including a review of maintenance records, assessment of findings, and a closing conference to present control actions based on the findings.

C. Level-One Investigation

Use the following procedure when Legionnaires' disease may be related to the work environment.

1. STEP 1

Obtain an overview of all water systems at the facility. A facilities engineer or experienced member of the building maintenance staff should be available to explain system operation and assist in the walkthrough investigation. This person should have a working knowledge of the system's design and current operation.

The overview of the water systems should include plumbing systems, heating-ventilating-air-conditioning (HVAC) systems, and other water reservoirs. A review of the plumbing system should include both hot and cold domestic water systems, water heaters, distribution pipes, water coolers, water treatment equipment, connections to process water systems protected (or unprotected) by backflow preventers, and storage tanks.

The HVAC system review should include cooling towers, evaporative condensers, fluid coolers, humidifiers, direct evaporative air-cooling equipment, indirect evaporative air-cooling equipment, air washers for filtration, etc. Note the location of the fresh-air intakes of the building's air-handling units relative to water sources such as the cooling towers.

Investigate other potential sources of employee exposure including decorative fountains, plant misters, whirlpools, spas, tepid-water eye-washes and safety showers, humidifiers, and water for cooling industrial processes.

Review maintenance records on water systems including water heaters and cooling towers. The records should include temperature checks of domestic water, visual and physical checks of cooling towers, and reports of cooling-tower water-quality assessment and chemical treatment.

Identify the locations of portions of the system in which water is allowed to stagnate such as storage tanks or unused plumbing pipe sections ("dead legs"), or infrequently used faucets. Check for cross-connections between domestic and process water systems, and note the condition and type of back-flow prevention devices.

Investigate recent major maintenance or changes in the system's operation. Determined if there were recent or frequent losses of water pressure from the incoming water supply due to line breakage or street repairs. The failure of a back-flow prevention device under loss of pressure can contaminate the system.

2. STEP 2

Conduct a walk-through investigation of the facility. Equipment you will need includes a thermometer for measuring water temperatures, a flashlight, and a film or video camera to record observations.

Measure and record the temperature of water drawn from each storage-type water heater in the facility. This temperature may be significantly below the water heater's gauge temperature because of heat stratification. Note the presence of rust and scale in this water.

Record the maximum temperature of water at faucets connected to each water heater on the system. Record temperatures at locations near, intermediate, and distant from the heaters. It may be necessary to run the water for several minutes before it reaches a temperature maximum.

Examine the water temperature and the potential for stagnation of cold-water storage tanks used for reserve capacity or to maintain hydrostatic pressure. These should be protected from temperature extremes and covered to prevent contamination. Record the temperature of the domestic cold-water lines at various locations within the facility. Note both the initial temperature and the final equilibrium temperature on the cold-water line, and record the time required to reach equilibrium, because this can be an indicator of the amount of stagnation in the system.

Evaluate cooling towers, evaporative condensers, and fluid coolers for biofilm growth, scale buildup, and turbidity. Record the location of the tower relative to fresh-air intakes, kitchen exhausts, leaves, plant material, or other sources of organic material that might contribute to the growth of the organism.

Record the general condition of the cooling tower. Determine the presence and condition of drift eliminators, which are designed to limit the vapor release from the units, along with the basin temperature of the water in the cooling tower if it is currently being operated. If the cooling tower is operating and is suspected of being contaminated, wear appropriate respiratory protection in the form of a half-face piece respirator equipped with a HEPA or similar type of filter capable of effectively collecting one-micron particles during the examination of the system.

Note the location and evaluate the condition of the sumps for the cooling tower(s), evaporative condenser(s), and fluid cooler(s). These sumps are sometimes located indoors to protect them from freezing. Record the locations of any cross-connections between the cooling tower water system and any domestic water system. These may supply a back-up source of cool water to refrigeration condenser units or serve to supply auxiliary cooling units.

The lack of a regular maintenance schedule or water-treatment program for a cooling tower or evaporative condenser system strongly suggests a potential for Legionella contamination.

3. STEP 3

Assess the results of the walkthrough investigation to determine the course of action. If no potential problems are identified, the operating temperatures measured at water heaters are $60^{o}C$

(140 ^{o}F) or above, and the delivery temperature at distant faucets is 50^{o}C (122^{o}F) or higher, no further action will be necessary. However, if the system is poorly maintained and operating temperatures are below recommended minimums, then recommendations for corrective action should be made.

4. STEP 4

Recommend Control Actions. Details of suggested control actions are discussed in Section E. These actions may include disinfection of the domestic water system via heat treatment, chlorination, or other means, and cleaning and disinfecting the cooling tower system according to the Wisconsin Division of Health protocol for "Control of Legionella in Cooling Towers" or a similar process for cleaning heat rejection systems that follows sound practices to minimize potential for Legionella growth.

Additional actions may include eliminating dead legs in the plumbing system, insulating plumbing lines and installing heat tracing to maintain proper temperatures in the system, eliminating rubber gaskets, and removing or frequently cleaning fixtures such as aerators and shower heads.

Corrective actions limited to raising the water heater temperature without evaluating the system for points of stagnation, heat loss and gain, cross-contamination, and other factors that contribute to growth are generally not sufficient.

For a level-one investigation it is not recommended that water samples be collected to confirm the presence of Legionella in the system. The absence of proper operating conditions alone is sufficient for assuming that the water system can pose an unnecessary risk to the employees. Take water samples after the completion of the control actions to confirm that the corrective measures were successful. The employer may also want to obtain samples before starting corrective actions to assess the extent of the problem.

The employer should take necessary corrective actions even if the results of presampling are negative. Water sampling can produce false negatives, a contaminated portion of the system may have been missed, and the absence of Legionella organisms at the time of sampling does not insure that the system will remain negative.

If, after control actions, the Legionella levels in a water source exceed the guidelines in Appendix III:7-3, re-examine the water system to determine if potential contamination points within the system were overlooked and reassess control procedures to determine if they were performed properly. Repeat the procedures as needed until contamination levels meet the guidelines.

D. Level-Two Investigation

A level-two investigation is similar to a level-one investigation with several additional steps. Supplemental actions include: (1) medical surveillance of all employees currently on sick leave to identify any new cases, (2) employee awareness training on the disease to minimize employee concerns and aid in early recognition of new cases, (3) assessment of past sick-leave absences for

undetected cases of the disease, and (4) collection of water samples during the walk-through assessment.

1. STEP 1

Assess water systems as described for a level-one investigation.

2. STEP 2

Conduct a second walkthrough survey of the facility and collect water samples. Estimate the size of the building and the number of water services during the initial walkthrough and prearrange supply and shipping of the required number of sterile sample containers with the appropriate laboratory. (See Appendix III:7-2 for water sampling procedures.).

3. STEP 3

Initiate an employee awareness program and monitor current sick leave for new cases. It is important to ensure that employees understand the early symptoms of the disease and seek medical assistance promptly. It is imperative not to alarm the workers. It is equally important to stress the importance of the need to know the health status of all employees on sick leave. (See Appendix III:7-1, Employee Awareness Program.)

4. STEP 4

Review worker absences to detect other cases. This requires identification of all employees who took three or more consecutive days of sick leave from approximately six weeks before the case of Legionnaires' disease was identified up to the present. Request those employees who may have had pneumonia during this period to undergo additional voluntary tests for evidence of Legionnaires' disease. (See Appendix III:7-4, Case Identification.)

5. STEP 5

Assess results of worker absence survey and analysis of water systems. If evidence indicates more than one case of Legionnaires' disease at the workplace, then the site should be treated as having an outbreak. Take immediate control of all water sources to eliminate potential for exposure, and take measures to eliminate the hazard. (See Appendix III:7-5.)

No action is necessary if the results of the investigation are negative, that is, (1) all water and HVAC systems are well maintained and in good operating condition; (2) all water sample results are negative or acceptably low (Appendix III:7-3); and (3) no new cases of the disease have been identified at the work site. Under these circumstances, assume that the site is not the origin of the identified case.

6. STEP 6

For recommended control actions, see the level-one investigation.

ONGOING OUTBREAK

If the evidence indicates that two or more cases of Legionnaires' disease have occurred at a site, and at least one of the cases was within the last 30 days, assume that an outbreak is in progress and requires a high-priority investigation and prompt action. Conduct a level-two investigation as outlined above, and take the following precautions to protect building occupants.

Immediately initiate control measures to prevent additional exposures to all water systems that have a reasonable potential for worker exposure including hot and cold domestic water, cooling towers, humidifiers, and any other potential sources of water exposure. Collect appropriate water samples to determine Legionella levels before shutting down the water systems (Appendix III:7-2). These sample results will be invaluable in establishing the cause of the outbreak. A member of the building maintenance or engineering staff who has a working knowledge of the system's design and current operation can explain how the water system operates and the proper procedure for a controlled shutdown.

These control actions need not require facility shutdown. Temporary provisions can allow work to continue: bottled water can be supplied for drinking, shutting off water heaters can eliminate hot-water access, and temporary cooling towers can allow work to continue.

V. Controls

A. General Discussion

This section contains background information on water system operations and proper controls to prevent Legionella amplification. This discussion encompasses a variety of water systems, some of which have not been implicated with outbreaks of Legionnaires' disease. Nevertheless, it is important to remember that any water system can be a source of disease if the water in it is subjected to conditions that promote growth of the organism. Remember, however, that the primary sources of exposure to contaminated water are heat rejection systems (cooling towers, fluid coolers, etc.) and domestic hot-water systems.

B. Cooling Towers, Evaporative Condensers, and Fluid Coolers

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

Because all of these systems use a fan to move air through a recirculated water system, a considerable amount of water vapor is introduced into the surroundings despite the presence of

drift eliminators designed to limit vapor release. In addition, this water may be in the ideal temperature range for Legionella growth, 20^{o}-50^{o}C, 68^{o} -122^{o} F.

1. INSPECTION AND MAINTENANCE

Visual inspection and periodic maintenance of the system are the best ways to control growth of Legionella and related organisms. Good maintenance is necessary both to control Legionella growth and for effective operation. The system should be properly monitored and maintained to prevent buildup of scale and sediment and bio-fouling, all of which support Legionella growth and reduce operating efficiency.

2. BIOCIDE

Unfortunately, measurements of water quality such as total bacterial counts, total dissolved solids, and pH have not proven to be good indicators of Legionella levels in cooling towers. Periodic use of biocides is needed to ensure control of Legionella growth.

Little information exists on the demonstrated effectiveness of many commercial biocides for preventing Legionella growth in actual operations. Recent Australian studies indicate that Fentichlor [2,2'-thiobis(4-chlorophenol) used weekly for 4 hours at 200 ppm, or bromo-chloro-dimethyl-hydantoin (BCD) in a slow-release cartridge at an initial concentration of 300 ppm are effective in controlling the growth of Legionella. There are no U.S. suppliers of Fentichlor, although the chemical is liscensed by the EPA for water treatment in cooling towers. Towerbrom 60M^{TM}, a chlorotriazine and sodium bromide salt mixture, has been reported to be effective when alternated with BCD for control of Legionella in U.S. studies of Legionella contamination of cooling towers. The Australian study also indicates that quaternary ammonium compounds, widely used for control of bio-fouling in cooling towers, are not effective in controlling Legionella.

Traditional oxidizing agents such as chlorine and bromine have been proven effective in controlling Legionella in cooling towers. Continuous chlorination at low free residual levels can be effective in controlling Legionella growth. It is important, however, that the proper oxidant level be established and maintained because free residual chlorine above 1 ppm may be corrosive to metals in the system and may damage wood used in cooling towers; free residual levels below 1 ppm may not adequately control Legionella growth. Chlorine also combines with organic substances in water to form toxic by-products that are of environmental concern.
Frequent monitoring and control of pH is essential for maintaining adequate levels of free residual chlorine. Above a pH of 8.0, chlorine effectiveness is greatly reduced. Proper control of pH will maintain the effectiveness of chlorination and minimize corrosion.

Bromine is an effective oxidizing biocide. It is frequently added as a bromide salt and generated by reaction with chlorine. Bromine's effectiveness is less dependent than chlorine on the pH of the water; it is less corrosive; and it also produces less toxic environmental by-products.

The effectiveness of any water-treatment regimen depends on the use of clean water. High concentrations of organic matter and dissolved solids in the water will reduce the effectiveness of

any biocidal agent. Each sump should be equipped with a "bleed," and make-up water should be supplied to reduce the concentration of dissolved solids.

3. DESIGN

One of the most effective means of controlling the growth of Legionella is to maintain sump water at a low temperature. 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 that may be low enough to limit Legionella amplification. System design should recognize the value of operating with low sump-water temperatures.

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. Other important design features include easy access or easily disassembled components to allow cleaning of internal components including the packing (fill). Enclosure of the system will prevent unnecessary drift of water vapor, and other design features to minimize the spray generated by these systems are also desirable.

4. FREQUESNCY OF CLEANING

Cooling towers should be cleaned and disinfected at least twice a year. Normally this maintenance will be performed 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 of Legionella may require additional cleaning. 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 Legionella growth.

5. WISCONSIN PROTOCOL

Acceptable cleaning procedures include those described in the Wisconsin Protocol. This procedure calls for an initial shock treatment with 50 ppm free residual (total) chlorine, addition of detergent to disperse bio-fouling, maintenance of 10 ppm chlorine for 24 hours, and a repeat of the cycle until there is no visual evidence of biofilms. To prevent exposure during cleaning and maintenance, wear proper personal protective equipment: a Tyvek-type suit with a hood, protective gloves, and a properly fitted respirator with a high-efficiency particulate (HEPA) filter or a filter effective at removing one-micron particles.

6. RECORDKEEPING

A description of the operating system (which includes all components cooled by the system) and details of the make-up water to the system should be available. Written procedures for proper operation and maintenance of the system should indicate the use of scale and corrosion inhibitors, antifoaming agents, and biocides or chlorine use and should be readily available. Log books should list dates of inspections and cleanings, water-quality test results, and maintenance.

C. Domestic Hot-Water Systems

1. BACKGROUND

Domestic hot-water systems are frequently linked to Legionnaires' outbreaks. The term "domestic" applies to all nonprocess water used for lavatories, showers, drinking fountains, etc., in commerical, residential, and industrial settings. Disease transmission from domestic hot water may be by inhalation or aspiration of Legionella-contaminated aerosolized water. Water heaters that are maintained below 60^{o}C (140^{o}F) and contain scale and sediment tend to harbor the bacteria and provide essential nutrients for commensal micro-organisms that foster growth of L. pneumophila. Large water heaters like those used in hospitals or industrial settings frequently contain cool zones near the base where cold water enters and scale and sediment accumulate. The temperature and sediment in these zones can provide ideal conditions for amplification of the organism. Dead legs and nonrecirulated plumbing lines that allow hot water to stagnate also provide areas for growth of the organism.

2. DESIGN

Water systems designed to recirculate water and minimize dead legs will reduce stagnation. If potential for scalding exists, appropriate, fail-safe scald-protection equipment should be employed. For example, 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. Proper insulation of hot-water lines and heat tracing of specific lines can help maintain distribution and delivery temperatures.

3. MAINTENANCE

To minimize the growth of Legionella in the system, domestic hot water should be stored at a minimum of 60^{o}C (140^{o}F) and delivered at a minimum of 50^{o}C (122^{o}F) to all outlets. The hot-water tank should be drained periodically to remove scale and sediment and cleaned with chlorine solution if possible. The tank must be thoroughly rinsed to remove excess chlorine before reuse.

Eliminate dead legs when possible, or install heat tracing to maintain 50^{o}C (122^{o}F) in the lines. Rubber or silicone gaskets provide nutrients for the bacteria, and removing them will help control growth of the organism. Frequent flushing of these lines should also reduce growth.

Domestic hot-water recirculation pumps should run continuously. They should be excluded from energy conservation measures.

4. CONTROL

Raising the water-heater temperature can control or eliminate Legionella growth. Pasteurize the hot water system by raising the water-heater temperature to a minimum of 70^{o}C (158^{o}F) for 24 hours and then flushing each outlet for 20 minutes. It is important to flush all taps with the hot water because stagnant areas can "re-seed" the system. Exercise caution to avoid serious burns from the high water temperatures used in Pasteurization.

Periodic chlorination of the system at the tank to produce 10 ppm free residual chlorine and flushing of all taps until a distinct odor of chlorine is evident is another means of control. 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 is extremely important to ensure that there is adequate residual chlorine in the system.

Alternative means to control Legionella growth include the use of metal ions such as copper or silver (which have a biocidal effect) in solution. Ozonization injects ozone into the water. 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, but stagnant zones may diminish the effectiveness of this treatment. Scale buildup on the UV lamp surface can rapidly reduce light intensity and requires frequent maintenance to ensure effective operation.

D. Domestic Cold-Water Systems

Domestic cold water systems are not a major problem for Legionella growth. Maintaining cold-water lines below 20^{o}C will limit the potential for amplification of the bacteria. It is surprising, however, that elevated levels of Legionella have been measured in ice machines in hospitals. Cold-water lines near heat sources in the units are believed to have caused the amplification.

Dental water lines have recently been recognized as common sources of water contaminated with high concentrations of microorganisms including Legionella. However, to date an increased risk of disease among dental staff or patients has not been demonstrated. Dental water line operating conditions are especially appropriate for Legionella proliferation because the water is stagnant a majority of the time, the narrow plastic tubing encourages biofilm formation, and the water temperature is usually 20^{o}C (68^{o}F) or higher some systems maintain water at 37^{o}C (98.6^{o} F). Filtration of water at the point of use with replaceable, in-line, 0.22 micron pore size filters is recommended for minimizing risk to patients and staff in a dental facility.

Water tanks that allow water to remain uncirculated for long periods can also promote growth of bacteria. Such tanks should be eliminated or designed to reduce storage time to a day or less. They should also be covered to prevent contamination and protected from temperature extremes.

Cross-contaminations of the domestic cold-water system with other systems should always be suspected. All connections to process water should be protected by a plumbing code-approved device (e.g., back-flow preventer, air gap, etc.).

If significant contamination of the domestic cold water system occurs, the source of contamination must be determined. Inspect the system for "dead legs" and areas where water may stagnate. Elimination of these sections or frequent flushing of taps to drain the stagnant areas may be necessary to limit growth of the organism. Insulate cold-water lines that are close to hot-water lines to reduce the temperature in the line.

If the cold-water lines have significant contamination, hyperchlorination can eradicate Legionella. Free chlorine levels of 20 to 50 ppm are allowed to remain for one hour at 50 ppm,

or two hours at 20 ppm. Faucets are then allowed to run until the odor of chlorine is present, and the water is allowed to remain for approximately two hours.

E. HVAC Systems

HVAC systems are not normally amplification sites for Legionella. The organism cannot survive without water, and a properly operated, well-maintained HVAC system is unlikely to be a source of problems. However, the HVAC system can disseminate contaminated water aerosols.

Water-aerosol sources are classified as either external or internal.

External sources may emit contaminated aerosolized water that is drawn into a system's fresh-air intake. Mist discharged from cooling towers, evaporative condensers, and fluid coolers can be ingested by the HVAC fresh air intake. When evaluating this path, you should consider:

- prevailing wind direction and velocity,
- building effects (e.g., low-pressure zones on leeward sides of buildings and on roof),
- architectural screen walls, and
- distance from tower to intake.

Fresh-air intake areaways, typically concrete plenums located at grade level, supply fresh air to air handlers in the basement or lower levels of buildings and can collect organic material (e.g. leaves, dirt, etc.) and water from rain or irrigation.

Do not ignore direct paths such as through an open window. The transmission path through the HVAC system is torturous, and the bacteria may die from desiccation in the airstream or impact on internal surfaces like filters, duct lining, etc. When evaluating external sources, examine the potential for direct transmission.

Internal sources may provide contaminated aerosolized water that is then disseminated by the air-distribution system. Contaminated water can leak from pipes into HVAC ducts, where it can be aerosolized and distributed by the system. Potential sources of contaminated water include domestic water systems, fire-sprinklers, refrigeration condensers, etc.

HVAC system humidifiers can be hazards. Four types are common:

- Heated-pan humidifiers use a heat source to evaporate water from a pan open to the air stream. Intermittent use of the device coupled with a warm pan of water may support Legionella growth. Contaminant-free water is essential.
- Direct steam-type humidifiers inject boiler-generated steam directly into the air stream. These systems normally operate above 70 ^{o} C (158 ^{o} F), and Legionella cannot survive at that temperature.
- Atomizing humidifiers use mechanical devices or pneumatic air to create a water mist that evaporates into the air stream. A contaminant-free water source is essential.

- Direct evaporative air coolers may be used as humidifiers. These devices mix water and air in direct contact to create a cool, wet air stream by evaporation. These devices include sumps, which may stagnate when not in use.

When draining properly, the water that passes through the condensate pans of cooling coils in an air handler is normally not a source of growth for the organism because of the low temperature of water condensate.

Indirect evaporative air cooling in systems designed for dryer climates. One common design circulates cool water from a cooling tower sump through a water coil in the supply air stream. If the coil develops a leak, then pumped cooling tower water will be injected directly into the supply air stream with potentially deleterious effects if the sump water is contaminated with Legionella.

Indirect evaporative air cooling is also found in air-to-air heat exchangers. One side of the heat exchanger is an evaporative-cooled wet air stream, and the other side supplies air for the conditioned space. If the heat exchanger leaks, the wet air stream can mix with supply air and cause problems if the wet air stream is contaminated with Legionella.

Many air-handling systems designed for dryer climates employ direct evaporative air cooling. Wet evaporative coolers, slinger air coolers and rotary air coolers common in commercial applications. These devices mix water and air in direct contact to create a cool, wet air stream by evaporation. If these systems are using 100% outside air in a dry climate, the water sump temperature may be low and will not represent a significant risk. However, improperly operated and maintained systems that use warm, stagnant sump water can present problems.

Other equipment may also be potential sources of Legionella.

- Residential humidifiers are small, free-standing, portable units that use an internal fan and wet media to disseminate a wet air stream. The sumps of these devices are frequently contaminated with Legionella. Daily cleaning is necessary to maintain acceptable water quality, but these units seldom receive appropriate maintenance, and their use in the commercial or industrial workplace is strongly discouraged.

- Computer room air-conditioners typically include humidifiers and frequently are not well maintained. They may contain a sump filled with contaminated water.

The following are issues to consider when designing HVAC systems to minimize risk from Legionella contamination. Most apply to all types of microbial contamination.

- Minimize use of water reservoirs, sumps, and pans. Chemically untreated, stagnant, warm-water sources provide an ideal environment for Legionella growth.

- Provide a way to drain water sumps when not in use, e.g., an electric solenoid valve on the sump drain. If an HVAC sump is used during the hours when a building is occupied, drain the sump during unoccupied hours.

- Provide a "bleed" for water sumps so that dissolved solids do not form sediments in the sump.
- Slope 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. The American Conference of Governmental Industrial Hygienists publishes "Guidelines for the Assessment of Bioaerosols in the Indoor Environment," which lists recommended minimum distances between cooling towers and fresh-air intakes.
- 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.
- Use steam or atomizing humidifiers instead of units that use recirculated water. Do not use raw steam from the central heating boiler because it contains corrosion inhibitors and anti-scaling chemicals. Atomizing humidifiers must have contaminant-free water.

Operate all HVAC equipment as originally designed, and maintain it so that it can perform as designed. Test all HVAC equipment periodically to insure that it is performing as designed. Inactive sumps must be properly drained and bled to prevent accumulation of sediments. Maintenance failures can produce contaminated, stagnant water that can become an ideal environment for *Legionella* growth if heated (e.g., by sunlight).

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APPENDIX III:7-1. Employee Awareness Program

The purpose of an employee awareness program is to inform the employees of the potential outbreak, and to educate them about the disease. This educational program should be part of a level-two investigation or for a Legionnaires' disease outbreak. This program is of critical importance to aid in early recognition of the disease. It is also important to help alleviate employee concerns about the disease. This program should supplement the case identification program to discover previously undetected cases of the illness at the work site.

The employer should implement the following elements of this program immediately upon recognition of more than one probable or confirmed case of disease in the work place:

1. An initial employee training session which provides basic information about the disease and actions being taken to investigate the problem.

2. An ongoing general information service to provide updates and answer questions that may arise among employees.

3. Medical and psychological counseling services when an outbreak has occurred.

Below is a sample letter and supplemental information on the disease that the employer can use for informing employees of a potential or actual outbreak.

SAMPLE LETTER FROM EMPLOYER TO EMPLOYEES

DATE:

MEMO TO: ALL EMPLOYEES

FROM: MANAGEMENT OFFICIAL

SUBJECT: Legionnaires' Disease

On _____, we were notified that one of the employees of our company had contracted legionellosis, commonly referred to as Legionnaires' disease. The employee is assigned to _____ on _____ shift.

We want to share with you some general information concerning the disease. In addition, we want to tell you what we are currently doing here at _____ to ensure all necessary steps are taken to address health concerns.

Legionellosis, or Legionnaire's disease, is a type of pneumonia caused by Legionella bacteria. Legionnaires' disease is not contagious, and you cannot catch it from another person. The bacteria are common and grow in water. People often receive low-level exposure in the environment without getting sick. Legionellosis usually occurs only when someone who is already susceptible receives concentrated exposure to the bacteria. Persons

who are heavy smokers, elderly, or whose ability to resist infection is reduced are more likely to contract Legionnaires' disease than healthy nonsmokers. According to the Centers for Disease Control in Atlanta, there are between 10,000 and 50,000 cases of Legionnaire's disease every year in the U.S. We are cooperating fully with local health officials who are investigating this matter. Most cases of legionellosis are isolated and are not associated with an outbreak. To date, _____ case(s) of the disease has/have occurred among employees in this facility.

To identify any other cases, we will review sick-leave records for the period _____ to _____. Employees who took more than three consecutive days of sick leave will be identified, and we will attempt to determine if any in that group experienced pneumonia-like symptoms (fever, shortness of breath, cough). Those who used three or more consecutive days of sick leave during this period can expect to be contacted by a representative of our company for an interview. If you experienced a pneumonia-like illness in the past two months but used fewer then three consecutive days of sick leave, contact _____ to arrange an interview.

To assure that you are being protected during the interim, we are also instituting a medical surveillance program to identify any new or old cases. Part of this surveillance will be to ask you a few questions about your illness when you call in sick to your supervisor.

In addition, we are offering counseling and employee information services. If you would like to take advantage of these services or want more information, contact your manager. For the present, please pay attention to the following important points:

WHAT YOU SHOULD DO NOW:

1. If you are not sick, there is no need for you to see a doctor.

2. If you are now sick with a cough and fever:

A. See your private doctor or contact _____ to arrange to see a _____ physician.

B. Tell the physician that you work in a building that may be involved in a Legionnaires' disease outbreak.

C. If you see a physician, notify _____ so that your illness can be tracked.

If you have any concerns or questions concerning this issue, please ask your manager. Your health and safety are of great concern to us, and we will be grateful for your cooperation in this matter. As further information develops we will keep you informed.

SAMPLE INFORMATION TO BE OBTAINED BY INTERVIEW WITH EMPLOYEES CALLING IN ON SICK LEAVE

Interviewer:_____Date:_____

SUPERVISOR SURVEY FORM

We are screening employee illnesses as a result of our Legionnaire's disease incident. You are not obligated to participate in the survey, but your participation will help you and your fellow workers.

We recommend that you see a physician if you currently have pneumonia-like symptoms such as severe chills, high fever, a cough, and difficult breathing.

Are you currently experiencing these symptoms?

Yes_____ No_____ Prefer not to answer_____

- If the answer to the question is "No," do not complete the rest of this form. Thank you for your cooperation.
- If the answer is "Yes," please read the statement below and complete the bottom half of this form (Employee name, etc).
- If you answer is "Prefer not to answer," please complete ONLY the bottom half of this form (Employee name, etc).

STATEMENT: You will be contacted by _____ to obtain additional information necessary to complete our survey.

Thank you!

Employee's Name _____

Work Telephone Number _____

Home Telephone Number _____

Shift: Day ___ Swing ___ Graveyard ___ Rotating ___

Branch _____/Organization Code _____

Employee's Supervisor _____

Telephone Number _____

Date _____

PLEASE FORWARD TO _____ BY 10:00 am EACH DAY

LEGIONNAIRES' DISEASE: QUESTIONS AND ANSWERS

BACKGROUND

Legionnaires' disease is a common name for one of the several illnesses caused by Legionella bacteria. Legionnaires' disease is an infection of the lungs that is a form of pneumonia. A person can develop Legionnaires' disease by inhaling water mist contaminated with Legionella.

Legionella bacteria are widely present at low levels in the environment: in lakes, streams, and ponds. At low levels the chance of getting Legionnaires' disease from a water source is very slight. The problem arises when high concentrations of the organism grow in water sources. Water heaters, cooling towers, and warm, stagnant water can provide ideal conditions for the growth of the organism.

Scientists have learned much about the disease and about the Legionella bacteria since it was first discovered in 1976. The following questions and answers will help you learn more of what is currently known about Legionnaires' disease.

Q. What are the symptoms of Legionnaires' disease?

A. Early symptoms of the illness are much like the flu. After a short time (in some cases a day or two), more severe pneumonia-like symptoms may appear. Not all individuals with Legionnaires' disease experience the same symptoms. Some may have only flu-like symptoms, but to others the disease can be fatal.

Early flu-like symptoms:

- slight fever
- headache
- aching joints and muscles
- lack of energy, tired feeling
- loss of appetite

Common pneumonia-like symptoms:

- high fever (102^{o} to 105^{o} F, or 39^{o} to 41^{o} C)
- cough (dry at first, later producing phlegm)

- difficulty in breathing or shortness of breath
- chills
- chest pains

Q. How common is Legionnaires' disease?

A. It is estimated that in the United States there are between 10,000 and 50,000 cases each year.

Q. How does a person get Legionnaires' disease?

A. A person must be exposed to water contaminated with Legionella bacteriua. This exposure may happen by inhaling or drinking water contaminated with the Legionella bacteria. For example, inhaling contaminated water mist from a cooling tower, a humidifier, or even a shower or sink can cause the disease.

Q. How soon after being exposed will a person develop symptoms of the disease?

A. If infection occurs, disease symptoms usually appear within 2 to 10 days.

Q. Are some people at a higher risk of developing Legionnaires' disease?

A. Yes, some people have lower resistance to disease and are more likely to develop Legionnaires' disease. Someof the factors that can increase the risk of getting the disease include:

- organ transplants (kidney, heart, etc.),
- age (older persons are more likely to get disease),
- heavy smoking,
- weakened immune system (cancer patients, HIV-infected individuals),
- underlying medical problem (respiratory disease, diabetes, cancer, renal dialysis, etc.),
- certain drug therapies (corticosteroids), and
- heavy consumption of alcoholic beverages.

Q. Is Legionnaires' disease spread from person to person?

A. No. Legionnaires' disease is not contagious and cannot be transmitted from one person to another.

Q. What causes Legionnaires disease?

A. Legionnaires' disease is caused by inhaling water contaminated with rod-shaped bacteria called Legionella pneumophila. There are over 30 different species of Legionella, many of which can cause disease. Legionella pneumo-phila is the most common species that causes disease.

Q. Does everyone who inhales Legionella into the lungs develop Legionnaires' disease?

A. No. Most people have resistance to the disease. It is thought that fewer than 5 out of 100 persons exposed to water contaminated with Legionella will develop Legionnaires' disease.

Q. Is Legionnaires' disease easy to diagnose?

A. No. The pneumonia caused by Legionella is not easy to distinguish from other forms of pneumonia. A number of diagnostic tests allow a physician to identify the disease. These tests can be performed on a sample of sputum, blood, or urine.

Q. How is Legionnaires' disease treated?

A. Erythromycin is currently the antibiotic of choice. Early treatment reduces the severity and improves chances for recovery. In many instances this antibiotic may be prescribed without the physician's knowledge that the disease is Legionnaires' because erythromycin is effective in treating a number of types of pneumonia.

Q. How did Legionnaires' disease get its name?

A. Legionnaires' disease got its name from the first outbreak in which the organism was identified as the cause. This outbreak occurred in 1976, in a Philadelphia hotel where the Pennsylvania American Legion was having a convention. Over 200 Legionnaires and visitors at this convention developed pneumonia, and some died. From lung tissue, a newly discovered bacterium was found to be the causeof the pneumonia and was named Legionella pneumophila.

Q. Is Legionnaire's disease a new disease?

A. No, Legionnaires' disease is not new, but it has only recently been identified. Unsolved pneumonia outbreaks that occurred before 1976 are now known to have been Legionnaires' disease. Scientists are still studying this disease to learn more about it.

Q. Are Legionella bacteria widespread in the environment?

A. Yes, studies have shown that these bacteria can be found in both natural and man-made water sources. Natural water sources including streams, rivers, freshwater ponds and lakes, and mud can contain the organism in low levels.

Q. Could I get the disease from natural water sources?

A. It is unlikely. In the natural environment the very low levels of this organism in water sources probably cannot cause disease.

Q. What water conditions are best for growth of the organism?

A. Warm, stagnant water provides ideal conditions for growth. At temperatures between 68 ^{o} and 122 ^{o} F the organism can multiply. Temperatures of 90 ^{o} -105 ^{o} F are ideal for growth. Rust (iron), scale, and other micro-organisms can also promote the growth of Legionella.

Q. What common types of water are of greatest concern?

A. Water mist from cooling towers or evaporative condensers, evaporative coolers (swamp coolers), humidifiers, misters, showers, faucets, and whirlpool baths can be contaminated with the organism and if inhaled or swallowed can cause the disease.

Q. Can Legionnaires' disease be prevented ?
A. Yes. Avoiding water conditions that allow the organism to grow to high levels is the best means of prevention. Specific preventive steps include:

- Regular maintenance and cleaning of cooling towers and evaporative condensers to prevent growth of Legionella. This should include twice-yearly cleaning and periodic use of chlorine or other effective biocide.
- Maintain domestic water heaters at 140 ^{o} F (60 ^{o} C). The temperature of the water should be 122 ^{o} F or higher at the faucet.
- Avoid conditions that allow water to stagnate. Large water-storage tanks exposed to sunlight can produce warm conditions favorable to high levels of Legionella. Frequent flushing of unused water lines will help alleviate stagnation.

Q. Do you recommend that I operate my home water heater at 140 ^{o} F?

A. Probably not if you have small children or infirm elderly persons who could be at serious risk of being scalded by the hot water. However, if you have persons living with you who are at high risk of contracting the disease, then operating the water heater at a minimum temperature of 140 ^{o} F is probably a good idea.

Q. What can be done if a water system is already contaminated or is suspected of being contaminated?

A. Special cleaning procedures can eliminate Legionella from water sources. In many cases these procedures involve the use of chlorine-producing chemicals or high water temperatures. Professional assistance should be sought before attempting to clean a water system.

Q. Can my home water heater also be a source of Legionella contamination?

A. Yes, but evidence indicates that smaller water systems such as those used in homes are not as likely to be infected with Legionella as larger systems in work places and public buildings.

Q. Can Legionella bacteria cause other diseases?

A. Yes. In addition to Legionnaires' disease, the same bacteria also cause a flu-like disease called Pontiac fever.

Q. How does Pontiac fever differ from Legionnaires' disease?

A. Unlike Legionnaires disease, which can be a serious and deadly form of pneumonia, Pontiac fever produces flu-like symptoms that may include fever, headache, tiredness, loss of appetite, muscle and joint pain, chills, nausea, and a dry cough. Full recovery occurs in 2 to 5 days without antibiotics. No deaths have been reported from Pontiac fever.

Q. Are there other differences between Legionnaires' disease and Pontiac fever?

A. Yes. Unlike Legionnaires' disease, which occurs in only a small percentage of persons who are exposed, Pontiac fever will occur in approximately 90% of those exposed. In addition, the time between exposure to the organism and appearance of the disease (called the incubation period) is generally shorter for Pontiac fever than for Legionnaires' disease. Symptoms of Pontiac fever can appear within one to three days after exposure.

APPENDIX III:7-2. Physical Survey and Water Sampling Protocol*

Arrange with the appropriate laboratory for supply and shipment of sterile sampling containers, and for analysis of water samples. During the initial walk-through, estimate the size of the building and the number of water services at the facility to determine the number of samples and the size of the purchase order.

When investigating the water services within a building, it will be helpful to obtain or prepare a simple schematic diagram of the water services. Note the following features:

1. The location of the incoming supply and/or private source.

2. The location of storage tanks, water treatment systems, and pumps.

3. The location of water heaters and boilers.

4. The type of fittings used in the system (e.g., taps, showers, valves) and the material from which the pipework is made.

5. The location of all cooling towers, evaporative condensers, and fluid coolers at the facility. 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.

6. The location of any evaporative cooling systems or humidifiers.

7. The location of ornamental fountains, whirlpools, eye washes, safety showers, or other water sources within or near the facility.

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. Also note carefully any disconnected fittings, "dead legs," and cross-connections with other services.

Once you have identified these features, take water samples from:

1. The incoming water supply.

2. Each storage tank and water heater.

3. A representative number of faucets for each of the hot and cold water systems in the facility.

4. All cooling towers, evaporative condensers, humidifiers, spas, showers, etc.

5. The water entering or leaving any other type of fitting or piece of equipment under particular suspicion.

It is important not to overlook any potential water sources in the building. Water from ice machines, hand spray bottles, decorative fountains, and for plastic injection molding equipment have been implicated in past outbreaks or have been found to be significantly contaminated. The ability to maintain an open mind is essential in conducting an investigation because of the variety of potential sources of contamination at a facility.

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* Source: Dennis, P. J. L. "An Unnecessary Risk: Legionnaires' Disease" in Biological Contaminants in Indoor Environments, ASTP STP 1071, P. R. Morey, J. C. Feeley, Sr., and J. A. Otten, Eds. American Society for Testing and Materials, Philadelphia. 1990.

WATER SAMPLING PROCEDURE

Wear appropriate respiratory protection in the form of a half-face piece respirator equipped with a HEPA filter or a similar type of filter media capable of effectively collecting particles in the one micron size range during the examination of water systems if a significant potential exists for exposure to high concentrations of contaminated aerosols.

Collect samples in polypropylene (nalgene) containers (250 mL-1 L) that have been autoclaved at 121°C for 15 minutes. The microbiological laboratory that will analyze the samples should be able to provide the bottles. A local hospital or state health department should be able to autoclave the bottles. It is important not to flush the system to be sampled before collecting samples. Collect at least a 250 mL sample. Measure the temperature of the sampled water. It is preferable to accomplished this by measuring the water stream flowing from the water source and not by placing the thermometer in the sample container. To avoid cross-contamination of the samples, sanitize the thermometer with isopropyl alcohol before measuring the temperature of each sample. When measuring temperature from faucets, showers, water fountains, etc., record the initial water temperature, and then allow the fixture to discharge until the temperature stabilizes. Record the initial and final temperatures, and the time needed to stabilize.

Domestic Water Heaters

- Take a sample of water from the bottom drain.
- Collect a sample of water from the outlet pipe if the plumbing provides for access.

Faucets and Shower

- Collect a "before-flush" (initial flow) sample of water.
- Collect an "after-flush" sample of water when the maximum temperature has been reached.

The initial (before-flush) sample is intended to indicate the level of contamination at the sample point or fitting, and the final sample should reveal the quality of the water being supplied to the fitting. Collect sterile-swab samples from faucets or shower heads by removing the fitting and

vigorously swabbing the interior. Swab samples may be positive for *Legionella* even when water samples from the source are negative. Sterile test tubes containing sterilized swabs are available for convenient sampling and shipping.

Cooling Towers

- Take a sample from the incoming supply to the tower.
- Take samples from any storage tanks or reservoirs in the system (i.e., chilled-water return tanks or header tanks).
- Take a sample from the basin of the cooling tower at a location distant from the incoming make-up water, and from the water returning from the circulation system at the point of entry to the tower.
- Take a sample of any standing water in the condensate trays or from the cooling coils.

Humidifiers, Swamp Coolers, and Spas

- Take a sample from the water reservoirs. Sample the incoming water supply if it is accessible.
- For cooling towers, humidifiers, swamp coolers, and building water services, collect samples of sludge, slimes, or sediments, particularly where accumulations occur.
- Take swabs of shower heads, pipes, and faucets and rehydrate from water taken from the sampling site. Swab areas of scale buildup (i.e., remove shower heads, faucet screens, and aerators). Use prepackaged sterile swabs and small glass or polypropylene bottles (autoclaved) for this purpose.

SAMPLE TRANSPORTATION

Prepare samples for shipment carefully, as follows:

- 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).

Samples should not be refrigerated or shipped at reduced temperature. They should be protected from temperature extremes such as sunlight or other external heat or cold sources. Ship to laboratory using overnight mail. If shipping on a Friday, make arrangements for weekend receipt. The samples should be stored at room temperature (20° ± 5°C) and processed within 2 days.

APPENDIX III:7-3. Water Sampling Guidelines*

Use the following guidelines to assess the effectiveness of water system maintenance. These guidelines are based on limited data and are subject to change. They are intended to apply only to water systems being used by healthy individuals and are not necessarily protective for persons who are immunocompromised.

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

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

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

Colony Forming Units (CFU) of Legionella per milliliter

Action	Cooling Tower	Domestic Water	Humidifier
1	100	10	1
2	1000	100	10

* Adapted from George K. Morris Ph.D., and Brian G. Shelton, Pathcon Technical Bulletin 1.3, Legionella in Environmental Samples: Hazard analysis and Suggested Remedial Actions, June 1991, Pathogen Control Associates, 270 Scientific Dr., Suite 3, Norcross, Georgia 30092.

APPENDIX III:7-4. Legionnaires' Disease Case Identification

The purpose of this phase of an investigation will be to identify cases of Legionnaires' disease among the workers. The investigation will include identification of all employees who took three or more consecutive days of sick leave days from six weeks before the Legionnaires' case was identified to the present. Following a screening process, all employees who have been identified as having had pneumonia, or potentially having had pneumonia, during this period will be requested to undergo voluntary medical testing to detect evidence of Legionnaires' disease. A physician's diagnosis of pneumonia or pneumonia-like symptoms that include a fever (101^{o}F) and cough indicate a need for further evaluation. A sample program is described below:

1. Examine sick-leave records to identify all employees who used three or more consecutive days of sick leave from 6 weeks before the earliest known case to the present. These employees will be interviewed. If it appears that a employee experienced a pneumonia-like illness, the attached surveillance questionnaire will be completed. Employees who feel that they might have had symptoms of Legionnaires' disease but did not use three or more consecutive days of sick leave should also be interviewed.

2. Employees who have experienced a pneumonia-like illness and have seen a physician should be requested to sign a medical release form to allow the company and/or OSHA to obtain additional information from the physician.

3. The physicians of all employees who have seen a physician and have signed a medical release will be interviewed using the physician interview survey form (attached).

4. Employees participating in surveys such as the one described above must be informed of their Privacy Act rights as well as their right to protect their own medical information. Physician-patient confidentiality must not be violated. Necessary medical information may be communicated only with the patient's written permission. When seeking employees' permission, clearly inform them that the purpose of obtaining a proper diagnosis and sharing this information with the Agency is to protect them and their fellow workers against the potential threat of legionellosis. All medical records will be handled in accordance with 29CFR 1913.10. It may be necessary for the CSHO to obtain medical releases from the employees interviewed so that amplifying information can be obtained from a company health unit or the employee's physician.

5. Arrangements similar to that described above should be sought for permanent contract employees controlled by separate contractor organizations in the building, e.g., janitors, cafeteria workers, security personnel.

6. Based on an interview with the employee's physician, potential cases should be considered for a clinical test to detect additional cases. Most probably this will be a serological test to determine the antibody level of the individual. A single antibody titer of 1/256 or greater based on a physician's diagnosis of pneumonia should be interpreted as a probable case of Legionnaires' disease. In the event that a antibody titer level for Legionella was obtained at the time of illness, or if serum collected from the patient at the

early phase of the illness (acute phase) is available, then an antibody titer level should be determined from this sample to determine the convalescent to acute titer ratio. A fourfold increase in this titer will be sufficient to confirm a case of Legionnaires' disease.

7. Other diagnostic tests may also be appropriate. If the potential case occurred recently, then a urine antigen test may detect Legionella pneumophila serogroup-1 antigen. A positive urine antigen test for a diagnosed pneumonia case is also accepted as a evidence of a confirmed case. However, this test is available only for Legionella pneumophila serogroup-1 infections. Culture currently symptomatic individuals for Legionella. A positive culture indicates confirmation.

8. If this process detects one or more additional cases of disease, then the facility should be considered to have experienced an outbreak. The immediacy of the action will depend on whether the outbreak is ongoing or occurred 30 days or more in the past.

9. Take prompt action to control exposure at the site if there is evidence that the outbreak is still occurring. Whatever the circumstances, initiate control procedures and continue medical surveillance of the workforce to detect any new cases of disease and identify the water source responsible for the outbreak.

HEALTH SURVEILLANCE QUESTIONNAIRE – LEGIONELLOSIS

Records show that you took sick leave for three consecutive days or more. We would like to ask a few questions.

1. Name: (last)_____, (first)_____

   Age:_____ Sex: _____ Work Location: _____

   Home Phone:_____ Work Phone:_____

2. Dates of absence(s):_____

3. Stated reason for absence:_____

Ask about the following symptoms:

4. Fever: Yes ____ No____ If yes, highest temperature _____.
5. Cough: Yes____ No ____
6. Headache: Yes_____ No_____
7. Diarrhea: Yes_____ No_____
8. Shortness of breath: Yes ____ No ____
9. Chest pain: Yes ____ No ____
10. Did you see a physician about these symptoms? Yes ___ No ___

    Was a chest x-ray taken? Yes_____ No_____

    Were you diagnosed as having pneumonia? Yes ___ No ___

    Were you tested for legionellosis? Yes_____ No_____

    Physician's name:_____ Phone:_____

    Physician's Address:_____
11. Were you admitted to a hospital? Yes ____ No ____

    If yes, which hospital?_____

    Admission Date: _____ Date released: _____

12. Interviewer:_____ Date:_____

PHYSICIAN SURVEY QUESTIONNAIRE – LEGIONELLOSIS

We are calling to inform you that _____ is a patient of yours and an employee at _____. He/she has signed a medical release giving us permission to contact you to obtain information about her/his recent illness. This questionnaire will be used to determine if your patient's recent illness could be classified as a pneumonia that may have been caused by exposure to *Legionella* at the workplace.

1. Name of Physician: _____
   Address:_____
   Phone:_____

2. Date of visit(s): (1st)_____ (2nd)_____ (3rd)_____

3. What was the patient's complaint?:_____
   _____

Cough?	yes	no	unknown
Short of breath?	yes	no	unknown
History of fever?	yes	no	unknown

4. Physical Findings: _____
   _____

   Abnormal chest or lung findings: _____
   _____

Rales?	yes	no	not examined
Dyspnea?	yes	no	not examined
Cyanosis?	yes	no	not examined

   Temperature _____
   Other: _____

5. Chest x-ray done? yes no

   Findings: _____

6. Sputum culture? yes no

   Results: _____

   Laboratory: _____

Sputum cultured for *Legionella?* yes no
Laboratory:_____

7. Diagnostic testing? yes no

Type of test: Urine Antigen Test, Direct Fluorescent Antibody Serology Tests:
Indirect Fluorescent Antibody (IFA) _____
ELISA _____
Laboratory:_____

8. Diagnosis or impression: _____

EPIDEMIOLOGICAL QUESTIONNAIRE

Background

Employee's Name:_____ Age:_____ Gender:_____
(last, first)

Home:_____
(city, zip)

Race/Ethnicity: white, black, native American, Hispanic, Asian, Other (circle one)

Are you currently taking any oral steroid medications?: Y/N

On what date did you first become ill?: ___ /___ /___

How many days were you ill?: _____

Was anyone else in your family ill?: Y/N

If Yes, who? _____

What symptoms did they have? _____

Since _____, have any of your friends been diagnosed with pneumonia?:
Yes/No

If Yes, who? _____

Work Exposure

During the 10 days prior to your illness:

Job Description: _____

Primary work area: _____

List all areas in _____ building where you spend any time:

Area	**Hours per week**
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Did you shower at work?: Yes/No

If Yes, where and how may times per week?: _____

List all places you eat lunch:_____

List all places where you take a break: _____

List all restrooms you use: _____

Do you smoke in the restrooms (or spend "extra" time, i.e., if a lounge is present): Yes/No

If Yes, Where:_____

Did you attend any training courses outside of the building?: Yes/No

If Yes, where were they held? _____

Do you have a second job?: Yes/No

If Yes, what job and where:

_____

Any other places that you have not mentioned where you spend time while on the job?:

_____

Community Exposure *(During the 10 days prior to your illness)*

Did you use any health clubs?: Yes/No

If Yes, which ones?: _____

How many times?_____

Did you use any hot tubs (whirlpool spas)?: Yes/No

If Yes, list which hot tubs and when used:

_____

Did you attend any churches?: Yes/No

If Yes, where_____

How many times?_____

Have you had any dental work performed?: Yes/No

If Yes, where_____

How many times?_____

Which grocery stores did you go to?: _____

How often?_____

Did you go to the movies?: Yes/No

If Yes, which one? _____

How often?_____

Did you go to any shopping malls?: Yes/No

If Yes, which one(s)?_____

Did you go to any other public places which you feel might be significant (i.e. public meetings, schools etc.)?: Yes/No

If Yes, where? _____

APPENDIX III:7-5. Water Treatment Protocols for Facilities that have Experienced a Legionnaires' Outbreak

BACKGROUND

This section describes actions required to abate the threat of further infection in a building in which an outbreak of Legionnaires' disease has occurred. For purposes of this document, an "outbreak of Legionnaires' disease" may be said to exist when medically confirmed cases of Legionnaires' disease are epidemiologically associated with a building or some portion of a building. This usually means that two or more confirmed cases of Legionnaires' disease have been identified within a six-week period at the site.

Under most circumstances evacuation of the building is not recommended. It will be necessary, following confirmation of an outbreak, to isolate individuals who are at high risk of contracting the disease from all potential sources of infection. Individuals at high risk include the immunosuppressed, such as persons who have had organ transplants, individuals receiving chemotherapy including corticosteriods, and other individuals in poor health. In addition, a medical monitoring program must be instituted to track all workers currently on sick leave.

Following these initial actions, the building must be inspected to identify all potential Legionella sources including the HVAC cooling systems (cooling towers, evaporative condensers), domestic water systems, humidifiers, and any sources of water that is maintained above 20^{o}C (68^{o}F) and has a potential for being aerosolized.

Before flushing or disinfecting the water in these suspected sources, take water samples for analysis to determine the predominant serotypes and subtypes of L. pneumophila in the water source and to determine the number of colony forming units (CFU) per unit of water. This information will be helpful in identifying the source of the disease if the subtype of L. pneumophila has been identified in the afflicted worker population. Because of the 10-day to two-week delay in obtaining sample results, corrective action should begin immediately.

Because sampling for Legionella can be inconclusive, sampling results alone should not determine the appropriate course of action in a building where an outbreak has occurred. ALL POTENTIAL SOURCES OF CONTAMINATION WILL BE ASSUMED TO BE CONTAMINATED AND TREATED ACCORDINGLY IN THE EVENT THAT AN OUTBREAK HAS OCCURRED. Water sampling and testing must be in accordance with currently accepted, state-of-the-art procedures.

Treatment of potential sources of contamination following sampling is described below. After the treatment collect and analyze water samples for CFU of L. pneumophila to determine the effectiveness of the treatment. Upon re-use of a water system following treatment, periodic maintenance and regular water sampling are essential to ensure that the maintenance continues to be effective. Included are proper maintenance procedures for controlling the organism in a facility's water sources.

COOLING TOWERS AND EVAPORATIVE CONDENSERS

An HVAC condenser water system absorbs heat from the AC refrigeration units and rejects it to the atmosphere through evaporation in cooling towers. Evaporative condensers operate similarly to cooling towers except that refrigerant coils are inside the water path, and water passes over the coils to cool the refrigerant gas directly. Because both cooling towers and evaporative condensers use a fan system to move air through a recirculated water system, they introduce a considerable amount of water vapor into the surroundings even with drift eliminators designed to limit vapor release. In addition, this water is typically in the 20^{o}-50^{o}C (68^{o}-122^{o}F) range, ideal for L. pneumophila growth.

WATER SAMPLING PROTOCOL

Before starting decontamination, collect an adequate number of water samples in sterile containers. These samples should be cultured to determine the degree of contamination and the subtype of L. pneumophila before treatment. Collect at least three water samples (200 milliliters to 1 liter volume). Include water from the incoming make-up water supply, water from the basin of the unit most distant from the make-up water source, and recirculated water from the HVAC system at its point of return to the unit.

CLEAN-UP PROCEDURE

1. Clean and disinfect the entire cooling system including attached chillers and/or storage tanks (sumps) following the"Wisconsin Protocol" Emergency Protocol.
    a. "Shock" treat cooling tower water at 50 ppm free residual chlorine.
    b. Add dispersant.
    c. Maintain 10 ppm chlorine for 24 hours.
    d. Drain system.
    e. Refill and repeat steps a through d.
    f. Inspect system for visual evidence of biofilm. If found, repeat steps a through d.
    g. Perform mechanical cleaning (cooling tower design may require modified procedures).
    h. Refill system, bring chlorine to 10 ppm, and circulate for one hour.
    i. Flush system.
    j. 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. After completing step 1, 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.

4. Once the nondetectable level for L. pneumo-phila has been achieved, institute maintenance as outlined in the Wisconsin Protocol to insure continued safe and proper operation.
    a. Inspect equipment monthly.
    b. Drain and clean quarterly.

c. 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, and monthly microbiologic analysis to ensure control of bacteria.
d. Document operation and maintenance in a log or maintenance records book.

5. Test cooling-system water at the following intervals to verify that there is no significant growth of Legionella.
a. Test weekly for the first month after return to operation.
b. Test every two weeks for the next two months.
c. Test monthly for the next three months.

The standard for Legionella concentration throughout the six months of monitoring is fewer than 10 CFU per milliliter (based on PathCon guidelines). If no water samples exceed this level, monitoring may be suspended. The maintenance program must continue indefinitely.

If any sample contains 10 or more CFU Legionella per milliliter, take immediate steps to reduce levels to acceptable limits. These steps may include increased frequency of application or concentration of biocides, pH adjustment, additional "shock" treatments, or any other action that reduces Legionella levels. Take new water samples and begin the testing schedule again.

Make the results of all water monitoring tests available to building occupants.

DOMESTIC WATER SYSTEMS

Domestic water systems are designed to provide heated water for washing, cleaning, consumption, etc. A large building may have multiple independent systems. 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. It is recommended that water heaters be kept at a minimum of 60^{o}C (140^{o}F) and all water be delivered at each outlet at a minimum of 50^{o}C (122^{o}F).

It is essential to identify all parts of the domestic water systems where water may stagnate (e.g., "dead legs" or laterals that have been capped off, storage tanks that have "dead zones" or are not frequently used). For treatment to be effective, the stagnant zones must be removed from the system. Rubber and plastic gaskets in the plumbing system may also serve as a Legionella growth medium. Eliminate or minimize use of these materials and substitute materials not conducive to Legionella growth. It is also important to 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.

WATER SAMPLING PROTOCOL

Collect water samples before beginning treatment to determine potential contamination. Draw 200 milliliters to 1 liter of water from the draw-off valve of all water heaters into a sterile

container. Check the temperature of the water in these units to determine if it is significantly lower than the set temperature. Sample a representative number of domestic hot-water faucets or outlets. It is important not to flush the faucet before taking a sample because the end section of the water system may be a source of contamination. Collect a 200 milliliter to 1 liter "preflush sample" of the first hot water drawn from the outlet. Allow the water to run and measure the temperature, and then collect a second, "postflush" sample when the water temperature is constant. Submit the water samples to a laboratory qualified to measure CFU of Legionella per milliliter of water.

Use the clean-up procedure below to treat all hot-water systems that have either been tested and found to contain detectable levels of Legionella or have been assumed to be contaminated.

CLEAN-UP PROCEDURE

1. Disinfect the system using any effective chemical, thermal, or other treatment method. For example:
    a. Pasteurize the hot water system by heating the water to at least 70^{o}C (158^{o}F) and maintain this temperature for a minimum of 24 hours. Maintaining the temperature at 70^{o}C (158^{o}F) and continuously flush each faucet on the system with hot water for 20 minutes.
    b. 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.
    c. Follow any other technique that has demonstrated effectiveness and safety.

2. Maintain domestic water heaters at 60^{o}C (140^{o}F) and water delivered at the faucet at a minimum of 122^{o}F (50^{o}C). Where these temperatures cannot be maintained, control Legionella growth with a safe and effective alternative method.

3. After treatment, resample the hot water from each storage tank. If Legionella are detected, re-treat and resample the water system. If no measurable levels are found in this system and all other potential sources have also been addressed, go to the next step.

4. Test the domestic hot- or warm-water system for Legionella on the following schedule to assure that recontamination has not occurred:
    a. Weekly for the first month after resumption of operation.
    b. Every two weeks for the next two months.
    c. Monthly for the next three months.

Use the Pathcon criteria for Legionella in domestic water systems during the monitoring period. If 10 or more CFU per milliliter of water are present, re-treat the system according to steps 1-3 above. Resume weekly testing (step 4a) after retreatment. If levels remain below 1 CFU per milliliter, no further monitoring is necessary. If the levels are between 1 and 9 CFU per milliliter, continue monthly sampling of the water indefinitely and continue efforts to determine the source of contamination.

Make test results available to building residents.

TEPID WATER SYSTEMS

Warm-water systems or tepid water systems dilute domestic hot water from a water heater with cold water upstream from the outlet source are not recommended. Warm water left in these lines is at ideal temperatures for amplification of L. pneumophila. 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.

DOMESTIC COLD-WATER SYSTEMS

Domestic cold-water systems are designed to provide water for drinking, washing, cleaning, toilet flushing, etc. These systems have not been a major source of concern for Legionnaires' disease because L. pneumo-phila will not amplify at low temperatures. Cold-water storage and delivery should be at less than 20^{o}C (68^{o}F) to minimize potential for growth. Cold-water lines near hot-water lines should be insulated. Try to eliminate stagnant places in the system as dead legs or storage tanks that are not routinely used.

Detectable levels of L. pneumophila in the system may indicate contamination of the source water supply and should represent the maximum allowable level in the system.

If sampling of the system indicates a level of contamination significantly greater than that of the incoming domestic water supply system, treat the system and identify the source of contamination or amplification. By definition, these systems have no provision for heating water, and therefore disinfection cannot be by heat treatment.

Follow the clean-up procedure below if cold-water systems are shown to contain measurable Legionella or are assumed to be contaminated.

CLEAN-UP PROCEDURE

1. Clean and disinfect all cold water systems including storage tanks, drinking fountains, water lines, and water outlets.
    a. Use an accepted chemical disinfectant such as chlorine or other acceptable biocide.
    b. Use any other technology that has been shown to be safe and effective.

2. Ensure that cold-water systems are maintained so that conditions do not promote growth of Legionella. Maintain temperatures 20^{o}C (68^{o}F) and keep residual chlorine in the range of 1-2 ppm. In practice this level of chlorination may be objectionable and may also be excessively corrosive to metal pipes and containers.

3. Take samples according to sampling guidelines. If analysis shows no detectable Legionella and all otherpotential sources have been addressed, go to step 4.

4. Flush all cold-water outlets and fountains for four minutes, twelve hours before re-entry.

5. When steps 1 through 4 have been successfully completed, return the building to normal operation but testthe domestic cold-water system for Legionella according to the following schedule:

a. Weekly for the first month after resumption of operation.
b. Every two weeks for the next two months.
c. Monthly for the next three months

The same criteria used for hot water systems described above will also be used for the cold-water system during the monitoring period. Ten or more CFU per milliliter of water require retreatment of the system according to steps 1-3 above. Following retreatment, resume weekly testing and repeat the schedule outlined in 4a-c. If Legionella levels remain below 1 CFU per milliliter, additional monitoring is not necessary. If levels are between 1-9 CFU per milliliter, continue monthly sampling of the water source indefinitely and try to identify the source of contamination.

Make monitoring results available to building occupants.

HVAC AIR DISTRIBUTION SYSTEMS

Under normal conditions HVAC systems are not likely to be sources of L. pneumophila unless water contaminated with the bacteria enters the system. Under normal conditions, condensate pans on coiling coils should not serve as a water source in which amplification of the bacteria can occur because the temperature of the water is below $20^{o}C$ ($68^{o}F$). Improperly drained condenser pans may produce tepid conditions that can encourage microbial and fungal growth. Proper maintenance will lessen problems related to other diseases such as humidifier fever and asthmatic responses, and will minimize the possibility of a Legionnaires' outbreak.

Most probably, for a Legionnaires' disease outbreak to be linked directly with the HVAC system, Legionella-contaminated water must continuously enter the system, be aerosolized, and be delivered to building occupants. Examine the systems to rule out this possibility.

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

2. Eliminate all water leaks and remove any standing water found in the system. Replace or eliminate any water-damaged insulation in the system.

3. Operate the HVAC system using 100% outside air for 8 hours before returning the building to normal operation.

Sampling of air in the ducts to prove that the duct system is free of Legionella is not required and would be pointless. No reliable way to detect Legionella in the air is available, and Legionella can live only in water. If the ducts are dry, they cannot serve as a source of Legionella.

Following return of the building 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 62-1989 must be met.

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, generally the cool temperatures in HVAC systems are not conducive to growth of L. pneumophila. Cold-water humidifiers in HVAC systems must be connected to a domestic water source and provided with a drain line to remove the water. Stand-alone, console-type humidifiers that re-circulate 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 eliminate potential microbe problems.

Cold-water humidifiers require rigorous maintenance to ensure that the water source does not contribute to potential problems. Since humidifiers discharge into HVAC air distribution systems, inspect for standing water and treat according to the HVAC Air Distribution System protocol above. Where water in humidifiers has been sampled and shown to contain measurable Legionella, or where such water has been assumed to be contaminated with Legionella, use the following protocol.

1. Disinfect water in piping or reservoirs feeding the humidifier with chlorine or other effective biocides.

2. Sample the humidifier water to assure "kill" of Legionella. Samples must have no detectable CFU of Legionella per milliliter of water. If one or more are detected, repeat treatment and sampling.

3. Ensure that an adequate maintenance program is in effect to reduce the growth of Legionella. Water storage temperatures should be above or below the 20^{o}-50^{o}C (68^{o}-122 ^{o}F) range, and the system must be kept clean.

4. Before using the humidifier, flush the piping and/or reservoir thoroughly to remove biocides.

5. When steps 1 through 4 have been successfully completed, return the humidifier to operation and test the unit's water system to detect recontamination with Legionella according to the schedule below:

   a. Weekly for the first month.
   b. Every two weeks for the next two months.
   c. Monthly for the next three month

The criterion for Legionella in humidifier water systems during monitoring is fewer than 1 CFU per milliliter. If no samples exceed the criterion, suspend monitoring and continue the maintenance program indefinitely.

If any sample shows 1 or more CFU of Legionella per milliliter, re-treat and retest the system according to the schedule above(4a-c).

Make monitoring results available to building occupants.