Public Works and Government Services Canada
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Public Works and Government Services Canada

MD 15161 – 2013 Control of *Legionella* in Mechanical Systems

Standard for Building Owners, Design Professionals, and Maintenance Personnel

Includes addenda A and B

Mechanical and Electrical Engineering

Advisory and Practices (Professional Services) Directorate
Professional and Technical Service Management
Real Property Branch
Public Works and Government Services Canada

Disponible en français

Public Information

Public Works and Government Services, Canada is pleased to present *Standard MD 15161 – 2013: Control of Legionella in Mechanical Systems*.

The objective of this document is to provide minimum requirements for design, operation, maintenance and testing to prevent legionellosis associated with building water systems in federal facilities. It applies to both new and existing buildings managed by PWGSC or its service providers. It does not apply to leased buildings.

The document was developed by Mechanical and Electrical Engineering, Advisory and Practices (Professional Services) (APPS) Directorate, Professional and Technical Service Management (PTSM), Real Property Branch (RPB), Public Works and Government Services Canada (PWGSC) in consultation with specialists and engineering professionals in the regions and in the private sector, and by review of industry regulations as well as the Quebec regulations for cooling towers.

Clients, property managers, project managers, design professionals, and maintenance personnel must become familiar with this document and apply the standard in a consistent manner to federal facilities across Canada.

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Travaux publics et Services gouvernementaux Canada a le plaisir de vous présenter la *Norme IM 15161 – 2013 : « Lutte contre la Legionella dans les systèmes mécaniques »*.

L'objectif de ce document est de fournir les exigences minimales en ce qui a trait à la conception, à l'exploitation, à l'entretien et à l'essai de systèmes dans lesquels l'on retrouve de l'eau dans les bâtiments fédéraux pour prévenir une éclosion de maladie du légionnaire. Ces exigences s'appliquent aux bâtiments (nouvelles constructions et constructions existantes) gérés par TPSGC ou ses fournisseurs de services. Les exigences ne s'appliquent pas aux bâtiments loués.

Le présent document a été rédigé par le groupe du Génie mécanique et électrique de la Direction des conseils et pratiques (Services professionnels), Gestion des services professionnels et techniques, Direction générale des biens immobiliers de Travaux publics et Services gouvernementaux Canada, en consultant la règlementation de l'industrie et les règlements du Québec relativement aux tours de refroidissement, ainsi qu'en collaborant avec les spécialistes et les professionnels techniques des régions et du secteur privé.

Les clients, les gestionnaires immobiliers, les gestionnaires de projet, les professionnels de la conception et le personnel d'entretien doivent bien connaître ce document et être en mesure d'appliquer la norme de manière uniforme pour les installations fédérales au Canada.

Pour plus de renseignements sur les IM15128–2013, veuillez communiquer avec :

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Preface

General

The Mechanical and Electrical Engineering (M&E) group within Advisory and Practices (Professional Services) (APPS) directorate, Professional and Technical Service Management (PTSM), Real Property Branch (RPB), Public Works and Government Services Canada (PWGSC) has developed this document in consultation with specialists and engineering professionals in the regions and in the private sector, and by review of industry regulations as well as the Quebec regulations for cooling towers.

Intended Audience

Clients, building owners, property managers, design professionals, engineers, and maintenance personnel must become familiar with this document and apply this standard in a consistent manner for federal projects throughout Canada.

Feedback

We invite comments, additional information, and suggestions for changes, corrections, or recommendations that will improve this document. For this purpose, use the attached form entitled “Request for Changes” and send by e-mail, regular mail, or by fax to the address shown.

Background

MD 15161 was first published by PWGSC in 1986. Its first edition reflected many of the requirements for the control of *Legionella* in mechanical systems, based on an exhaustive study of the subject. The document was revised in 2006 considering the latest research in the field, including the development of new ASHRAE guidelines. Subsequently, there was an outbreak of Legionnaires’ disease in Québec City in 2012 that led to several fatalities; the source of this outbreak was traced to a cooling tower in a downtown Québec City building.

Following this outbreak, PWGSC carried out an extensive review of building maintenance programs as well as testing protocols for control of *Legionella* bacteria. It also reviewed current industry practices for *Legionella* control, with assistance from private sector consultants. This standard is the result of this extensive effort.

Acknowledgments

We acknowledge the valuable inputs from technical professionals in the national headquarters and from the Regions of the Real Property Branch, who took time to review and comment on this document.

We also acknowledge the valuable work done by our private-sector Consultants Genivar Inc., Sporometrics and Stantec Consulting Ltd.

Revisions

Version	Date of Issue	Description
1.0	2013-06-05	Original Issued by Anna Cullinan, DG PTSM
1.1 November 2013	2013-11-05	Including Addendum A issued by Anna Cullinan, DG PTSM
1.2 February 2015	2015-02-06	Including Addendum B issued by Veronica Silva, DG PTSM

MD 15161 – 2013
Control of *Legionella* in Mechanical Systems
Request for changes

Send to:
National Manager,
Mechanical and Electrical Engineering,
Advisory and Practices (Professional Services),
Professional and Technical Service Management (PTSM),
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Type of change suggested:

Correction of information
Deletion of information
Addition of Information

Location of suggested changes:

If necessary, photocopy relevant page(s) of this manual and attach to this sheet.

Page: _____ Chapter: _____ Paragraph No.: _____

Details of suggested changes, with rationale:

Use additional sheets if necessary)

Name: _____ Organization: _____

Signature: _____ Phone No.:_____ Date: _____

Table of Contents

List of Tables

Chapter 1: General

1.1 Purpose

The purpose of this document is to provide the minimum requirements for design, operation, maintenance and testing to prevent legionellosis associated with building water systems in federal buildings.

1.2 Scope

The target audience for this document is property managers, project managers, design professionals, maintenance personnel, and property owners.

This standard applies to all Crown-owned buildings, except remote residential housing, that are managed by PWGSC and/or its service providers.

In this standard the word “shall” is used to express a requirement that the user is required to satisfy in order to comply with this standard. The word “should” is used to express a recommendation that is advised but is not a requirement for compliance with this standard.

Unless noted otherwise in this document, mechanical systems within Government of Canada buildings shall be designed, constructed, and operated in accordance with industry standards and best practices for the prevention and control of *Legionella* bacteria. These include the requirements of the latest versions of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) guidelines, including ASHRAE *Guideline 12: Minimizing the Risk of Legionellosis Associated with Building Water Systems*, Cooling Technology Institute (CTI) *Guidelines WTB-148*: *Best Practices for Control of Legionella*, Quebec regulations for cooling towers and the draft ASHRAE standard for control of legionella in water systems.

Equipment such as cooling towers shall be registered with all applicable provincial and municipal equipment registries.

Where this standard conflicts with the requirements of applicable legislation or regulations, the most stringent requirement shall take precedence.

This standard provides the minimum requirements that must form part of a facility’s *Legionella* Bacteria Control Management Program (LBCMP).

Checklists and forms shall be used to ensure the consistent implementation and reporting of the facility’s LBCMP.

Personnel must take all necessary health and safety precautions including the use of personal protective equipment when taking water samples for bacterial testing, and cleaning or disinfecting systems.

1.3 Definitions

Action Limit	For test results, the limit at which a corrective action is required.
Aerosol	A suspension in a gaseous medium of solid particles, liquid particles, or solid and liquid particles having negligible falling velocity. Airborne water particles are usually less than 5 micron in diameter and are breathable into the lower areas of the lungs.
Algae	Small, usually aquatic, plants which require light to grow. They are often found growing on the exposed surfaces and edges of cooling towers, and in open air water tanks.
Amplification	The growth of *Legionella* bacteria from a low concentration to a high concentration, usually at amplification sites.
Bacteria	Plural of bacterium; see below.
Bacterium	A microscopic unicellular organism, capable of independent growth.
Biocide	A substance that kills micro-organisms.
Biofilm	The concentration of nutrients and microorganisms in the interface between liquid and solid surfaces. Can readily accept *Legionella* bacteria.
Bleed	Water discharged from a cooling tower water system to control the concentration of salts and other impurities in the circulating water. Usually expressed as a percentage of the recirculating water flow.
Cleaning	Removal of sediments, sludge, and debris by physical means.
Chlorinate	To add chlorine to the water, often in the form of sodium hypochlorite.
Cooling tower	An apparatus or system through which warm water is discharged against an air stream, and in doing so evaporation occurs and cools the water.
Cooling tower drift	Drift of water droplets from a cooling tower.
Corrosion inhibitor	A chemical designed to prevent or slow down the corrosion of metals, generally in piping.
Dead leg	A length of pipe containing water, temporarily or permanently blocked at one end.
Detergent	A cleansing agent capable of penetrating biological films, sludge, and sediment and having the ability to emulsify oil and hold materials in suspension.

Dipslide	A glass or plastic slide coated with culture media on which microorganisms can be grown and estimated.
Disinfection	Reduction of population of microorganisms using chemical or physical means. Not necessarily the same as sterilization.
Dispersant	A chemical usually added with other treatment chemicals to loosen organic material adhering to surfaces and prevent accumulation of sludge.
Dissemination	A mechanism that permits transfer of *Legionella* from the reservoir to the point of exposure to people.
Drift	The water aerosol that emerges from the airflow outlet of a cooling tower. It is distinct from "plume."
Drift eliminator	Equipment containing a complex system of baffles designed to remove water aerosols.
Evaporative cooler	A device that provides cooling by evaporation of water in an airstream.
Evaporative condenser	Equipment that circulates water to wet a condenser coil and directs air over the coil to provide evaporative cooling.
Fouling	Organic growth or other deposits on heat transfer surfaces causing loss of heat-transfer efficiency.
Free chlorine	Free chlorine refers to the active form of chlorine that is available as a disinfectant, as opposed to the *"combined"* form of chlorine that is not available for disinfection. For example, salt water has no free chlorine; it is all combined as *sodium chloride*. Free chlorine generally refers to the *hypochlorous* and the *hypochlorite ions* in aqueous solutions, and is measured in ppm.
Halogen	Generic name for chlorine, bromine, and iodine according to the periodic table.
Hazard	Any source of potential damage, harm or adverse health effects
Legionella	A genus of bacterium causing Legionnaires' disease.
Legionella Bacteria Control Management Program (LBCMP)	The program established for each building with a specific system risk assessment/analysis of each *Legionella* Susceptible System, with a program for maintenance and testing based on either ASHRAE or CTI guidance documents.
Legionnaires' disease	An illness characterized by pneumonia, caused by infection with *Legionella* species such as *Legionella pneumophila*.

Legionella Susceptible Systems	Water systems in a building that pose the risk of *Legionella* amplification.
Legionellosis	Another name for Legionnaires' disease.
MERV	Acronym for *"minimum efficiency reporting value."* The MERV rating is the standard method for comparing the efficiency of an air filter. The higher the MERV rating, the better the filter is at removing particles from the air.
Oxidant	A chemical that is oxidizing in nature, such as chlorine
Outbreak	Two or more cases of a disease linked by a common cause.
pH	A scale used to describe the hydrogen ion concentration in aqueous solutions. Pure water has a pH of 7. A smaller value indicates an acidic condition; a number greater than 7 is alkaline. The range of pH values is 0–14.
Plume	A cloud of water vapour emerging from a cooling tower. It is not the same as *"drift."*
Pontiac fever	A self-limited short-duration, non-fatal fever caused by *Legionella* bacteria. The incubation period of the disease is from 5 hours to 66 hours, and the attack rate is up to 95%. Symptoms include chills, headache, muscle pain, and other flu-like symptoms.
Potable water	Water that is suitable for consumption by building occupants.
Primary Air handling Equipment	Equipment that conditions outdoor air and/or mixed air (combination of outdoor air and re-circulation air) and delivers the conditioned air to spaces and/or equipment in the building. It may be installed in a location that is protected from the weather or exposed to the weather. Examples of such equipment include the following: packaged, manufactured, custom manufactured and built-up (field fabricated).
Reservoir	A site where bacteria has been found.
Risk	The chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard.
Scale inhibitor	Chemical added to water to inhibit formation of scale.
Slime	A mucous-like material that is produced as part of an organism's metabolism and allows adherence of a protective layer to surfaces.
Sludge	A general term for soft mud-like deposits on heat-transfer surfaces or other important sections of a cooling system.

Sodium hypochlorite	A chlorine-releasing water soluble chemical used for disinfection.
Surfactant	A soluble surface acting agent that reduces surface tension of water.
Sterilization	The process of eliminating all disease-causing organisms in a piece of equipment. Sterilization is not necessarily the same as disinfection
Total bacteria count (TBC)	An estimate of the number of viable units of bacteria per millilitre of water under the conditions of testing.
Terminal Air Handling Equipment	Equipment that conditions re-circulation air and/or air delivered from primary air handling equipment. Examples of such equipment include: fan coils, heat pumps, induction units, computer room air conditioners (CRAC).
Utility water system	A building water distribution system that provides water intended for uses other than human consumption.
Validation	The element of *verification* focused on collecting and evaluating scientific and technical information to determine if the Management Program, when properly implemented, will effectively control the hazards. Obtaining evidence that the elements of the *Legionella* Bacteria Control Management Program are effective.
Verification	Those activities, other than monitoring, that determine the validity of the Management Program and whether the system is operating according to the plan. The application of methods, procedures, tests, and other evaluations, in addition to monitoring, to determine compliance with the *Legionella* Bacteria Control Management Program.
Windage	Physical loss of water from the base of a cooling tower caused by wind of unusual pattern passing through it.

1.4 Acronyms

APPS	Advisory and Practices (Professional Services)
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CFU	Colony forming unit
CTI	Cooling Technology Institute
EPA	Environmental Protection Agency
GE/mL	Genome equivalents per millilitre
LBCMP	*Legionella* Bacteria Control Management Program
LP_{SG1}	*Legionella pneumophila* serogroup 1,
LP_{TOT}	*Legionella pneumophila* including all serogroups
MERV	Minimum efficiency reporting value
mg/L	Milligrams per litre
NCA	National Capital Area

NLPL Non-*Legionella Pneumophila Legionella* bacteria, rarely involved in *Legionella* infection
O&M Operation and maintenance
OSHA Occupational Safety and Health Agency
PCR Test Polymerase chain reaction test; also see qPCR Test
PTSM Professional and Technical Service Management
ppm Parts per million
qPCR Test Quantitative PCR Test; reporting units are GE/mL
TBC Total bacteria count

1.5 Roles and Responsibilities

1.5.1 The roles and responsibilities for key personnel for applying this Standard are provided in Table 1.1.

Table 1.1: Roles and Responsibilities

Key Persons	Roles and Responsibilities
Director General, PTSM	Monitors compliance with Standard Provides functional direction on applying the Standard Provides training on applying the Standard Reviews regional reports and LBCMP for selected buildings from each region Issues updates to Standard
Regional Directors General ; Director General NCA Operations	Implements Legionella Standard in the regions Monitors and reports on regional compliance with the Standard Monitors test results and maintains records of LBCMP for each facility Reports on results in excess of action limits to senior management Ensures application of Standard to facilities managed by PWGSC service provider
Facility Manager/Facility Manager for service providers	Develops and updates LBCMP for each facility Maintains all records required by LBCMP Implement requirements of LBCMP

1.6 Legionella Bacteria Control Management Program (LBCMP)

1.6.1 Each facility shall have its own written individual LBCMP tailored to address the *Legionella* susceptible systems that are present in that facility. Approaches noted by ASHRAE, CTI *Legionella* standards, and manufacturers' operation recommendations shall be used for guidance. As a minimum, the facility LBCMP shall include the following key elements:

1.6.1.1 The LBCMP must be reviewed and signed by a Professional Engineer;

1.6.1.2 Completion of forms LBCMP 1 through 6, as shown in Appendix E;

1.6.1.3 A review of all susceptible water systems in the building;

1.6.1.4 Contact list for the Property Manager, operations personnel, service contractors, equipment manufacturers;

1.6.1.5 Key water systems with the greatest potential for *Legionella* amplification include but are not limited to:

a. Cooling towers and evaporative condensers (reference Chapter 3);
b. Open water systems (eg.decorative fountains, waterfalls) (reference Chapter 4);
c. Misters, atomizers, air washers, humidifiers (reference Chapter 5); and
d. Domestic water systems (reference Chapter 6);

1.6.1.6 An inventory of each *Legionella* susceptible system in the building;

1.6.1.7 A single line schematic plan, including water sampling locations, of each *Legionella* susceptible system in the building;

1.6.1.8 Procedure for maintaining the quality of water in order to minimize the growth of bacteria, including *Legionella*;

1.6.1.9 A risk and hazard assessment of each *Legionella* susceptible system, including a classification of the building's *Legionella* risk level,

1.6.1.10 System operations and procedures for:

a. Winterizing and re-starting, if applicable;
b. Stopping and re-starting during the operation period;
c. Decontamination;
d. Water treatment; and
e. Reduction and control of corrosion, scaling, and the accumulation of organic matter;

1.6.1.11 Procedure(s) and manuals for operating and maintenance;

1.6.1.12 Protocols for maintenance and testing (method, location, and frequency) of water quality;

1.6.1.13 List of the chemical products and substances to be used and their description, if applicable;

1.6.1.14 Measures for verifying the mechanical components of the facility and equipment of water cooling towers and water systems;

1.6.1.15 Maintenance log and all other maintenance records. These must be available for inspection and review at any time on-site and reported as necessary or required; and

1.6.1.16 The LBCMP shall be assessed and updated if any of the following occur:

a. After five (5) years from initial creation, and every five (5) years after that, to ensure a periodic assessment and updated risk assessment;
b. A major change in procedures, or replacement of equipment;
c. Change in procedures or processes for maintaining the water quality; and
d. The need for decontamination work procedures when water quality of system water reaches action levels.

1.7 Personal Protective Equipment

Personnel must take all necessary health and safety precautions including the use of personal protective equipment when taking water samples for bacterial testing, and cleaning or disinfecting systems.

Chapter 2: *Legionella* Risk and Hazard Assessment

2.1 General

2.1.1 Each *Legionella* susceptible system identified in the LBCMP shall have its *Legionella* level of risk identified and documented.

2.1.2 Each facility shall have its *Legionella* level of risk identified and documented.

2.2 System Risk Assessment

2.2.1 The system *Legionella* risk level shall be identified as low, medium, or high based on the presence of *Legionella* hazard characteristics specific to that type of system. Table 2 below provides a guideline that may be used to identify the system risk level based on the system's *Legionella* hazard characteristics that may be present; it is only illustrative. Other industry *Legionella* guidelines and standards may be consulted to identify specific *Legionella* hazard characteristics that may not be identified in Table 2.1.

Table 2.1:System Risk and Hazard Assessment Guidelines

System Type	Hazard Characteristics	Risk Level
Cooling Tower	No evaporative condenser	Low
	Located more than 10 m from air intake	Low
	Located less than 10 m from air intake	High
	Excessive drift from tower exhaust	High
	Water temperature always below 20 °C at any point in the system	Low
	Water temperature in 20-35 °C range at any point in the system	Medium
	Water temperature exceeds 35 °C at any point in the system	High
	Located within 10 m of kitchen exhausts, vegetation etc.	High
	Recent history of elevated bacterial levels	High
Open Water Systems	Water temperature always below 20 °C at any point in the system	Low
	Water temperature in 20-35 °C range at any point in the system	Medium
	Water temperature exceeds 35 °C at any point in the system	High
	Aerosolization of water occurs	High
	Located within 10 m of kitchen exhausts, vegetation etc.	High
	Located close to public areas	Medium
	Recent history of elevated bacteria levels	High

System Type	Hazard Characteristics	Risk Level
Humidifiers	Direct steam, infrared or gas humidifier	Low
	Any other type of humidifier	High
	Water stagnation exists	Medium
Drain Pans	Water stagnation exists	Medium
	No water stagnation	Low
Domestic Cold Water Systems	Piping subjected to periods of prolonged water stagnation	Low to Medium
	Water temperature always below 20 °C	Low
	Water temperature in 20-35 °C range	Medium
	Potential for cross-contamination with process water	High
	Piping is not insulated to Code	Medium
	Shower facilities connected	Medium
Domestic Hot Water System	Water storage temperature exceeds 60 °C	Low
	Water storage temperature in 50-60 °C range	Medium
	Water storage temperatures below 50 °C	High
	Water distribution temperature below 50 °C	High
	Piping subjected to periods of prolonged water stagnation	High
	No re-circulation pump	High
	Shower facilities connected	High

2.3 Facility Risk Assessment

2.3.1 The facility *Legionella* risk level shall be identified as low, medium, or high based on the *Legionella* risk level of the systems present in the facility, as indicated in Table 2.2.

Table 2.2 Facility Risk Assessment

System Risk Level (based on Table 2-1)	Facility Risk Level
Contains *any* high risk system,	High
Contains only Medium & low risk systems	Medium
Contains only low risk systems	Low

Chapter 3: Cooling Towers and Evaporative Condensers

3.1 General

3.1.1 For the purposes of this standard, the term “cooling tower” shall also include “evaporative condenser.”

3.1.2 Cooling towers present a significant risk for exposure to *Legionella* as they allow favorable conditions for the growth of *Legionella* bacteria.

3.1.3 Plumes arising from cooling towers also pose a significant risk for transmission of *Legionella* bacteria.

3.1.4 The risks should be minimized with proper design, start-up and commissioning, maintenance, and testing, as indicated in the following sections.

3.1.5 Cooling towers may be subject to local regulations.

3.2 Design

3.2.1 This section applies to new facilities and to major upgrades to existing facilities.

3.2.2 The minimum separation distance shall be 10 metres between the cooling tower and any air intake or other critical receptor.

3.2.3 A separation distance exceeding 10 meters shall be used if there is a greater risk of contamination.

3.2.4 Do not locate cooling towers near kitchen exhaust fans, truck bays, other sources of organic materials, or outdoor areas that are densely populated.

3.2.5 Consider factors such as the height of adjacent structures, direction and velocity of prevailing winds, and the presence of enclosures and screenings around adjacent cooling towers while siting cooling towers.

3.2.6 Cooling towers shall be equipped with high-performance drift eliminators.

3.2.7 The design air velocity through the fill and the drift eliminators shall not exceed 3 m/s.

3.2.8 There shall be no bypass of air around the drift eliminators.

3.2.9 The drift eliminators shall be easily removable for cleaning, inspection, and/or replacement.

3.2.10 Tower construction material in contact with the water shall be corrosion resistant and compatible with disinfectants, biocides, and other cleaning agents.

3.2.11 Provide bolted and/or gasketed removable access openings to facilitate inspection and cleaning.

3.2.12 Design cooling tower basins for easy accessibility for cleaning and disinfection.

3.2.13 Protect wetted surfaces from direct sunlight to minimize bacterial growth under warm conditions.

3.2.14 Eliminate dead legs and reservoirs where water stagnation can occur.

3.2.15 Eliminate short-circuiting of cooling tower air with the discharge back into the cooling tower inlet.

3.2.16 For water chemical treatment purposes, include provisions for automatic continuous bleed, manual cleaning at regular intervals, application of scale and rust inhibitors on a continuous basis, and application of biocides, including shock chlorination, at timed intervals using automatic equipment.

3.2.17 Connect the discharge from cooling tower drain and/or overflow into the sanitary sewer such that back pressure, surcharge, cross-contamination, and/or reverse flow cannot occur.

3.3 Start-Up, Shut-Down, and Commissioning

3.3.1 No cooling tower shall be handed over, accepted, or put into service until commissioning is successfully completed.

3.3.2 Commissioning shall include, but may not be limited to, the following:

3.3.2.1 Completion of a written maintenance program, including the manufacturer's required maintenance and treatment program.

3.3.2.2 Thorough clean-out of all mechanical equipment prior to service.

3.3.2.3 Disinfection of the entire system following the disinfection procedure in section 3.4 Operation & Maintenance.

3.3.3 When a system is to be shut down for more than three days, it shall be drained. When this is not practical, stagnant water shall be pre-treated with an appropriate biocide regimen before start-up, allowing for proper contact time according to the supplier's recommendations.

3.3.4 For any start-up at any time, follow the cleaning and disinfection procedure indicated in Section 3.4 below

3.4 Operation & Maintenance

Inspection

3.4.1 Weekly inspection of cooling towers shall include as a minimum:

3.4.1.1 Visual inspection under normal operating conditions, for signs of microbial growth, algae, water leaks, splashing, blockages, and restrictions at air inlets.

3.4.1.2 Inspection of water treatment equipment for correct operation and adequate stock of chemicals.

3.4.2 Monthly inspection of cooling towers shall include as a minimum:

3.4.2.1 The requirements of the cooling tower weekly inspection.

3.4.2.2 Examination of water flow through the tower for normal unrestricted flow.

3.4.2.3 Examination of drift eliminators internally and externally for damage and for excessive drift.

3.4.2.4 With system power off, examination of the internal structure of the tower for the condition of the plant and equipment. Report any deterioration of materials, particularly the fill, drift eliminators, basin, and water distribution system.

3.4.2.5 Test for free chlorine or other biocide levels.

3.4.3 Yearly inspection of cooling towers shall include as a minimum:

3.4.3.1 The requirements of the cooling tower monthly inspection.

3.4.3.2 A more detailed inspection of all system components and a detailed assessment by a water treatment specialist for indications of corrosion, biofilms, or deposits.

Cleaning

3.4.4 Cooling towers shall be maintained in a clean working condition whenever the equipment is in use.

3.4.5 Start-up and annual cleaning of cooling towers shall include as a minimum:

3.4.5.1 Use additives to aid in cleaning, including detergents and anti-foaming agents.

3.4.5.2 Circulate the water for at least one hour throughout the system to provide coarse cleaning of the wetted surfaces.

3.4.5.3 Switch off equipment and drain to waste in a manner approved by the local water authority.

3.4.5.4 Thoroughly clean the internal shell, fill and sump off the cooling tower, moving or flushing away all debris.

3.4.5.5 Refill with clean water.

3.4.5.6 Dose with free chlorine or other biocide at recommended levels and circulate for one hour.

3.4.5.7 Clean all filters, strainers, water nozzles, and fittings.

3.4.5.8 Refill with clean water and treat again as required.

Disinfection

3.4.6 Disinfection shall be carried out at system start-up and when required by bacterial testing results.

3.4.7 Shock chlorination is one acceptable method for disinfection of cooling towers.

3.4.8 The disinfection procedure using shock chlorination for cooling towers shall be as follows:

3.4.8.1 Ensure that the tower has been cleaned according to the cleaning procedure.

3.4.8.2 Turn OFF the cooling tower fan during shock chlorination.

3.4.8.3 Shock chlorinate the whole system including the cooling-tower distribution basin and fill with the circulating pump(s) in operation.

3.4.8.4 During shock chlorination, maintain pH at less than 7.

3.4.8.5 Maintain free chlorine residual of at least 5 ppm for at least 6 hours, or alternatively, a residual of 15 ppm for at least 2 hours.

3.4.8.6 This shall be followed by continuous, automatically controlled feed of suitable water treatment chemicals with scale and rust inhibitors.

3.4.8.7 Use an effective biocide program for microbiological control, complying with all federal, provincial/territorial, or municipal requirements.

Water Treatment Plan

3.4.9 The written water treatment plan for control of microbiological activity including *Legionella*, scale, and corrosion shall be site specific, prepared by a qualified person as part of the LBCMP, and shall include at minimum where chemical treatment is used:

3.4.9.1 Specification of all equipment and chemicals used for the purpose of treating the open recirculation loop.

3.4.9.2 Use of corrosion inhibitors or other manufacturer-approved product.

3.4.9.3 Use of surfactants and other chemicals to control fouling due to formation of biofilms.

3.4.9.4 Application of biocides or the use of other measures to control the growth of bacteria.

3.4.10 Water treatments shall be used according to supplier recommendations, or as recommended by local specialist water treatment contractors.

3.4.11 Interactions between the chemicals must be considered when planning the water treatment program. For example, the effectiveness of chlorine-based biocides may be reduced by interactions with surfactants.

3.4.12 Chemical dosing application points shall be in the turbulent zones of the distribution system to ensure rapid dilution and mixing. Acceptable methods of dosing application may include:

3.4.12.1 Continuous drip feed

3.4.12.2 Shock dosing

3.4.12.3 Metered dosing

3.4.13 Consider the use of alternating biocides, as *Legionella* bacteria often develop a resistance to a single type of biocide.

3.5 Minimum Bacterial Testing Requirements

Water Sampling Locations

3.5.1 Water-sampling locations for bacterial testing shall be in accordance with the facility LBCMP.

3.5.2 The facility LBCMP should consider, at a minimum, the following locations for water sampling:

3.5.2.1 Storage tanks or reservoirs in the cooling tower system

3.5.2.2 Cooling tower basins

Bacterial Testing Results

3.5.3 Record the bacterial testing results on the facility LBCMP testing form (LBCMP-4).

3.5.4 Report the bacterial testing results in accordance with the regional and national reporting protocols.

Minimum Bacterial Testing Requirements and Frequency (Normal Operation)

3.5.5 While the system is in normal operation, perform weekly dipslide tests to determine the total bacteria count (TBC) at each water sampling location. Refer to Figure 1 located in Appendix D.

3.5.6 While the system is in normal operation, perform monthly *Legionella* bacteria culture tests to identify *Legionella pneumophila* serogroup 1 (LP_{SG1}), total *Legionella pneumophila including all serogroups (*LP_{TOT}*)* and the Non-*Legionella pneumophila Legionella* (NLPL) bacteria levels. Refer to Figure 1 located in Appendix D.

3.5.7 One week after system start-up, perform a *Legionella* bacteria culture test to identify the LP_{SG1}, LP_{TOT} and the NLPL bacteria levels. Refer to Figure 1 located in Appendix D.

Minimum Bacterial Testing Requirements (Emergency Mode)

3.5.8 Use the emergency-mode bacterial test procedure if:

3.5.8.1 There have been multiple reported cases of Legionnaires' disease in the past 30 days in the region within a 10 km radius of the building location and/or,

3.5.8.2 The building has had recurring *Legionella* bacteria levels detected by the Legionella bacteria culture test that required disinfection of the system within the past 90 days and/or,

3.5.8.3 Regional health authorities direct more stringent bacterial testing

3.5.9 Unless directed otherwise by the regional health authority, or due to regional restrictions, a weekly qPCR test should be performed to obtain rapid, Legionella specific results, to determine the *Legionella Pneumophila* bacteria count at each water sampling location.

Dipslide Testing Limits and Actions

3.5.10 When the TBC is less than 10,000 cfu:

3.5.10.1 Continue with normal O&M.

3.5.11 When TBC is between 10,000 and 100,000 cfu:

3.5.11.1 Review and adjust the O&M procedures and the water treatment program as required to ensure acceptable bacterial levels in the system.

3.5.12 When TBC exceeds 100,000 cfu:

3.5.12.1 Clean and disinfect the cooling tower system within 48 hours.

3.5.12.2 Review and adjust the O&M procedures and the water treatment program as required to ensure acceptable bacterial levels in the system.

3.5.12.3 If the condenser water temperature is below 18°C, continue operation with the revised O&M procedures.

3.5.12.4 If the condenser water temperature is above 18°C, wait one week then perform a *Legionella* bacteria culture test in accordance with clauses 3.5.13 through 3.5.16 below.

***Legionella* Bacteria Culture Testing Limits and Actions**

3.5.13 Perform *Legionella* bacteria culture test in accordance with ISO 11731-1998 and ISO/TS 11731-2-2004.

3.5.14 When the LP_{SG1} count and/or the LP_{TOT} count is less than 10 cfu/mL, and/or the NLPL count is less than 1,000 cfu/mL:

3.5.14.1 Continue with normal O&M.

3.5.15 When the LP_{SG1} count is between 10 and 100 cfu/mL, and/or the LP_{TOT} count is between 10 and 1,000 cfu/ml, and/or the NLPL count is between 1,000 and 10,000 cfu/mL:

3.5.15.1 Clean and disinfect the cooling tower system within 48 hours.

3.5.15.2 Review and adjust the O&M procedures and the water treatment program as required to ensure acceptable bacterial levels in the system.

3.5.15.3 Repeat the *Legionella* bacteria culture test after one week.

3.5.16 When the LP_{SG1} count exceeds 100 cfu/mL, and/or the LP_{TOT} count exceeds 1,000 cfu/ml, and/or the NLPL count exceeds 10,000 cfu/ml,

3.5.16.1 Shut down the cooling tower and immediately clean and disinfect the system.

3.5.16.2 Review and adjust the O&M procedures and water treatment program to ensure acceptable bacterial levels in the system.

3.5.16.3 Repeat the *Legionella* bacteria culture test after one week.

qPCR Testing Limits and Actions

3.5.17 Perform qPCR Test in accordance with ISO/TS 12869

3.5.18 When the *Legionella pneumophila* bacteria count is less than 10 GE/mL:

3.5.18.1 Continue with normal O&M.

3.5.19 When the *Legionella pneumophila* bacteria count is between 10 and100 GE/mL:

3.5.19.1 Review and adjust the O&M procedures and adjust the water treatment plan as required to ensure acceptable bacterial levels in the system.

3.5.20 When the *Legionella pneumophila* bacteria count exceeds 100 GE/mL:

3.5.20.1 Clean and disinfect the cooling tower system within 48 hours.

3.5.20.2 Review and adjust the O&M procedures and the water treatment program as required to ensure acceptable bacterial levels in the system;

3.5.20.3 If the condenser water temperature is below 18°C, continue operation with the revised O&M procedures.

3.5.20.4 If the condenser water temperature is above 18°C, wait one week then perform a *Legionella* bacteria culture test in accordance with clauses 3.5.13 through 3.5.16 above.

3.6 Operation, Maintenance and Testing Schedule

3.6.1 Table 3.1 below indicates a summary of the minimum frequency for operation, maintenance and testing requirements of cooling towers.

Table 3.1 :Cooling Towers O&M and Testing Summary

Activity	Item	Minimum Frequency
Operation & Maintenance	Inspection	Start-up Procedure Weekly Monthly Annual
	Cleaning	Start-up Procedure Annual
	Disinfection	Start-up Procedure When required by bacterial testing results
Testing	Dip-slide test	Weekly, when cooling tower is in operation
	Legionella bacteria culture test	One week after system start-up When the condenser water temperature is above 18°C and the dip-slide test results indicate TBC > 100,000 cfu or qPCR test results indicate Legionella Pneumophila > 100 GE/ml Monthly when cooling tower is in operation
	qPCR Test	Weekly, when used during emergency mode

Chapter 4: Open Water Systems

4.1 General

4.1.1 This section deals with open water systems located inside or outside buildings, as part of the facility.

4.1.2 Open water systems include decorative water features such as fountains, waterfalls, and open pools.

4.1.3 Decorative water features are often located in the foyers or in common areas of many buildings and can pose a risk for *Legionella* bacterial growth.

4.1.4 In decorative water features, water is often sprayed or cascades over media, resulting in aerosols contaminated with bacteria.

4.2 Design Requirements

4.2.1 This section applies to new systems and to upgrades to existing systems.

4.2.2 Incorporate provision for maintenance at the design stage.

4.2.3 Locate drains or sumps at the lowest level of the reservoir, with no low points that are not served by drains or sumps.

4.2.4 Provide access to equipment for maintenance.

4.2.5 Avoid stagnant areas or areas that are difficult to clean; use circulating pumps to maintain water flow.

4.2.6 Do not locate decorative water features near kitchen exhausts, plants, truck bays, or other sources of contamination.

4.2.7 Avoid water stagnation near submerged lighting, to reduce the risk of *Legionella* growth due to warmer temperatures.

4.2.8 Airflows should be directed toward the water feature, to reduce the risk of exposure for people in the vicinity.

4.3 Operation and Maintenance

4.3.1 Any open water system not in operation for three or more consecutive days must be drained and shall have all components cleaned, disinfected, and then refilled.

4.3.2 Inspect visually for signs of microbial activity, algae, or debris.; inspection frequency to be at least once a week..

4.3.3 Clean all equipment and component water features at least once a week to reduce build-up of dirt, debris, and organic matter that can serve as nutrients for *Legionella* bacteria.

4.3.4 Disinfect system when bacterial testing results exceed action limits.

4.3.5 For disinfection, use an effective biocide program for microbiological control, complying with all federal, provincial/territorial, or municipal requirements.

4.4 Minimum Bacterial Testing Requirements

Water Sampling Locations

4.4.1 Water sampling locations for bacterial testing shall be in accordance with the facility LBCMP.

4.4.2 The facility LBCMP should consider, at a minimum, the following locations for water sampling:

4.4.2.1 Water reservoirs

4.4.2.2 Filter assemblies

Bacterial Testing Results

4.4.3 Record the bacterial testing results on the facility LBCMP testing form (LBCMP-4).

4.4.4 Report the bacterial testing results in accordance with the regional and national reporting protocols.

Minimum Bacterial Testing Requirements and Frequency (Normal Operation)

4.4.5 While the system is in normal operation, perform weekly dipslide tests to determine the total bacteria count (TBC) at each water sampling location. Refer to Figure 2 located in Appendix D.

4.4.6 While the system is in normal operation, every two months perform *Legionella* bacteria culture tests to identify *Legionella pneumophila* serogroup 1 (LP_{SG1}), total *Legionella pneumophila including all serogroups* (LP_{TOT}) and the Non-*Legionella pneumophila Legionella* (NLPL) bacteria levels. Refer to Figure 2 located in Appendix D.

4.4.7 One week after system start-up, perform a *Legionella* bacteria culture test to identify the LP_{SG1}, LP_{TOT} and the NLPL bacteria levels. Refer to Figure 2 located in Appendix D.

Minimum Bacterial Testing Requirements (Emergency Mode)

4.4.8 Use the emergency-mode bacterial test procedure if:

4.4.8.1 There have been multiple reported cases of Legionnaires' disease in the past 30 days in the region within a 10 km radius of the building location and/or,

4.4.8.2 The building has had recurring *Legionella* bacteria levels detected by the Legionella bacteria culture test that required disinfection of the system within the past 90 days and/or,

4.4.8.3 Regional Health authorities direct more stringent bacterial testing.

4.4.9 Unless directed otherwise by the regional health authority, or due to regional restrictions, a weekly qPCR test should be performed to obtain rapid, Legionella specific results, to determine the *Legionella Pneumophila* bacteria count at each water sampling location.

Dipslide Testing Limits and Actions

4.4.10 When the TBC is less than 10,000 cfu:

4.4.10.1 Continue with normal O&M.

4.4.11 When TBC is between 10,000 and 100,000 cfu:

4.4.11.1 Review and adjust the O&M procedures and the water treatment program as required to ensure acceptable bacterial levels in the system.

4.4.12 When TBC exceeds 100,000 cfu/mL:

4.4.12.1 Clean and disinfect the system within 48 hours.

4.4.12.2 Review and adjust the O&M procedures and the water treatment program as required to ensure acceptable bacterial levels in the system.

4.4.12.3 Wait one week then perform a Legionella bacteria culture test in accordance with clauses 4.4.13 through 4.4.16 below.

Legionella Bacteria Culture Testing Limits and Actions

4.4.13 Perform *Legionella* bacteria culture test in accordance with ISO 11731-1998 and ISO/TS 11731-2-2004..

4.4.14 When the LP_{SG1} count and/or the LP_{TOT} count is less than 1 cfu/mL, and/or the NLPL count is less than 1,000 cfu/mL:

4.4.14.1 Continue with normal O&M.

4.4.15 When the LP_{SG1} count is between 1 and 10 cfu/mL, and/or the LP_{TOT} count is between 1 and 100 cfu/ml, and/or the NLPL count is between 1,000 and 10,000 cfu/mL:

4.4.15.1 Clean and disinfect the system within 48 hours.

4.4.15.2 Review and adjust the O&M procedures and the water treatment program as required to ensure acceptable bacterial levels in the system.

4.4.15.3 Repeat the *Legionella* bacteria culture test after one week.

4.4.16 When the LP_{SG1} count exceeds 10 cfu/mL, and/or the LP_{TOT} count exceeds 100 cfu/ml, and/or the NLPL count exceeds 10,000 cfu/ml:

4.4.16.1 Shut down the system and immediately clean and disinfect the system.

4.4.16.2 Review and adjust the O&M procedures and water treatment program to ensure acceptable bacterial levels in the system.

4.4.16.3 Repeat the *Legionella* bacteria culture test after one week.

qPCR Testing Limits and Actions

4.4.17 Perform qPCR Test in accordance with ISO/TS 12869.

4.4.18 When the *Legionella* pneumophila bacteria count is less than 10 GE/mL:

4.4.18.1 Continue with normal O&M.

4.4.19 When the *Legionella pneumophila* bacteria count is between 10 and100 GE/mL:

4.4.19.1 Review and adjust the O&M procedures and adjust the water treatment plan as required to ensure acceptable bacterial levels in the system.

4.4.20 When the *Legionella pneumophila* bacteria count exceeds 100 GE/mL:

4.4.20.1 Clean and disinfect the system within 48 hours.

4.4.20.2 Review and adjust the O&M procedures and the water treatment program as required to ensure acceptable bacterial levels in the system.

4.4.20.3 Wait one week, then perform a *Legionella* bacteria culture test in accordance with clauses 4.4.13 through 4.4.16 above.

4.5 Operation, Maintenance and Testing Schedule

4.5.1 Table 4.1 below indicates a summary of the minimum frequency for operation, maintenance and testing requirements of open water systems.

Table 4.1 :Open Water Systems O&M and Testing Summary

Activity	Item	Frequency
Operation & Maintenance	Inspection	Weekly
	Cleaning	Weekly
	Disinfection	When required by bacterial testing results
Testing	Dip-slide test	Weekly, when system is in operation
	Legionella bacteria culture test	One week after system start-up When dip-slide test results indicate TBC > 100,000 cfu or qPCR test results indicate Legionella Pneumophila > 100 GE/ml Every two months when system is in operation
	qPCR Test	Weekly, when used during emergency mode

Chapter 5: HVAC Systems and Components

5.1 General

5.1.1 Components of HVAC systems that may have risks associated with *Legionella* include air filters, humidifiers, condensate pans, and any other areas where water may be present.

5.2 Air Filters

5.2.1 **Design Requirements**

5.2.1.1 For new primary air handling equipment, excluding packaged type, provide high-efficiency filters with a minimum MERV rating of 13. For packaged type primary air handling equipment provide high efficiency filters with a minimum MERV rating of 13 where possible.

5.2.1.2 For existing air-handling systems, consider filter upgrade to MERV 13.

5.2.1.3 Design the air filter assembly to help prevent contamination of the air supply during maintenance.

5.2.2 **Operation & Maintenance**

5.2.2.1 Inspect filters, frames, chambers, and housing for general condition and integrity of fit weekly for primary air handling equipment and at least annually for terminal air handling equipment.

5.2.2.2 Replace filters found to be in poor condition.

5.3 Humidifiers

5.3.1 **Design Requirements**

5.3.1.1 Humidifiers forming part of any new HVAC system shall be indirect steam injection type.

5.3.1.2 Systems that use untreated potable water are preferred as maintenance requirements are lower and chemicals are not released into the airstream.

5.3.1.3 Direct steam from treated boiler water or other treated sources shall not be used.

5.3.1.4 Evaporative pan, drum-type, water spray- type, sprayed coil-type humidifiers or air washers shall not be used in new building designs.

5.3.1.5 During renovation projects, existing humidifiers shall be replaced with approved types of humidifiers.

5.3.1.6 For existing buildings, existing humidifiers systems can continue to operate only if proper precautions are taken to minimize microbial growth, including regular scheduled maintenance, total avoidance of water stagnation in the humidifiers, the use of biocides, and chemical treatment. If this is not practicable, the humidifiers shall be taken out of service.

5.3.1.7 Avoid the use of room humidifiers and misters, as they can provide a ready source of aerosols for dissemination of bacteria.

5.3.1.8 Include a provision to drain the systems when not in use to prevent standing water.

5.3.1.9 Design systems to allow for adequate access for inspection and maintenance.

5.3.2 **Operation and Maintenance**

5.3.2.1 Start-up and maintenance procedures must include cleaning and inspections for all key components of the systems.

5.3.2.2 Visually inspect humidifiers for signs of microbial growth, sediment or stagnant water at least once a month for non steam systems and every 3 months for steam systems.

5.3.2.3 If stagnant water accumulation is observed, follow the test protocol indicated in Section 5.3.3 below.

5.3.2.4 Maintain, clean and drain these systems following manufacturer recommendations when visual inspection indicates a problem

5.3.2.5 Disinfect system when bacterial testing results exceed action limits.

5.3.3 **Minimum Bacterial Testing Requirements**

Water Sampling Locations

5.3.4 Water sampling locations for bacterial testing shall be in accordance with the facility LBCMP.

5.3.5 The facility LBCMP should consider, at a minimum, the following locations for water sampling:

5.3.5.1 Water reservoirs

5.3.5.2 Stagnant water

Bacterial Testing Results

5.3.6 Record the bacterial testing results on the facility LBCMP testing form (LBCMP-4).

5.3.7 Report the bacterial testing results in accordance with the regional and national reporting protocols.

Minimum Bacterial Testing Requirements (Normal Operation)

5.3.8 While the system is in normal operation, perform dipslide tests monthly for non steam systems and every three months for steam systems to determine the total bacteria count (TBC) where stagnant water is present. Refer to Figure 3 located in Appendix D.

5.3.9 While the system is in normal operation, every three months perform *Legionella* bacteria culture tests on non-steam systems, to identify *Legionella pneumophila* serogroup 1 (LP_{SG1}), total *Legionella pneumophila including all serogroups (*LP_{TOT}*)* and the Non-*Legionella pneumophila Legionella* (NLPL) bacteria levels. Refer to Figure 3 located in Appendix D.

Minimum Bacterial Testing Requirements and Frequency (Emergency Mode)

5.3.10 Use the emergency-mode bacterial test procedure if:

5.3.10.1 There have been multiple reported cases of Legionnaires' disease in the past 30 days in the region within a 10 km radius of the building location and/or,

5.3.10.2 The building has had recurring *Legionella* bacteria levels detected by the Legionella bacteria culture test that required disinfection of the system within the past 90 days and/or,

5.3.10.3 Regional Health authorities direct more stringent bacterial testing.

5.3.11 Unless directed otherwise by the regional health authority, or due to regional restrictions, a weekly qPCR test should be performed to obtain rapid, Legionella specific results, to determine the *Legionella Pneumophila* bacteria count at each water sampling location.

Dipslide Testing Limits and Actions

5.3.12 When the TBC is less than 1,000:

5.3.12.1 Continue with normal O&M.

5.3.13 When TBC is between 1,000 and 10,000:

5.3.13.1 Review and adjust the O&M procedures and ensure proper drainage.

5.3.14 When TBC exceeds 10,000:

5.3.14.1 Clean and disinfect the system within 48 hours.

5.3.14.2 Review and adjust the O&M procedures and ensure proper drainage.

5.3.14.3 Wait one week then perform a *Legionella* bacteria culture test in accordance with clauses 5.3.15 through 5.3.18 below.

Legionella Bacteria Culture Testing Limits and Actions

5.3.15 Perform *Legionella* bacteria culture test in accordance with ISO 11731-1998 and ISO/TS 11731-2-2004.

5.3.16 When the LP_{SG1} count and/or the LP_{TOT} count is less than 1 cfu/mL, and/or the NLPL count is less than 1,000 cfu/mL:

5.3.16.1 Continue with normal O&M.

5.3.17 When the LP_{SG1} count is between 1 and 10 cfu/mL, and/or the LP_{TOT} count is between 1 and 100 cfu/ml, and/or the NLPL count is between 1,000 and 10,000 cfu/mL:

5.3.17.1 Clean and disinfect the system within 48 hours.

5.3.17.2 Review and adjust the O&M procedures and ensure proper drainage.

5.3.17.3 Repeat the *Legionella* bacteria culture test after one week.

5.3.18 When the LPSG1 count exceeds 10 cfu/mL, and/or the LP_{TOT} exceeds 100 cfu/ml, and/or the NLPL count exceeds 10,000 cfu/ml:

5.3.18.1 Shut down the system and immediately clean and disinfect the system.

5.3.18.2 Review and adjust the O&M procedures and ensure proper drainage.

5.3.18.3 Repeat the *Legionella* bacteria culture test after one week.

qPCR Testing Limits and Actions

5.3.19 Perform qPCR Test in accordance with ISO/TS 12869

5.3.20 When the *Legionella pneumophila* bacteria count is less than 10 GE/mL:

5.3.20.1 Continue with normal O&M.

5.3.21 When the *Legionella pneumophila* bacteria count is between 10 and100 GE/mL:

5.3.21.1 Review and adjust the O&M procedures and ensure proper drainage.

5.3.22 When the *Legionella pneumophila* bacteria count exceeds 100 GE/mL:

5.3.22.1 Clean and disinfect the system within 48 hours.

5.3.22.2 Review and adjust the O&M procedures and ensure proper drainage.

5.3.22.3 Wait one week then perform a *Legionella* bacteria culture test in accordance with clauses 5.3.15 through 5.3.18 above.

5.4 Operation, Maintenance and Testing Schedule for Humidifiers

5.4.1 Table 5.1 below indicates a summary of the minimum frequency for operation, maintenance and testing requirements of humidifiers:

Table 5.1 :Humidifiers O&M and Testing Summary

Activity	Item	Frequency
Operation & Maintenance	Inspection	During start-up procedure Non Steam Systems: Monthly when system is in operation Steam Systems: Every 3 months when system is in operation
	Cleaning	During start-up procedure Monthly when system is in operation
	Disinfection	When required by bacterial testing results
Testing	Dip-slide test	Non Steam Systems: Monthly, when system is in operation and stagnant water is present. Steam Systems: Every 3 months when system is in operation and stagnant water is present.
	Legionella bacteria culture test	Non Steam Systems:Every three months when system is in operation When dip-slide test results indicate TBC > 10,000 cfu or qPCR test results indicate Legionella Pneumophila > 100 GE/ml
	qPCR Test	Weekly, when used during emergency mode

5.5 Drain Pans

5.5.1 **Design and Requirements**

5.5.1.1 This section applies to new equipment and to major upgrades to existing equipment.

5.5.1.2 Drain pans shall be designed for easy cleaning.

5.5.1.3 Drain connections shall be in the bottom or in a depression in the side of the pan to eliminate standing water in the pan.

5.5.1.4 Drain pans shall be equipped with deep seal trap rated for twice the maximum static pressure in the system.

5.5.2 **Operation and Maintenance**

5.5.2.1 Start-up and maintenance procedures must include cleaning and inspections for all key components of the systems.

5.5.2.2 Visually inspect drain pans for signs of microbial growth, sediment and/or stagnant water at least once a month for primary air handling equipment and annually for 20% of terminal air handling equipment such that all of the equipment is inspected over a 5 year period.

5.5.2.3 Check for water accumulation in drain pans, and if there is any water accumulation, ensure that the drain pans are draining properly.

5.5.2.4 Maintain and clean drain pans following manufacturer recommendations at least yearly.

5.6 Operation and Maintenance Schedule for Drain Pans

5.6.1 Table 5.2 below indicates a summary of the minimum frequency for operation and maintenance requirements of drain pans:

Table 5.2 :Drain Pans O&M Summary

Activity	Item	Frequency
Operation & Maintenance	Inspection	During start-up procedure Primary air handling equipment: Monthly when system is in operation Terminal air handling equipment: Annually 20% of the systems such that all systems are inspected every 5 years.
	Cleaning	During start-up procedure Annually
	Disinfection	When required by bacterial testing results

Chapter 6: Domestic Water Systems

6.1 General

6.1.1 For the purpose of this Standard, domestic water systems include both hot and cold potable water systems.

6.1.2 The proper design and operation of the domestic water system is essential for *Legionella* control.

6.1.3 *Legionella* bacteria proliferate most rapidly in the 25–42°C temperature range.

6.1.4 Below 20°C, the bacteria are dormant but still viable; the bacteria do not survive at temperatures above 49°C, and maximum bacterial growth occurs at a temperature of 42°C.

6.1.5 Provide access for ease of maintenance in all new systems.

6.1.6 All new piping systems shall be designed to prevent water stagnation. If, due to system design and operation, water stagnation cannot be avoided, provide means to periodically flush the piping system automatically.

6.1.7 Natural rubber, silicone, or PVC pipe shall not be used in new systems, as these materials may contribute nutrients for the growth of bacteria.

6.1.8 In new hot and cold water systems, piping between the faucet and the circulating mains shall be as stated in Table 6.1:

Table 6.1: Maximum Pipe System Length

Maximum Pipe System Length	
Pipe Size	**Maximum length between faucet and circulating main, metres**
NPS 1/2	10
NPS 3/4	5
NPS 1	2

6.1.9 All new domestic water piping systems shall be installed with suitable backflow prevention devices to separate the domestic water systems from non-potable water systems in the building.

6.2 Cold Water Systems

Design Requirements

6.2.1 This section applies to new equipment and to major upgrades to existing equipment.

6.2.2 Cold water temperatures shall be maintained below 20°C.

6.2.3 When designing a distribution pipe system, consider that growth of *Legionella* may occur in low-flow or under-used sections of a pipe distribution system.

6.2.4 Areas at risk include drinking fountains, dead-end lines, attached hoses, shower nozzles, tap faucets, and hot water tanks/reservoirs.

6.2.5 Design and locate water circulation pumps in a manner that enables the stated water temperatures to be maintained.

6.2.6 Water distribution systems should be constructed using copper piping.

6.2.7 To eliminate stagnant water in piping systems, avoid long piping runs.

6.2.8 Locate cold water piping below hot pipes to minimize the potential for warming up due to convection.

Operation & Maintenance

Inspection

6.2.9 Inspect system for the presence of pipes serving fixtures that experience periods of prolonged water stagnation at water temperatures between 20 and 50 degrees Celsius at least every 5 years.

6.2.10 Operate and maintain the potable water treatment equipment serving the building, where present, in accordance with prescribed federal and provincial/territorial requirements for drinking water quality.

6.2.11 Inspect drinking fountain for signs of microbial growth at least annually.

Disinfection

6.2.12 If a potable water system is suspected as the source of *Legionella* bacteria, a mechanical system inspection shall be conducted.

6.2.13 When an outbreak of Legionellosis has been associated with a potable water system, when suspected cases of the disease occur or bacterial testing results indicate a need, disinfection shall be performed. .

6.2.14 The recommended method of disinfection for cold potable water systems shall be the use of a hyper-chlorination procedure as follows:

6.2.14.1 Add an approved drinking water product in accordance with the use directions for the supplier of the product.

6.2.14.2 All outlets shall be flushed until chlorine concentration at representative taps and faucets is confirmed by measurement and documented.

6.2.14.3 Close all outlets and disinfect with chlorine for a minimum of 2 hours, but not exceeding 24 hours then thoroughly flush all outlets.

6.2.14.4 Measure chlorine concentration at representative outlets to confirm it is within regulated limits before reuse of the system.

Minimum Bacterial Testing Requirements

6.2.15 Perform a monthly total residual oxidant test on the building's incoming domestic water supply in accordance with federal and provincial/territorial requirements for drinking water quality, if the building is not fed by a municipally treated water supply or if concerns have been identified with the municipally treated water supply for the building.

6.3 Operation, Maintenance and Testing Schedule for Cold Water Systems

6.3.1 Table 6.2 below indicates a summary of the minimum frequency for operation, maintenance and testing requirements of cold water systems.

Table 6.2 :Cold Water Systems O&M and Testing Summary

Activity	Item	Frequency
Operation & Maintenance	Inspection	Every 5 years: for the presence of pipes serving fixtures that experience periods of prolonged water stagnation at water temperatures between 20 and 50 degrees Celsius Annual: drinking fountains for signs of microbial growth
	Disinfection	When required by bacterial testing results When potable water systems suspected as Legionella source
Testing	Residual oxidant concentration	Monthly on the incoming building water supply if the building is not fed by a municipally treated water supply or if concerns have been identified with the municipally treated water supply.

6.4 Hot Water Systems

Design Requirements

6.4.1 This section applies to new equipment and to major upgrades to existing equipment.

6.4.2 Hot water shall be maintained or stored above 60°C, distributed to each outlet at a minimum of 50°C and reduced to below 43°C at the point of use.

6.4.3 Do not oversize water storage tanks as this may result in improper water circulation.

6.4.4 Storage tanks shall have no pockets from which scale, sediment, and sludge would be difficult to remove.

6.4.5 Consider the use of instantaneous water heaters, either as standalone devices or in conjunction with storage heaters.

6.4.6 The storage tanks shall be designed to permit sterilization at a temperature of at least 75°C.

Start-Up and Commissioning

6.4.7 Before any domestic hot water storage tank or heater is commissioned, it shall be sterilized by maintaining a minimum temperature of 70°C for a period of not less than 48 hours.

6.4.8 Before any domestic hot water system is commissioned, it shall be thoroughly flushed out and the disinfected. The recommend disinfection method is the use of a chlorine-producing agent with a residual of at least 2 ppm for 24 hours, followed by thorough flushing of the system.

Operation and maintenance

6.4.9 Verify and record hot water storage tank temperature monthly for systems that are connected to shower facilities (including emergency showers). Follow the bacterial testing protocols of clause 6.4.19 when tank temperature is below 50°C. Follow the requirements of clause 6.4.24.1 when the tank temperature is between 50 and 60 degrees Celsius. A domestic hot water system shall not be operated at a temperature that can cause scalding unless suitable protection measures are in place. Verify and record hot water storage tank temperatures annually for systems that serve multiple areas in the building and are not connected to showers.

6.4.10 Drain, flush and clean hot water storage tank at least annually for systems that serve multiple areas in the building and/or those that are connected to shower facilities.

Disinfection

6.4.11 Perform disinfection when indicated by the bacterial test results or the potable water source is suspected as a source of legionella bacteria.

6.4.12 The recommended methods of disinfection of hot water systems include the thermal shock treatment method or the hyper-chlorination method.

6.4.13 Thermal shock treatment method:

6.4.13.1 Municipal building and sanitary codes shall be followed.

6.4.13.2 Maintain the storage tank water temperatures at a minimum of 70°C for 24 hours while progressively flushing each outlet in the system for at least 20 minutes.

6.4.14 Hyper-chlorination, method:

6.4.14.1 An approved drinking water product shall be added in accordance with use directions for the supplier of the product.

6.4.14.2 All outlets shall be flushed until chlorine concentration at representative outlets is confirmed by measurement and documented.

6.4.14.3 Close all outlets and disinfect with chlorine for a minimum of 2 hours, but not to exceeding 24 hours then thoroughly flush all outlets.

6.4.14.4 Measure chlorine concentration at representative outlets to confirm it is within federal/provincial/territorial limits before reuse of the system.

Minimum Bacterial Testing Requirements

Water Sampling Locations

6.4.15 Water sampling locations for bacterial testing shall be in accordance with the facility LBCMP.

6.4.16 The facility LBCMP should consider, at a minimum, the following locations for water sampling;

6.4.16.1 Most remote shower facilities

Bacterial Testing Results

6.4.17 Record the bacterial testing results on the facility LBCMP testing form (LBCMP-4).

6.4.18 Report the bacterial testing results in accordance with the regional and national reporting protocols.

Minimum Bacterial Testing Requirements and Frequency (Normal Operation)

6.4.19 Where the domestic hot water storage tank temperature is found to be below 50°C, perform monthly dipslide tests of the domestic hot water storage tank(s) to determine the total bacteria count (TBC). Refer to Figure 4 located in Appendix D.

6.4.20 Perform *Legionella* bacteria culture tests to identify *Legionella pneumophila* serogroup 1 (LP_{SG1}), total *Legionella pneumophila including all serogroups* (LP_{TOT}) and the Non-*Legionella pneumophila Legionella* (NLPL) bacteria levels (Refer to Figure 4 located in Appendix D)

6.4.20.1 Every six months from the locations identified in clause 6.4.16.

6.4.20.2 Annually, at the most remote fixture, for systems with a storage temperature below 50 deg C that serve multiple areas in a building and are not connected to showers.

Minimum Bacterial Testing Requirements (Emergency Mode)

6.4.21 Use the emergency-mode bacterial test procedure if:

6.4.21.1 There have been multiple reported cases of Legionnaires' disease in the past 30 days in the region within a 10 km radius of the building location and/or,

6.4.21.2 The building has had recurring *Legionella* bacteria levels detected by the Legionella bacteria culture test that required disinfection of the system within the past 90 days and/or,

6.4.21.3 Regional Health authorities direct more stringent bacterial testing.

6.4.22 Unless directed otherwise by the regional health authority, or due to regional restrictions, a weekly qPCR test should be performed to obtain rapid, Legionella specific results, to determine the *Legionella Pneumophila* bacteria count at each water sampling location.

Dipslide Testing Limits and Actions

6.4.23 When the TBC is less than 1,000 cfu:

6.4.23.1 Continue with normal O&M.

6.4.24 When TBC is between 1,000 and 10,000 cfu:

6.4.24.1 Review and adjust the O&M procedures and adjust the storage tank temperature to 60°C where the system is equipped with measure to prevent scalding at the point of use.

6.4.25 When TBC exceeds 10,000 cfu:

6.4.25.1 Disinfect the system within 48 hours and maintain tank temperature at a minimum of 50°C.

6.4.25.2 Review and adjust the O&M procedures and adjust the storage tank temperature to 60°C where the system is equipped with measure to prevent scalding at the point of use.

6.4.25.3 Wait one week then perform a *Legionella* bacteria culture test in accordance with clauses 6.4.26 through 6.4.29 below.

Legionella Bacteria Culture Testing Limits and Actions

6.4.26 Perform *Legionella* bacteria culture test in accordance with ISO 11731-1998 and ISO/TS 11731-2-2004.

6.4.27 When the LPSG1 count and/or the LP_{TOT} count is less than 1 cfu/mL, and/or the NLPL count is less than 1,000 cfu/mL:

6.4.27.1 Continue with normal O&M.

6.4.28 When the LPSG1 count is between 1 and 10 cfu/mL and/or the LP_{TOT} count is between 1 and 100 cfu/ml, and/or the NLPL count is between 1,000 and 10,000 cfu/mL:

6.4.28.1 Disinfect the system within 48 hours and maintain tank temperature at a minimum of 50°C.

6.4.28.2 Review and adjust the O&M procedures and adjust the storage tank temperature to 60°C where the system is equipped with measure to prevent scalding at the point of use.

6.4.28.3 Repeat the *Legionella* bacteria culture test after one week.

6.4.29 When the LPSG1 count exceeds 10 cfu/mL, and/or the LP_{TOT} exceeds 100 cfu/ml, and/or the NLPL count exceeds 10,000 cfu/ml:

6.4.29.1 Shut down the system and immediately disinfect the system.

6.4.29.2 Review and adjust the O&M procedures and adjust the storage tank temperature to 60°C where the system is equipped with measure to prevent scalding at the point of use.

6.4.29.3 Repeat the *Legionella* bacteria culture test after one week.

qPCR Testing Limits and Actions

6.4.30 Perform qPCR Test in accordance with ISO/TS 12869

6.4.31 When the *Legionella pneumophila* bacteria count is less than 10 GE/mL:

6.4.31.1 Continue with normal O&M.

6.4.32 When the *Legionella pneumophila* bacteria count is between 10 and100 GE/mL:

6.4.32.1 Review and adjust the O&M adjust the storage tank temperature to 60°C where the system is equipped with measure to prevent scalding at the point of use.

6.4.33 When the *Legionella pneumophila* bacteria count exceeds 100 GE/mL:

6.4.33.1 Disinfect the system within 48 hours.

6.4.33.2 Review and adjust the O&M procedures and adjust the storage tank temperature to 60°C where the system is equipped with measure to prevent scalding at the point of use.

6.4.33.3 Wait one week then perform a *Legionella* bacteria culture test in accordance with clauses 6.4.26 through 6.4.29 above.

6.5 Operation, Maintenance and Testing Schedule for Hot Water Systems

6.5.1 Table 6.3 below indicates a summary of the minimum frequency for operation, maintenance and testing requirements of hot water systems.

Table 6.3 :Hot Water Systems O&M and Testing Summary

Activity	Item	Frequency
Operation & Maintenance	Inspection	During start-up procedure for hot water tanks Verify hot water storage temperature set-point: Monthly, for systems connected to shower facilities (including emergency showers) Annually for systems that serve multiple areas in the building and are not connected to showers
	Cleaning	Annual
	Disinfection	When required by bacterial testing results When potable water systems suspected as Legionella source
Testing	Dip-slide test	Monthly, if hot water storage temperature is below 50°C
	Legionella bacteria culture test	When dip-slide test results indicate TBC > 10,000 cfu or qPCR test results indicate Legionella Pneumophila > 100 GE/ml Every six months for the most remote shower facility Annually, at the most remote fixture, for systems with a storage temperature below 50 deg C that serve multiple areas in a building and are not connected to showers
	qPCR Test	Monthly, when used during emergency mode

Chapter 7: References

7.1 Bibliography

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American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), *Minimizing the Risk of Legionellosis Associated with Building Water Systems*. ASHRAE Guideline 12-2000, February 2000.

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Atlanta, GA (404-636-8400). *Legionellosis Position Paper*, 1998.

Cooling Technology Institute, Legionellosis Guideline: Best Practices for Control of *Legionella* (CTI Guidelines WTP-148), July 2008

Gazette Officielle du Quebec, January 16, 2013, Vol. 145, No. 3, Draft Regulation, Safety Code, Building Act, *Legionella* Prevention Regulations.

Flanders, W.D., Morris, G.K. and Shelton, B.G. (1994). *Legionnaires' Disease Outbreaks and Cooling Towers with Amplified Legionella Concentrations*. Current Microbiology 28, 359-363.

Millar, J.D., Morris, G.K. and Shelton, B.G. (1997) *Legionnaires' Disease: Seeking Effective Prevention.* ASHRAE Journal, 22-29

OSHA Technical Manual, Section III, *Chapter 7: Legionnaires' Disease.* Occupational Safety and Health Administration, Department of Labor, Washington, D.C.

7.2 Web- Based Resources

http://www.breezair.ie/legionnaire.htm

http://www.ccohs.ca/oshanswers/diseases/legion.html

http://www.epa.gov/ost/humanhealth/microbial/*Legionella*fs.pdf

http://www.hcinfo.com

http://www.osha.gov

http://www.cdc.gov

http://www.ashrae.org

http://www.cti.org

http://www.*Legionella*.org

http://www.nea.gov.sg/cms/qed/cop_*Legionella*.pdf

Appendix A: Legionnaires' Disease Overview

Background

The term "Legionnaires' disease" was coined in 1976 after a respiratory disease affected many delegates attending a convention in Philadelphia held by the American Legion of Pennsylvania. There were 221 recorded cases of a strange illness that led, ultimately, to 34 documented fatalities. Eventually, the bacteria that was responsible for the disease was isolated, and was later named as *Legionella pneumophila*, or *L. pneumophila*. The source of the bacteria was traced to the building water systems. Initially, the cooling towers were implicated, but further investigations revealed that deficiencies in the potable water system were the most probable source.

In 2012, a significant outbreak of Legionnaires' disease occurred in Québec City, resulting in 13 deaths and 170 documented cases of the disease. The source of the infection was traced to a cooling tower in a privately owned building in Lowertown, Québec City.

Two distinct illnesses, Legionnaires' disease and Pontiac fever, have been associated with *Legionella* bacteria. The milder form is Pontiac fever, an influenza-like illness that is rarely fatal. Legionnaires' disease is a much more serious form, with severe pneumonia-like symptoms, and is fatal in 10–15% of the cases.

The bacterium responsible for Legionnaires' disease belongs to the genus *Legionella*. There are approximately 35 *Legionella* species known to produce the disease, and many of these species are commonly found in water bodies such as lakes and rivers. They can survive for several months in a wet environment and multiply in the presence of algae and organic matter. The species Legionella Pneumophila has often been implicated in Legionnaire's disease.

Legionnaires' disease is not infectious, as it cannot be transmitted from person to person. According to the U.S. OSHA it is an "opportunistic" disease that most commonly attacks individuals who have a weakened immune system. Disease transmission normally occurs via inhalation of an aerosol of water contaminated by the bacteria.

Legionella is potentially a serious health concern in many public buildings. The only effective way of preventing such outbreaks is the proper design, operation, and maintenance of components in mechanical systems that are susceptible to bacterial growth and dissemination. Testing is useful for determining the effectiveness of the operation and maintenance program.

Outbreaks

The major stages in the outbreaks of Legionnaires' disease are as follows:

1. Proliferation and Amplification

This occurs in water systems where the bacteria feed on available nutrients such as organic matter. The most favourable conditions for amplification of the bacteria include a temperature range of 25–42°C, pH levels in water in the range of 6–8, stagnation of water supply, the presence of amoebae, and the formation of sludge, sediments, and biofilms. Natural products such as rubber and wood favour amplification, while growth is inhibited by metals such as copper.

2. Dissemination

Formation of aerosols such as mists, sprays, and droplets is the primary means of dissemination for *Legionella* bacteria. Cooling towers, evaporative coolers/condensers, water jet humidifiers, atomizers, spas, and, fountains are all possible sources.

3. Inhalation

Deep inhalation of the *Legionella* bacteria is the primary source of infection. The attack rate is 2–7%, with an incubation period of 2–10 days. The risk of acquiring the disease is higher for elderly people, smokers, heavy drinkers, and, those with pre-existing lung disease. Statistics indicate that women are three times more likely to get the disease than men.

By inhalation, the small droplets carrying the bacteria are deposited deeply in the lower respiratory tract. Exposure time does not have to be long for the disease to occur. Cases of the disease have occurred simply by walking near a building having a contaminated cooling tower and by washing without showering after a brief exposure.

Survival of the bacteria in aerosols is reported to be at a maximum at 65% relative humidity. The risk of acquiring the infection increases with the number of bacteria deeply inhaled, and therefore, with the proliferation of these bacteria in the water source and the extent to which they are dispersed in aerosols.

If the dose received overwhelms the susceptible host's natural defence mechanisms, the bacterium multiplies intra-cellularly and infection occurs. Although previously healthy people may contract the disease, the persons most at risk are those who have a pre-existing condition that weakens their immune system.

4. Diagnosis

This is the last stage in the recognition of a case of Legionnaires' disease. With proper treatment methods, fatalities occur in a very small percentage of the cases.

Appendix B: The Use of Biocides for *Legionella* Control

Background

All biocides used in PWGSC facilities shall be registered with Health Canada's Pest Management Regulatory Agency.and shall have a pest control registration number on the primary display panel of the product label. A registered biocide must be used according to the label instructions and the precautionary information on the label, to ensure that it does not pose unacceptable risk to humans.

Biocides are compounds selected for their ability to kill microbes, but with low toxicity to humans, plants, and, animals. For *Legionella* bacterial control, they are generally employed in the water treatment system of cooling towers and in the water supply system. Biocide use is a key to controlling risks in *Legionella* susceptible systems.

The ideal biocide shall be effective against a wide range of bacteria, algae, protozoa, and fungi, and should have a long activity time. It shall have no toxicity to humans and be environmentally acceptable. It shall be quick-acting and effective at low concentrations over a wide pH range. It must be compatible with other chemicals used, and should not cause deterioration of materials with which it comes into contact. It shall be capable of penetrating foam, sludge, slime, and scale within the system without foaming.

The effectiveness should not be reduced by contaminants within the water system or by substances present in the make-up water. Its concentration shall be easily measurable using simple test procedures. There are no biocides that meet all of these requirements. In practice, it is often necessary to use more than one type of biocide with other additives to achieve desired results.

Each facility will have a local specialist provider for water treatment. While approaches may vary by provider, for each building system, the goal must be to control microbial growth, including *Legionella*. Both ASHRAE and CTI have detailed information related to water treatment, approaches, biocide applications, and controls. These best practices should be consulted and followed.

In general, there are two types of biocide: oxidizing and non-oxidizing.

Oxidizing Biocides

Oxidizing biocides include halogens such as chlorine, and bromine, and, chlorine dioxide. Chlorine and bromine react very rapidly with microbiological species and chemicals in the water. This reactivity is both their strength and their weakness. Rapid reaction means a quick and effective kill, but it also means that the biocide reacts very quickly with other chemicals in the system, such as scale inhibitors and corrosion inhibitors. Hence, they leave very little residuals for continuous protection against bacteria.

Chlorine- and bromine-based formulations are only effective at concentrations exceeding 0.5–1 ppm; these levels can, however, cause rapid corrosion of piping and other materials. Also, the effectiveness of these biocides varies with pH, and careful control of pH in the range of 7–10 is required. Chlorine-based formulations do not penetrate biofilms very easily; hence, some form of dispersant may also be required.

Chlorine is generally used in the form of sodium hypochlorite, a chemical that liberates free chlorine in the presence of water.

Chlorine dioxide has better properties than chlorine or bromine for *Legionella* control. It is fast-acting and more effective at higher temperatures than chlorine, and less corrosive. It reduces the formation of chlorinated by-products and is very effective at concentrations as low as 0.1 ppm. It does not lose effectiveness over a wide pH range of 4–10. Also, it better penetrates biofilms that can harbour *Legionella* bacteria.

Chlorine dioxide is approved in many countries for potable water treatment. It can be fed to domestic cold water systems as well as to heating water systems. Feeding chlorine dioxide to the domestic cold water system delivers better water protection as it treats the system further upstream and allows more contact time for killing the bacteria. Even at maximum feed rates, chlorine dioxide leaves no noticeable taste or odour.

Bromine is moderately effective against *Legionella*, and it requires a higher concentration of 0.5–1.5 ppm. It is more effective than chlorine as a biocide at higher pH. Its effectiveness is less dependent on pH as compared to chlorine, and it is not as corrosive. Stabilized bromine chloride at concentrations of 4–10 ppm may also be used as a biocide.

There are numerous other oxidizing biocides available, and their use must be carefully selected and controlled for the application.

Non-Oxidizing Biocides

Non-oxidizing type biocides include organic compounds such as BNPD (2-bromo-2-nitropropane-1, 3-diol), glutaraldehyde, dithiocarbamates, isothiazolin, DBNPA (di-bromo-nitrilo-propionamide), and some quaternary ammonium compounds.

These chemicals are typically slow to act and are added to water systems such as cooling towers in large, weekly doses, then allowed to decrease until the next addition. This type of treatment is based on overdosing the system during addition, and then leaving a residual that destroys the bacteria over a period of time.

Non-oxidizing biocides have several drawbacks. They are often toxic to humans and animal species. They are dangerous to store and handle, and disposal of cooling water containing these chemicals may be difficult and costly, due to environmental regulations. These biocides are used in larger quantities and may be more expensive than oxidizing biocides.

Alternating the Use of Biocides

Alternating the use of different types of biocides during water treatment minimizes the growth of resistant strains of bacteria. Alternating the dose and frequency of application is also helpful.

A good biocide program includes the use of alternate types at regular intervals and at the proper dosage. This strategy minimizes the development of resistant strains of bacteria.

Appendix C: Legionella Test Methods

Personnel must take all necessary health and safety precautions including the use of personal protective equipment (PPE) when taking water samples for bacterial testing. Refer to the *OSHA Technical Manual Section III Capter VI Legionaire's Disease* for guidance on require PPE.

A testing program for *Legionella* is not a substitute for sound engineering practice. Very often, reliance on negative test results provides a false sense of security. Test results are from a specific area and time, whereas conditions in water systems can vary quickly and dramatically. Systems that do not have a regimented inspection and cleaning or a water treatment system are always at risk.

There is no simple correlation between the presence of the organism in a water source and the risk of infection. The bacteria are often present in water systems without being associated with any known case of Legionnaires' disease. Also, the risk of illness depends on many factors other than exposure, including host susceptibility, strain virulence, and efficiency of aerosolization.

However, testing can be useful when carried out for a specific purpose such as verifying the effectiveness of a water treatment method or tracing the source of an outbreak.

Legionella Culture Test (Swab or Bulk Water Collection)

The gold standard for *Legionella* testing is culturing according to *ISO/TS 11731:2004 Water Quality – Detection and Enumeration of Legionella – Part 2: Direct Membrane Filtration Method for Waters with Low Bacterial Counts*. This form of testing is widely accepted as the most reliable diagnostic test for *Legionella* bacteria, including the strain that causes Legionnaire's disease. It is also accepted by the US Centre for Disease Control.

However, this method has some drawbacks; the main one is that species of *Legionella* are slow-growing and culture results may only be available after 7–14 days. Initial outgrowth may be slow, and genus-level identification normally requires at least one round of subculture involving an additional period of incubation. The presence of naturally occurring bacterial or fungal co-contaminants may necessitate additional subculture or may mask the presence of *Legionella* altogether.

Samples for this method are collected either using a swab or by collection of approximately 500–1,000 mL of water in a container. Specialist laboratories need to be consulted prior to collection to ensure that proper sampling techniques are followed, samples are handled and transported properly, and that sample collection bottles are appropriate.

Culture test methods can allow for the quantification of total bacteria, *Legionella* bacteria, as well as specific serotypes including *Legionella pneumophila* serotype 1, the causative organism in many outbreaks.

Test results are generally reported as Non-*Legionella pneumophila Legionella* (NLPL) species and *Legionella pneumophila* serogroup 1 (LPSG1) species. Units for both types of test results are colony forming units per millilitre, or cfu/mL.

Dipslide Test

This method of testing is recommended by the U.K. Health and Safety Executive (HSE). For cooling towers, HSE recommends weekly dipslide testing, with action limits ranging from 10,000 to 100,000 cfu/mL. At 10,000 cfu/ml, HSE suggests a review of operations. When the higher action limit of 100,000 cfu/mL is reached, HSE recommends corrective action such as cleaning and disinfection.

The dipslide test is a surrogate test for *Legionella*, as it measures only total bacteria count (TBC). The test simply warns that the TBC of a water source has attained a level showing that the nutrients and temperature conditions may be conducive to *Legionella* growth.

The use of commercially available dipslides makes this method easy and relatively inexpensive. Sampling involves the use of a kit provided by specialist suppliers, and collection of a bulk water sample on a media. Bacteria levels are determined visually, and the results are available within 24–72 hours.

Used dipslide tests should be sterilized before disposal by soaking for at least 60 minutes in a 5% bleach solution.

Polymerase Chain Reaction (PCR) Test

The polymerase chain reaction (PCR) test is based on analysis of the DNA of the *Legionella* bacteria. Different types of PCR tests can produce qualitative as well as quantitative results in a very short period of time.

A very large number of PCR-based analyses for *Legionella* as a whole and *L. pneumophila* as a specific target have been developed, including a recent ISO standard (ISO/TS 12869:2012 *Water Quality – Detection and Quantification of Legionella spp. and/or Legionella pneumophila by Concentration and Genic Amplification by Quantitative Polymerase Chain Reaction (qPCR)*). They have the immediate advantage over culture techniques in that they can return results in 1–2 days. PCR-based tests for *Legionella* can be broken down into three major categories.

The first category is simple PCR (also referred to as conventional PCR), a presence/absence indication of *Legionella* DNA, and/or DNA of specific *Legionella* types. Simple PCR techniques can include nested forms that use targets within targets to focus on specific DNA markers, or multiplex forms that can simultaneously detect multiple targets.

The second category is quantitative PCR (qPCR), which can provide information on the quantities of *Legionella* DNA present, as well as quantities of DNA of selected individual species or other subtypes (e.g., *L. pneumophila* as a whole, or *L. pneumophila* serogroup 1). Modifications to the standard qPCR assay, such as the inclusion of hydrolysis probes, can significantly enhance the analytical specificity of the procedure. Quantitative information on the gene target can, in turn, be used to predict the amount of *Legionella* in the sample in genome equivalents per millilitre (GE/mL), an approximation of the total *Legionella* cell population.

A third approach is “viability PCR,” where sample pretreatments with DNA-destroying agents such as ethidium or propidium azide can be used to eliminate DNA that is not protected within living cells. These pre-treatment techniques can then be combined with simple PCR or qPCR to confirm the presence or estimate of the quantity of DNA associated with probable living inoculum of *Legionella*.

An issue with the simple PCR test is that it may detect the residual DNA of dead cells. This may be of advantage in cases where significant *Legionella* inoculum has been killed by disinfectant in water being transported to the lab, or has been killed by a biocide application before the source of an outbreak has been traced. It becomes a disadvantage in situations where a few clinically insignificant dead cells may give the same reading (“present” as opposed to “absent”) as a high inoculum of hazardous living material.

Comparison of Culture-Based Testing Versus PCR Testing

A summary comparison of the culture-based testing and analyses method versus the PCR testing and analyses method is shown in Table A1 below:

Table A1: Comparison of Test Methods

Advantages of Culture-Based Analyses	**Disadvantages of Culture-Based Analyses**
• Quantitative results (cfu/mL) allow interpretation of data as it relates to source strength. • Serotyping of bacteria allows comparison with the organism serotype found in the infected patients.	• Application of biocides to the water source may prevent detection. • Analysis takes 7 to 10 days. • Thiosulfate or metabisulfite must be added to samples to prevent chlorine in the water from killing bacteria during shipping.
Advantages of PCR Analyses	**Disadvantages of PCR Analyses**
• Analysis can be performed in 1 to 2 days. • Quantitative results if the qPCR method is used (genome equivalents/mL). • Treating the water with biocides prior to sampling does not prevent detection of *Legionella*. • Costs comparable to culture-based analyses.	• Identification to species level can be accomplished, but serotyping of organisms is not possible. * Note that the limitation to detecting *L. pneumophila* serogroup 1, by far the most medically important serogroup, has been overcome by development of a specific detection procedure.

Reference Source: Sporometrics

Appendix D: Legionella Testing Protocols

Appendix E: Checklists and Forms for LBCMP

- LBCMP-1 – Facility Checklist
- LBCMP-2 – Contact List
- LBCMP-3 – *Legionella* Susceptible System Inventory
- LBCMP-4 – Testing Form
- LBCMP-5 – Chemical Products and Substances List
- LBCMP-6 – System Risk and Hazard Assessment Form