

# Legionella Risk Management for Safety Professionals

Joint ChABSA / AIHA Meeting - January 15 2020

Richard W Gilpin PhD RBP CBSP SM(NRCM)  
Dr Richard W Gilpin LLC  
[www.legionella.com](http://www.legionella.com)



1

## Who am I?

Research microbiologist –  
35 years medical faculty at Johns Hopkins  
Medicine [retired], University of Maryland  
Medicine & Medical College of Pennsylvania  
(Drexel University Medicine)

Presented / published 61 microbiology / biosafety  
papers cited 379 times & read 9,474 times on  
ResearchGate



2

## I'll cover:

Legionnaires' disease  
*Legionella* bacterium & Dx  
Transmission sources  
Risk reduction  
Decontamination



3

Legionnaires' disease  
43-years & counting



4

## Legionellosis

### Legionnaires' disease - LD

atypical pneumonia with rapid onset  
high fever, myalgia, cough, atypical  
radiogram – often misdiagnosed

Pontiac fever – mild – no pneumonia

<https://www.cdc.gov/legionella/health-depts/surv-reporting/case-definitions.html>



5

## Legionnaires' disease - LD

Airborne aerosol transmission to lungs

Incubation	2 to *10 days
Attack rate	5% of population
Pneumonia	100%, Rapid onset
Course	15% to 40% fatal



6

## Legionnaires' disease risk factors

Age  $\geq$  50 years

Smoking (current or historical)

Chronic lung disease  
(such as emphysema or COPD)

Immune system disorders due to  
disease or medication

Systemic malignancy



7

## Legionnaires' disease risk factors

Underlying illness such as diabetes,  
renal failure, or hepatic failure

\*Recent travel with an overnight stay  
outside of the home, including stay  
in a healthcare facility

\*Exposure to hot tub aerosol

\*Exposure to cooling tower drift



8

## Legionnaires' disease

Limited sputum production

Limited consolidation [no dark shadow]

Limited alveolar exudate

Small white blood cell count increase

IV Antibiotic therapy essential at onset

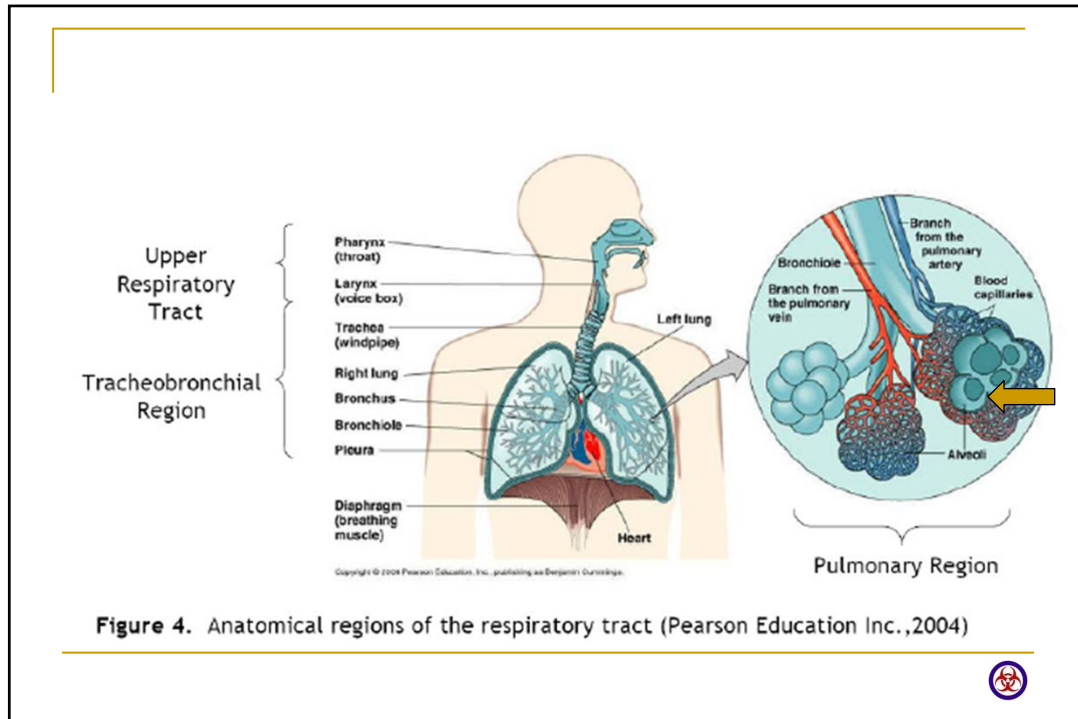


9

## Radiograph – not remarkable



10



11

***Legionella* grow in macrophages**

*Legionella* contact lung alveolar [air sack] macrophages [wbc] & transduce a signal to change phagosome movement

Alveolar macrophages engulf the bacteria into vacuoles where the bacteria multiply to high numbers & produce fluid that prevents air exchange [Drowning]

12

## Legionnaires' disease - LD

Many serogroups of *L. pneumophila*  
Serogroup 1 most common Dx in US

15 other *Legionella* species clinically  
associated with LD

15-30% of pneumonia patients admitted  
to intensive care units may have LD

50,000 to 70,000 cases in US/yr \*NAS2019



13

Trigger Outbreak  
Philadelphia  
1976



14

1976 – Bellevue Stratford Hotel  
Philadelphia PA

Legionnaires' [ex-military] Convention

221 cases of serious pneumonia of  
\*Unknown Etiology [Neg lab Dx]

34 deaths

Source – untreated roof cooling tower  
[Personal knowledge of CT & 1980's Senate hearing]



15

National Enquirer – Dec. 6, 1977



16



## *Legionella* bacterium – CDC 1977

*Legionella* [new bacterial genus named by CDC]  
61 *Legionella* species as of October 2019

First cultured in embryonated eggs with  
tissue from a Guinea pig with a fever

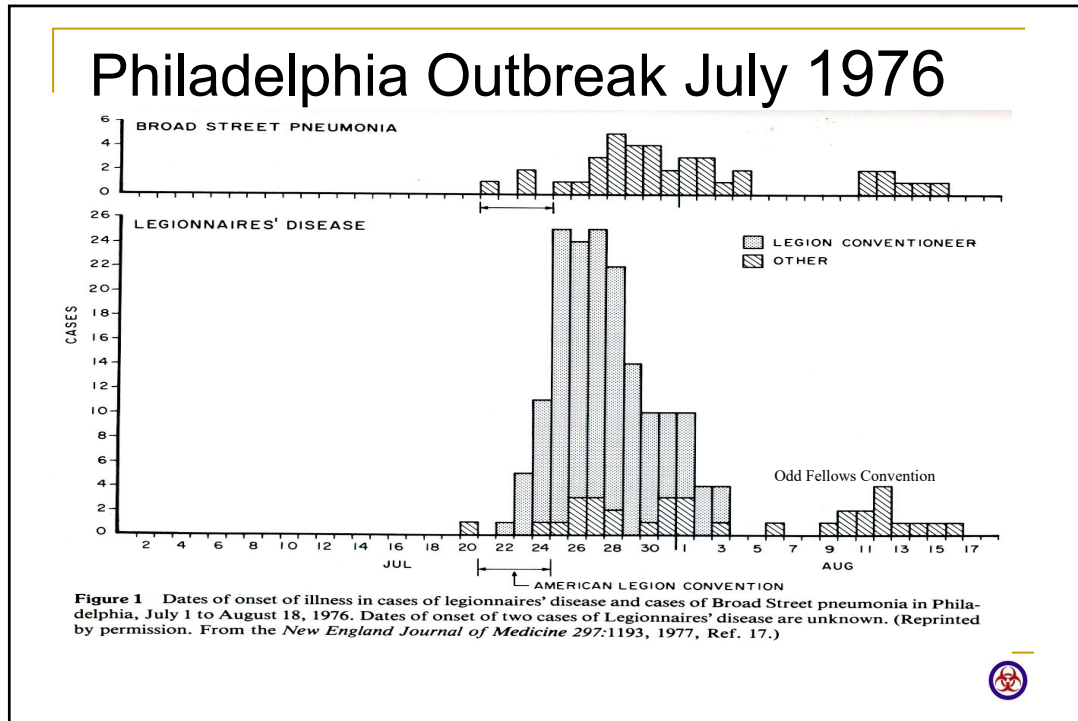
Guinea pig had been injected with blood from  
a deceased Philadelphia Legionnaires'  
Conventioneer



17



18



19

## My lab started working with *Legionella* in 1978

**Cytochrome spectra of *Legionella pneumophila***

Paul L. Kronick and Richard W. Gilpin  
 Franklin Research Center, Philadelphia, Pennsylvania 19103, U.S.A. and  
 Department of Microbiology, The Medical College of Pennsylvania, Philadelphia 19129, U.S.A.

59 *Microbios Letters* 14 59-63 1980

***Legionella bozemanii***  
 Still Another Cause of Pneumonia

Jack D. Sobel, MD; Richard Krieger, MD; Richard Gilpin, PhD; Linda Griska, MD; Pasha Agarwal, MD

JAMA, July 15, 1983—Vol 250, No. 3 *Legionella bozemanii* Pneumonia—Sobel et al 383

20

## 1985 Our first paper on cooling tower testing

*Water Res.* Vol. 19, No. 7, pp. 839-848, 1985  
Printed in Great Britain. All rights reserved

0043-1354/85 \$3.00 + 0.00  
Copyright © 1985 Pergamon Press Ltd

### DISINFECTION OF CIRCULATING WATER SYSTEMS BY ULTRAVIOLET LIGHT AND HALOGENATION\*

RICHARD W. GILPIN<sup>1</sup>, SUSAN B. DILLON<sup>1†</sup>, PATRICIA KEYSER<sup>1</sup>, ALICE ANDROKITES<sup>1</sup>,  
MARY BERUBE<sup>1</sup>, NICHOLA CARPENDALE<sup>1</sup>, JANE SKORINA<sup>1</sup>, JAMES HURLEY<sup>1</sup>  
and ADELE M. KAPLAN<sup>2</sup>

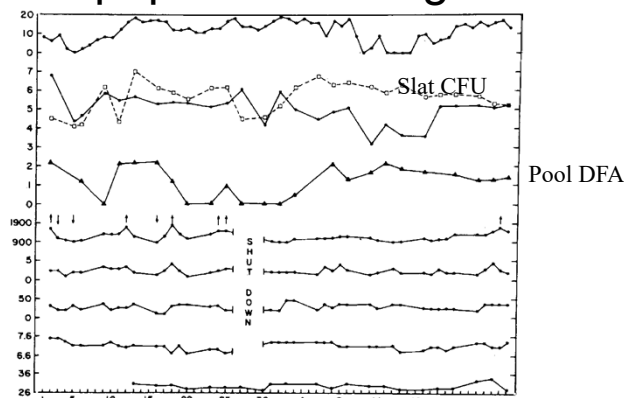
<sup>1</sup>Department of Microbiology and Immunology and <sup>2</sup>Department of Community and Preventive  
Medicine, The Medical College of Pennsylvania, Philadelphia, PA 19129, U.S.A.

(Received March 1984)



21

## 1985 Our first paper on cooling tower testing

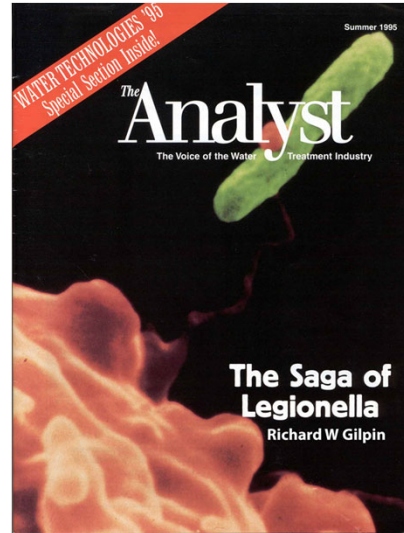


Biological, chemical and physical parameters of a large cooling tower. Samples were tested on the indicated days during the summer months. Cooling degree days (Degree d) were calculated from a base temperature of 18°C. Viable counts of bacteria from (●) pool water (CFU ml<sup>-1</sup>) and (□) slats (CFU mm<sup>-2</sup>); DFA-positive bacteria (▲) in pool water (number ml<sup>-1</sup>); dissolved solids (mg ml<sup>-1</sup>) calculated by multiplying conductivity measurements µmho cm<sup>-2</sup> by a factor of 0.75; chromate and phosphate concentrations are µg/ml. Temperature is °C. Arrows indicate increased (↑) or decreased (↓) blowdown.



22

## 1995 \* The Analyst \* Assoc Water Technol



23

## 2014 \* Applied Biosafety \* ABSA Vol 19 #2

Articles

### **Quantitative Measurement of *Legionella pneumophila* Counts in Routinely Maintained Commercial and Industrial Cooling Towers**

Richard W. Gilpin<sup>1\*</sup> and Adele M. Kaplan Gilpin<sup>2</sup>

<sup>1</sup>Richard W. Gilpin, Ph.D., Ltd., Baltimore, Maryland and <sup>2</sup>University of Maryland School of Medicine, Baltimore, Maryland



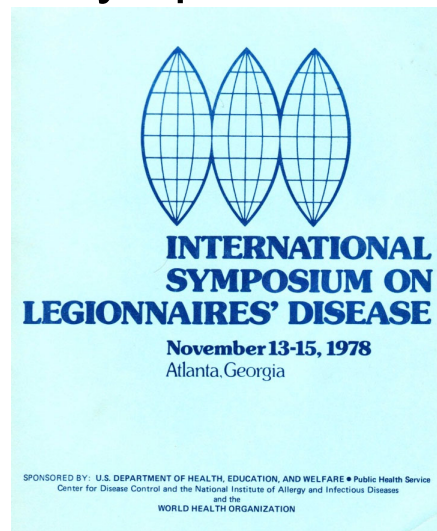
24

## *Legionella* bacterium & Dx

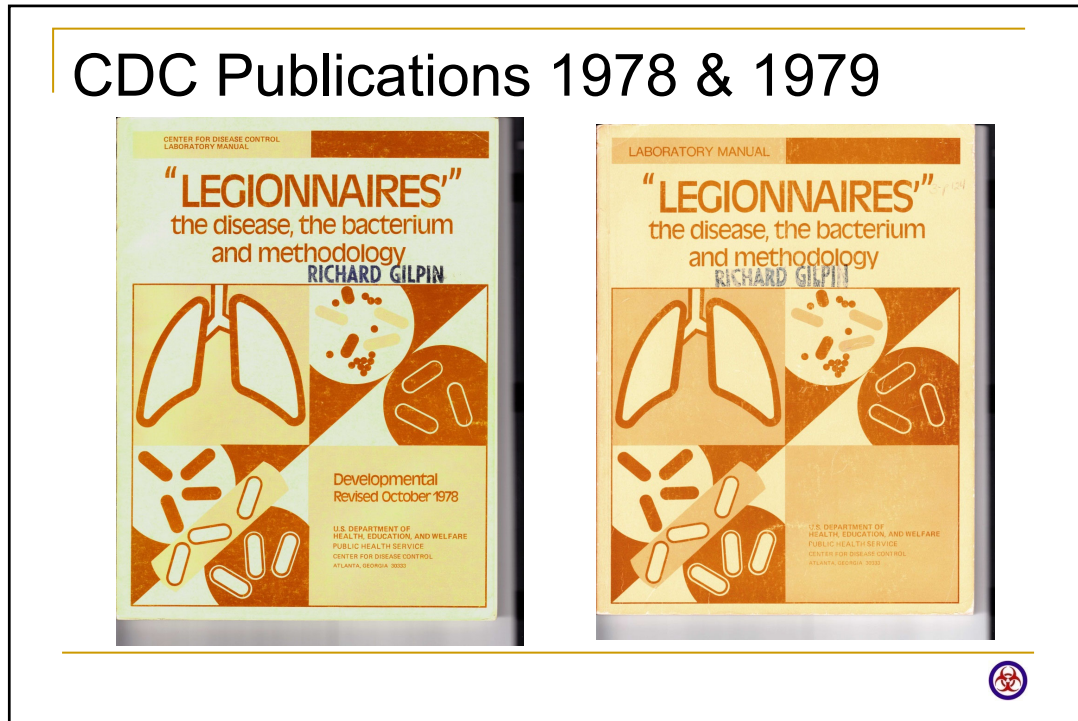


25

## First CDC Symposium – 1978 I was there



26



27

## 1978 CDC Lab Dx Methods

Indirect fluorescent antibody test

\*Direct fluorescent antibody test – 1<sup>st</sup> Dx method

Original culture in Mueller-Hinton agar  
containing 1% hemoglobin &  
1% IsoVitalex in a candle jar @ 35°C


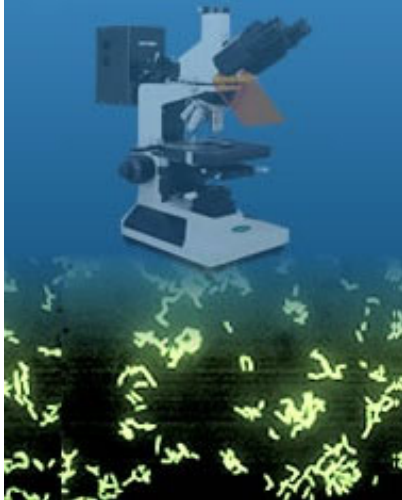
Later grown on Feeley-Gorman agar

Much later - Buffered Charcoal Yeast  
Extract (BCYE) agar

28



## Direct Fluorescent Antibody [DFA] Test

Fluorescein-conjugated IgG attaches to bacterial cell wall



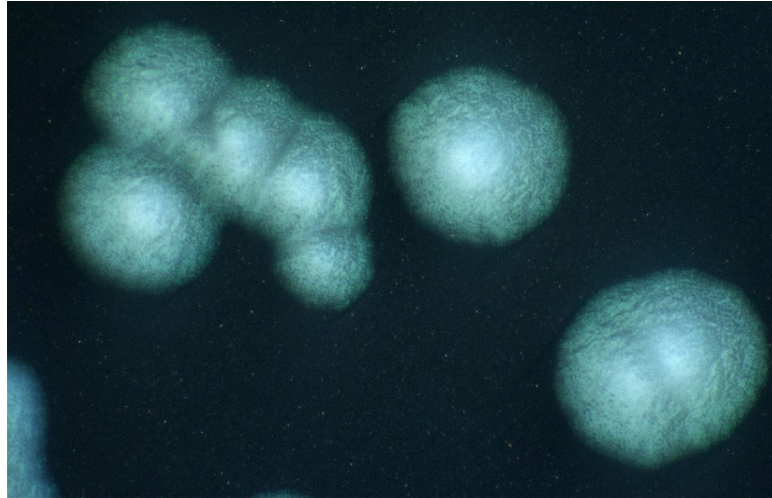
29

## *Legionella* on BCYE Agar



30

## *Legionella* Colonies on BCYE Agar



31

## *Legionella* Bacterium

Gram negative rod (stains poorly)

Rod morphology (long rods in old culture)

Strict aerobe – requires aeration

Facultative intracellular parasite

Grown on medium with reduced free radicals [no growth on usual Dx media]

Grows in amoebae within biofilms



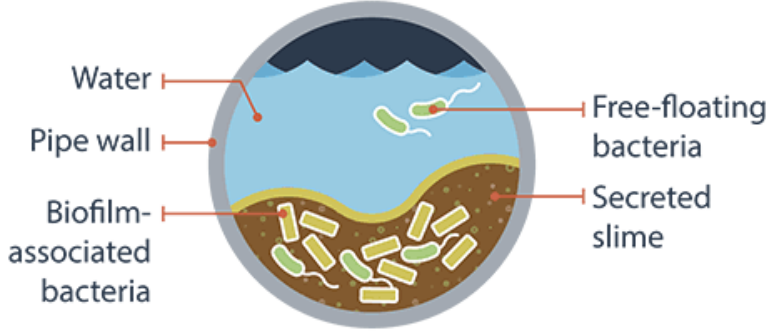
32



## Legionella [green] in Biofilm

<https://www.cdc.gov/legionella/wmp/overview/growth-and-spread.html>

*Legionella* can live and grow in biofilm



The diagram illustrates a cross-section of a pipe. The top part is labeled 'Water' and contains several green, rod-shaped bacteria labeled 'Free-floating bacteria'. The bottom part is labeled 'Pipe wall' and contains a layer of brown 'Secreted slime' with green bacteria embedded within it, labeled 'Biofilm-associated bacteria'. The entire diagram is titled 'Cross section of pipe'.

Water


Pipe wall

Biofilm-associated bacteria

Free-floating bacteria

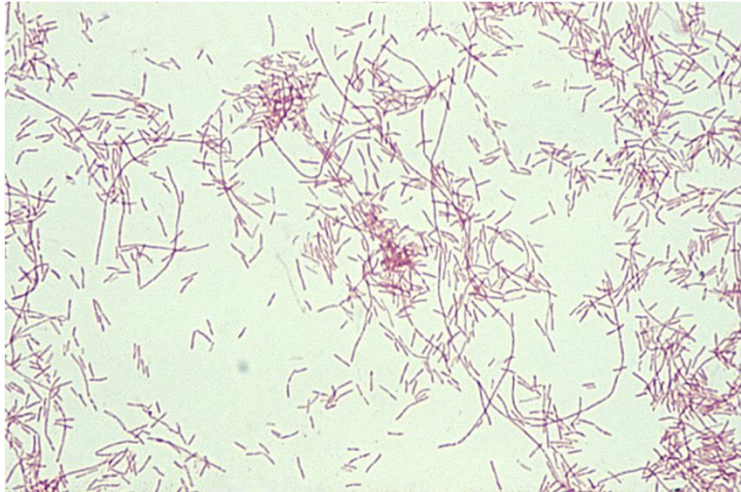
Secreted slime

Cross section of pipe




33

## Weakly Staining Gram Negative Rod



The micrograph shows a dense population of Legionella bacteria. They appear as thin, purple-stained rods of varying lengths, some appearing as single rods and others as short chains. The background is a light, slightly grainy green.



34

## Current CDC Lab Confirmation

Culture on BCYE agar:

Isolation of any *Legionella* organism from respiratory secretions, lung tissue, pleural fluid, or other normally sterile fluid

<https://www.cdc.gov/legionella/clinicians/diagnostic-testing.html#preferred-tests>



35

## Transmission sources



36

# Transmission by Aerosol Inhalation



37

## Mechanical Aerosol Sources

Cooling towers\*

Evaporative condensers

Showers

Spas\*

Hot tubs\*

Grocery store & Outdoor misters



38

## Mechanical Water Sources

Fountains\*

Warm water pipes/fixtures

Vehicle wash facilities

Ice machines

Water-containing dental equipment



39



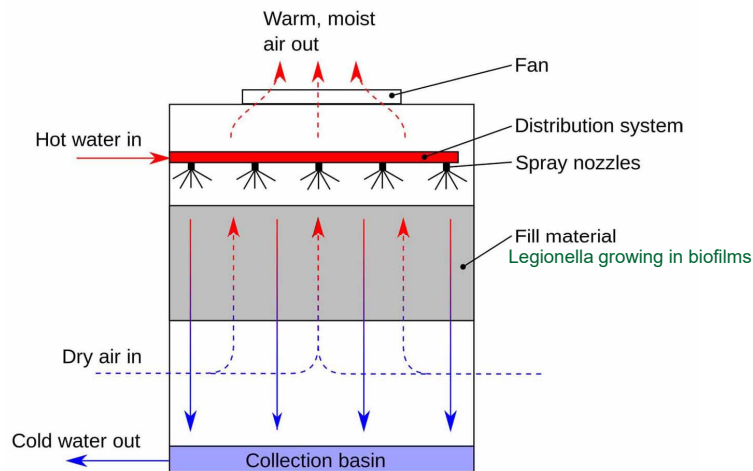
40

## Cooling Towers Showing Water Drift



41

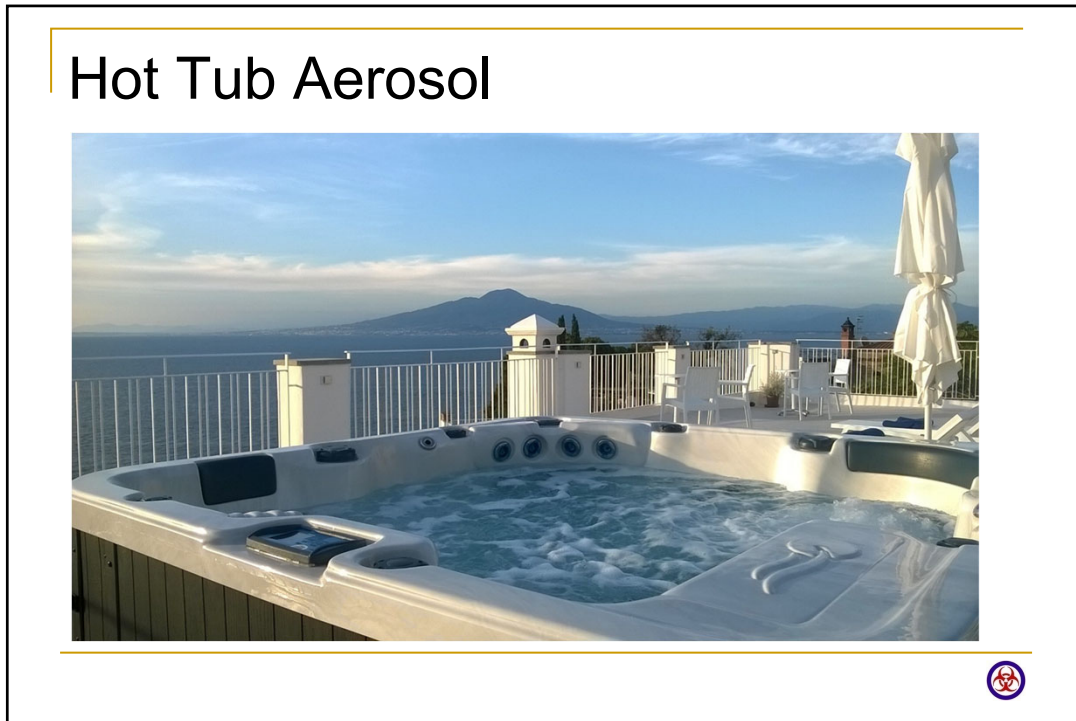
## How Cooling Towers Work



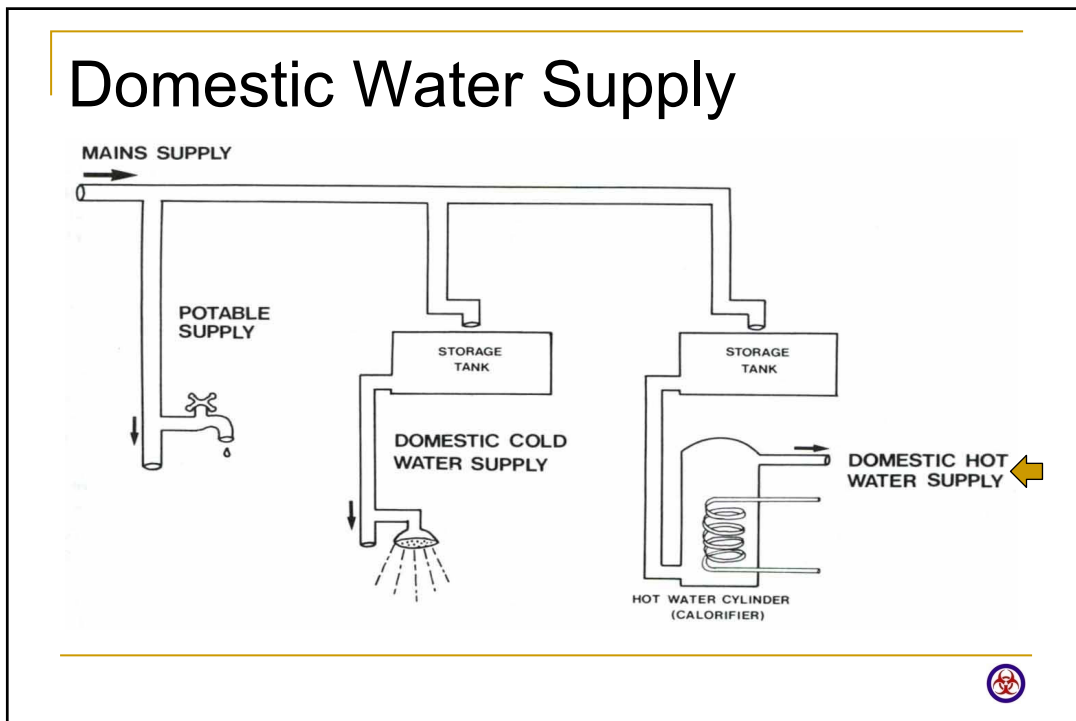
<https://www.coolingtowerproducts.com/blog/how-cooling-towers-work-diagram-pictures-2015.htm>



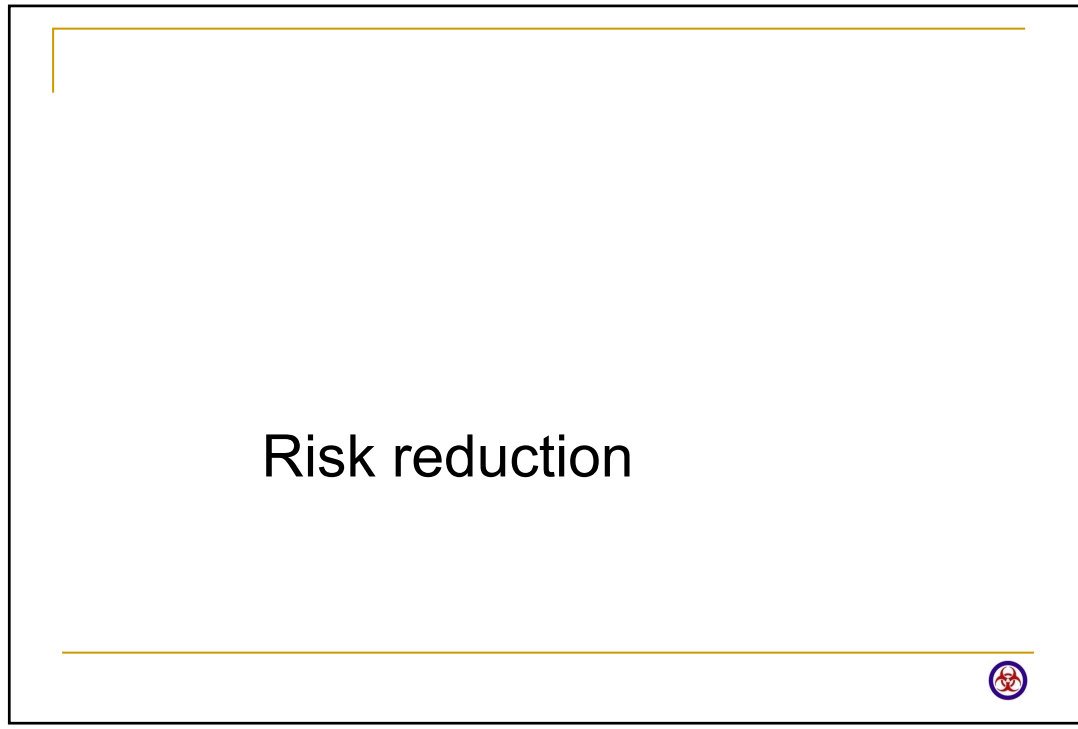
42



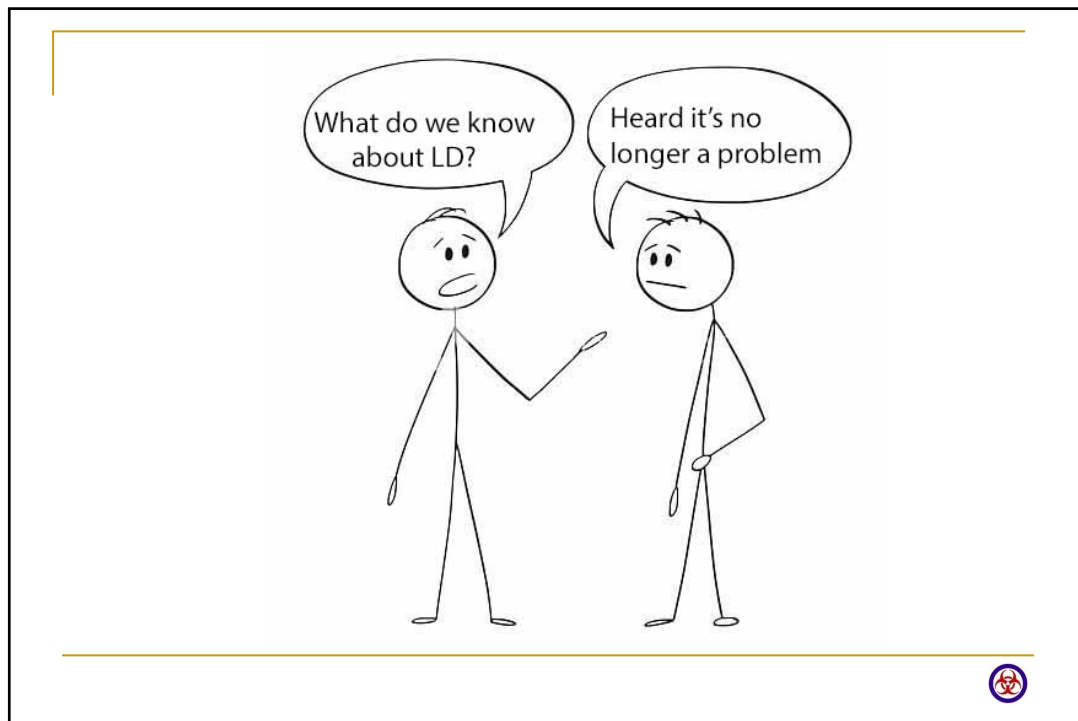
43



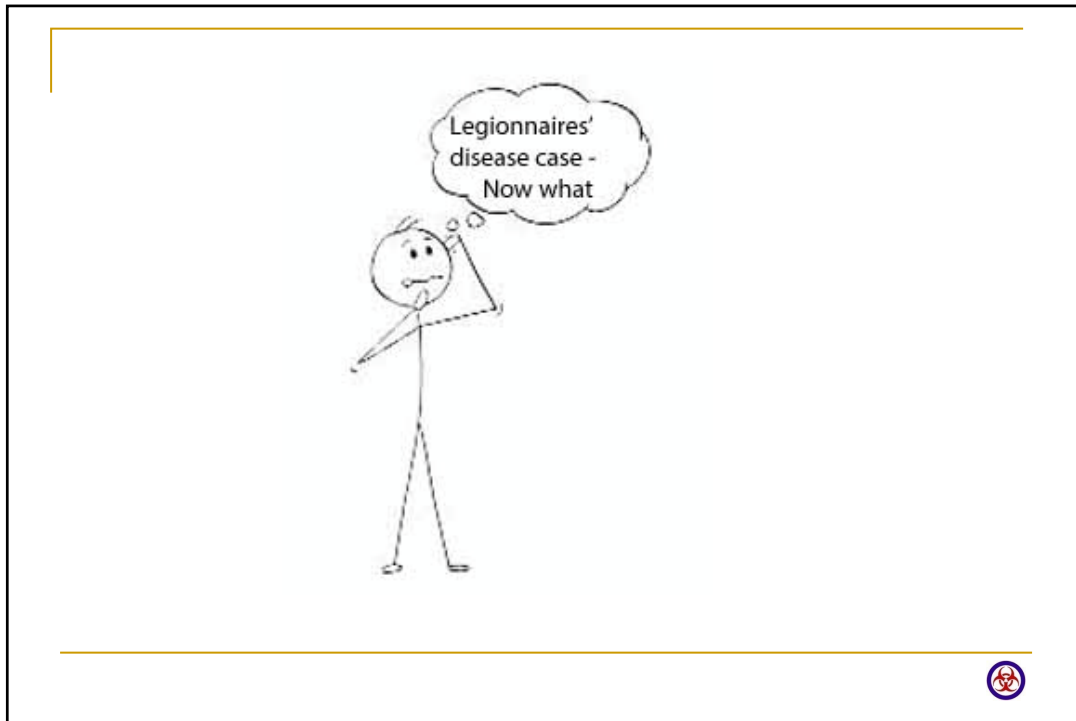
44



45




46



47

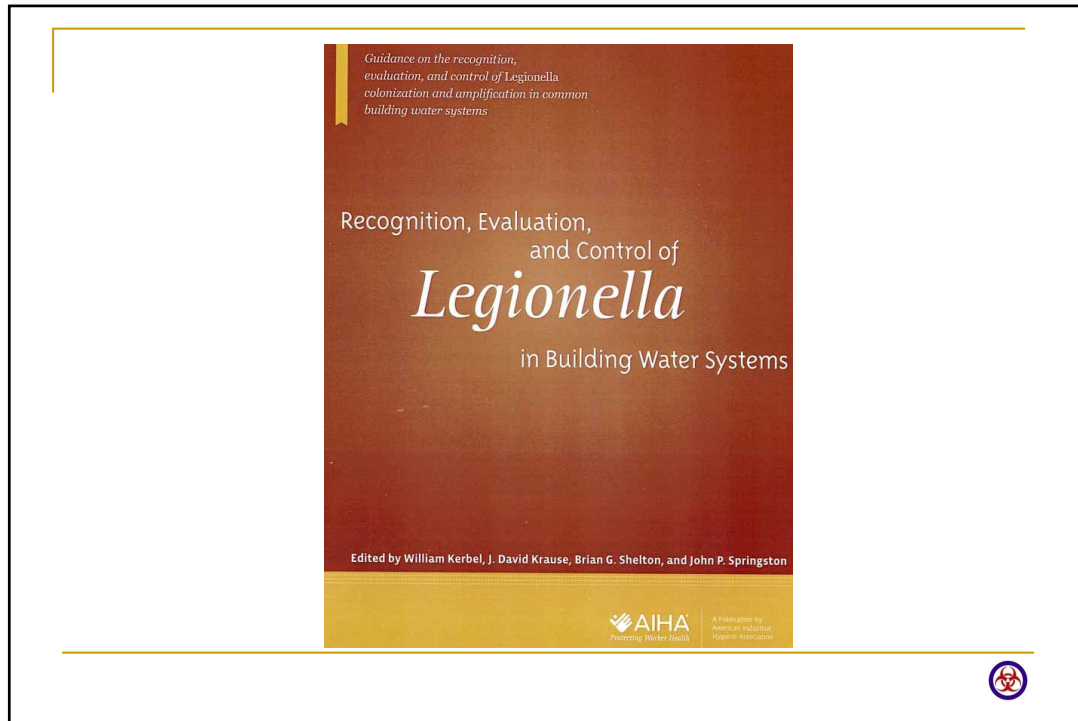
“Industrial hygienists follow the practice of anticipation, recognition, evaluation, and control of hazards and potential hazards in workplace settings”

From: Recognition, Evaluation, and Control of Legionella in Building Water Systems. 2015. William Kerbel et al. AIHA

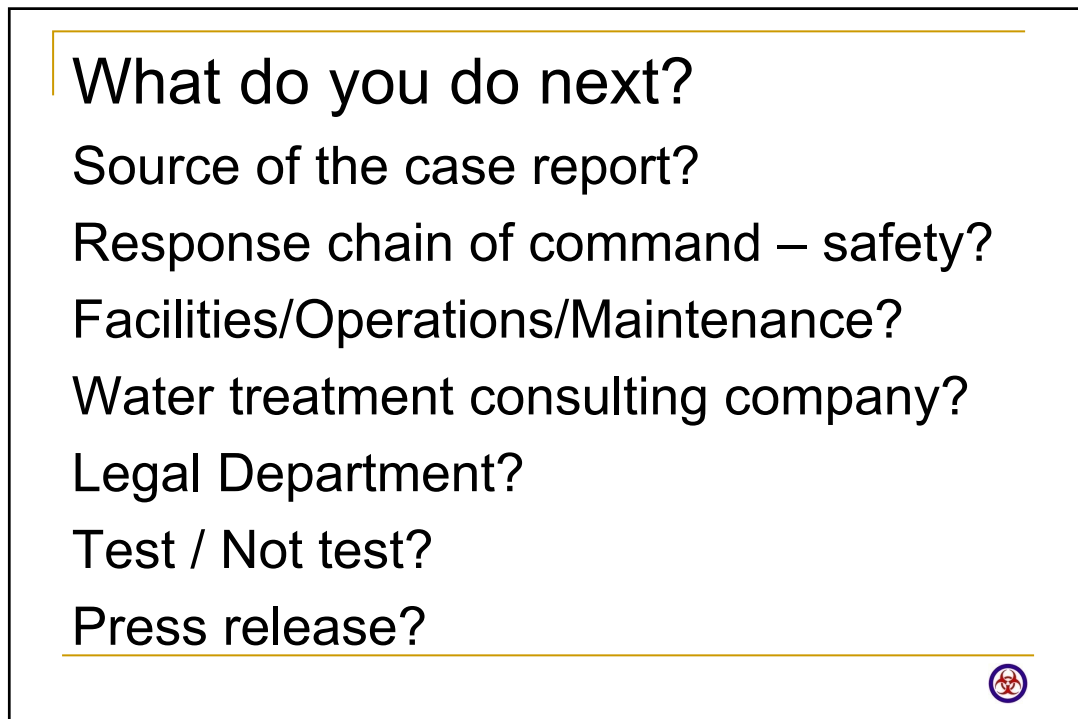
A biohazard symbol is located in the bottom right corner of the text box.

48





49



50

The screenshot shows a news article from WXYZ Detroit. At the top, it displays the date '12/2/2019' and the headline 'Elevated levels of Legionella found in Wayne State University building'. Below the headline, there are navigation elements including a 'Menu' button, a search icon, and a 'Watch Live' button. A 'Quick links...' dropdown menu is also visible. The article is categorized under 'NEWS' and includes social media icons for Facebook, Twitter, and Email. The main title of the article is 'Elevated levels of Legionella found in Wayne State University building'. Below the title, it states 'Posted: 6:42 AM, Jun 26, 2019' and 'Updated: 12:31 PM, Jun 26, 2019'. A biohazard icon is located in the bottom right corner of the screenshot.

51

June 2019 testing began after WSU employee and two contractors were diagnosed with Legionnaires' disease


*Legionella* bacteria were discovered in rooftop cooling towers at several campus buildings

A biohazard icon is located in the bottom right corner of the slide.

52

**Wayne State University Plan**  
Constant monitoring [biocides, pH, testing]  
Aggressive decontamination when  
bacterial numbers rise

**Water Safety Team:**  
Infectious Disease specialists  
EHS  
Facilities  
Planning & Management



53

*“We can’t do an experiment but we can go back and look for correlations”.*



Water Safety Officer Beth Olson (BA 2010, Department of Biological Sciences) from Environmental Health and Safety inspects a cooling tower with Carl Ballou, Engineer with Facilities, Planning and Management.



54

October 2019 - NC Officials Traced 124 Legionnaires' disease cases to a Hot Tub display at a State Fair  
**One week AFTER State Fair closed**, NC Division of Public Health found sudden spike in Legionnaires' disease cases



A photograph of the Davis Event Center, a large, modern building with a prominent entrance. In the foreground, a large blue sign with white text reads "DAVIS EVENT CENTER". The building is surrounded by green grass and some red shrubs. A small biohazard symbol is visible in the bottom right corner of the slide frame.

55

Risk Reduction  
Site Review Guidelines  
Water Management

A slide with a white background and a black border. The text is centered and reads "Risk Reduction", "Site Review Guidelines", and "Water Management" in a large, bold, black font. A small biohazard symbol is visible in the bottom right corner of the slide frame.

56

## ASHRAE Standard 188 - 2018

Legionellosis: Risk Management for Building Water Systems

The presence of *Legionella* bacteria in building water systems is not in itself a sufficient cause

Environmental conditions promoting *Legionella* growth must be present

Aerosol generation must be present to transmit LD

Exposure of susceptible persons to colonized water by inhalation or aspiration into lungs



57

## ASHRAE Standard 188 - 2018

*Legionella* bacteria are not transmitted person-to-person or by normal (non-aspirated) ingestion of *Legionella* contaminated water

Develop risk analysis plans for site review to identify and monitor water containing valves, tanks, boilers, heat rejection equipment, and aerosol producing equipment that may be associated with *Legionella* growth




58

## ASHRAE Site Review Factors

- \*Cooling towers / Evaporative condensers
- \*Whirlpools / Hot tubs / Spas
- \*Ornamental fountains, Misters, Air washers, Humidifiers


Centralized water heaters in multiple unit buildings  
Buildings more than 10 stories high  
Buildings where at risk people stay  
    [disease, diabetes, immunocompromised]  
Buildings where people over 65 years of age stay



59

## Sources of Information

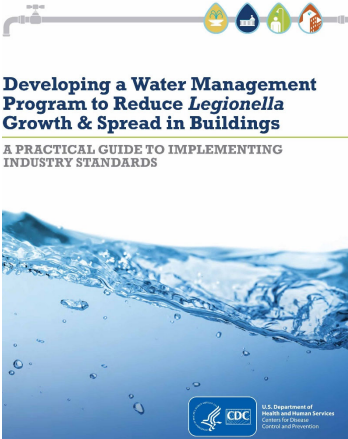
<b>AIHA</b> American Industrial Hygiene Association	<b>APIC</b> Association for Professionals in Infection Control and Epidemiology
<b>ASHRAE</b> American Society of Heating, Refrigerating and Air-Conditioning Engineers	
<b>AWT</b> Association of Water Technologies	<b>CDC</b> Centers for Disease Control and Prevention
<b>CMS</b> Centers for Medicare & Medicaid Services	<b>CTI</b> Cooling Technology Institute
<b>EPA</b> US Environmental Protection Agency	<b>NSF</b> National Science Foundation
<b>NSF</b> NSF International – equipment certification	<b>OSHA</b> US Occupational Safety and Health Administration
<b>VA</b> US Department of Veterans Affairs	



60


# Sources of Information - CDC

June 5, 2017 Version 1.1



**Developing a Water Management Program to Reduce *Legionella* Growth & Spread in Buildings**  
A PRACTICAL GUIDE TO IMPLEMENTING INDUSTRY STANDARDS

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




61

# Potable Water Treatment

- Chlorine vs Monochloramine\*
- Chlorine dioxide
- Copper-silver ionization
- Hot water temperature above 140 °F\*
- Ozone

Flannery, et al., 2006, Emerg Infect Dis 12:588-596



62

## Cooling Tower Treatment – Many choices

- Bromine - oxidizing biocide\*
  - continuously or several hours/day
  - or 3 times/week to get a 0.5 to 1.0 ppm bromine
- Non-oxidizing microbiocides alone not effective
- Chlorine dioxide - oxidizing biocide
  - 4 timed slug feed dosages of 3-5 ppm chlorine dioxide/day
- THPS - tetrakis(hydroxymethyl)phosphonium sulfate (Richard D. Miller, et al., AWT Annual Convention 2011)



63

## Our Legionella Testing



64



## Our DFA Routine Testing

The highest number of *Legionella* we found in a water sample was 150,000/ml of CT water

1980's - 7% of the tower samples tested by our laboratory had *Legionella* counts greater than 200/ml of tower water – Now about 1% or less

Water line samples are usually negative

Highest recent counts from hospital water samples have come from decorative fountains



65

## Our Remedial Action Criteria

**< 0.2 to 1 CFU/ml**

- This is the most common test result
- This does not require remedial action
- Obtain another test of this site in a month to check for evidence of increasing numbers of *Legionella*
- Some operators perform routine monitoring monthly, many operators monitor quarterly



66

## Our Remedial Action Criteria

### > 1 to 10 CFU/ml

- This is the second most common test result
- The decision to disinfect the system should be made by considering the numbers of *Legionella*, the location of the system, and the type of employee, patient or visitor population
- If the system is not disinfected, obtain another test within a few weeks to check for evidence of increased numbers of *Legionella*



67

## Our Remedial Action Criteria

### > 10 CFU/ml

- This is the least likely test result
- This result represents a public health concern
- Disinfection of the system is indicated
- If greater than 100 CFU/ml, take action immediately
- Obtain another test within a few weeks to check for evidence of increased numbers of *Legionella*



68

## Decontamination



69

## Cooling Tower Decontamination

State of Wisconsin Department of Health and Social Services “Control of *Legionella* in Cooling Towers, Rev. 8/87, POH4242”; ASHRAE; or CTI

Cooling tower shock treatment with 50 ppm free residual chlorine with a non-sudsing detergent. Maintain 10 ppm free residual chlorine for 24 hours following the initial shock dose. Repeat once. Flush & return to service



70

## Water Line Decontamination

Heat hot water systems to 160 °F (71 °C) -  
170 °F (77 °C) for one hour and measure  
that temperature at each tap – May not  
remove biofilms

The American Water Works Association  
hyper-chlorination method: 50 ppm for 1  
hour - Labor intensive - More effective\*



71

GTS Legionella Testing Lab  
- since 1981 -

[www.legionella.com](http://www.legionella.com)

Subscribe to our newsletter



72

# Thank you

Richard W Gilpin PhD RBP CPSB SM(NRCM)  
gilpin@legionella.com  
(410) 961-6638  
Biosafety Training – Legionella Testing

