Waterborne Pathogen Disinfection and Remediation in Healthcare Facilities

Presented by:
Michael Castro

Michael Castro, MPH, CWT
District Manager
Barclay Water Management

- 24 years of experience
- Voting member of ANSI/ASHRAE Std. 188
- Committee member of ANSI/ASHRAE Std. 514
- Initiated Development of ASTM Std. D8422:
  - Intermittent Use Validation of POU Water Filters
- Certified Trainer for ASSE 12080 *Legionella* Water Safety & Management Specialist Program
- Co-authored a chapter entitled *Legionella: Causes, cases, and mitigation*

Learning Objectives

1. Identify different interventions used to mitigate *Legionella* and other waterborne pathogen challenges

2. Evaluate benefits, challenges and limitations to short-term and long-term disinfection and remediation strategies

3. Discuss peer reviewed publications to support evidence-based performance claims

4. Describe next steps in the evaluation and the implementation of interventions when Water Management Program validation (environmental *Legionella* sampling) identifies risks to patients, visitors, and staff.

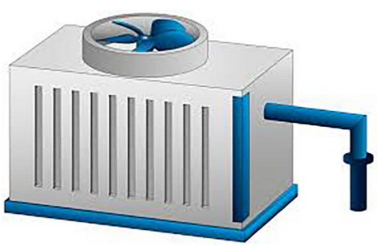
Jan. 1988 & Jan. 2006

Opening Questions

- Have you already evaluated your options if your facility has significant **environmental *Legionella* colonization**/contamination?
- Does your facility want to be **proactive or reactive** with respect to waterborne pathogen challenges?
- Who is confident that you know which potable water **disinfectant** your hospital receives in the city water?

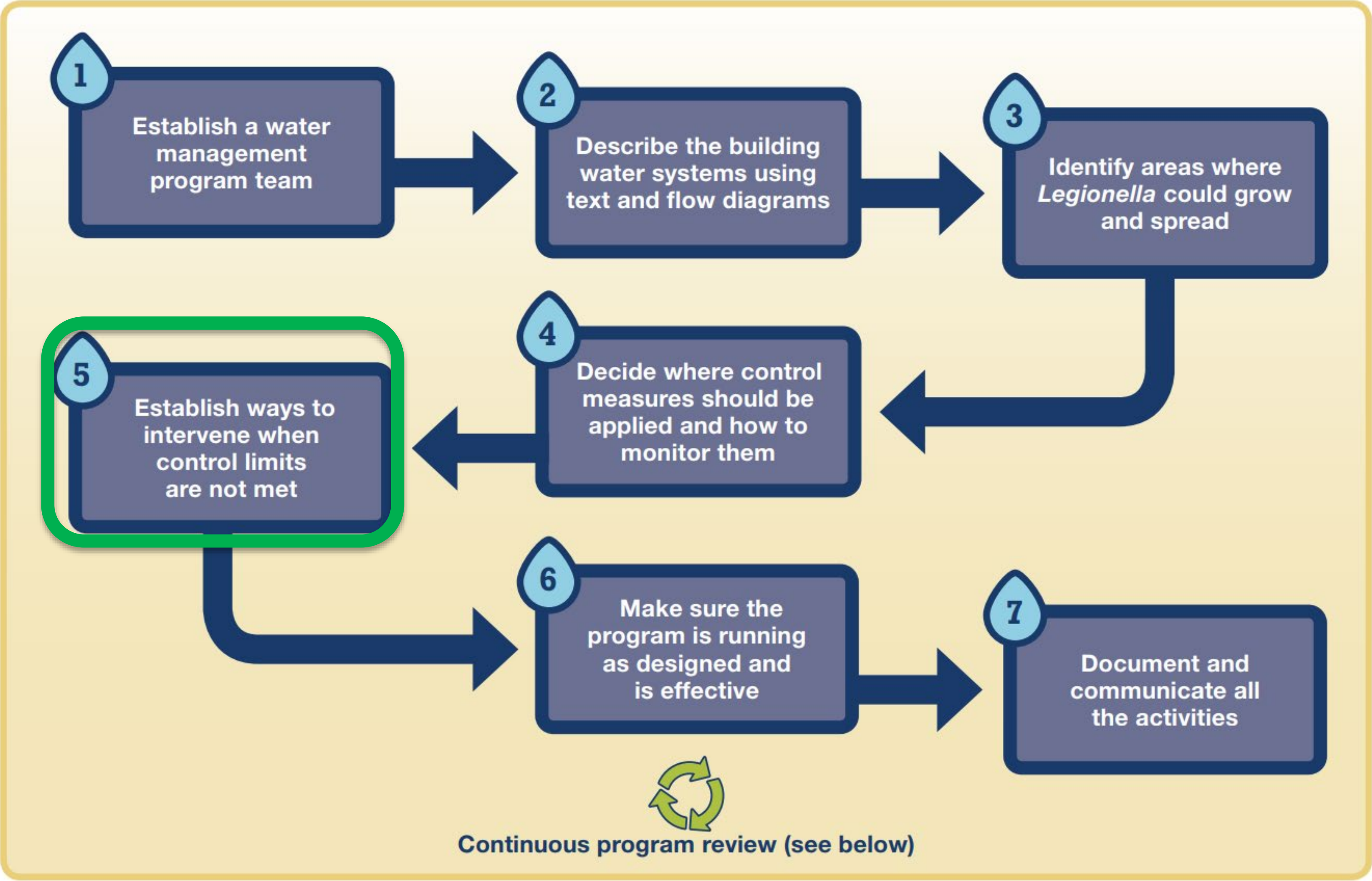
Legionella Reservoirs in Building Water Systems

- **Potable Water**
  - Showerheads
  - Faucets
  - Ice Machines
- Cooling Towers
- Decorative Fountains
- Whirlpool Baths or Spas
- Misting Systems
- Dental Lines
- Humidifiers
- Water Fountains





Water Management Program Interventions



Water Management Program Validation

LABORATORY REPORT

Hospital
123 Hospital Dr
New York, NY 10100

REPORT NO.: 123
SAMPLE DATE: 10-06-2022
REPORT DATE: 10-24-2022

#	Sample Name	*Pseudomonas aeruginosa* (CFU/100mL)
1	NICU Room 1	47
2	NICU Room 2	106
3	NICU Room 4	88
4	NICU Room 7	131
5	NICU Room 13	91

What Happens Next?

ASHRAE Guideline 12-2020

Managing the Risk of Legionellosis Associated with Building Water Systems

Table C-1 Performance Indicators for Water Management Programs for Potable Water Systems [a]

Calculated *Legionella*, CFU/mL [b]	Program Performance	Suggested Response
≤1 or not detected	*Legionella* growth appears well controlled.	Continue Program.
>1	Conditions may allow *Legionella* growth.	Implement the guidance in Section C5 [d].
Trending of Test Results over Time [c]	**Program Performance**	**Suggested Response**
10 to 100 fold increase	*Legionella* growth appears to be poorly controlled.	Implement the guidance in Section C5 [d].
>100 fold increase	*Legionella* growth appears to be uncontrolled.	Implement the guidance in Section C5 [d].

In **health care facilities** where **at-risk persons** are housed or treated and where ***Legionella* growth does not appear well controlled**, **consider implementing measures** from the healthcare facility's water management plan **to protect patients** from exposure to water aerosols while implementing the guidance in Section C5.

CDC *Legionella* Toolkit
(June 24, 2021, Version 1.1)

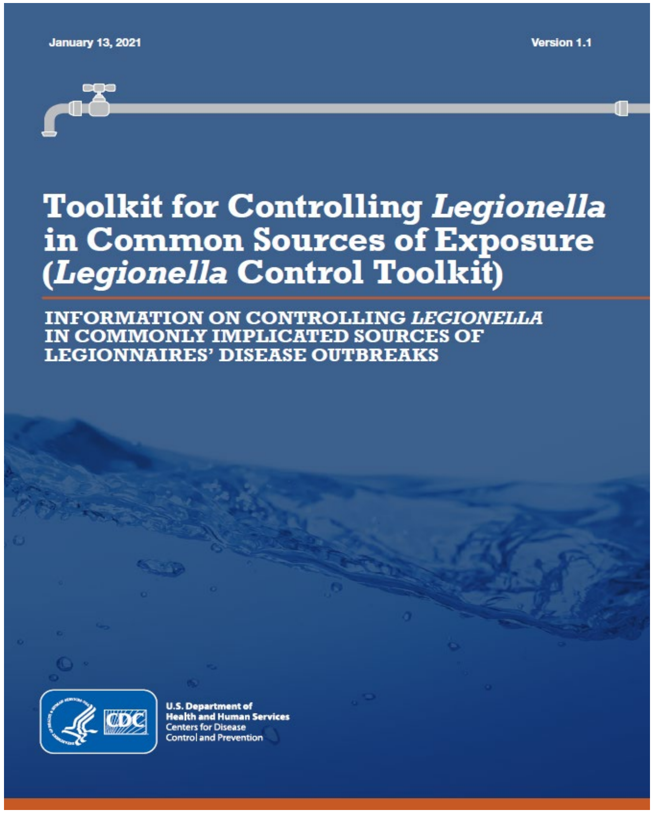
Figure 1. Routine *Legionella* testing: A multifactorial approach to performance indicator interpretation*°Δ

Concentration indicates that *Legionella* growth appears:

Uncontrolled	Poorly Controlled	Well Controlled	
≥10 CFU/mL[†] in potable water **OR** ≥100 CFU/mL in non-potable water	1.0–9.9 CFU/mL in potable water **OR** 10–99 CFU/mL in non-potable water	Detectable to 0.9 CFU/mL in potable water **OR** Detectable to 9 CFU/mL in non-potable water	No *Legionella* detected in a single round of testing

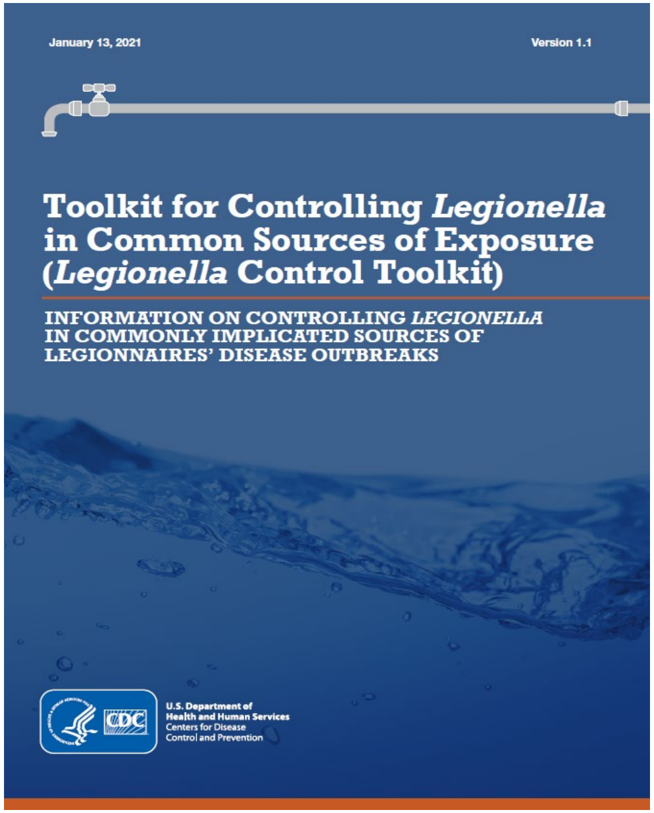
Change in concentration over time indicates that *Legionella* growth appears:

Uncontrolled	Poorly Controlled	Well Controlled	
100-fold or greater increase in concentration (e.g., 0.05 to 5 CFU/mL)	10-fold increase in concentration (e.g., 0.05 to 0.5 CFU/mL)	*Legionella* concentration steady (e.g., 0.5 CFU/mL for two consecutive sampling rounds)	No *Legionella* detected in a single round of testing



CDC *Legionella* Toolkit (June 24, 2021, Version 1.1)

- If Legionella growth does not appear well controlled in healthcare facilities…**consider implementing immediate control measures**…
- If the **root causes** of *Legionella* growth are not identified and controlled, ***Legionella* growth is likely to reoccur.**



SAN DIEGO STATE UNIVERSITY

San Die[...]sease

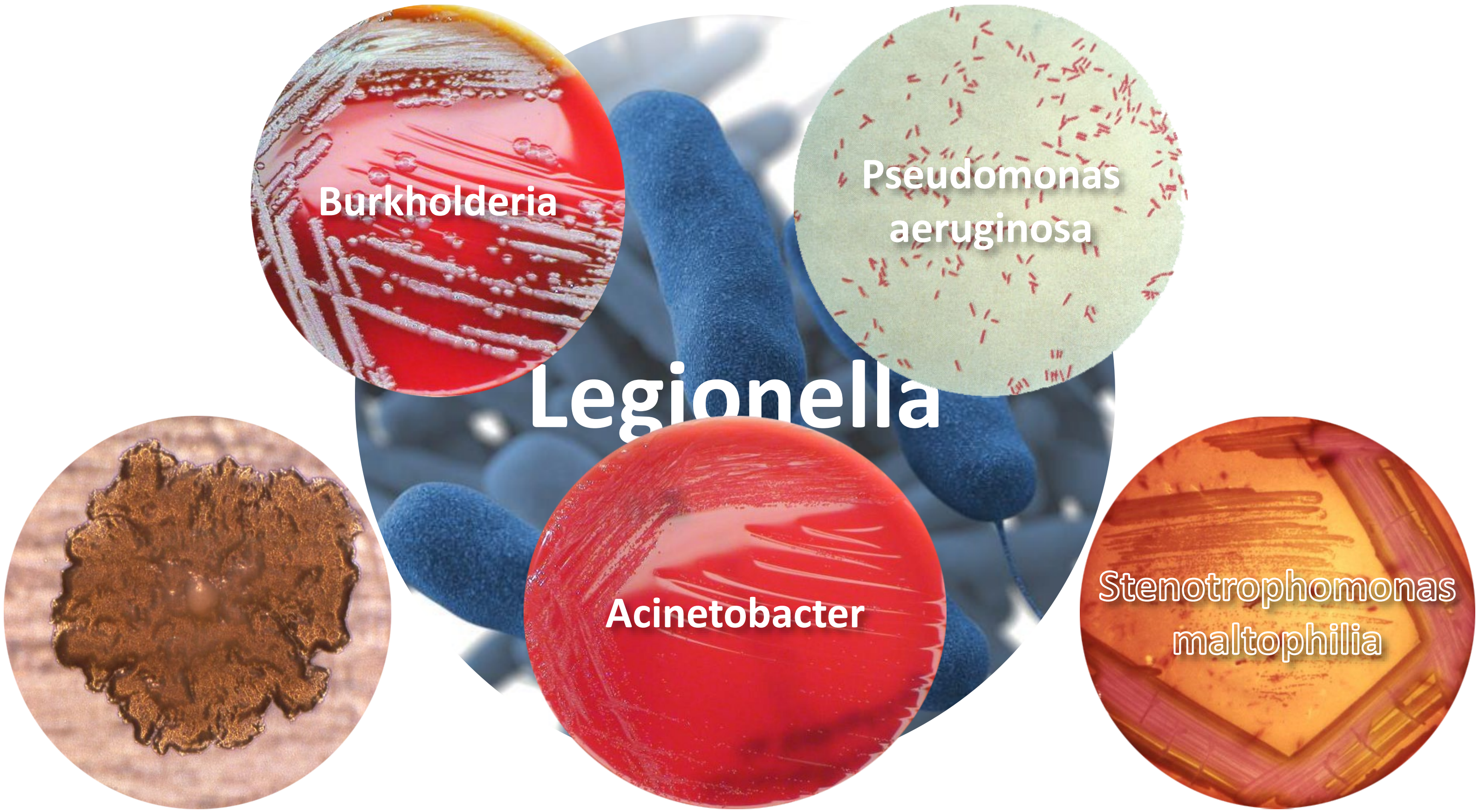
Legionella can be[...]
like hot tubs, hot[...]

Cases of Legionnaires' disease linked to two Las Vegas hotels

Two people who stayed at Caesars Palace Hotel and Casino were diagnosed with Legionnaires' disease, as was one former guest of the Orleans Hotel & Casino.

https://www.nbcsandiego.com/news/local/san diego state professor-dies of-legionnaires disease/3181301/
https://www.nbcnews.com/news/us news/legionnaires disease-las vegas-hotels rcna101815

It's Not Just About Legionella Anymore



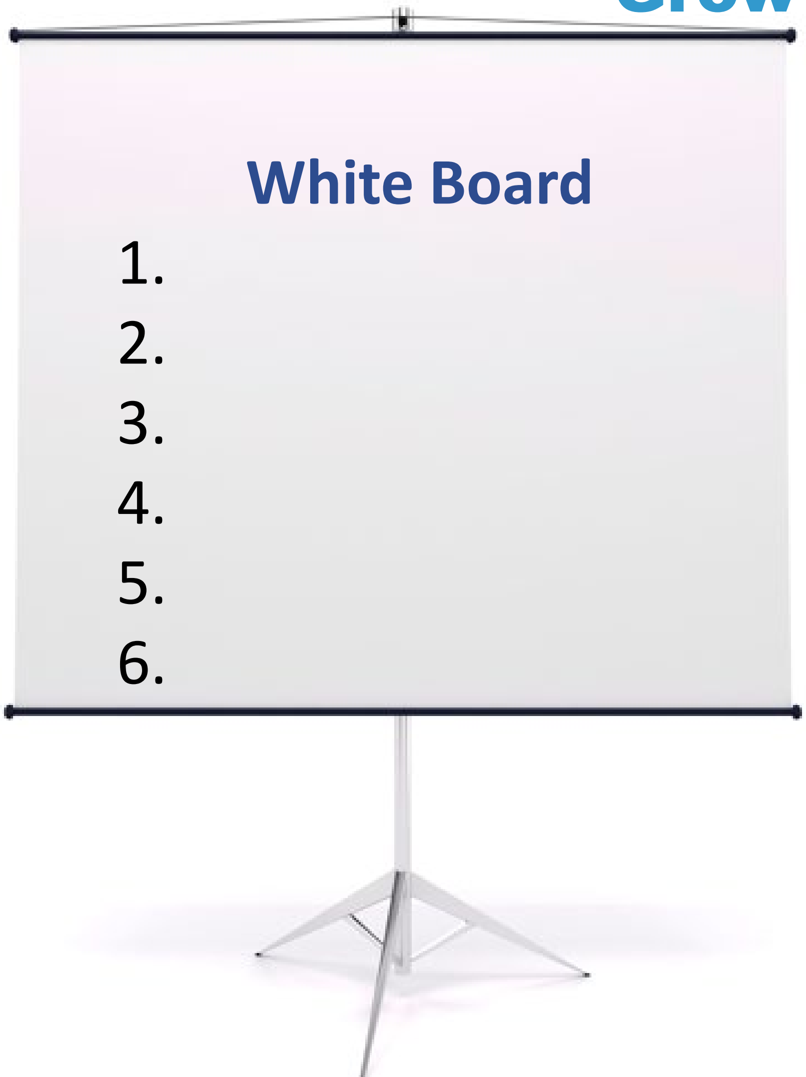
Other Waterborne Pathogens in Healthcare

- ***Pseudomonas aeruginosa*** [1, 2]
  - ~51,000 healthcare-associated *P. aeruginosa* infections occur in the US annually resulting in ~400 deaths per year. 13% are multidrug-resistant
  - Infants with *P. aeruginosa* infections showed crude mortality rates of 18 to 100% (mean = 62.7%)

- **Nontuberculous Mycobacteria (NTM)** [3]
  - Oregon Study: 35.1% died in the 5 years following respiratory identification
  - ~85,000 people in the US currently suffering from NTM infection

1: https://www.cdc.gov/hai/organisms/pseudomonas.html;
2: Jefferies, J. M., Cooper, T., Yam, T., & Clarke, S. C. (2012). Pseudomonas aeruginosa outbreaks in the neonatal intensive care unit – a systematic review of risk factors and environmental sources. Journal of Medical Microbiology, 1052–1061; 3: https://ohsu.pure.elsevier.com/en/publications/mortality-after-respiratory-isolation-of-nontuberculous-mycobacte

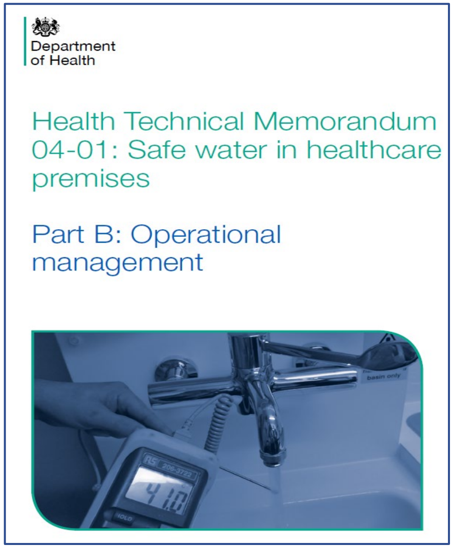
Most Efficient Ways to Grow Bacteria



Most Efficient Ways to Grow Bacteria

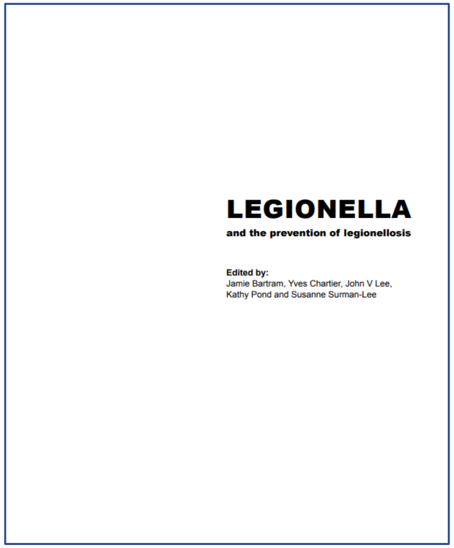
- Allow them access
- Provide water & food (nutrients)
- Provide thermal comfort (ideal temperatures)
- Provide stable environment (stagnancy)
- Provide protected environment (complexity in componentry)
- Do not disrupt their environment (aged plumbing systems)
- Teach them heat and chemical resistance
- Selectively kill weak organisms
- Allow population to evolve and diversify
- Provide a home they can eat (EPS gingerbread house)
- Add new components which are pre-colonized
- Backwash stagnant fire hydrant systems into their home

An Abundance of Guidance Exists


Department of Health

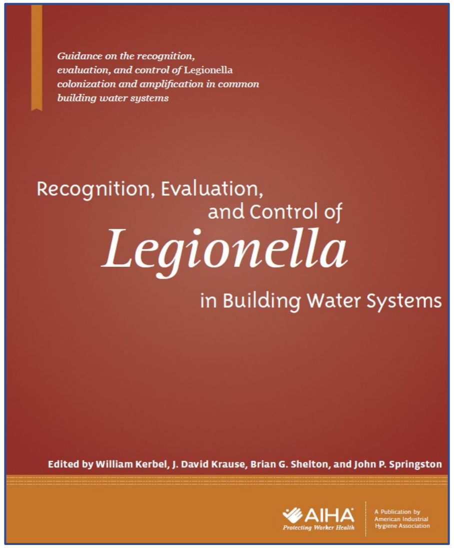
Health Technical Memorandum 04-01: Safe water in healthcare premises

Part B: Operational management


LEGIONELLA

and the prevention of legionellosis

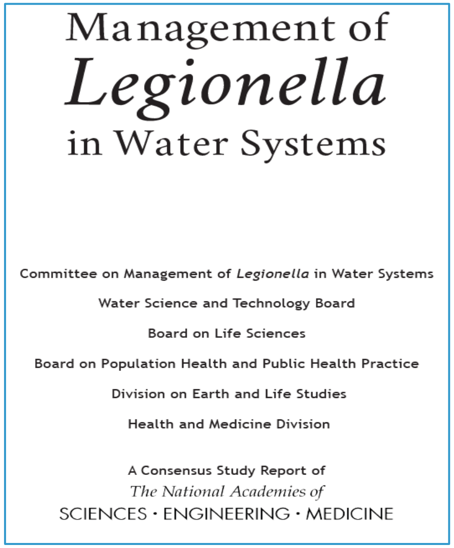
Edited by:
Jamie Bartram, Yves Chartier, John V Lee, Kathy Pond and Susanne Surman-Lee


Guidance on the recognition, evaluation, and control of Legionella colonization and amplification in common building water systems

Recognition, Evaluation, and Control of *Legionella* in Building Water Systems

Edited by William Kerbel, J. David Krause, Brian G. Shelton, and John P. Springston

AIHA — Protecting Worker Health — A Publication by American Industrial Hygiene Association


Management of *Legionella* in Water Systems

Committee on Management of *Legionella* in Water Systems

Water Science and Technology Board

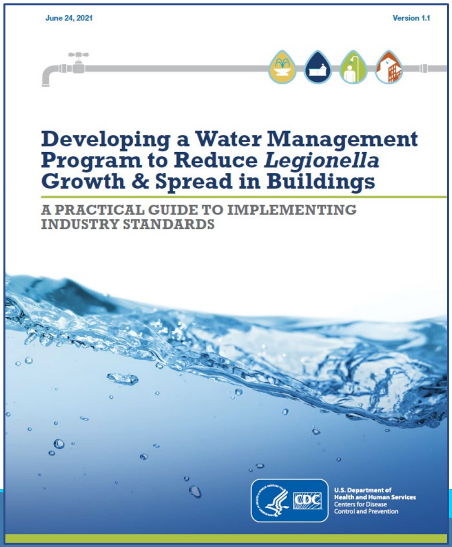
Board on Life Sciences

Board on Population Health and Public Health Practice

Division on Earth and Life Studies

Health and Medicine Division

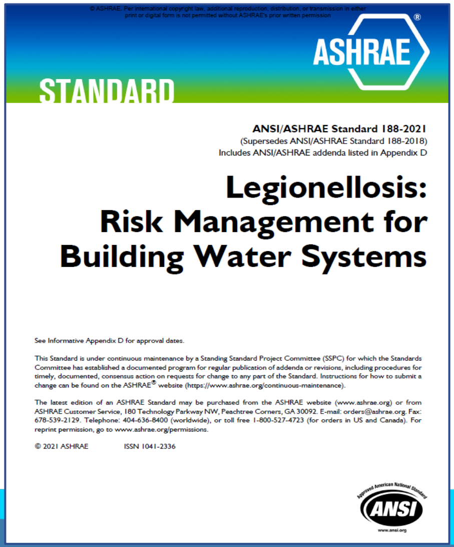
A Consensus Study Report of *The National Academies of* SCIENCES · ENGINEERING · MEDICINE


June 24, 2021 — Version 1.1

Developing a Water Management Program to Reduce *Legionella* Growth & Spread in Buildings

A PRACTICAL GUIDE TO IMPLEMENTING INDUSTRY STANDARDS

U.S. Department of Health and Human Services — Centers for Disease Control and Prevention


ASHRAE — STANDARD

ANSI/ASHRAE Standard 188-2021
(Supersedes ANSI/ASHRAE Standard 188-2018)
Includes ANSI/ASHRAE addenda listed in Appendix D

Legionellosis: Risk Management for Building Water Systems

See Informative Appendix D for approval dates.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

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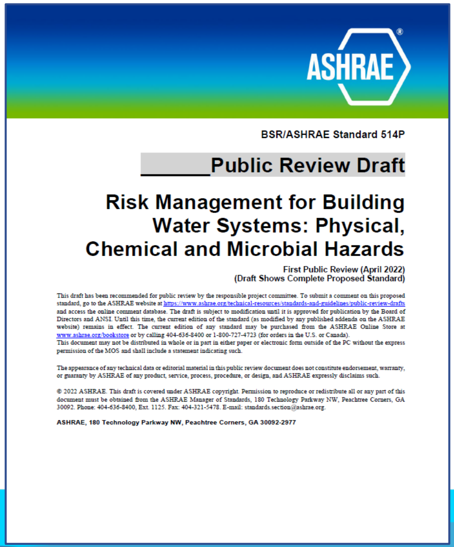
Approved American National Standard — ANSI


ASHRAE

BSR/ASHRAE Standard 514P

Public Review Draft

Risk Management for Building Water Systems: Physical, Chemical and Microbial Hazards

First Public Review (April 2022)
(Draft Shows Complete Proposed Standard)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at https://www.ashrae.org/technical-resources/standards-and-guidelines/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the standard (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).
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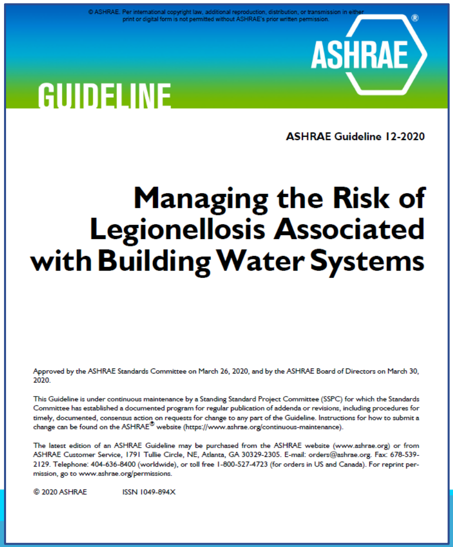
ASHRAE — GUIDELINE

ASHRAE Guideline 12-2020

Managing the Risk of Legionellosis Associated with Building Water Systems

Approved by the ASHRAE Standards Committee on March 26, 2020, and by the ASHRAE Board of Directors on March 30, 2020.

This Guideline is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Guideline. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

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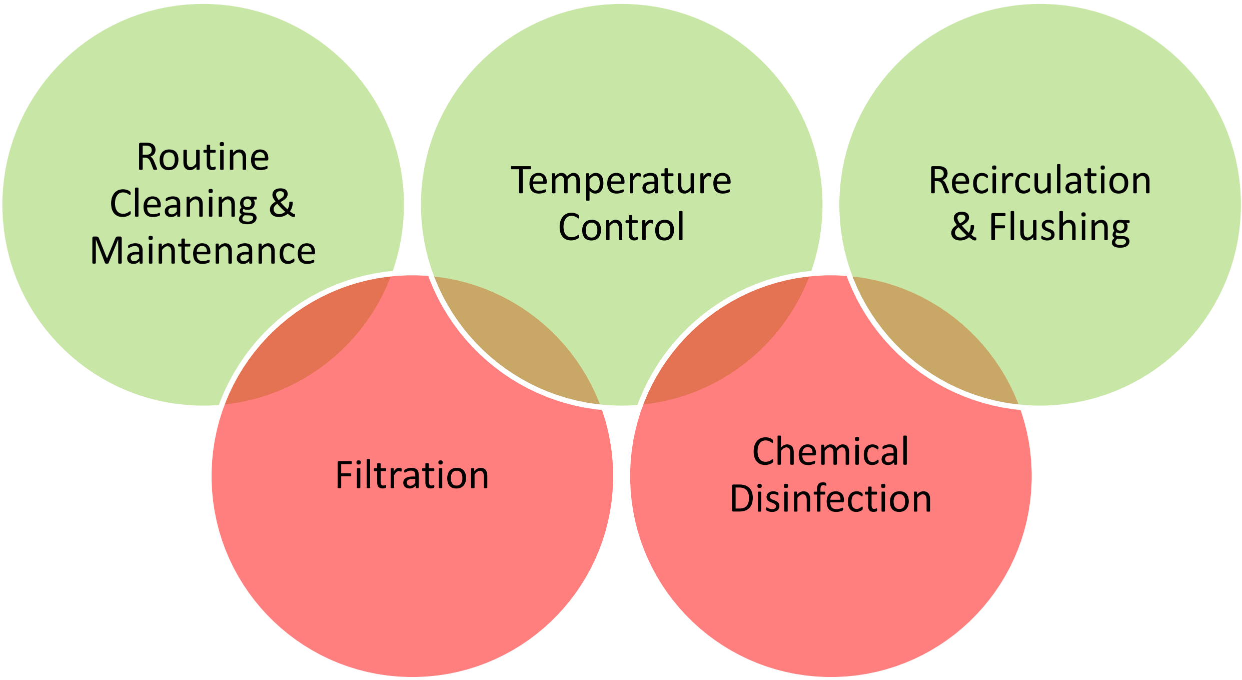
Limit Amplification by Bundling Interventions



- Keep it clean
- Keep it hot
- Keep it cold
- Keep it moving
- Keep residual chemistry

Keep it Hot & Keep it Cold

- **Benefits:**
  - **Prevent** *Legionella* **multiplication**
  - **Maintain** biofilm **stasis**
  - Prevent heat loss or gain with insulation

- **Obstacles:**
  - Heating rapidly **depletes** many **disinfectant residuals**
  - **Capacity of water heaters** is inappropriate to deliver high temperatures
  - **Scalding** & **plumbing code** requirements
  - Increased corrosion
  - Decreased equipment life
  - Cold water main may be warm already

*Flemming, P.-C. (2016). Executive Summary: Results of the Collaborative research project "Biofilms in Drinking Water Installations". Duisburg, Germany: University Duisburg-Essen.

Water Research
Volume 149, 1 February 2019, Pages 460-466

Role of hot water temperature and water system use on *Legionella* control in a tertiary hospital: An 8-year longitudinal study

Laura Gavaldà [a], Marian Garcia-Nuñez [b,c,d], Sara Quero [b], Carmen Gutierrez-Milla [a], Miquel Sabrià [b,c,e]

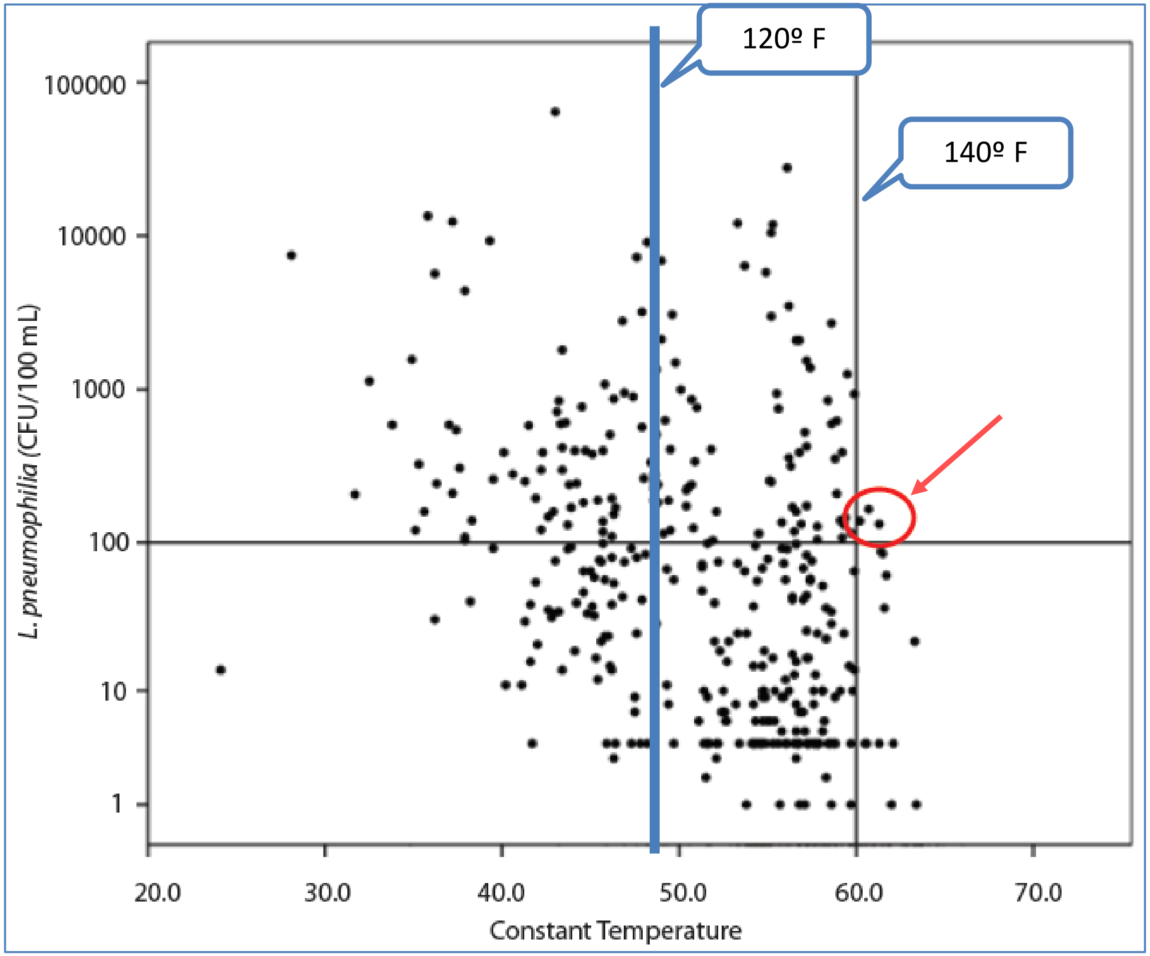
- Hot water temps dramatically drop to ambient in 20 min.
- *Legionella* is significantly higher at POU if **not used daily**.
- **Weekly flushing** of taps and showers **is not enough** to minimize *Legionella* colonization.

Temperature Control Measures, Really?

Is 120°F or 140°F a true control measure?

- Hot water-constant temperature is an important predictor for the presence of L. pneumophila

- Only 3 (0.55%) of 541 samples exceeded the technical measures level when the hot water temperature was consistently above 140°F



Corrective Action: Remediation Options

<u>Short-Term Disinfection Options</u>

- Chemical Shock / Hyper-halogenation (chlorine)
- Point-of-Use Microbiological Filters (widespread use)
- Thermal Disinfection/Superheat & Flush
- Flushing

<u>Long-Term Disinfection Options</u>

- Sodium Hypochlorite (chlorine)
- Copper/Silver Ionization
- Chlorine Dioxide
- Monochloramine
- Ozonation / Ultraviolet Disinfection
- Point-of-Use Microbiological Filters (targeted deployment)

How Do We Select the Best Intervention?

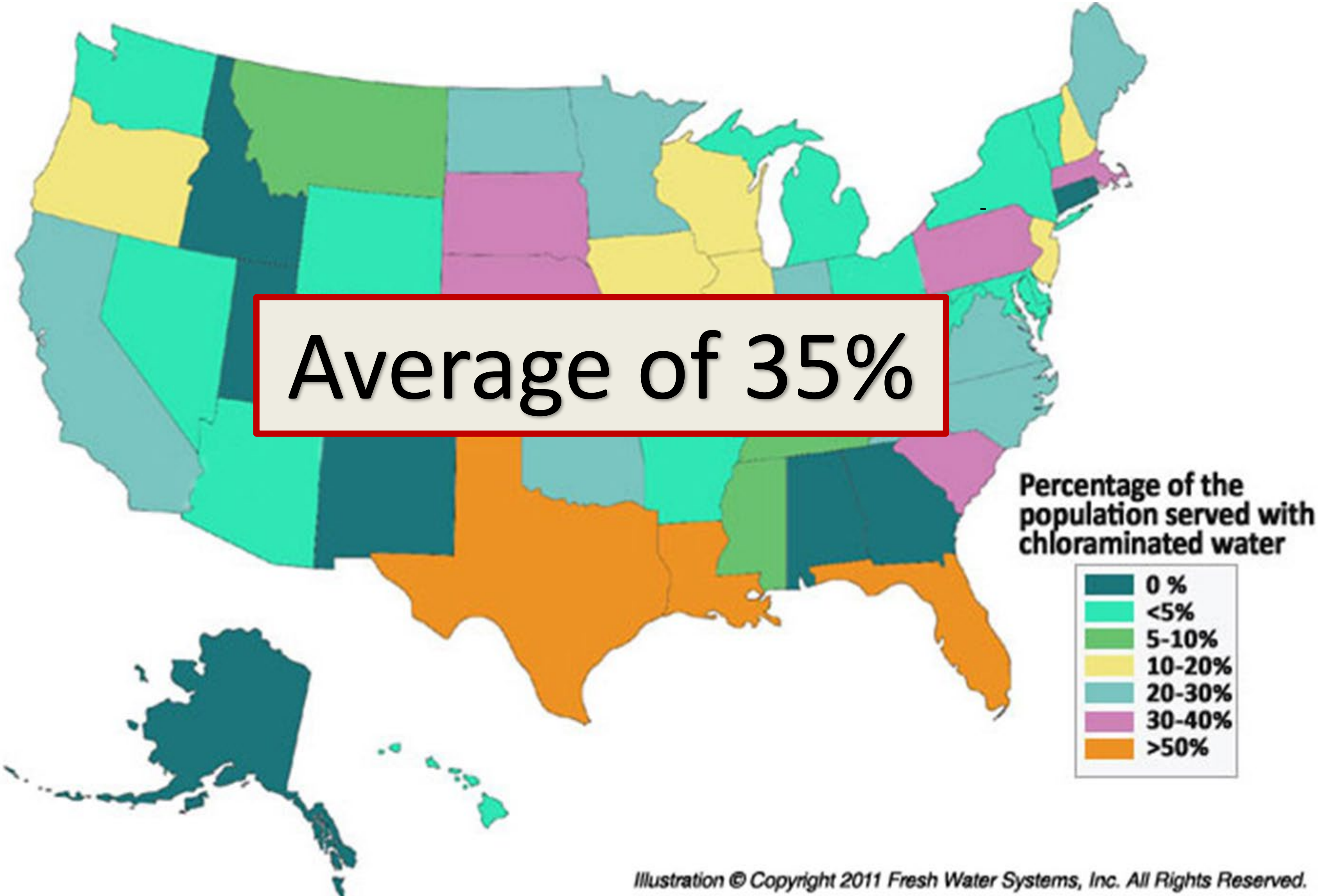
When to Consider

- Water temperature
- Incoming chemistry
- Supplemental chemistry
- Efficacy against biofilm
- Third-party publications
- Alarming, data & trending
- Corrosion/metallurgy

What to Consider

- EPA permitting requirements
- Cost (capital & operational)
- Footprint
- Service requirements
- Manpower requirements
- Safety features
- Other bundled interventions used

Drinking Water Disinfectants in USA



Drinking Water Disinfectants in USA

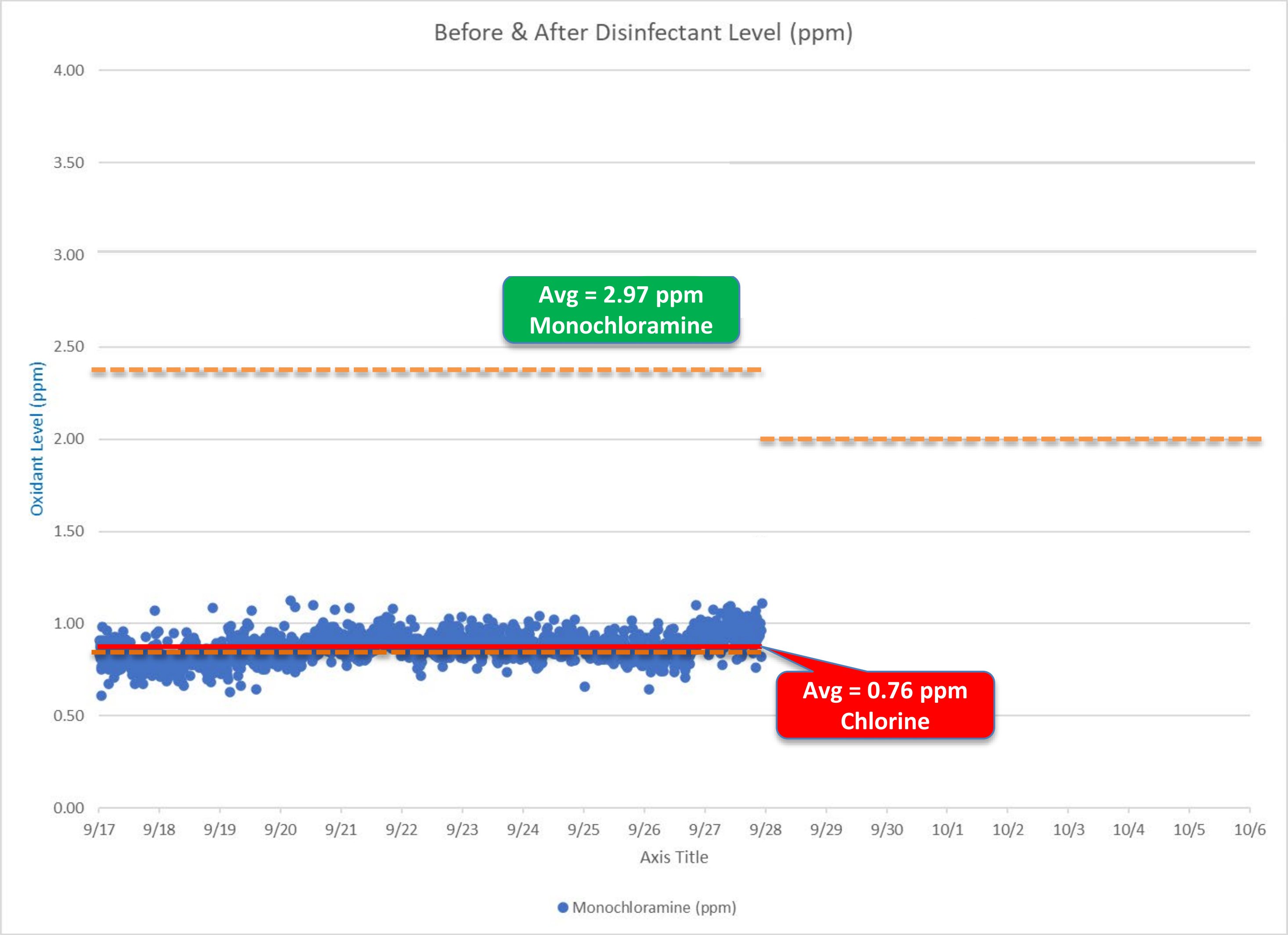
Effect of monochloramine disinfection of municipal drinking water on risk of nosocomial Legionnaires' disease

Jacob L Kool, Joseph C Carpenter, Barry S Fields

Findings Hospitals supplied with drinking water containing free chlorine as a residual disinfectant were more likely to have a reported outbreak of Legionnaires' disease than those that used water with monochloramine as a residual disinfectant (odds ratio 10·2 [95% CI 1·4–460]). This result suggests that 90% of outbreaks associated with drinking water might not have occurred if monochloramine had been used instead of free chlorine for residual disinfection (attributable proportion 0·90 [0·29–1·00]).

Effect of monochloramine disinfection of municipal drinking water on risk of nosocomial Legionnaires' disease; Jacob L Kool, Joseph C Carpenter, Barry S Fields THE LANCET • Vol 353 • January 23, 1999, Page 272:

What is Supplemental Disinfectant?

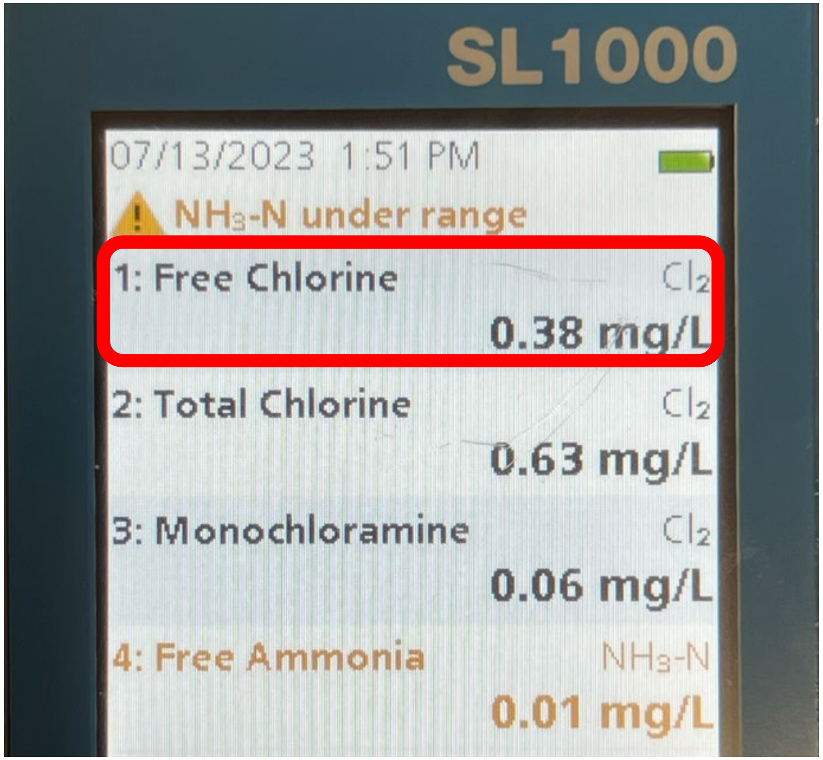


When is Supplemental Disinfection Considered?

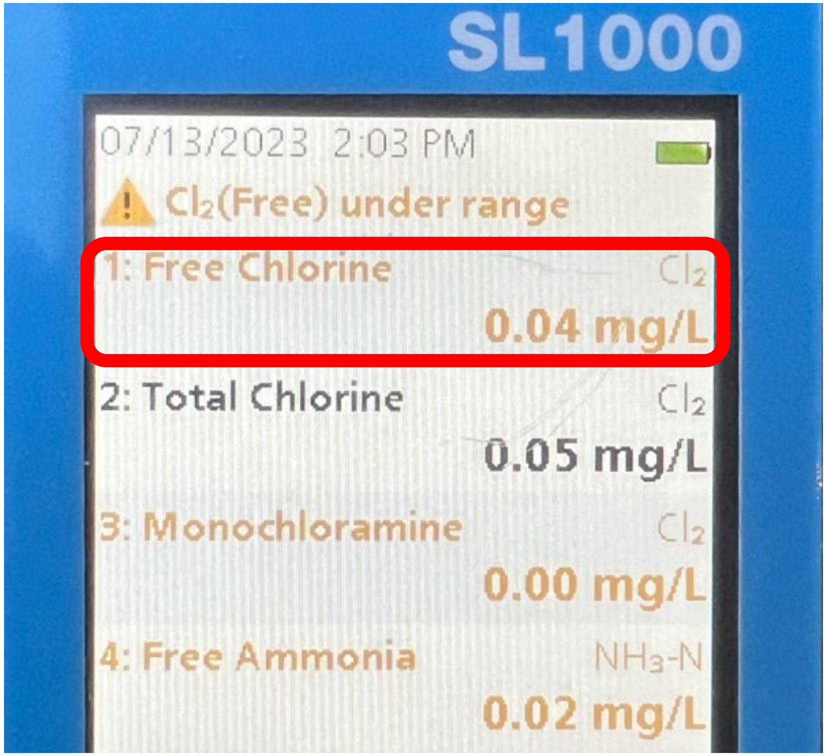
- Poor temperature control or heavy organic load
- Inadequate disinfectant at the point-of-use
- Amplification of *Legionella* within complex plumbing systems
- Case of Legionnaires' disease

Inadequate Disinfectant at the Point-of-Use

Cold Water Main
(point-of-entry)



Potable Hot Water
(distal faucet)



Inadequate Disinfectant at the Point-of-Use

Distal Point Chlorine Mapping Study: Cold Water

Room Number/ Location/Door Tag	Fixture Type/Source	Hot/Cold/Tempered	Free Chlorine	Total Chlorine	Initial Temp (F°)	Final Temp (F°)	Time to Temp (min:sec)
Cold Main Point of Entry	Hose Bib			1.06	N/A	77.2	N/A
Cold Main Point of Entry (Softener Effluent)	Hose Bib	Cold	0.02	0.07	N/A	77.6	N/A
Cold Main Booster Pump	Hose Bib			1.41	N/A	78.6	N/A
Cold Main	Hose Bib	Cold	0.69	1.46	N/A	77.1	N/A
11410 (14th floor)	Manual/Wrist Blade Faucet			0.97	80.3	77.1	:20
10602 (6th floor)	Manual/Wrist Blade Faucet	Cold	1.01	1.33	83.2	77.4	:16
32526 (25th floor)	Manual/Wrist Blade Faucet	Cold	1.40	1.42	80.0	78.1	:35
22016 (20th floor, right sink)	Manual/Wrist Blade Faucet	Cold	0.31	0.45	84.0	77.5	:26

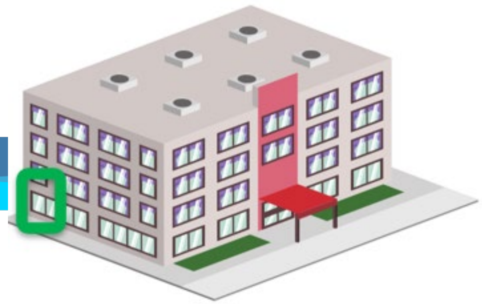
Free Chlorine Avg: 0.72 ppm

Inadequate Disinfectant at the Point-of-Use

Distal Point Chlorine Mapping Study: Hot Water

Room Number/ Location/Door Ta	Fixture Type/Source	Hot/Cold/Tempered	Free Chlorine	Total Chlorinc	Initial Temp (F°)	Final Temp (F°)	Time to Temp (min:sec)
Hot Water Return (High Zone)	Hose Bib			0.11	N/A	123.8	N/A
Hot Water Return (Low Zone)	Hose Bib	Hot	0.05	0.08	N/A	116,6	N/A
Hot Water Return (High Zone)	Hose Bib			0.16	N/A	131.3	N/A
Hot Water Return (Low Zone)	Hose Bib	Hot	0.04	0.07	N/A	121.8	N/A
Hot Water Return (High Zone)	Hose Bib			0.15	N/A	126.5	N/A
Hot Water Return (Low Zone)	Hose Bib	Hot	0.10	0.21	N/A	131.0	N/A
Hot Water Return (High Zone)	Hose Bib			0.09	N/A	125.1	N/A
Hot Water Return (Low Zone)	Hose Bib	Hot	0.05	0.09	N/A	117.6	N/A
11410 (14th floor)	Manual/Wrist Blade Faucet			0.06	104.5	129.5	:25
Suite 11603 (16th floor, guest bathroom)	Manual/Wrist Blade Faucet	Hot	0.08	0.09	69.6	126.9	:51
Suite 11603 (16th floor, master #2, sink #2)	Manual/Wrist Blade Faucet	Hot	0.04				1:50

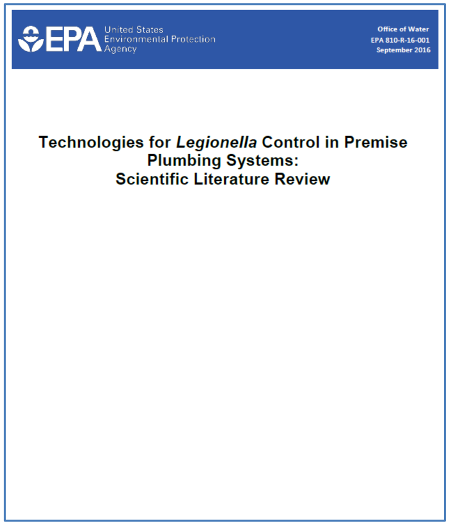
Free Chlorine Avg: 0.05 ppm



Is Supplemental Disinfection Effective?

- **Multiple studies:** "**support maintaining a chloramine residual** in the premise plumbing system in the range of 1 to 2 ppm as an effective means for **containing biofilm growth, minimizing *Legionella* colonization and preventing outbreaks**."

- "Within healthcare facilities such as hospitals and nursing homes the **potable water supply is the most common source of [*Legionella*] exposure**."



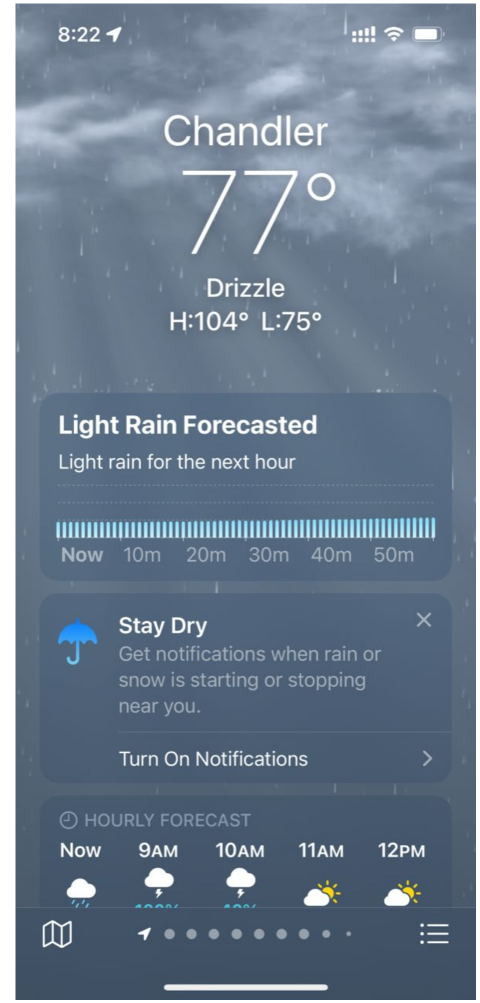
EPA United States Environmental Protection Agency

Office of Water
EPA 810-R-16-001
September 2016

Technologies for *Legionella* Control in Premise Plumbing Systems:
Scientific Literature Review

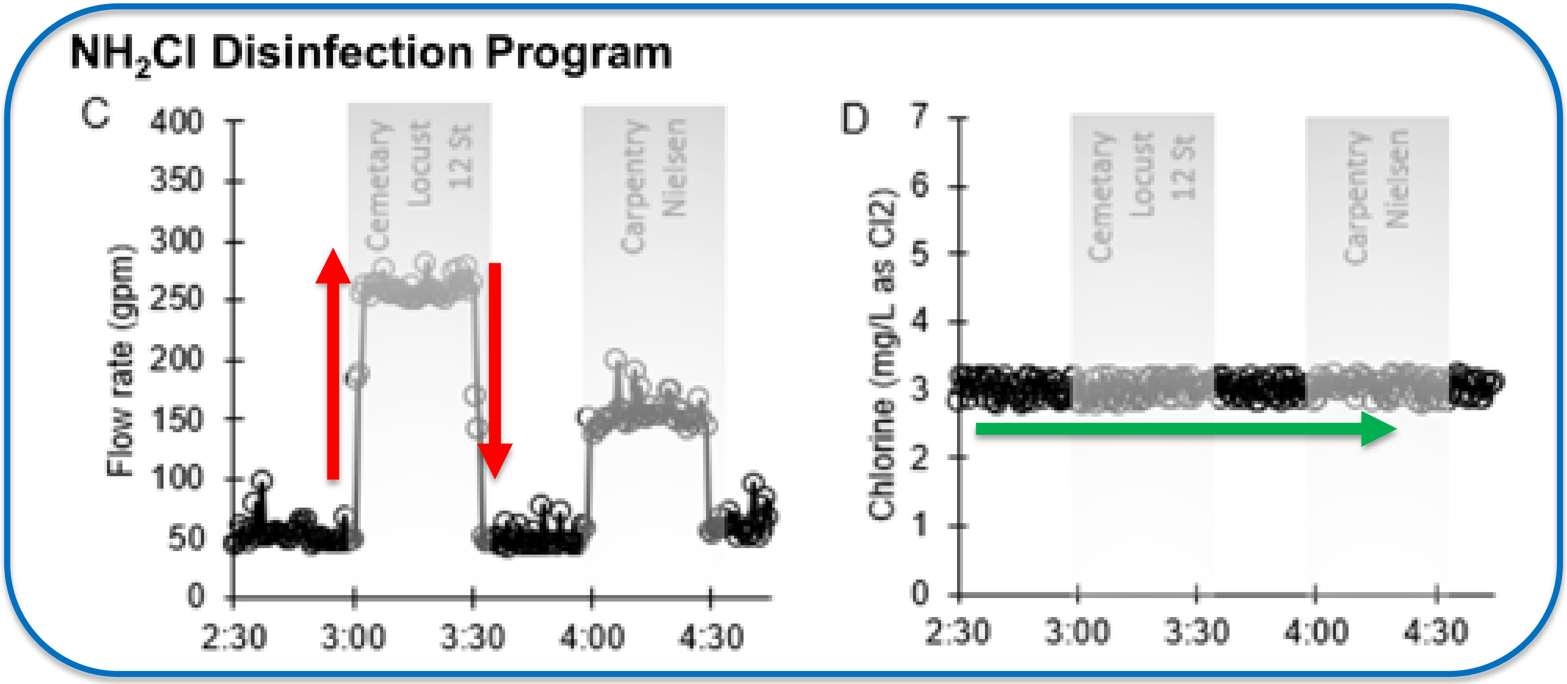
- **San Francisco study by CDC/Health Department:**
  "Our study demonstrated that ***Legionella* colonization** in a plumbing system **was effectively eliminated by** monochloramine [**supplemental disinfection**]. Hospitals or other facilities colonized with *Legionella* spp. might control *Legionella* growth and prevent disease transmission by adding [a supplemental disinfection] to their potable water system."

Cold Water:
A Relative Term

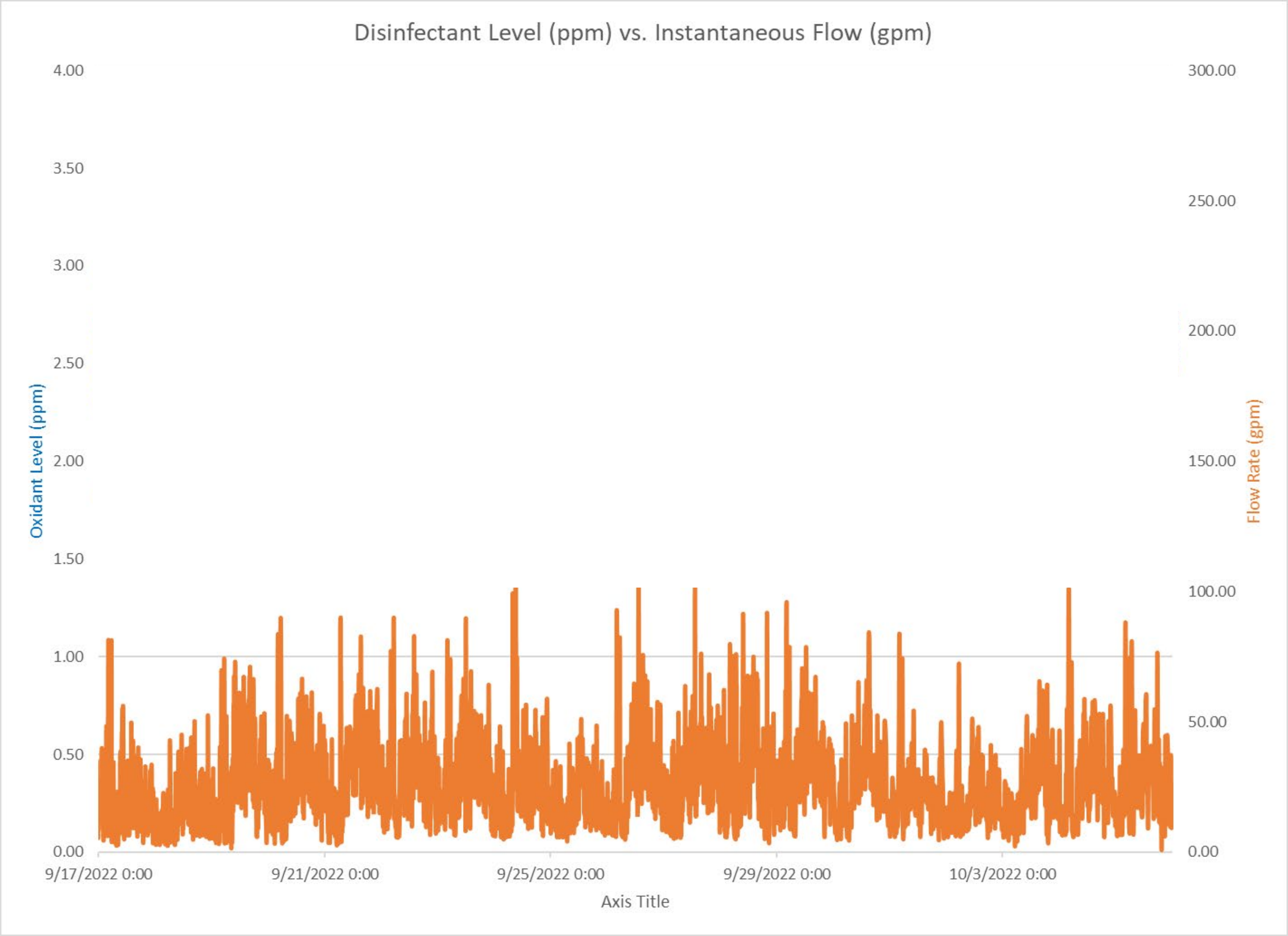


Response to Variable Flow

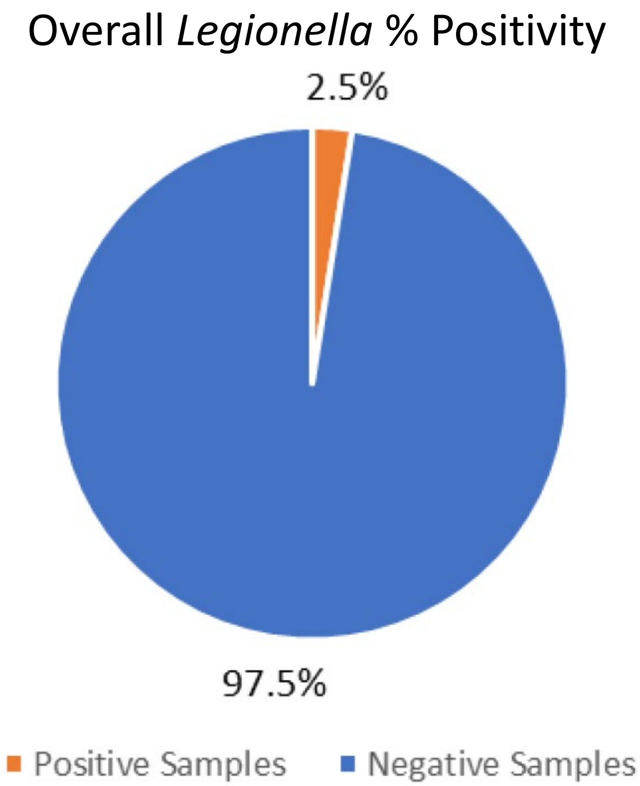
Water Flow Rate Disinfectant Level

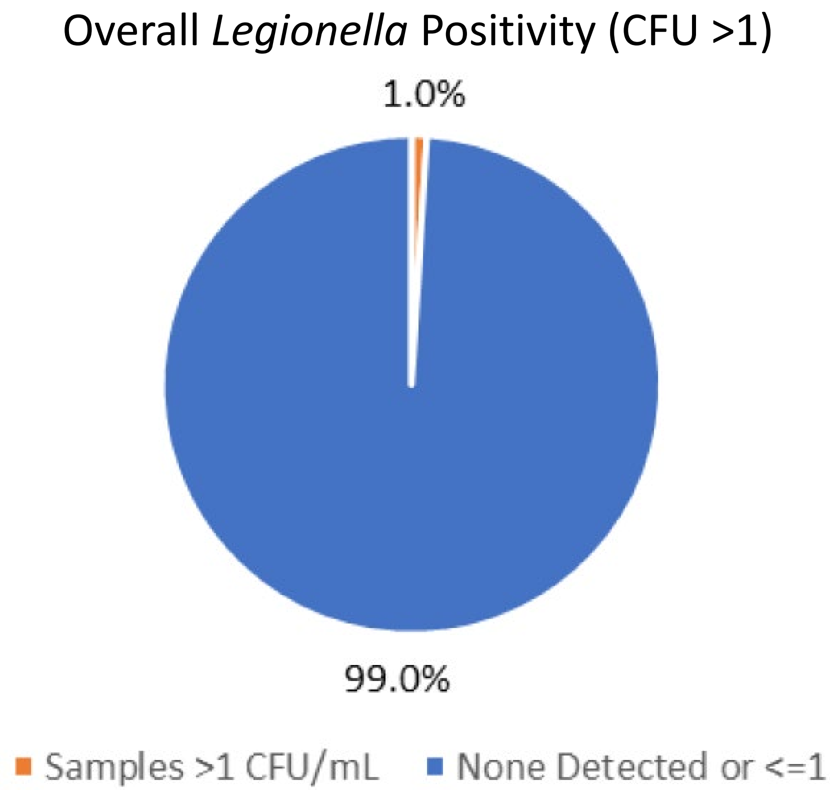


Response to Variable Flow



Efficacy of Intervention





- 10,432 *Legionella* cultures taken on 50 systems
- 261 (2.5%) Positive *Legionella* cultures
- 102 (1%) Positive *Legionella* cultures > 1 CFU/mL

Publication Review

INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY FEBRUARY 2011, VOL. 32, NO. 2

REVIEW ARTICLE

Controlling *Legionella* in Hospital Drinking Water: An Evidence-Based Review of Disinfection Methods

Yusen E. Lin, PhD, MBA;[1] Janet E. Stout, PhD;[2,3] Victor L. Yu, MD[3]

Hospital-acquired Legionnaires' disease is directly linked to the presence of *Legionella* in hospital drinking water. Disinfecting the drinking water system is an effective preventive measure. The efficacy of any disinfection measures should be validated in a stepwise fashion from laboratory assessment to a controlled multiple-hospital evaluation over a prolonged period of time. In this review, we evaluate systemic disinfection methods (copper-silver ionization, chlorine dioxide, monochloramine, ultraviolet light, and hyperchlorination), a focal disinfection method (point-of-use filtration), and short-term disinfection methods in outbreak situations (superheat-and-flush with or without hyperchlorination). The infection control practitioner should take the lead in selection of the disinfection system and the vendor. Formal appraisals by other hospitals with experience of the system under consideration is indicated. Routine performance of surveillance cultures of drinking water to detect *Legionella* and monitoring of disinfectant concentrations are necessary to ensure long-term efficacy.

Infect Control Hosp Epidemiol 2011;32(2):166-173

The epidemiological link between presence of *Legionella pneumophila* in the hospital drinking water and the occurrence of hospital-acquired legionellosis was first made in the early 1980s by Tobin and Stout.[1,2] The first documented study of disinfection was published in 1983 using thermal eradication, which we termed "superheat-and-flush" method.[3] In 1990, the first comprehensive review of disinfection methodologies was published; definitive recommendations as to which methodology was superior were not made.[4] In 1998, two reviews on disinfection methodologies were published; one for engineers and healthcare facility managers[5] and another for physicians and infection control practitioners.[6] At that time, disadvantages of both hyperchlorination and ul-

pathogens, including *Pseudomonas aeruginosa, Stenotrophomonas maltophilia, Acinetobacter baumannii,* and mycobacterial species. We recommend copper ion concentrations of 0.20–0.80 mg/L and silver ion concentrations of 0.01–0.08 mg/L for *Legionella* eradication. The recommended concentrations for *Legionella* eradication are 0.2–0.4 mg/L and 0.02–0.04 mg/L, respectively; lower ion concentrations have proven effective after initial installation.[7-10] Copper ion concentrations should be monitored weekly with use of a field colorimeter kit. Silver concentrations can be tested only by atomic absorption spectroscopy or inductively coupled plasma method and should be tested once every 2 months. Water samples for ion analysis should be clear and free of

Management of *Legionella* in Water Systems

Committee on Management of *Legionella* in Water Systems

Water Science and Technology Board

Board on Life Sciences

Board on Population Health and Public Health Practice

Division on Earth and Life Studies

Health and Medicine Division

A Consensus Study Report of
The National Academies of
SCIENCES · ENGINEERING · MEDICINE

Free Chlorine (Sodium Hypochlorite)

Benefits:

- Extremely easy to access, install, and feed
- Used in drinking water for over 100 years
- Inexpensive

Challenges:

- Highly corrosive to piping
- Requires on site chemistry
- Creates disinfection byproducts (TTHM/HAAs)
- Highly reactive (must feed to both hot and cold)
- Poor biofilm penetration
- Requires extended length of time to reduce *Legionella*
- In studies, less effective than monochloramine and chlorine dioxide against *Legionella* bacteria as measured by CT
- Impact taste and odor

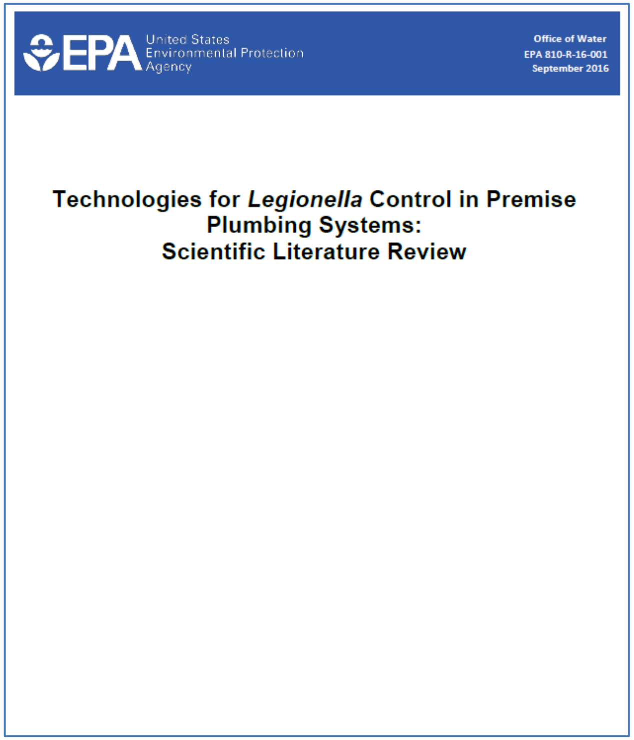
Supplemental Chlorine

Efficacy of Chlorine

- **Lin et al., 1998a:** Relatively high doses of chlorine (2–6 ppm) were needed for continuous control of *Legionella* in water systems.

- **Muraca et al. (1987):** Chlorine was more effective at a higher temperature (109.4 °F) compared to 77 °F, but decayed faster at higher temperatures.

- **Kim et al. (2002):** Association with protozoa may explain why chlorine can suppress *Legionella* in water systems but cannot usually prevent its regrowth.


EPA United States Environmental Protection Agency

Office of Water
EPA 810-R-16-001
September 2016

Technologies for *Legionella* Control in Premise Plumbing Systems: Scientific Literature Review

Supplemental Chlorine Dioxide

Benefits:

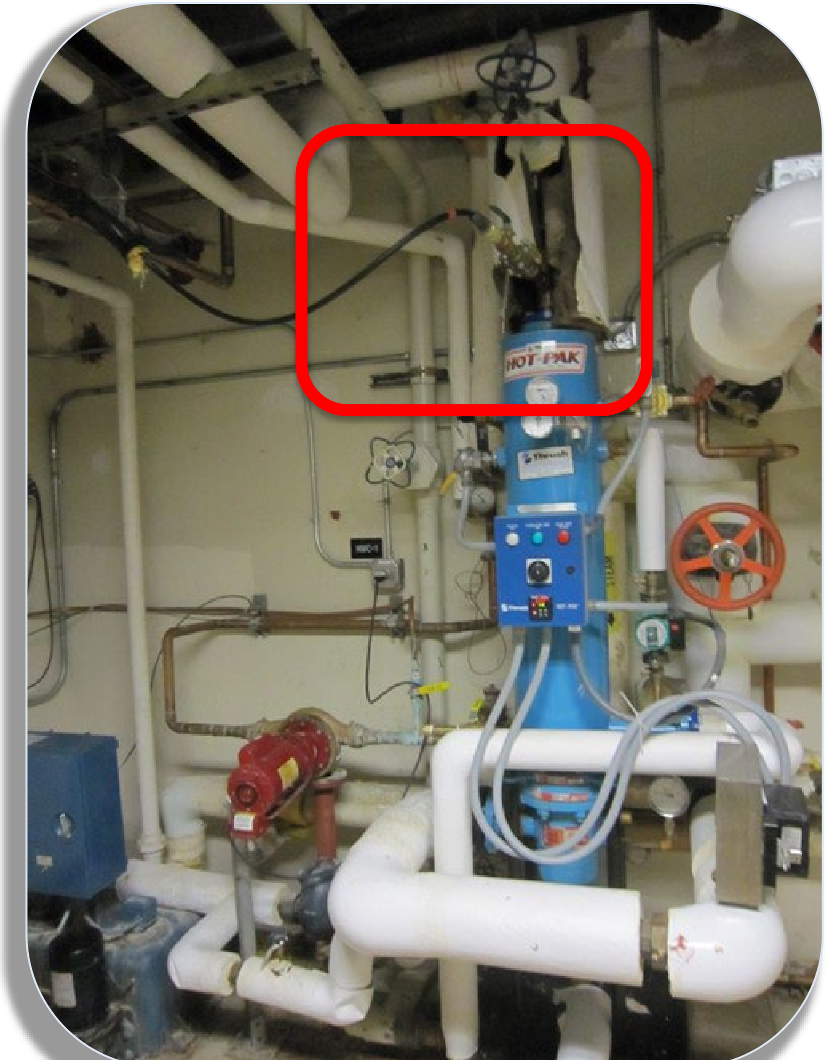
- Effective against *Legionella* and other types of bacteria
- Effective over a wide range of pH levels
- Little Impact on taste and odor

Challenges:

- Extremely corrosive to piping
- Cold water application requires extended length of time to reduce *Legionella*
- Degrades quickly (especially in hot water systems)
- Separate feed system required to control hot and cold water
- Tight control band (maximum dosage limit of 0.8 ppm; 1.0 ppm chlorite)
- Penetrates biofilm more effectively than Sodium Hypochlorite; but less effectively than Monochloramine
- Creates disinfection byproducts (chlorite and chlorate)
- **Daily chlorite monitoring usually required on permitted systems**

Supplemental Chlorine Dioxide

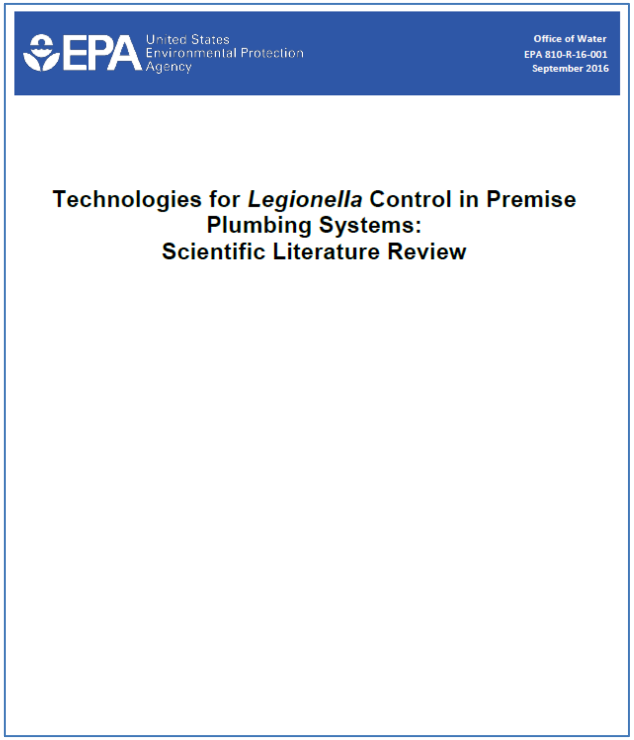
Supplemental Chlorine Dioxide



Efficacy of Chlorine Dioxide

- **Loret et al. (2005):** “Biofilm thickness was reduced to <5 µm with chlorine dioxide and several other disinfectants, as compared to a measured biofilm thickness of 13–35 µm in the untreated pipe loop.”

- **Mustapha et al. (2015):** Laboratory study found that L. pneumophila was not inactivated at shock disinfection levels. At 4 ppm, L. pneumophila could be detected using cell culture, but at 6 ppm, no bacteria were detected.


EPA United States Environmental Protection Agency

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Technologies for *Legionella* Control in Premise Plumbing Systems:
Scientific Literature Review

Chlorine Dioxide: Email from California EPA

To Kinderman, Liz <ekinderman@barclaywater.com>

Cc Souza, Kurt <Kurt.Souza@waterboards.ca.gov>

From Wednesday, June 1, 2022 2:57 PM Bcc

Using chlorine dioxide is very serious when it comes to proper operation and potential for public health issues, I would recommend against it.

Thanks,

Kurt Souza
California EPA
State Water Resources Control Board
- Division of Drinking Water
Asst. Deputy Director

Send

Supplemental Copper-Silver Ionization

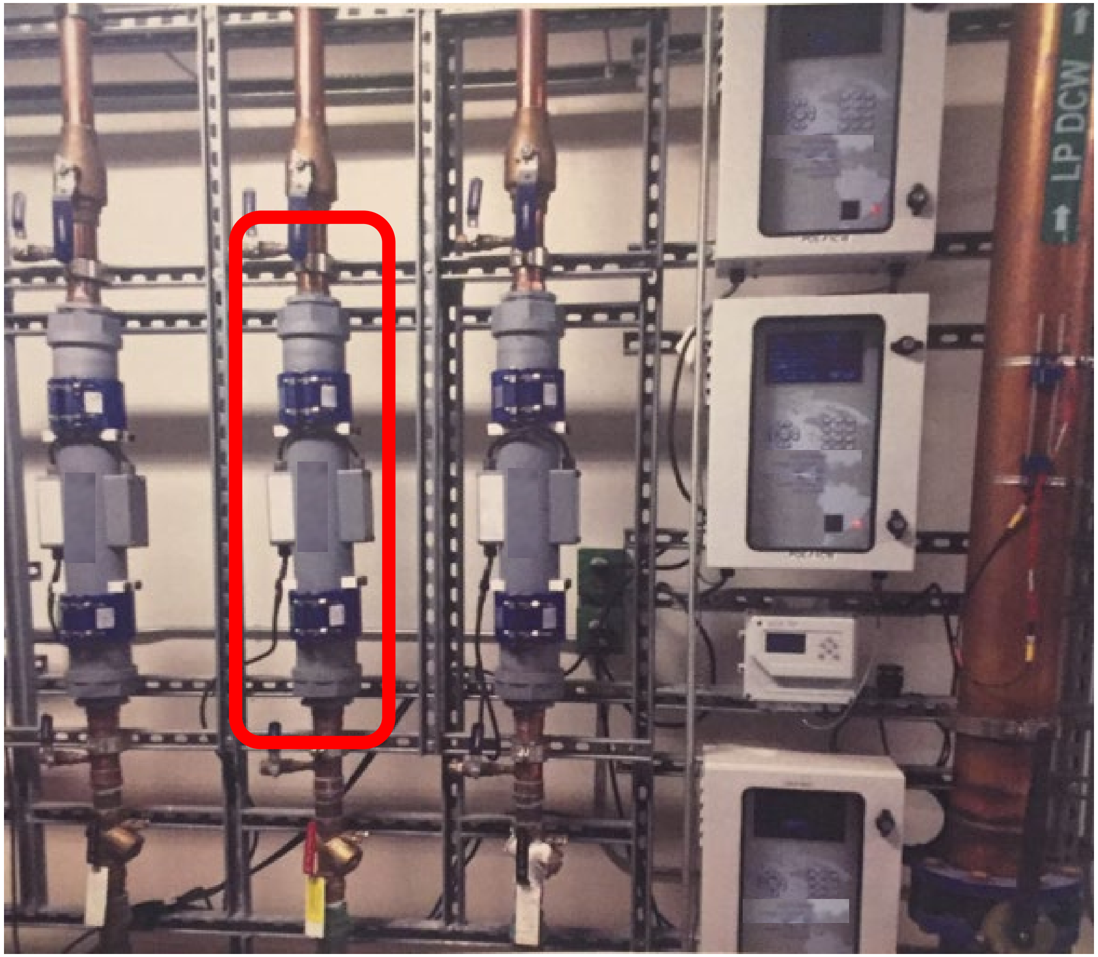
Benefits:

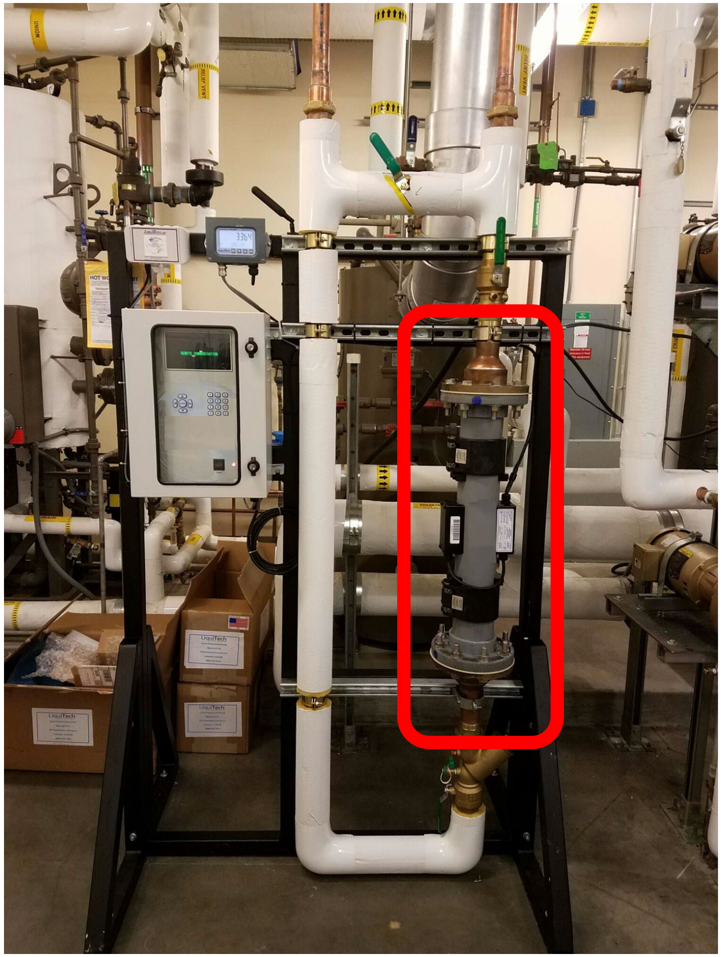
- No precursor chemistry used
- Copper and silver work synergistically to produce higher inactivation rate
- Copper destroys cell wall permeability, silver interferes with synthesis of proteins and enzymes
- Non-enforceable Maximum Contaminant Level (MCL); Only Secondary MCL

Challenges:

- **Only applied to Hot Water**
- No direct, online measurement of residual available (i.e. no Cu-Ag probe)
- Must use laboratory analyses to test for Cu-Ag (delay in treatment adjustment)
- No traceability for Cu-Ag treatment levels throughout the day
- pH restriction of 8.0; high pH waters may pose precipitation challenges
- Specialized maintenance: cleaning/replacement of plates (uses strong acid)
- Tight control limits: 1.3 ppm Copper, 0.1 ppm Silver

Supplemental Copper-Silver Ionization



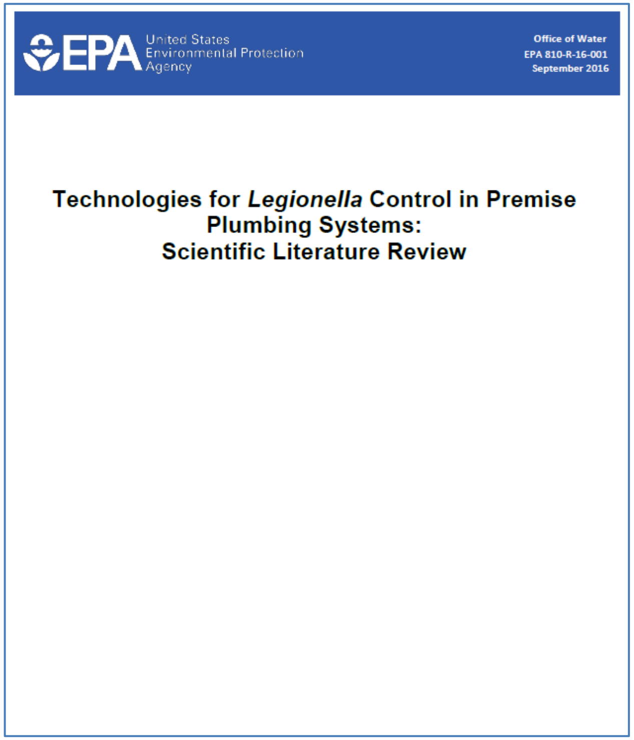


Efficacy of Copper-Silver Ionization

- **Dziewulski et al. (2015):** CSI efficacy demonstrated for inactivating both L. pneumophila and L. anisa under alkaline water conditions (pH 8.7–9.9). Positivity reduced from 70% to <30%.

- **Demirjian et al. (2015):** Outbreak at a Pennsylvania hospital – 23 of 25 locations sampled for *Legionella* culture were positive, while the mean copper and silver ion concentrations were measured at or above the manufacturer's recommended levels for *Legionella* control (0.30 and 0.02 ppm, respectively).

- **Chen et al. (2008):** Copper-silver ionization reduced positive L. pneumophila samples from 30% to 5%. Finally, after 11 months, positivity reduced to 0% after increasing Cu-Ag concentrations.


EPA United States Environmental Protection Agency

Office of Water
EPA 810-R-16-001
September 2016

Technologies for *Legionella* Control in Premise Plumbing Systems: Scientific Literature Review

Supplemental Monochloramine

Benefits:

- Rapidly effective against Legionella bacteria (CT) and biofilm penetration
- Stable in both hot and cold water systems
- Persists well within complex plumbing systems
- Treatment translates to hot water by feeding only cold water main
- Less corrosive than free chlorine or chorine dioxide
- Like free chlorine, used in drinking water for over 100 years
- Reduced disinfection byproducts compared to chlorine
- Remediation can be performed without service interruption (<4.0 ppm)

Challenges:

- Proper ratio of precursor chemicals must be used
- Concerns exist for dialysis and fish tanks
- Concerns with free ammonia when fed improperly

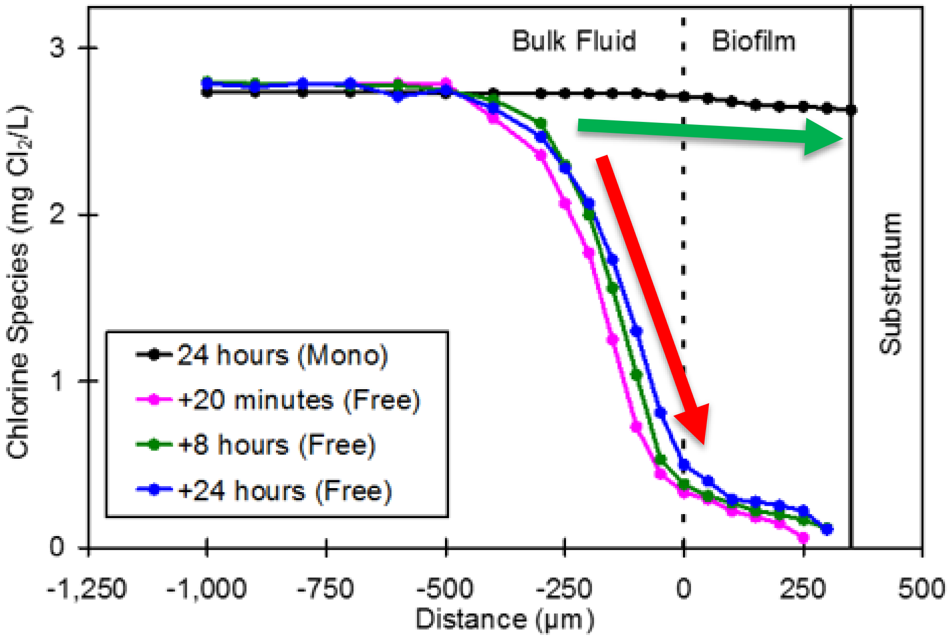
Supplemental Monochloramine

Efficacy of Monochloramine

Monochloramine vs Free Chlorine

Biofilm Penetration

- Monochloramine → complete penetration
- Free chlorine → penetration depth stabilizes
- Different reactivity with biofilm



Lee, W. H.; Wahman, D. G.; Bishop, P. L.; Pressman, J. G., Free chlorine and monochloramine application to nitrifying biofilm: comparison of biofilm penetration, activity, and viability. *Environ. Sci. Technol.* **2011,** *45*, (4), 1412–1419.

- For equivalent chlorine concentrations, monochloramine shown to penetrate biofilms 170 times faster than free chlorine
- Even after subsequent application to a monochloramine-penetrated biofilm, free chlorine penetration was limited

Efficacy Against Other Waterborne Pathogens

Water Research 189 (2021) 116656

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

A comprehensive evaluation of monochloramine disinfection on water quality, *Legionella* and other important microorganisms in a hospital

Darren A. Lytle[a,*], Stacy Pfaller[a], Christy Muhlen[a], Ian Struewing[b], Simoni Triantafyllidou[a], Colin White[c], Sam Hayes[a], Dawn King[a], Jingrang Lu[b]

<u>After treatment with monochloramine:</u>

- ***Legionella*** culture decreased from 68% to 6% positivity after monochloramine addition
- **Pseudomonas aeruginosa** demonstrated large and significant decrease
- ***nontuberculous Mycobacteria*** by culture were significantly reduced from 61% to 14%

Ice Machine Filtration

A bacterial infection killed three patients at Brigham and Women's. Here's how it got in.

Story by Jessica Bartlett • Monday | 6 | 22 | 4 Comments

An infectious disease clinician working closely with the cardiac surgery department had an inkling something was off. It was 2018, and she mentioned to colleagues at Brigham and Women's Hospital the unusual occurrence of a suspicious bacteria, which had popped up several times in the last year and a half. The rare bacteria, Mycobacterium abscessus, can sometimes cause hospital-acquired infections, often from contaminated water. But the number of times hospitalized patients had tested positive for it struck her as odd.

- "the hospital discovered the culprit: a water purification system feeding an ice and water machine on the cardiac unit."
- "experts did find high levels of mycobacteria from ice and water machine samples… DNA extracted from the machine samples was an exact match to a gene in the patient outbreak."

https://www.msn.com/en-us/news/us/a-bacterial-infection-killed-three-patients-at-brigham-and-women-s-the-culprit-a-water-purification-system/ar-AA18ikZo

Ice Machines in Healthcare

- Cleaning and maintenance
- Temperature control
- Flushing
- Filtration
  - Particulate
  - Carbon/taste (??)
  - Microbiological
- Sanitization

Ice Machine Image shared with Kind Permission from Follet Ice, 2019

Ice Machines in Healthcare

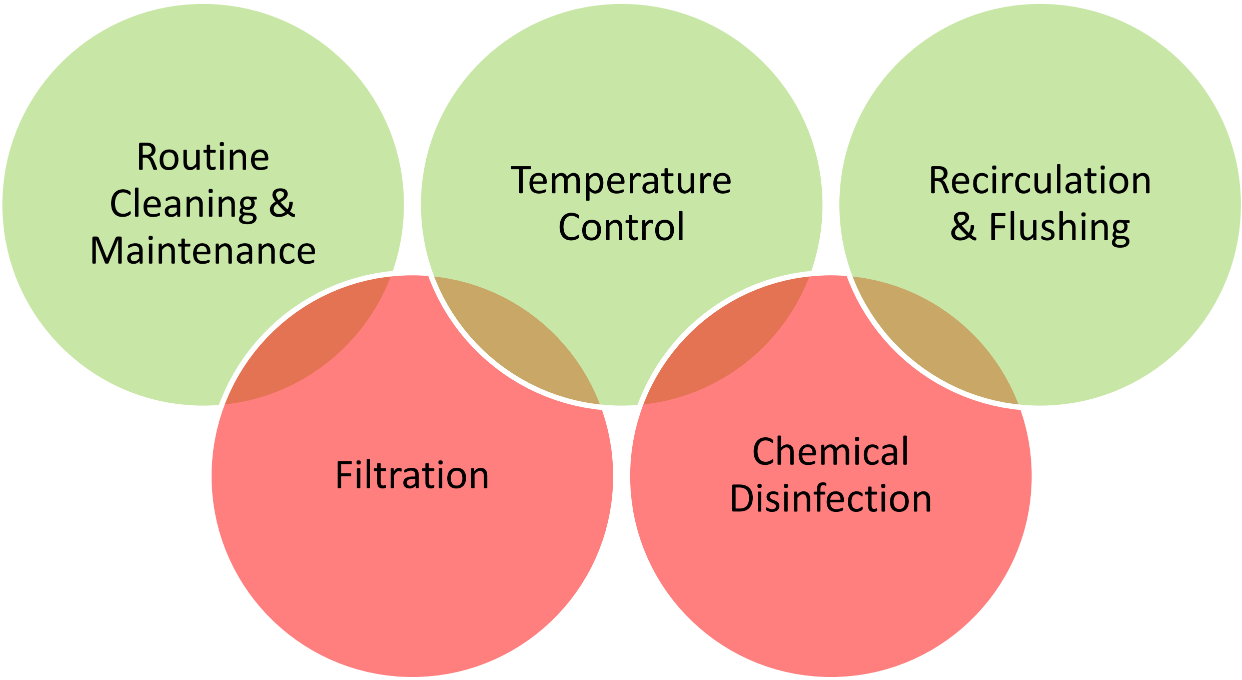
Legionella Colonization Prevention in Ice Machines

University of Pittsburgh
University of Pittsburgh Medical Center
Querry AM, Pasculle AW, Dudek E, Crouse J, Sundermann AJ, Young L, Tatar J, Troesch A, Meduho E, Wozniak J, Muto CA
University of Pittsburgh Medical Center – Presbyterian Hospital, Pittsburgh, Pennsylvania
UPMC LIFE CHANGING MEDICINE

Conclusions:

- Manufacturer/specified ice machine cleaning and descaling guidelines were associated with the highest colonization rates and could lead to increased *Legionella* hospital acquired infections.
- ***POU filters*** had a lower rate of colonization, but changing all filters within 31 days is challenging. Manual interventions have the ability to work, but need to be strictly followed and maintained.
- ***Continuous disinfection with Monochloramine*** was most effective as preventing *Legionella* colonization and was easiest to maintain.

Quick Takeaway

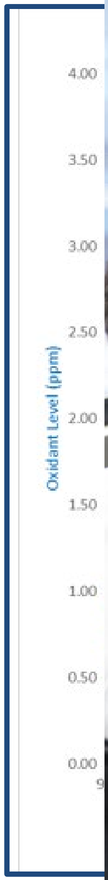


- Keep it <u>clean</u>
- Keep it <u>hot</u>
- Keep it <u>cold</u>
- Keep it <u>moving</u>
- Keep residual <u>chemistry</u>

I don't work in Facilities/Engineering.

What can I do?

When Indicated, Use the Available Interventions



Thank You!!!

Questions?

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