Cold water risks: Why Legionella isn't just a hot water problem

Objectives

- Identify key risk factors that contribute to Legionella growth in cold water systems and ice machines.
- Explore real-world cases of Legionnaires' disease linked to cold water.
- Discuss practical strategies to mitigate Legionella risk in ice machines.
- Explore water treatment solutions to reduce Legionella risk in a building's cold water system.
- Examine case studies of hospitals successfully implementing cold water strategies to reduce Legionella risk.

Municipal water

» Main source for most buildings including hospitals

» Sourced from reservoirs, rivers, wells, and lakes

» Treated at municipal water treatment plants to EPA Safe Drinking Water Act Standards

» Even though the EPA has standards that must be met by each municipality, the quality of tap water can differ from community to community.

» Distributed through pipes, booster stations, and storage tanks to buildings where it becomes the building's responsibility

Regulatory approach to Legionella and other waterborne pathogens

- The SDWA was passed by Congress in 1974 to protect public health by regulating public drinking water supplies
- Number of threats to drinking water: chemicals; animal wastes; pesticides; human threats; wastes injected underground; and natural substances.
- Opportunistic pathogens such as Legionella are naturally in source water
    - Municipal treatment is very effective against fecal pathogens, but less effective against opportunistic waterborne pathogens
    - Legionella and opportunistic waterborne pathogens survive municipal treatment and enter the distribution network and building systems
    - No level specified by regulation or public health standard

Sediment in our water supply

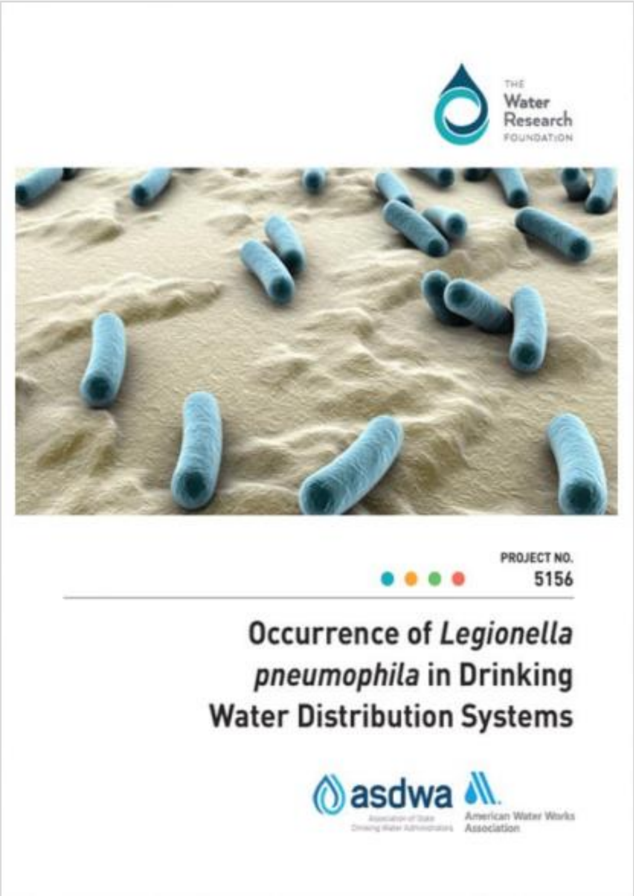
- Sediment is naturally occurring in source water from soil run off and other organics
- Sediment in our buildings can occur from:
  - Routine enter from the incoming water supply
  - Water main breaks and weather-related events such as heavy rain and floods
  - Aging pipes and equipment
  - Corrosion and scale
  - Construction and renovation events

But is it actually safe?

- Even when municipal water meets all SDWA and state regulations, and is safe to consume, it can impact on building's systems infrastructure and disease risk
- Once water enters the distribution system, building's service lines, and plumbing system, the quality of the water changes before it is used.
  - Water mains accumulate sediment which enters building systems and provide a nutrient source for pathogens.
  - Drinking water is not sterile. If warmed and stagnant inside building plumbing, microorganisms can grow and cause associated problems.
  - Disinfection residuals decrease which exacerbate problems and lead to the amplification of pathogens and increase hazardous disinfection byproducts

Legionella in municipal water

- Water Research Foundation published a study on the occurrence of Legionella pneumophila in drinking water distribution systems
- Two year study with 57 utilities testing for Legionella
  - 1.2% of all samples were positive
  - 32% of the utilities tested were positive
- Trend in L. pneumophila concentration with increasing water age
- Average water temperature was 68°F



Water Supply

- Water quality meets EPA requirements
- Does not mitigate the risk of Legionella and other waterborne pathogens

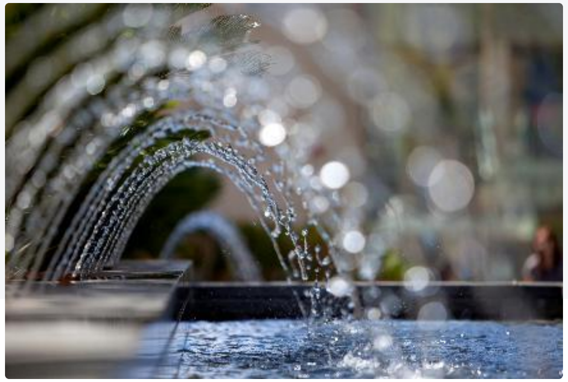
Building Water System

- Water quality decreases through distribution (sediment, biofilm)
- Pathogens and contaminants increase

Point of Use

- Water quality continues to decrease
- Increased disease risk, plumbing infrastructure impact

Buildings are designed to grow biofilms



Complex plumbing systems

» High surface area to volume
» Sediment, corrosion, and biofilm accumulation

Warm water environments

» Potable hot water
» Nonpotable systems
» Temps regulated by code and scald protection

Increased water age

» Water conservation efforts
» Low flow and sensor faucets

Low disinfection residual

» Municipal disinfection is not effective at typical incoming residuals

Sediment’s impact on risk

All-you can eat buffet

» High in carbon and provides a constant food source for bacteria and pathogens.

Impacts disinfection

» Consumes disinfectants which reduces the amount available for disinfection

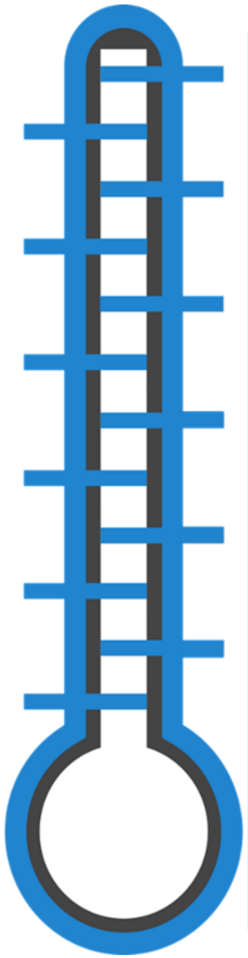
Protection for bacteria

» Provides surface area for bacteria and can shield it from disinfection

Increases proliferation

» Outbreaks linked construction are caused by sediment entry and increases

Legionella growth range



>158°F 70°C	• Disinfection Range
151°F 66.1°C	• 99% die in 2 minutes of direct contact
140°F 60 °C	• 99% die in 32 minutes of direct contact
131°F 55 °C	• 99% die in 5 – 6 hours of direct contact
77° - 113°F 20 - 50°C	• **Ideal growth range for Legionella**
68° - 122°F 20 - 50°C	• Growth range for Legionella
Below 68°F Below 20°C	• Legionella survive, but are dormant

- » Legionella will still survive below the growth range (<68°F)
- » Cold water in buildings can be within the growth ranges for Legionella for many reasons:
  - » Elevated source water temperature
  - » Water age
  - » Stagnant or low-use conditions
  - » Heat transfer

Growth factors in building water systems

Warm water

Nutrients in the water

Other microbes

Growth factors in building water systems

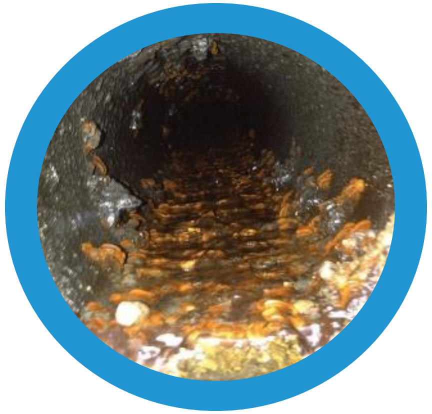
Warm water

Stagnation

Dead legs

Scale

Sediment



Bacteria

Chemicals

Residuals

Biofilm

Typical focus is on hot water risks

- Most cases are associated with the hot water system but there are contributing factors and risks associated with cold water
    - Legionella is a naturally occurring bacteria in source water.
    - Legionella is found in cold water systems
    - Legionella infiltrates building plumbing systems solely by entering through the cold water into the building.
    - Even though cold water (<68°F) does not promote the growth of Legionella and other organisms, it continually contaminates the plumbing
    - Water temperatures may rise above 68°F

Cold water risks

- Legionella is naturally occurring in the source water; all it requires to amplify are a specific set of growth conditions
  - Correct temperature
  - Lack of disinfection residual
  - A food source
  - Stagnant water
- Legionella is well documented to resist the municipal treatment process
- Water that generates hot water Legionella amplification is also used for cold.
- Elevated source water temperatures, cold water contamination, or building conditions that warm the cold water elevate risk in the cold water systems

Contributors to cold water risk

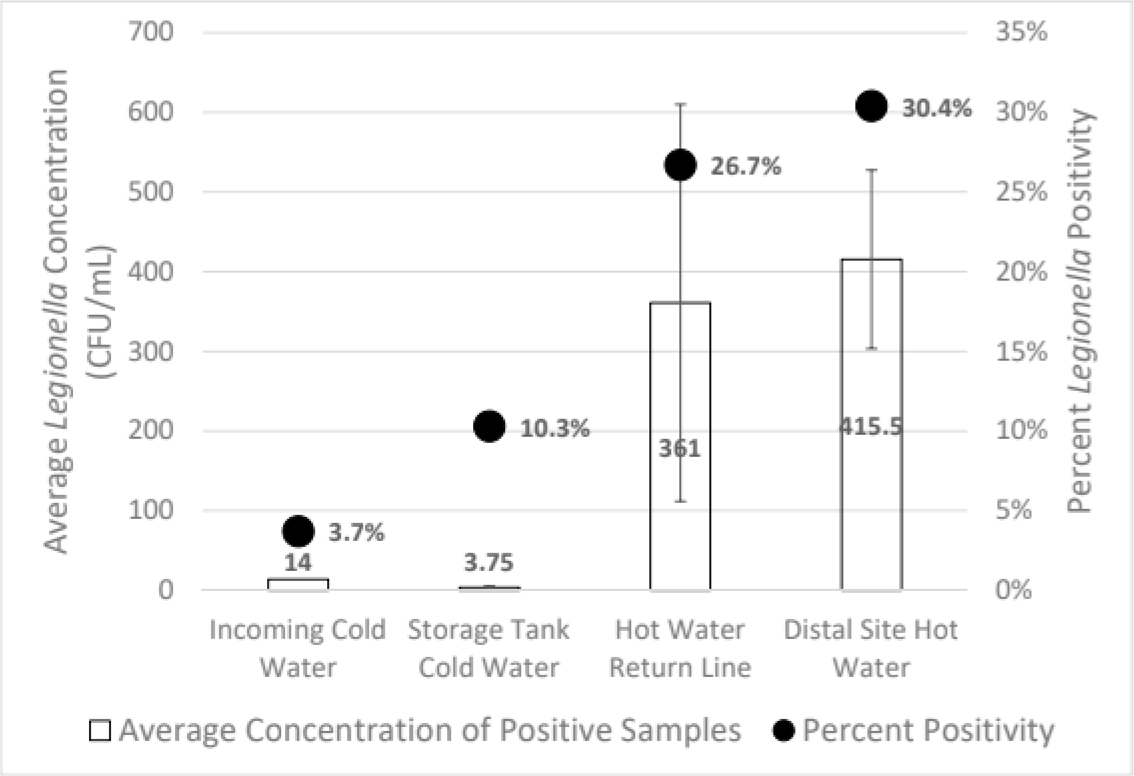
- Warm climates and seasonal changes can increase temperatures even before they enter the building
- Cold water can warm to favorable temperatures due to long pipe runs, low flow, heat transfer from being adjacent to hot water pipes and environments
- Cold water equipment that can add additional growth factors include:
  - Storage tanks (stagnation, warming, sediment accumulation)
  - Pumps (circulation and stagnation)
  - Water softeners (media for bacteria to grow)
  - Oxidant based treatment (ineffective residuals, corrosion increasing sediment)

External Risks to Cold Water

- Incoming cold water quality can be impacted by:
  - Nearby construction or renovation
  - Natural weather occurrences
  - Water main breaks, boil water advisories
  - High turbidity
  - Stagnation and sediment accumulation
  - Changes in source water
  - Aging infrastructure

Legionella entering in the cold water

- Study evaluating Legionella presence across 28 different buildings in NYC
- Legionella identified in 3.7% of incoming cold water samples (average temperature of 63°F)
- Positivity increased in cold water storage tanks with 10.3% of samples showing positivity (average temperature of 63°F)
- Growth factors were present immediately upon entering the building with storage tanks with sediment and stagnation



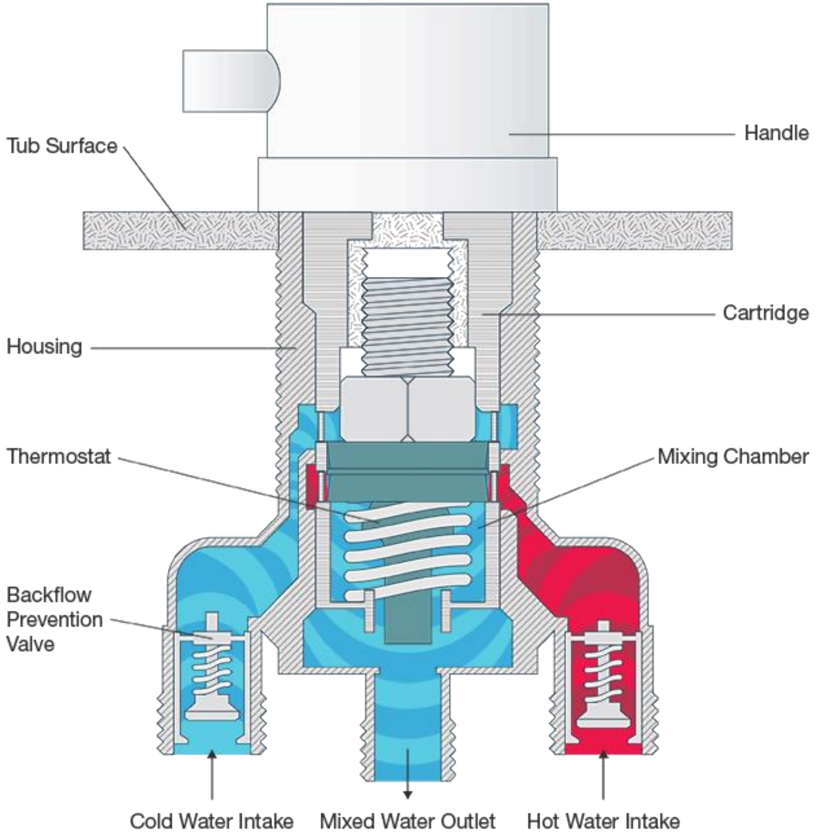
Pierre D, Baron JL, Ma X, Sidari FP 3rd, Wagener MM, Stout JE. Water Quality as a Predictor of *Legionella* Positivity of Building Water Systems. Pathogens. 2019 Dec 13;8(4):295.

Usage Risks

- Water consumption per building occupant has gone down
- Plumbing code has not kept up
  - Still mandating large diameter pipes.
  - Water does not get readily turned over
- Water conservation increases include:
  - Low flow fixtures, toilets, urinals
  - Move from hand washing to hand sanitizers
  - Lower patient stays resulting in minimal use of shower fixtures.

Cold water risks at the point of use

- Hot water must be tempered to prevent scalding
- Mixing valves that blend water are installed to lower the temperature at the distal sites to <120°F to prevent scalding
    - This temperature does not kill Legionella.
- If the cold water being blended is not treated **cold water can re-contaminate the hot water**
- The cold water should be considered in water management efforts



Legionella amplification in cold water

- Study evaluating recommendations that do not recommend routine assessment of cold water for Legionella
- Tested cold and hot water locations throughout healthcare facilities
- Cold water was more frequently contaminated than the hot water distal sites
  - 40% positivity vs 23% positivity
  - 35% had temperatures under 68°F
- Emphasized the importance of evaluating cold water positivity

Contamination of the cold water distribution system of health care facilities by *Legionella pneumophila*: Do we know the true dimension?

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Citation style for this article:
Arvand M, Jungkind K, Hack A. Contamination of the cold water distribution system of health care facilities by Legionella pneumophila: Do we know the true dimension?. Euro Surveill. 2011;16(16):pii=19844. Available online: http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19844

Article published on 21 April 2011

German water guidelines do not recommend routine assessment of cold water for *Legionella* in healthcare facilities, except if the water temperature at distal sites exceeds 25 °C. This study evaluates *Legionella* contamination in cold and warm water supplies of healthcare facilities in Hesse, Germany, and analyses the relationship between cold water temperature and *Legionella* contamination. Samples were collected from four facilities, with cases of healthcare-associated Legionnaires´ disease or notable contamination of their water supply. Fifty-nine samples were from central lines and 625 from distal sites, comprising 316 cold and 309 warm water samples. *Legionella* was isolated from central lines in two facilities and from distal sites in four facilities. 17% of all central and 32% of all distal samples were contaminated. At distal sites, cold water samples were more frequently contaminated with *Legionella* (40% vs 23%, p <0.001) and with higher concentrations of *Legionella* (≥1,000 colony-forming unit/100 ml) (16% vs 6%, p<0.001) than warm water samples. There was no clear correlation between the cold water temperature at sampling time and the contamination rate. 35% of cold water samples under 20 °C at collection were contaminated. Our data highlight the importance of assessing the cold water supply of healthcare facilities for *Legionella* in the context of an intensified analysis.

Introduction

Routine testing for *Legionella* of environmental water samples by culture has emerged as an effective strategy for prevention of hca-LD. Guidelines mandating routine monitoring of *Legionella* contamination of the WDS in hospitals and other healthcare facilities have been implemented in many European countries, including Spain, France, the United Kingdom, and Germany [1,9]. In contrast, the Centers for Disease Control and Prevention (CDC) recommends environmental cultures only when cases of hca-LD are discovered [10], an approach which remains controversial, taking into account that a specific diagnostic for LD is not routinely performed in many laboratories. For example, in the United States of America (USA) only 19% of the hospitals that participated in the CDC National Nosocomial Surveillance System did routinely provide *Legionella* testing of patients at high risk for developing hca-LD [11]. In Germany, the Federal Environment Agency (Umweltbundesamt) and the German National Public Health Institute (Robert Koch Institute) recommend periodical analysis of the WDS of hospitals, nursing homes and other healthcare facilities [12]. If a moderate to high level contamination is detected, i.e. at *Legionella* concentration of ≥1,000 colony-forming unit (cfu)/100 ml, an intensified analysis with additional sampling points according to the guidelines of the German Technical and Scientific Association for Gas and Water (DVGW) is recommended [12,13].

Cold Water Outbreak

- Two deaths associated with the cold water system at a rehabilitation center
- All hot water samples were non-detect while 62% of cold water distal sites were positive
- Identified that the cold water warmed up over the weekend from 77°F to 100°F in rehab unit due to:
  - Source water in Legionella growth range
  - Stagnant conditions
  - Heat transfer from hot water pipes

Brief Reports

Two Fatal Cases of Nosocomial *Legionella pneumophila* Pneumonia Associated with a Contaminated Cold Water Supply

C.J.P. Hoebe, J.J.M. Cluitmans, J.H.T. Wagenvoort

Legionella pneumophila is often the cause of unexpected serious pneumonia [1]. In our rehabilitation center we encountered two cases of severe nosocomial pneumonia occurring within a period of one year. Both patients were hospitalized in the same ward and ultimately died. *Legionella pneumophila* serotype 1 was cultured from the respiratory specimens of both patients. The bacteria originated from an unexpected and originally unsuspected source. Although the source of legionellae is frequently the hot water supply [1–3], we report nosocomial Legionnaires' disease resulting from *Legionella pneumophila* contamination of a thermally polluted cold water supply.

Don’t wear blinders when it comes to cold water!

- Cold water entering our buildings has Legionella – even if positivity is low!
- Building cold water systems have many growth factors that can contribute to Legionella presence
  - Storage tanks
  - Sediment (nutrient source)
  - Warming cold water
  - Stagnation
  - Ice machines

Ice Machines

» Identified the ice from an ice machine as the source of infection by aspiration

» Facility had routinely cleaned the ice machine following manufacturer's recommendations

» Testing showed positivity of Legionella pneumophila serogroup 1

» Conditions behind the ice machine in the internal components warmed water to 95°F prior to creating ice

Archives of Environmental & Occupational Health, Vol. 60, No. 6, 2005

A Case of Legionnaires' Disease Caused by Aspiration of Ice Water

Max A. Bencini, MD; Ed P. F. Yzerman, MD; Rutger H. T. Koornstra, MD; Catharina C. M. Nolte, BSc; Jeroen W. den Boer, MD; Jacob P. Bruin, BSc

ABSTRACT. The authors discuss the case of a 79-year-old patient who suffered from a swallowing disorder and developed Legionnaires' disease 2 days after her dismissal from an orthopedics ward, where she had recovered from hip surgery. To determine the source of the Legionnaires' disease, the authors performed an environmental investigation, which included a national, standardized questionnaire and a microbiological investigation of suspected sources. The investigation revealed ice from an ice-making machine in the hospital as the most probable source of the infection through aspiration, even though the hospital had rigorously adhered to strict assessment and decontamination schedules. The infectious serogroup was one that was not common to the area. From the data available, the authors inferred that a dose of 1–2000 colony-forming units might have caused Legionnaires' disease in this patient.

KEY WORDS: aspiration, disease-causing dose, ice cubes, ice-making machine, Legionnaires' disease

Ice Machine Risks

- Just like our potable water, ice is not sterile
- Ice machines can promote the growth of Legionella and other waterborne pathogens
- Pathogens survive freezing and can be transmitted when using ice
  - Ice served to immunocompromised patients
  - Medical solutions chilled on ice

Ice Machine Risks

» Legionella and other waterborne pathogens are in systems which supply ice machines

» Heat from the condenser and compressor provide favorable growth conditions

» Additional contributors include charcoal prefilters and high surface area

» Ice machines are difficult to clean and manufacturer's recommendations are for general cleanliness

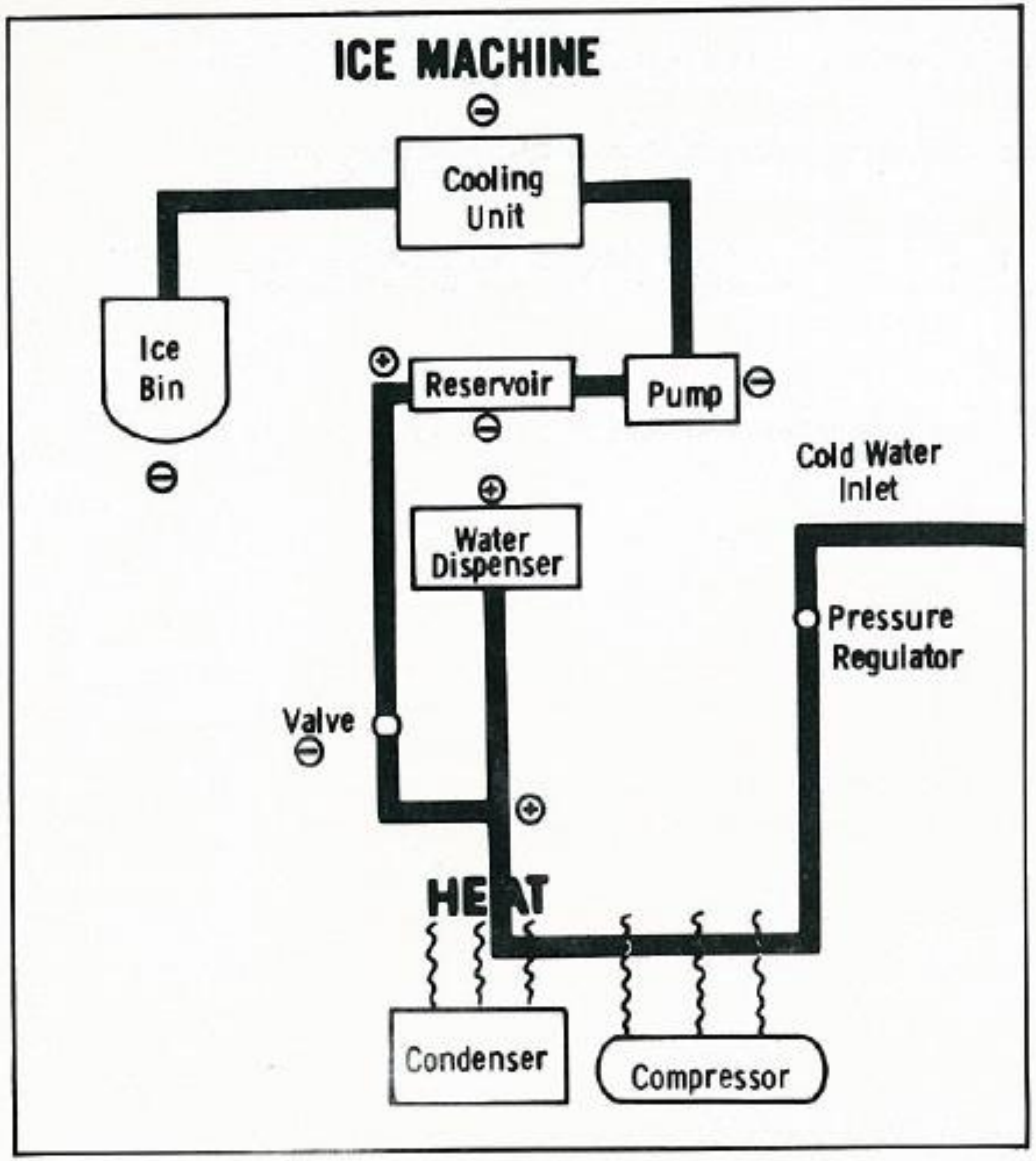


Figure 1. Schematic of an ice machine depicting the flow of cold water through the machine. *L. pneumophila* was isolated (+) from the waterline above the condenser/compressor, the water dispenser, and the reservoir. All other cultures were negative (−). The positivity in the line was in close proximity to the heat-generating portion of the ice machine.

Not just Legionella

Table 1. Characteristics of Waterborne Outbreaks and Infections in Healthcare Settings, 1997 January–2015 June

Hospital water system	*Mycobacterium fortuitum*	Contaminated shower water	A postoperative patient with breast cancer	Breast infection
Ice and ice machine	*Legionella pneumophila*	Microaspiration of ice or ice water	A patient with interstitial pneumonia and mechanical ventilation treated with steroids	Respiratory tract infection
Ice and ice machine	*Enterobacter cloacae*	Contaminated ice used for cardioplegia in cardiac surgery	Patients who received coronary artery bypass grafting	Postoperative wound infection
Ice and ice machine/ tap water	*Mycobacterium chelonae*	Application of contaminated nonsterile ice to the skin	Patients after cosmetic dermal filter injections at a plastic surgery clinic	Cutaneous infection
Ice and ice machine/ tap water	*Mycobacterium porcinum*	Contaminated water	Patients with pulmonary disease or extrapulmonary disease	Pulmonary infection, localized abscess, infected port, peritonitis
Ice bath	*Pseudomonas fluorescens*	Contaminated ice bath used for cardiac output infusion	Patients with cardiac diseases in a CCU	Bacteremia
Potable water	*Mycobacterium avium*	Contaminated water	Patients with AIDS and non-AIDS	Disseminated infection

CDC Cleaning Recommendation

- Guidelines for Environmental Infection Control in Healthcare Facilities
  - Disassemble and clean with detergent and dry
  - Clean ice storage chest with fresh water and detergent
  - Sanitize by circulating 50-100 ppm sodium hypochlorite through machine for 2 hrs. (if 100 ppm) or 4 hrs. (if 50 ppm)
  - Drain, flush with fresh water and dry
- Not listed (but should be) – Retest the ice machine to validate the cleaning!

BOX 3 . General steps for cleaning and maintaining ice machines, dispensers, and storage chests*

1. Disconnect unit from power supply.
2. Remove and discard ice from bin or storage chest.
3. Allow unit to warm to room temperature.
4. Disassemble removable parts of machine that make contact with water to make ice.
5. Thoroughly clean machine and parts with water and detergent.
6. Dry external surfaces of removable parts before reassembling.
7. Check for any needed repair.
8. Replace feeder lines as appropriate (e.g., when damaged, old, or difficult to clean).
9. Ensure presence of an air space in tubing leading from water inlet into water distribution system of machine.
10. Inspect for rodent or insect infestations under the unit and treat as needed.
11. Check door gaskets (open compartment models) for evidence of leakage or dripping into the storage chest.
12. Clean the ice-storage chest or bin with fresh water and detergent; rinse with fresh tap water.
13. Sanitize machine by circulating a 50–100 parts per million (ppm) solution of sodium hypochlorite (i.e., 4–8 mL sodium hypochlorite/gallon of water) through the ice-making and storage systems for 2 hours (100 ppm solution), or 4 hours (50 ppm solution).
14. Drain sodium hypochlorite solution and flush with fresh tap water.
15. Allow all surfaces of equipment to dry before returning to service.

Source: Adapted from Manangan LP, Anderson RL, Arduino MJ, Bond WW. Sanitary care and maintenance of ice-storage chests and ice-making machines in health care facilities. Am J Infect Control 1998;26:111-2.

* These general instructions should be used only where manufacturer-recommended methods and EPA-registered disinfectants are not available.

Prevention of Legionella Colonization of Ice Machines

- Evaluated differences in operation and maintenance of ice machines
  - **Semi-annual cleaning and descaling** per manufacturers recommendations
  - **In-line microbial filters** with quarterly bleach sanitization and descaling
  - **Cold water supplemental disinfection** with semi-annual bleach sanitization of machines

620. Legionella Colonization Prevention in Ice Machines

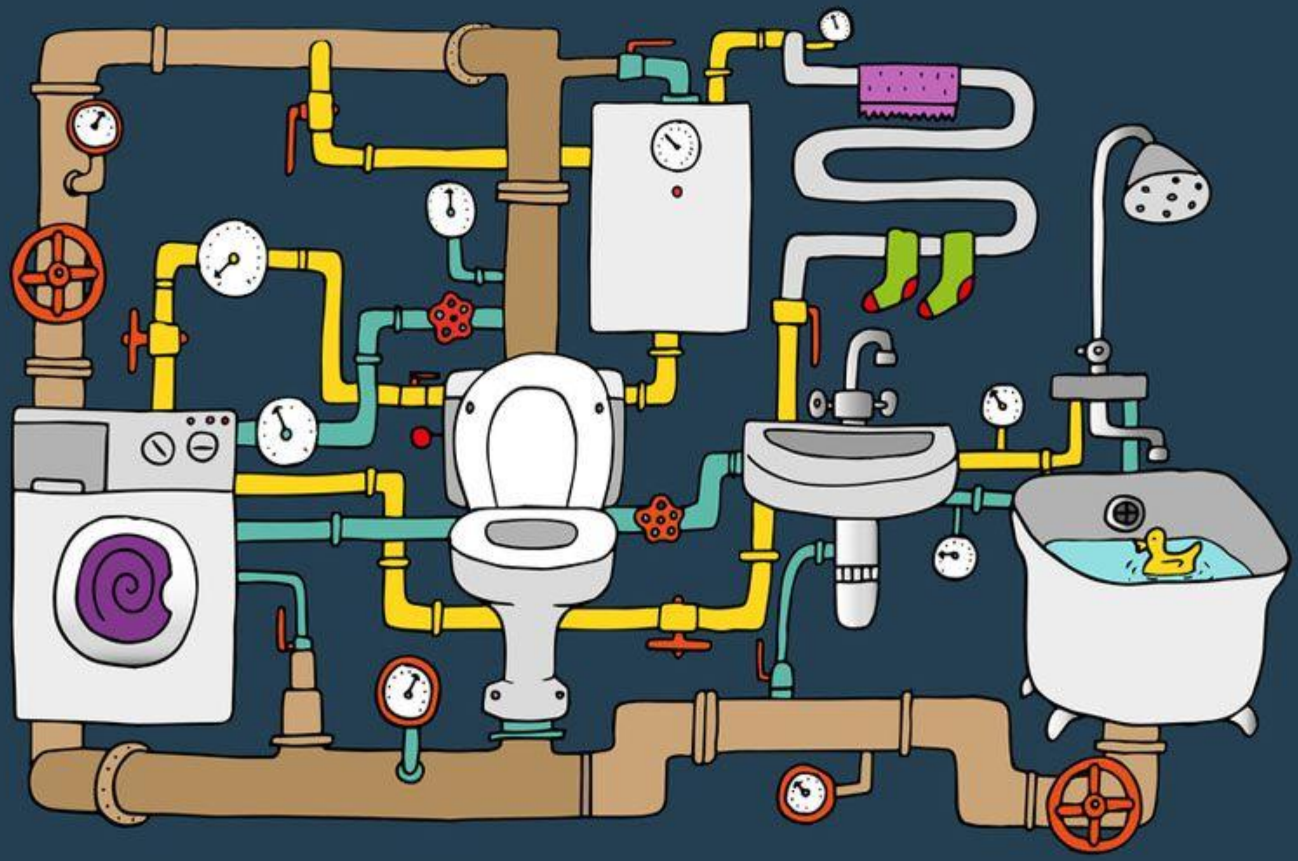
Ashley Querry, BS, CIC[1]; Anthony Pasculle, ScD[2]; Edward Dudek, MPPM[3]; Joseph Crouse, BS[4]; Alex Sundermann, BS, MPH[1]; Leon Young, BS MT[1]; Janina-Marie Tatar, MT (ASCP)[1]; Alex Troesch, Certificate in Heating and Air Conditioning[5]; Eric Meduho, Safety Specilist[6]; Julia Wozinak, BA, MA[6] and Carlene Muto, MD, MS, FSHEA[7]; [1]Infection Prevention and Control, University of Pittsburgh Medical Center Presbyterian, Pittsburgh, Pennsylvania, [2]Microbiology, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, [3]Maintance, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, [4]Engineering and Maintenance, University of Pittsburgh Medical Center, Pittsburgh, VT, [5]University Of Pittsburgh Medical Center Presbyterian, Pittsburgh, Pennsylvania, [6]University of Pittsburgh Medical Center Presbyterian, Pittsburgh, Pennsylvania, [7]Infection Prevention & Hospital Epidemiology, University of Pittsburgh Medical Center, Presbyterian University Hospital, Pittsburgh, Pennsylvania

Study Findings

- Current ice machine cleaning and descaling guidelines were associated with the highest colonization rates and could increase Legionella hospital acquired infections

- POU filters had a lower rate of colonization but changing all filters within 31 days is challenging.

- Continuous supplemental disinfection on the cold water was most effective in preventing colonization and was easiest to maintain.



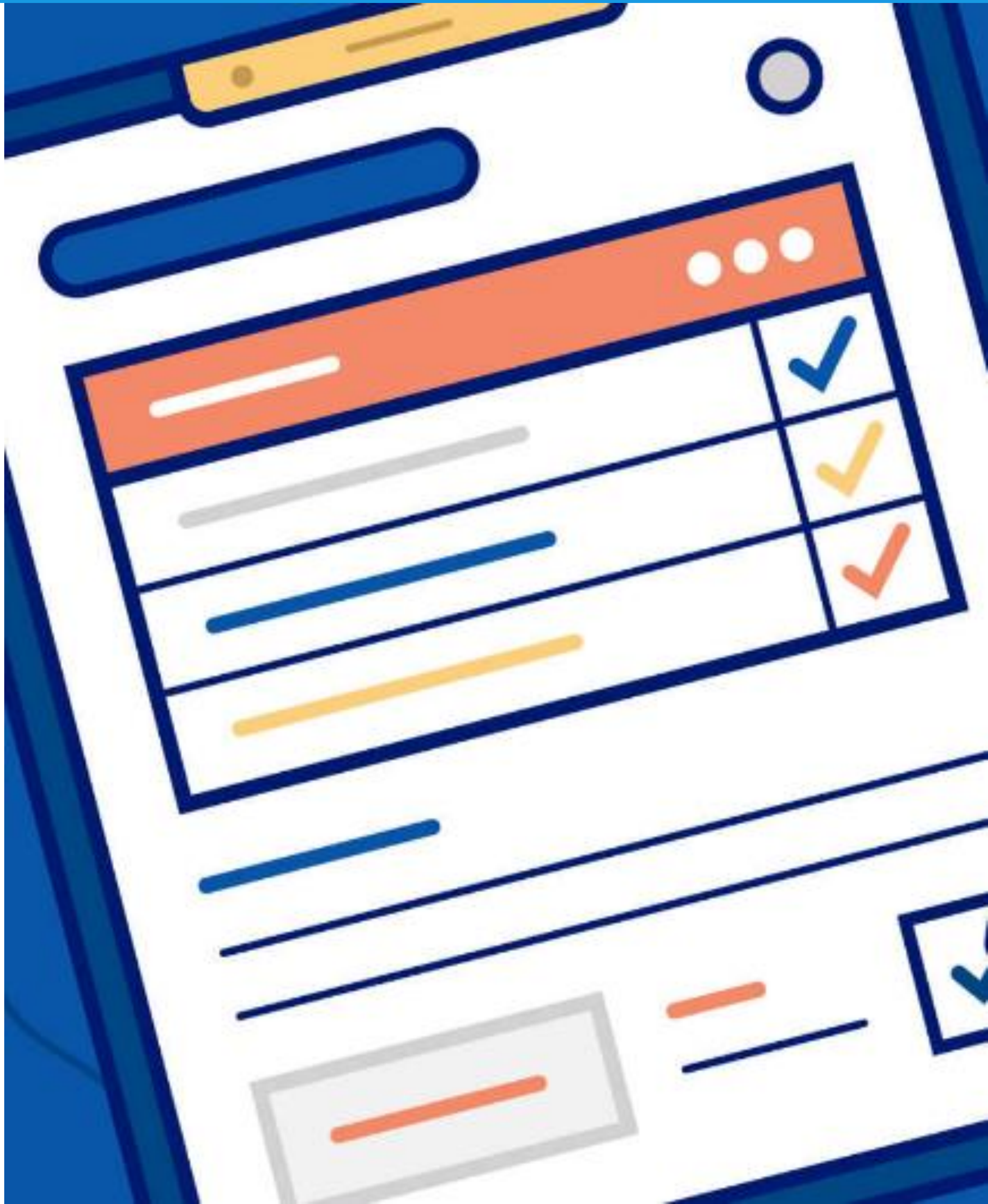
Cold water management

Continually identify and minimize risks

- Have a water management plan that considers the risks that cold water presents
- Understand your plumbing systems and make changes based on results and data
- Water testing and validation on cold and hot water is essential and allows for corrective actions and enhanced monitoring
- Include water management strategies that are address the cold water systems to minimize risk and protect your building and occupants

Include cold water in water management

- Choose effective solutions and control measures that protect your entire system including solutions that address growth factors in the cold water
  - Stagnation
  - Sediment and scale
  - External influences
  - Warming cold water

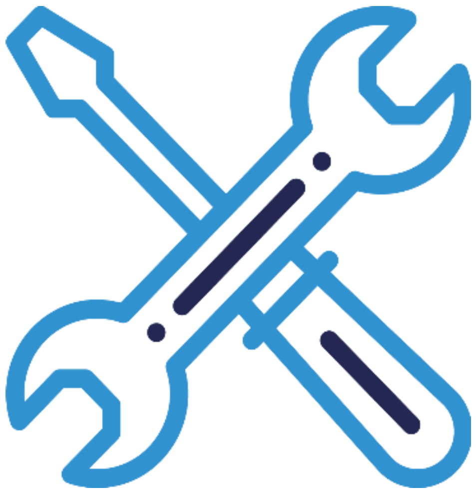


Hot water control measures can be used for cold water systems too!

Temperature

Flushing/Flow

Disinfection residuals



Equipment maintenance

Mitigating cold water risks

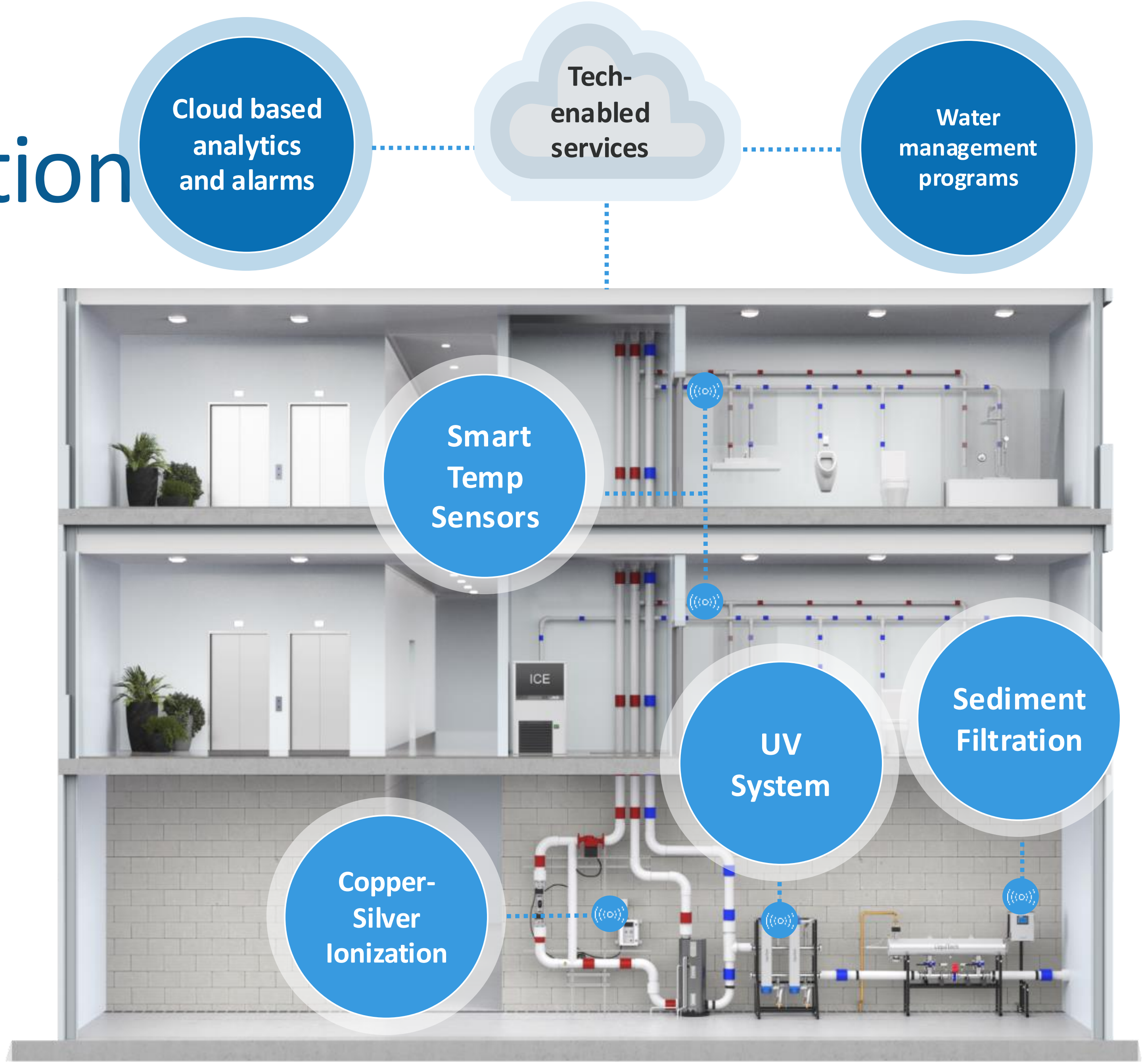
- A multi-barrier approach that tackles risks associated with the cold water systems with…
  - Point-of-entry sediment filtration
  - Ultraviolet disinfection as a first line of defense
  - Supplemental disinfection (cold or hot water)
  - Smart monitoring of temperature throughout the cold water
- Along with routine flushing and equipment maintenance provides a proactive approach to cold water risks.

Multi-barrier solution

» Mix of technology and service for the highest level of efficacy and safety on cold and hot water

» Protects water systems from the point of entry (cold) to the point of use (cold and hot)

» Broad approach to improve water management



Cold water sediment filtration

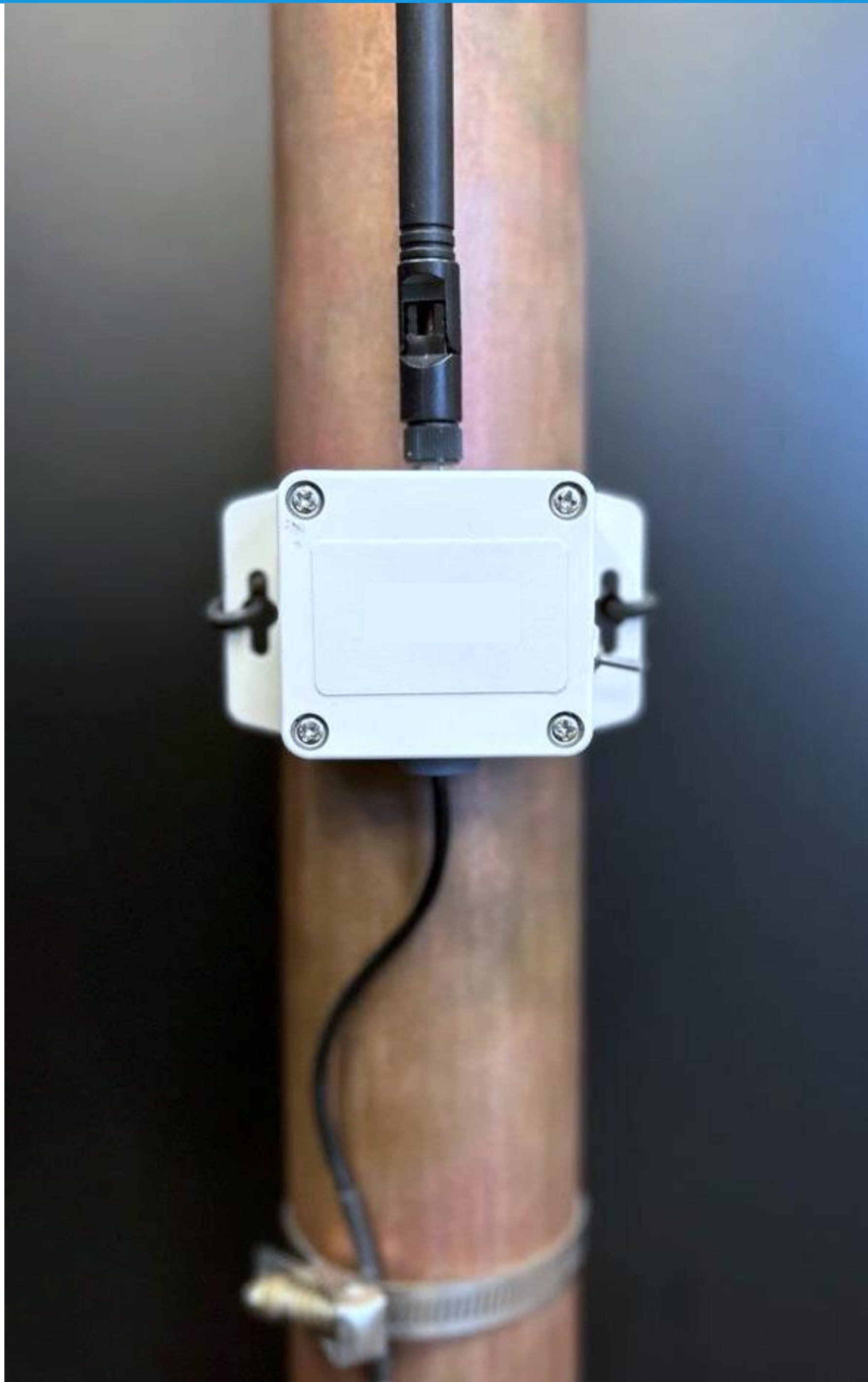
- Installed at point of entry, removes sediment – before it enters your plumbing systems
  - Remove the food source and protection for waterborne pathogens and biofilm
  - Improve disinfection efficacy (municipal and supplemental)
  - Enhances the efficacy of sterile processing (RO, DI) and improves utility water
- Protect the occupants and equipment from unexpected changes in cold water quality

UV Disinfection Systems

- Installed on the incoming water main and is a first line of defense for the cold water entering your system
- Kills 99.99% of microorganisms most commonly found in water, including Legionella and other waterborne pathogens
- Does not provide a disinfection residual downstream, so additional measures still needed

Smart temperature sensors

- Wireless sensors that can be installed in targeted areas throughout a cold water system to meet water management needs – water entry, risers, wings, etc.
- Record water temperature continuously and can identify and alert when cold water risks are present
  - Changes in incoming water temperatures
  - Areas of poor circulation or low use
  - Warming cold water conditions
- Provides data to implement targeted corrective actions, such as flushing programs



Treatment programs

- Cold water supplemental disinfection systems can be a proactive approach to risk and provide a residual throughout the cold and hot water systems BUT…
  - Select systems that are effective at penetrating biofilms and effective against pathogens
  - Ensure compatibility with plumbing materials and components and doesn’t contribute to corrosion
  - Understand the need for cold water vs hot water disinfection
  - Cold water installation requires more chemical and oxidant treatments will contribute additional hazardous chemicals, corrosion, and disinfection byproducts

Cold water flushing programs

- Flushing replaces aging water and can purge accumulated sediment and deposits in the water system
- Cold water flushing should include low use areas, equipment with reservoirs (tanks), far point locations, areas where cold water may warm up
- Can reduce favorable growth conditions by increasing residuals, maintaining temperatures, reducing the potential for stagnation.

Microbial Filtration

- Provide a barrier that prevents exposure to waterborne pathogens at the point of use
- Can be used at point of use (faucets, showers) and inline (ice machines)
- In ice machines, are a very effective method to prevent colonization, as no Legionella or waterborne pathogens will enter the machine
- Often used for emergency remediations and routinely in high-risk areas, even if other control measures are in place

Ice Machines

- Incorporate routine cleaning of ice machines into water management programs.
- Include testing for Legionella to validate the effectiveness of cleaning.
  - Testing should include ice and water (if a dispenser is present)
- Consider stronger disinfections as corrective actions in response to positivity
- Install in-line POU filters as preventative practice to prevent pathogen entry

Case studies

Cold water supplemental disinfection

» In response to cases of disease, facility performed superheat and flushes, but positivity persisted

» Due to incoming cold water temperatures (routinely above 86°F) and cold water positivity, installation on the cold water point of entry was chosen

» After getting optimal residuals in cold and hot water, positivity dropped from over 40% of sites to 5% of sites positive

Journal of Hospital Infection (2008) **68**, 152–158

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Efficacy of point-of-entry copper–silver ionisation system in eradicating *Legionella pneumophila* in a tropical tertiary care hospital: implications for hospitals contaminated with Legionella in both hot and cold water

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Received 3 October 2007; accepted 25 October 2007
Available online 14 January 2008

Northeast University

» Installed copper-silver on the hot water system and achieved non-detect

» Positivity found in the cold water system, investigation revealed:

  » Low use leading to water stagnation

  » Accumulation of sediment

  » Increased cold water temperatures within the ideal growth range for Legionella.

» Sediment filtration to reduce sediment and a targeted flushing led to non-detect

Major Cancer Center

- Installed copper-silver ionization on the hot water system and maintained non-detect
- Identified a case of Legionnaires' disease, found cold water and ice machine positivity
- Immediately used POU filters in high-risk units and on ice machines
- Installed multibarrier approach - sediment filtration and UV on the cold water, moved the copper-silver ionization to CW
- Achieved and maintained non-detect in both the cold and hot water systems

What to consider

- What are the risks associated with cold water and are they present in our building?
- What strategies can we utilize to minimize risk of Legionella in cold water systems?
- A multibarrier approach can mitigate the risks of cold water systems AND the hot water systems simultaneously
- **Understanding cold and hot water risks, water uses, and water management allows you to develop a plan for greater water safety**

Questions?