



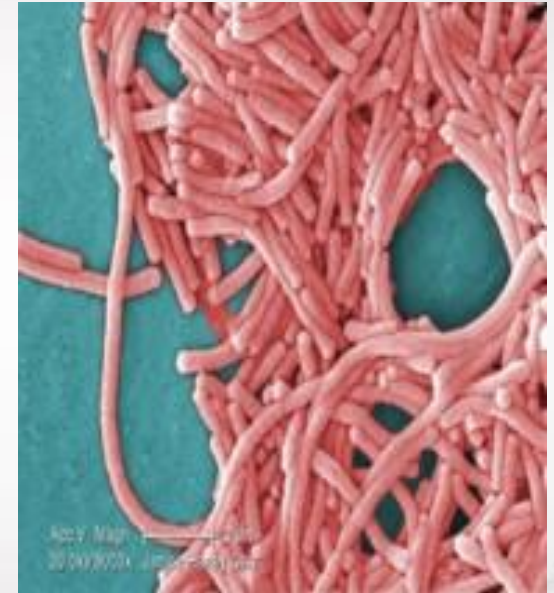
# ***Legionella: Monitoring and Environmental Controls***

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# *Legionella*

- Genus of bacteria found in freshwater worldwide.
- Known to infect protozoans such as *Amoeba*.
- *Legionella pneumophila* survives in water with temperatures between 77° and 124° F.
- Exposure to legionella typically requires inhalation of the bacterium through misted water particles or aerosols.



# Legionellosis

- When *Legionella* enters potable water systems and is breathed in via aerosols, it can infect lung cells as well.
- *Legionella pneumophila* and several closely related species are the causal agents of legionellosis.
- Legionellosis refers to a lung infection by *Legionella* that can develop into multiple illnesses.

# Legionellosis

- Legionellosis can lead to either Pontiac fever and Legionnaire's Disease.
- Pontiac fever goes largely unreported, likely due to its mild, flu-like symptoms.
- Symptoms of Pontiac fever include: Fever, chills, muscle pain, dry cough, fatigue, headaches, dizziness.
- Legionnaires' disease is more serious with many of the previously mentioned symptoms but includes pneumonia.

# Legionnaires' Disease

- Risk of disease increased in individuals who meet any of the following conditions: current or former smokers, cancer, chronic lung disease, compromised immune systems, or individuals above the age of 50.
- Onset of illness typically 2-10 days after exposure.
- Complications can lead to lung failure or death.
- Legionnaires' Disease has a mortality rate of around 10%.

# At-risk facilities

- Facilities housing sensitive populations such as hospitals and long-term care facilities
- Buildings with more than 10 stories
- Buildings with cooling towers
- Building with large, complex hot water distribution systems
- Hospitals
- Nursing Homes
- Senior living/assisted living facilities
- Hotels
- Office buildings
- Commercial operations using misting/spray
- Churches
- Dental equipment

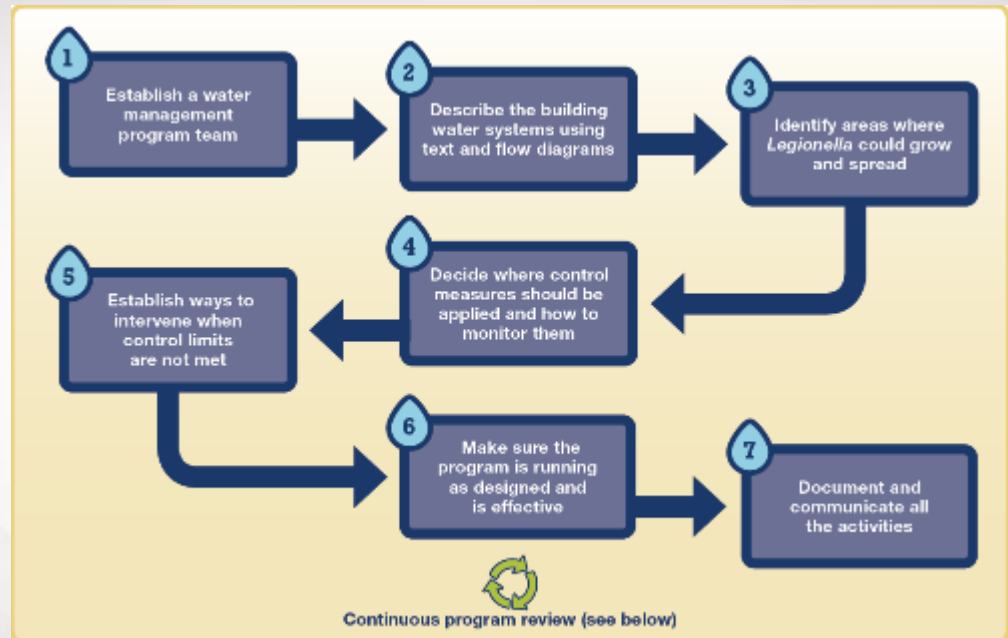
# ASHRAE Standard

- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has developed standards and guidance documents for *Legionella*.
- The ASHRAE 188 standard “Legionellosis: Risk Management for Building Water Systems” serves as a foundation for modern control procedures.
- Guidance documents including ASHRAE 188 may be found at [www.ashrae.org](http://www.ashrae.org).



# Water Management Program

- Water management programs are organized, multi-step plans to reduce *Legionella* in facility water systems and identify potential sources of exposure.





# Water Management Program

1. Establish a water management program team
2. Describe the building water systems using text and flow diagrams
3. Identify areas where *Legionella* could grow and spread
4. **Decide where control measures should be applied and how to monitor them**
5. **Establish ways to intervene when control limits are not met**
6. Make sure the program is running as designed and is effective
7. Document and communicate all the activities

*\*\*Reference CDC Toolkit or ODH factsheets for more information*  
*<https://www.cdc.gov/legionella/wmp/toolkit/index.html>*

# Water Management Program Team



# *Legionella* Controls and Monitoring

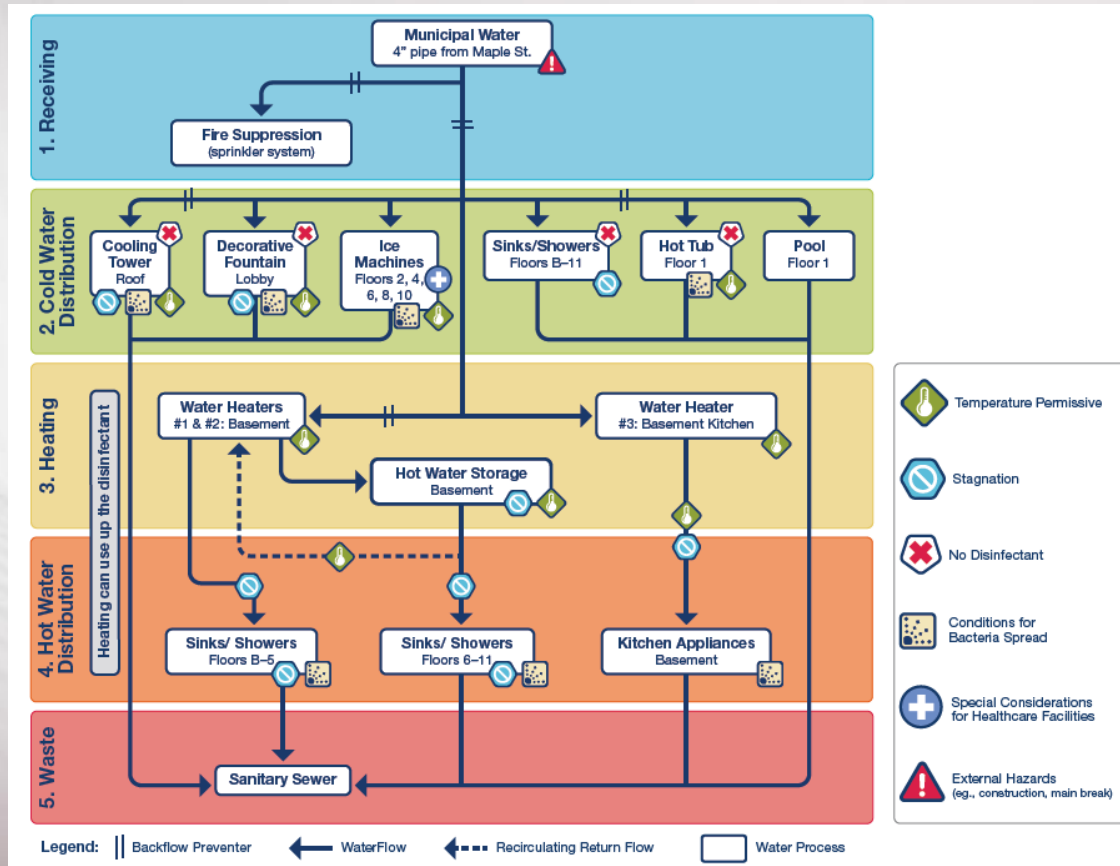
- Risk is reduced by minimizing available habitat through the administration of control measures and careful monitoring of the environment.
- Monitoring the water distribution system and establishing control measures.
- Control measures can be divided into short-term and long-term measures.

# Monitoring: General Recommendations

Prior to establishing control limits or beginning environmental monitoring, keep the following CDC recommendations in mind:

- Maintain hot water temperature at the highest temperature permitted by state regulations or codes (see guidance for healthcare-specific recommendations).
- Ensure disinfectant levels are detectable where water enters the building and at points of use.
- Measure the pH of the water to determine whether the disinfectant used in the building will be effective.

# Monitoring: Identifying Risk Areas



# Monitoring: Control Limits

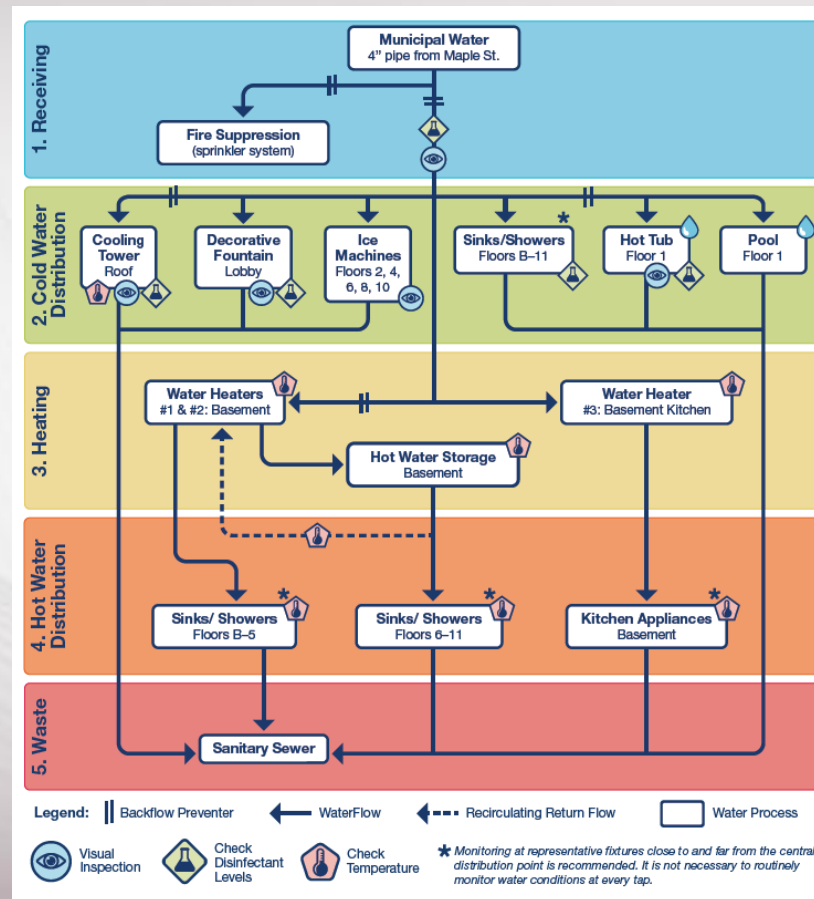
- When creating a water management program, establish a regular monitoring schedule to assess water parameters.
- Control limits are maximum, minimum and ranges of values for each parameter measured.

Examples may include:

- Maximum temperatures below 115 ° F in a healthcare facility.
- Chlorine levels below 0.5 ppm.

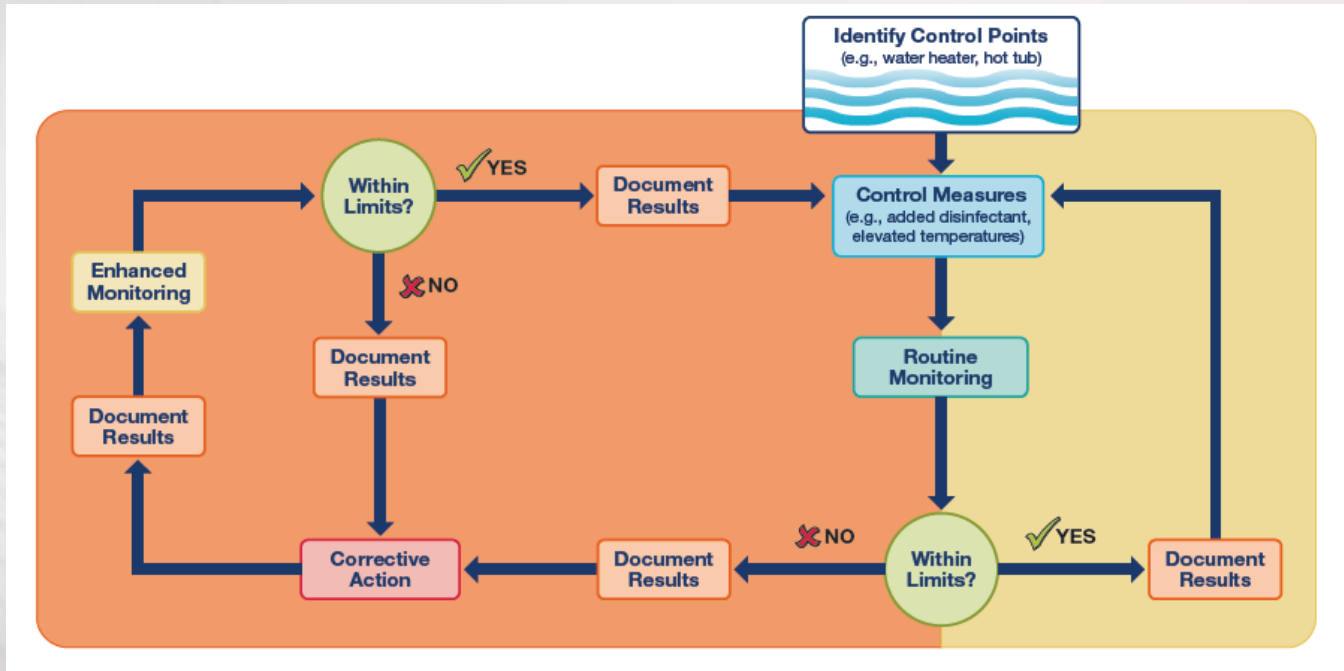
Responses for a failure to meet control limits should be detailed in the water management program of the facility.

# Monitoring





# Monitoring: Control Limits



# Monitoring: Temperature

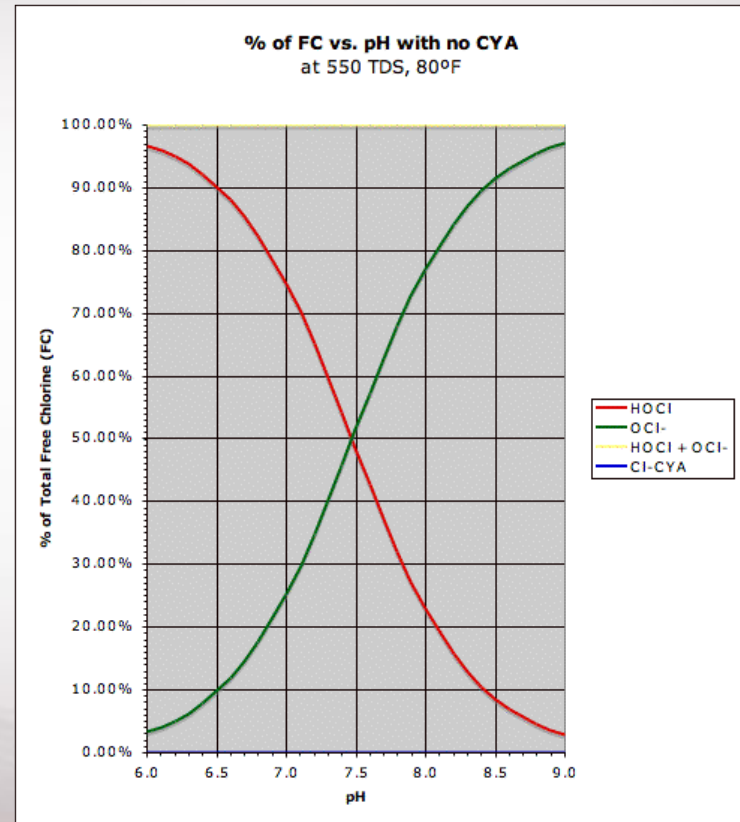
- *Legionella* is most active in warm freshwater.
- Checking temperature at multiple points, especially aerosol generating sources.
- Control limits but comply with plumbing code due to scalding risk.
- Set a maximum around 68° F for cold water.
- The minimum for hot water should ideally exceed 140 ° F for maximum effectiveness.

# Monitoring: Disinfectant Levels

- Contact local water treatment plant and confirm disinfectant type, typically chlorine or monochloramine.
- Check for residual free or total chlorine depending on the disinfectant used.
- Minimum limit should be set around 0.5 ppm for free chlorine and 1 ppm for total chlorine.
- Avoid using a pool chlorine test kit if possible, pool kits have difficulty detecting low quantities.

# Monitoring: pH

- Chlorine effectiveness decreases at a  $\text{pH} > 8$ .
- Adding chlorine will increase the pH, a buffer solution may be added.



# Monitoring: Other

- Additional monitoring of aerosolizing water features is also necessary.
- Perform routine inspections of hot tubs, decorative fountains and other features for visible biofilms.
- Facilities should also take note of any underused points of delivery in a water system. Stagnant water promotes *Legionella* growth.
  - For example, a floor of building closed off for maintenance could experience these conditions.

# Intervention

- If control limits are not met, intervention may be needed.
- Actions can vary from raising temperature to scrubbing biofilms.
- These actions should be detailed in water management program.

# Intervention

**Example 1—Biofilm growth in the decorative fountain**



1. During her weekly inspection of the fountain in the first floor lobby, Michalika Patterson notes that the fountain walls have accumulated a slimy growth.



2. As dictated by her water management program, Michalika immediately shuts off the fountain, drains it to the sanitary sewer, and scrubs it with a detergent recommended by the manufacturer.



3. She then follows the program's start up procedure to refill the fountain with water and checks the residual disinfectant levels to make sure that they are within control limits.



4. Michalika documents her observations and the performance of disinfectant cleaning in her log book. She informs her supervisor.

**Example 2—Unoccupied floor**



1. The eighth floor of the building is being renovated and is closed to the public. Jason Hamender understands that this may cause a temporary hazardous condition because water usage will decrease, which means that stagnation is possible.



2. After discussing the issue with his supervisor, Jason documents the potential for stagnation by daily flushing of the sinks and fixtures with hot and cold water in several rooms including those at the end of the hall, which are farthest from the vertical pipe serving that floor (trav).



3. Jason also increases the frequency of measuring temperature and chlorine levels on the eighth floor from weekly to daily for the duration of the renovation.



4. He documents the method and duration of flushing and records his daily temperature and chlorine readings in his log book. He reviews his documentation with his supervisor.



# Controls

- Beyond removing biofilms and flushing underused sinks, the WHO lists a number of physical and chemical controls.
- As previously mentioned, these can be divided into short-term and long-term control measures.

# Long-term Controls

- Long-term controls include any constant measure taken to reduce *Legionella* presence in a water system.
- Some initial steps are already taken by water treatment plants though individual facilities may add to it.
- These measures should be monitored regularly with set control limits.
- Contact water provider to learn disinfectant type.

# Long term control measures

- Temperature
- Chlorine
- Monochloramine
- Chlorine dioxide
- Copper-silver ionization
- Ultraviolet
- Ozone
- Point of use filtration

*\*\*Most of these methods require EPA licensure to implement.*

# Temperature Control

- Rules and regulations prevent hot water temperatures above 120 ° F in public potable water and healthcare facilities.
- Hotels rooms, offices, apartment rooms, and similar facilities with restricted access are permitted to keep higher control limits.
- Higher temperature cans reduce disinfectant presence.

# Temperature Control

- Temperature is among the most effective and easiest methods of control to implement.
- *Legionella* best survive in a specific range of temperatures (77° - 124° F).
- Control temperatures between 140 ° and 160 ° F are recommended.

# Chlorination

- Chlorine is often added at treatment plants and comes in a number of initial forms such as sodium hypochlorite.
- Chlorine breaks into ions (free chlorine) that work to deactivate bacteria.
- Safe drinking water standards limit potable water treatments to chlorine concentrations below 4ppm.
- Free chlorine levels exceeding 2 ppm are best for bacterial control.
- Free chlorine levels below 0.5 are often ineffective.

# Chlorination

- Chlorine ions are used up when deactivating bacterial cells, so residual levels decrease the further from initial treatment.
- Ensure that free chlorine and not total chlorine is measured.
- Chlorine test strips or kits intended for pools *do not* provide adequate resolution at low concentrations, instead look into using a colorimetric wheel DPD-based color indicators.



# Monochloramine ( $\text{NH}_2\text{Cl}$ )

- Second most common disinfectant used in water treatment.
- Most useful for residual disinfection in hot water systems.
- Recommended residual concentrations should be between 1 and 4 ppm.
- Measured using total chlorine versus free chlorine.

# Monochloramine (NH<sub>2</sub>Cl)

- Able to penetrate biofilms to reach *Legionella*.
- More persistent residual than chlorine in potable water.
- Weaker overall oxidant than chlorine.
- May pose risk to dialysis patients, requiring implementation of a carbon filter.
- Long-term use can lead to corrosion and pitting in pipes.

# Chlorine Dioxide (ClO<sub>2</sub>)

- Water soluble gas that is generated on-site using sodium chlorite and hydrochloric acid.
- Recommended for use in cold water systems since heat quickly degrades the compound.
- Should be generated at dosages between 0.4 and 0.7 ppm.
- Residual levels should be maintained at levels between 0.1 and 0.4 ppm.

# Chlorine Dioxide (ClO<sub>2</sub>)

- Ability to diffuse through membranes and biofilms makes this an effective addition to other disinfectants.
- Risks evolution of resistance in *Legionella* populations.
- May pose risk to dialysis patients, requiring implementation of a carbon filter.

# Copper-silver Ionization

- Water moves through chamber with copper and silver anodes.
- Electric current releases ions that deactivate bacteria.
- Copper residual should be maintained at concentrations between 0.3 and 0.8 ppm.
- Silver residual should be maintained at concentrations between 0.01 and 0.08 ppm.

# Copper-silver Ionization

- Slow residual build-up makes ineffective at start but easier to maintain.
- Less effective on bacteria like *Legionella* that associate with protozoans and biofilms.
- Unable to completely eliminate *Legionella* from treated potable system (0 cfu).
- Risks evolution of resistance in bacterial populations.
- Corrodes piping and leads to copper deposition.

# Ozone ( $O_3$ )

- Generated on-site as gas and dissolved into water.
- Dosages at generation should be between 0.32 and 0.79 mg/L.
- Functions as an oxidant when used to treat potable water.
- Ozone is unable to maintain a residual in the treated water system.
- Degrades quickly and should be used only as a secondary disinfectant.



# UV Radiation Control

- Ultraviolet light is used to disrupt protein synthesis in *Legionella* cells.
- Water is exposed to ultraviolet radiation in a central chamber.
- Equipment may not function at temperatures exceeding 95° F.
- Best used as a secondary disinfectant since it produces no residual.

# Point-of-use Filtration

- Filters placed at points-of-use can filter bacteria from water.
- Filters must be able to prevent *Legionella* cells 0.3 to 0.9  $\mu\text{m}$  wide and 2 to 20  $\mu\text{m}$  in length from passing through.
- Requires very fine filter such as reverse osmosis, nanofilters, ultrafilters or microfilters.
- If not regularly replaced, legionella could reproduce within the filter.
- Filters can be costly to implement depending on how many points of use will be filtered.

# Short-term Controls

- Short-term controls are the primary approach to outbreaks and emergencies.
- Focuses on eliminating as much *Legionella* from the system as possible.
- Renders potable water temporarily unavailable.
- These methods are meant to immediately reduce risk, however they do not prevent recolonization over time.
- May be more effective in clearing out *Legionella* colonizing biofilms.

# Superheat-and-flush Disinfections

- Raises temperature in water system above 160° F.
- Water is flushed out after short period (~45 mins) moving through system.
- Only used in hot water systems.
- Takes longer to implement than hyperchlorination.

# Hyperchlorination

- Extra chlorine is added to ensure *Legionella* populations are reduced as much as possible.
- Additional chlorine is added to system at levels between 20-50 ppm.
- Chlorine is flushed from system after around 24 hours.

# Point-of-use Filtration

- Point-of-use filtration is also effective as an outbreak response option.
- Filters allow for facilities to control *Legionella* exposure while organizing environmental sampling without killing off evidence.
- Point-of-use filters can be an excellent alternative to hyperchlorination and superheating if access to potable water cannot be restricted.

# Recommending a Consultant

In a complex water system where the source of an outbreak or case is unclear, it may be best to recommend the facility hire a consultant. When doing so, the CDC advises facilities to consider the following factors:

- Level of experience
- Laboratory expertise
- Environmental assessment experience
- Remediation expertise
- Water management expertise
- Knowledge of codes, standards, and regulations
- Potential conflicts of interest

# Contact Information

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