Legionella Control in the Cooling Towers and Domestic Water Systems

Charles Bertuch, PE
Bergmann Associates
Objectives of Learning

- Understanding Legionnaires Disease
- Overview of Current Legislation and Standards
- Understanding of Issues Related to Conditions, Good Practice, and Water Treatment for Cooling Towers and Domestic Water Systems
- Outline of Risk Assessment Process
- Overview of NYS DOH Requirements
Legionella Pneumophila Bacterium

- Naturally occurring in most water systems
- Has been detected in rivers, lakes, and streams
- Often present in mains water
- Easily colonises most domestic and warm water systems
- Requires food source (other bacteria & sediments)
- Prefers stagnant conditions
Legionnaire’s Disease

• Potentially fatal form of pneumonia
• Primarily contracted through inhalation of aerosols, fine droplets & mists
• 5-30% fatality rate. Highest in:
  • Older adults (over age 65)
  • People in hospitals or nursing homes (nosocomial cases)
  • Smokers
  • Those with weakened immune system
Legionnaire’s Disease

• Incubation period 2-10 days - typically 3-6 days

• Also refers to Pontiac Fever, Pontiac fever a nonfatal respiratory disease which causes a mild upper respiratory infection that resembles acute influenza.

• Approximately 25,000 cases per year, often undiagnosed or untreated
Philadelphia 1976

- American Legion Convention – Bellevue Stratford Hotel
- 10,000 Attendees, 221 Cases, 34 Deaths
- Began in cooling towers, exact vector never determined (most likely through central air conditioning system)
New York City 2015

- July/August: 133 Sickened, 16 Deaths
- All deceased had underlying health conditions
- Linked to Cooling Tower at Opera House Hotel
- Requirement to immediately test and clean all cooling towers in NYC
- Second outbreak in September: 10 Sickened
Finding the Source
Linking Cooling Towers and Patients by DNA

- **Affected Area**

**Outbreak Pattern Found**
- Red triangle: Opera House Hotel Cooling Tower
- Black circle: Patients (with *Legionella* DNA results)*

**Outbreak Pattern Not Found**
- Grey triangle: Cooling Towers†
- Green circle: Patients (without *Legionella* DNA results)

*As of last update, all patient results match the outbreak pattern.
†Includes cooling towers in which the outbreak pattern could not be determined and those with pending results.

Map updated on August 20, 2015.

Bronx, New York Highlighting Affected Zip Codes
Legislation & Standards

- NYC Dept of Health Order
- NYS Dept of Health Order
- ASHRAE 188-2015
- ASHRAE Guideline 12
- VA 1066-2014
Potential Sources

- Cooling Towers
- Domestic Water Systems
  - Piping
  - Tanks
  - Fixtures
- Decorative Fountains*
- Evaporative Coolers*

* - not covered in this presentation
Cooling Towers

- Evaporative effect of ambient air moving over warm water to reduce temperature.
- Sump temperatures $68^\circ - 122^\circ$ F ideal for legionella growth.
- Water vapor and droplets released to the atmosphere can carry bacteria.
- Risk for maintenance workers directly exposed to sump or tower components.
Cooling Towers

• **Oxidizing Biocide** – Destroys cell walls and oxidizes proteins within the organism.
  – Chlorine, Bromine, Iodine, Chlorine dioxide, Ozone, Hydrogen peroxide

• **Non-Oxidizing Biocide** – Legionella control by other means, including interference with cell metabolism and structure.

• Consult water treatment specialists for best application.
Cooling Towers

Temperature:

• Maintain sump water at a low temperature (68°F).

• Sump-water temperatures depend on tower design, heat load, flow rate, and ambient dry-bulb and wet-bulb temperatures.

• Under ideal conditions, sump-water temperatures in evaporative devices approach the ambient wet-bulb temperature, and may be low enough to limit Legionella amplification.
Cooling Towers

Maintenance:

• Cleaning: Clean and disinfect cooling towers based on Tower Maintenance Plan.
• Clean before initial start-up at the beginning of the cooling season and after shut-down in the fall.
• Testing: May indicate the need for additional cleaning.
• Any system that has been out of service for more than 3 days should be cleaned and disinfected.
• New systems require cleaning and disinfesting.
Cooling Towers

Tower Maintenance Plan

• Equipment inspection
• Drain and clean
• Water treatment regimen
• Scheduled microbiologic analysis
• Recordkeeping log book
• System Manual
• Written procedures for operation and maintenance.
Assessment of Learning

Name two means of controlling Legionella in Cooling Towers
Assessment of Learning

Name two means of controlling Legionella in Cooling Towers

1. Biocides (oxidizing and non-oxidizing)
2. Maintain sump water temperature < 68° F
Domestic Water Systems

- 77°F – 108°F Ideal temperature for amplification.
- Municipal chlorine residual may inhibit, but not eliminate Legionella.
- Stagnant cold water systems (dead ends or sporadic use) can become warm enough to support Legionella.
- Plumbing fixtures (shower heads, faucets, spas) can breed and aerosolize Legionella.
Domestic Water Systems

System Design

- Store hot water above 140° F
- Circulate hot water at 130° F (minimum return temperature 124° F)
- Utilize tempering valves to prevent scalding
- Avoid dead legs (hot and cold water).
- Provide drains to allow cleaning and disinfection.
- Circulate or cycle cold water to keep temperatures below 68° F
Domestic Water Systems

Water Treatment – Supplemental Chlorination

- Injection of sodium hypochlorite to achieve free chlorine residual $< 4$ mg/L at outlets.
- Accelerated corrosion of water systems
- Formation of disinfection byproducts
- Poor biofilm penetration
Domestic Water Systems

Water Treatment – Chloride Dioxide

• Injection of concentrated chlorine dioxide solution.
• Sodium hypochlorite to achieve ClO₂ residual 0.1 – 0.8 mg/L at outlets.
• Selective oxidation targets (organic materials).
• Superior biofilm penetration.
Domestic Water Systems

Water Treatment – Monochloramine

- Used as disinfectant by municipal drinking water providers
- More stable than chlorine, produces fewer regulated byproducts
- Injection of stabilized chlorine and buffered ammonium salt
- Target concentrations 2 – 4 mg/L
- Limited long term evaluations to date
Domestic Water Systems

Water Treatment – Copper Silver Ionization

- Flow cell with metallic copper and silver anodes
- Release of ions into the water controlled by adjusting current across anodes
- Copper and silver regulated under Safe Drinking Water Act
- Target concentrations $0.2 - 0.8 \text{ mg/L}$ copper, $0.01 - 0.08 \text{ mg/L}$ silver
Assessment of Learning

Name four types of secondary treatment for control of Legionella in domestic water systems?
Assessment of Learning

Name four types of secondary treatment for control of Legionella in domestic water systems?

1. Supplemental Chlorination
2. Chlorine Dioxide
3. Monochloramine
4. Copper Silver Ionization
Guide to Successful Control

Requires:

- Management Program
- Risk Assessments
- Control regime
- Maintenance and upgrade
- Review
Management Program

- Program Team – Responsible for developing and implementing the program
- Employees, suppliers, consultants
- Regular meeting to review risks, documentation, testing, and LD diagnoses
- Communicate reviews to facility management team
Risk Assessments

- Assess potential for Legionella growth
- Identify who is at risk
- Assess the potential for bacterial transfer
- Quantify and prioritize the risks
- Determine suitable means of control
Risk Assessments

Describe building water systems:

- Locations of end-point uses for potable and non-potable water
- Locations of water processing equipment
- How water is received and processed (stored, heated, cooled, recirculated, and delivered).
Risk Assessments

Process Flow Diagrams

HCA LD PREVENTION PLAN SCHEMATIC DIAGRAM
Building 1 Portable Water Distribution System

Building 1 Incoming Cold Water
P10 Receiving CL4

Hot Water Return Pump
DHW 14 Circulation CL13

HW Heater 1
DHW 11 Heating CL 19

Building 1 Floors 1-2 HW Usages
Sinks, Showers, Laundry, Kitchen

HW Heater 2
DHW 32 Heating CL 3

Building 1 Floors 1-2 CW Usages:
Sinks, Showers, Laundry, Kitchen

Sanitary Sewer
S1: Waste
## Risk Assessments – Hazard Analysis

- Evaluate risks at each processing step.
- Hazard description
- Likelihood of occurrence
- Controls in place

<table>
<thead>
<tr>
<th>Process Point ID</th>
<th>Description</th>
<th>Legionella hazard analysis and Risk Characterization</th>
<th>Does this processing step offer user control over water quality</th>
<th>Does this processing step offer user control over Legionella</th>
<th>Control location ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHW 1</td>
<td>Heating: Hot Water Heaters (x2)</td>
<td>Legionella can proliferate in hot water heaters if sufficient temperatures are not maintained. High Risk: Legionella proliferation in hot water systems has been widely documented</td>
<td>Yes</td>
<td>Yes</td>
<td>CL 8 CL 9</td>
</tr>
<tr>
<td>DHW 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P7</td>
<td>Receiving: From municipal water system at backflow preventer</td>
<td>Microbial populations with or harboring Legionella can grow in municipal water distribution systems. Low Risk: The municipal water supply is treated with monochloramine, regularly monitored for disinfectant residual, and at temperatures not conducive for Legionella replication</td>
<td>Yes</td>
<td>No</td>
<td>CL 5</td>
</tr>
</tbody>
</table>

From Special Pathogens Laboratory
Risk Assessments

Control Regime

• Evaluate risks associated with growth and transmission of Legionella at each processing step.
• Hazard description
• Likelihood of occurrence
• Controls in place
Risk Assessments – Control Measures

- Locations selected to include control points where users have control over Legionella.
- Establish control limits

<table>
<thead>
<tr>
<th>Validation Point</th>
<th>Water System</th>
<th>Parameter</th>
<th>Goal</th>
<th>Control Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL 1</td>
<td>Building 1 Potable Hot Water System</td>
<td>Incoming Cold Water Monochloramine</td>
<td>0.5 – 4 mg/L</td>
<td>0.5 – 4 mg/L</td>
</tr>
<tr>
<td>CL 10</td>
<td>Building 1 Potable Hot Water System</td>
<td>Hot Water Distal Outlet Temperature</td>
<td>105 – 110°F</td>
<td>&lt;110°F (&lt;124°F prior to tempering device)</td>
</tr>
</tbody>
</table>
Risk Assessments – Monitoring

- Procedure for monitoring whether control measures are within established limits

<table>
<thead>
<tr>
<th>Control Location</th>
<th>Parameter</th>
<th>Location (s)</th>
<th>Control Limits</th>
<th>Monitoring Frequency</th>
<th>Monitoring Method</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL 10</td>
<td>Hot Water Distal Outlet Temperature</td>
<td>Minimum of 10 distal outlets throughout the facility</td>
<td>&lt; 110° F</td>
<td>Quarterly</td>
<td>Thermometer</td>
<td>Chief Engineer</td>
</tr>
<tr>
<td>CL 1</td>
<td>Incoming cold water pH</td>
<td>At backflow preventer or cold water entry at each building</td>
<td>6.5 – 8.5</td>
<td>Continuously</td>
<td>Inline pH Probe</td>
<td>Chief Engineer</td>
</tr>
</tbody>
</table>
Risk Assessments – Corrective Actions

- Corrective action performed when control limit is violated
- Refer to detailed corrective action procedures

<table>
<thead>
<tr>
<th>Corrective Action</th>
<th>Event Trigger</th>
<th>CL/VP</th>
<th>Control Limit</th>
<th>Implementation Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Hot Water Heater Temperature Out of Range</td>
<td>CL 8, CL 9, CL 11</td>
<td>105 – 110°F</td>
<td>Within 24 hours of notice of control limit violation</td>
</tr>
<tr>
<td>4.2</td>
<td>Hot Water Distal Outlet Monochloramine Out of Range</td>
<td>CL 10, CL 13, CL 14</td>
<td>0.5 – 4 mg/L</td>
<td>Within 24 hours of notice of control limit violation</td>
</tr>
</tbody>
</table>

From Special Pathogens Laboratory
Cooling Towers Preventive Measures

Siting:

• Potential for discharge into occupied spaces, pedestrian areas, outdoor air intakes and building openings.

• Access for inspection and maintenance.
Cooling Towers Preventive Measures

Start up and Shutdown:

• New equipment: Procedures for cleaning as part of commissioning. Immediate initiation of water treatment.

• Shutdown: Procedures for chemical pre-treatment, pump cycling, and draining.

• Restart
Cooling Towers Preventive Measures

Maintenance:

• Schedule for inspection for cleanliness and operation
• Schedule for cleaning
• Water treatment system description, schedule and corrective action plan
• Documentation requirements
Domestic Water Systems Preventive Measures

Start up and Shutdown:

• New Systems: Flushing and disinfection before commissioning.
• Procedures for shutdown: drain, purge, treatment, and control settings.
• Plans for unplanned power loss, treatment interruption, component maintenance.
• Monitoring and treatment following interruptions.
• Re-establishing temperatures throughout the system.
Domestic Water Preventive Measures

Procedures for maintenance, monitoring, cleaning and disinfection of:

- Hot and Cold Water Storage Tanks
- Ice Machines
- Water-hammer Arrestors
- Expansion Tanks
- Water Filters
- Shower Heads and Hoses
- Electronic Faucets
- Aerators
- Faucet Flow Restrictors
- Non-steam Humidifiers
- Water Heaters
- Eyewash Stations
- Infrequently Used Equipment
Assessment of Learning

What criteria of Control Regimes are relevant to a facility Risk Assessment?
Assessment of Learning

What criteria are relevant to a facility Risk Assessment?

1. Risks associated with growth and transmission of Legionella at each processing step.
2. Hazard description
3. Likelihood of occurrence
4. Controls in place
NYS DOH Emergency Order
Cooling Towers and Domestic Water Systems

• Enacted in response to NYC Outbreak
• Effective Date August 17, 2015
• Applies to all cooling towers in NYS
• Applies to domestic water systems in hospitals and residential health care facilities
• Enforcement by County DOH, not fully developed
NYS DOH Emergency Order
Cooling Towers

On Line Registration – By September 16
• Location
• Use
• Manufacturer, model, serial number
• Capacity – tonnage and basin
• Water treatment system
• Party responsible for inspection and certification
NYS DOH Emergency Order
Cooling Towers

Testing and Cleaning – by September 16
• Collect samples, test at approved lab
• Take immediate action in response to test results

• No Detection – Maintain treatment program and monitoring
• 10< CFU/ml < 1000 – Disinfect, retest in 3 – 7 days.
• CFU/ml > 1000 – Decontaminate, retest in 3 – 7 days.

Disinfection: Dose tower water system with biocide
Decontaminate: Dose water system with chlorine at least 5 mg/l free chlorine for at least one hour
NYS DOH Emergency Order
Cooling Towers

Inspection and Reporting – By September 16
• Performed by PE, CIH, Certified Water Treatment Technologist, or consultant with training and experience
• Evaluate:
  – Presence of organic material, biofilm, algae, other visible contaminants
  – General condition of tower, basin, packing material and drift eliminator
  – Makeup water connections and control
  – Conductivity control
  – Function of dosing equipment
• Report to Owner and DOH
• Certification of inspection, testing, cleaning and development of maintenance program
NYS DOH Emergency Order
Cooling Towers

Maintenance Program – By March 1, 2016
• Follow ASHRAE 188-2015

Also -
• Schedule for sampling and analysis
• Emergency sampling for upset conditions
• Response to test results
NYS DOH Emergency Order
Cooling Towers

Certification – By November 1, 2016
• By PE, CIH, Certified Water Treatment Technologist, or consultant with training and experience
• Certification of inspection, testing, cleaning and maintenance program being followed
NYS DOH Emergency Order
Domestic Water Systems

- Applies to domestic water systems in hospitals and residential health care facilities as defined by Article 28 of Public Health Law
- Develop sampling plan for water distribution system
- Report results and take responsive actions
Assessment of Learning

What are the key dates for compliance with NYS DOH requirements for Cooling Tower Protection Against Legionella?
Assessment of Learning

What are the key dates for compliance with NYS requirements for Cooling Tower Protection Against Legionella?

1. Regulations enacted August 17, 2015
2. Testing, Inspection, Registration and Reporting due September 16, 2015
3. Maintenance Plans prepared by March 1, 2016
4. Certification due November 1, 2016
Questions?

Thank You