Assessing and Mitigating *Legionella* in Building Water Systems of Assisted Living Facilities

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Atlanta Marriott Marquis
Agenda

- Defining the Problem
- Pathogenic Bacteria
- Risk Assessment Techniques
- Remediation and Control Measures
- Two Case Studies

“Housing facility for people with disabilities or for adults who cannot or choose not to live independently.”
Defining The Problem

• Biofilm causes up to 85% of all Healthcare Acquired Infections (HAIs)
• Slimy agglomeration of living and dead microorganisms, often adhered to mineral scale
• Highly resistant to antimicrobial treatment; need to break membranes
• Becoming more virulent
Defining The Problem

- Water conditions that tend to promote the growth of *Legionella* include:
  - Stagnation
  - Temperature: 68 – 122 °F (20 – 50 °C)
  - pH between 5.0 and 8.5
  - < 0.5 ppm residual Chlorine
  - Sediment / scale / biofilm
  - Other microorganisms such as algae, flavobacteria, and Protozoa which supply essential nutrients and can harbor the organism
Risk Assessment Techniques

• Review of water systems
• Identifying potential risk areas or equipment
• Developing a water sampling plan
• Local State health department may want to approve the plan
• Measure temperature, pH, and residual chlorine levels
• Conduct *Legionella* sampling
• Recommend appropriate mitigation procedures
Risk Assessment Techniques

• Environmental Sampling:
  • Focus is on water and biofilm and not air
  • Personal protective equipment usually not necessary unless significant risk to airborne exposure exists (e.g., contaminated active cooling towers)
  • Targeted sampling vs random sampling
  • Proximal vs distal locations
  • High Risk vs Low Risk locations
  • Hot water (HW) vs cold water (CW) vs mixed
  • First-draw (pre-flush) vs flushed (post-flush) sampling
Remediation and Control Measures

• Thermal and Flush (Thermal Pasteurization)
  • Min 70 °C (158 °F) for 24 hours and flush for 20-30 min
  • Remove dead-legs first to avoid re-seeding
  • Temporary measure only
  • Recolonization can occur within weeks to months after treatment
  • Healthcare concerns regarding scalding
  • Flooding concerns
Remediation and Control Measures

**Mechanical**
- Cooling towers: drift eliminators and location
- Removal of aerators; dead legs
- Regular inspection and maintenance
- Point-of-use (POU) filters
- Water softeners
- Installing/boosting circulating pumps
- **FLUSHING!**
Remediation and Control Measures

• Chemical
  • No one-size-fits-all approach
  • Options include Chlorine, Monochloramine, Chlorine Dioxide, Copper-Silver Ionization, UV, and Ozone
  • Most disinfectants don’t provide for a total kill of bacteria
  • In most buildings, risk associated with premise plumbing may be addressed without additional treatment
  • Remove dead-legs first to avoid re-seeding
  • Permanent control measure once implemented properly
  • Added concern regarding disinfection byproducts
Remediation and Control Measures

• **Water Management Plan (WMP)**
  - Analysis of all building water systems
  - Identify risk areas
  - Monitoring and sampling
  - Control limits and corrective actions
  - Flushing and disinfection programs
  - Documentation and record keeping
  - Validation
Case Studies

- Two ALFs located in Northeast Florida
- *Legionella* Risk Assessment (LRA) were triggered due to suspected legionellosis cases
- Facility owners had no experience with *Legionella* and no WMP
- Both facilities were of recent construction
- Local health department involved
- Both facilities required installation of a Chlorine Dioxide secondary disinfection system
Case Study 1

• History:
  • In early 2014, four cases of LD were reported by local health department, suspected to be linked to the facility
  • Limited sampling by another consultant and the health department indicated the presence of *Legionella pneumophila* serogroup 1 in potable water
  • Facility flushed its water system with 170°F water (thermal pasteurization) as an initial response
  • Previous unconfirmed single case of LD in 2012?
  • Golder retained to conduct a LRA in May 2014.
Case Study 1

• **Important Building Information:**
  • Opened in 2010; 4 floors, with an “H” configuration and three designated wings, and 185 one or two bedroom units
  • Memory care units located in one wing on two floors
  • Late 2012/early 2013 an influx of silt and debris was reported within the potable water system, thought to be associated with adjacent construction activities
  • Two onsite boilers with four 257-gallon capacity hot water heaters set at 140 °F
  • Water softener system was installed in March 2013
  • Potable water supplied by CPVC piping through multiple vertical risers
  • One main water supply line that had free chlorine levels ranging from 0.73 to 0.85 ppm.
Case Study 1

• **Initial Findings:**
  • Several dead-legs identified
  • Free chlorine concentrations in the CW and HW were below 0.5 ppm
  • Faucet aerator screens or shower head screens showed evidence of significant debris accumulation and biofilm in nearly all inspected locations
  • Flushing also revealed sediment and cloudy water in isolated locations
  • An expansion tank in the mechanical room without a purge valve
  • No flushing in vacant units and ice makers in fridges turned off
Case Study 1

• **Initial Findings continued:**
  • Temperature: CW was over 80 °F; HW never exceeded 115 °F at fixtures even after 5 min. flushing (Note: HWR levels in the Mechanical Room were at 140 °F)
  • Distal points from the Mechanical Room were more problematic, leading to suspicion of poor flow/mixing in the HWR system.
  • HWR circuits inspected showed no flow conditions (lines were at ambient T)
  • HWR system appeared to have never been balanced as circuit setters were all at ½-open position
Case Study 1

- **Initial Findings continued:**
  - **Culture Analysis:**
    - No positive results for incoming water and mechanical room locations (0/8)
    - 95% positive for potable water samples (21/22), ranging from <1 CFU/ml to 2,940 CFU/ml
    - Higher *Legionella* concentrations detected in first draw sample, indicative of localized amplification which correlated with visual assessment
    - Flush sample results were also positive for *Legionella* inferring a systemic colonization, higher in the hot water system than the cold
Case Study 1

- **Recommendations:**
  - Immediate hyperchlorination of potable water system, followed by aggressive flushing
  - Removal and replacement of all sink aerators and showerheads (including flex hose)
  - Installing POU filters
  - Removal of all dead legs
  - Balancing of HWR system, including 100 circuit setters
  - Implement a routine flushing program
  - Develop and implement a site-specific WMP
Case Study 1

• Problems ...
  • Facility retained a local water treatment company and ordered POU filters on showers only to minimize occupant exposure while long term remediation options were developed
  • Sink aerators were replaced and a rigorous routine flushing schedule started
  • Immediate hyperchlorination of potable water system, followed by aggressive flushing was not done
  • Facility moved forward with installing a chlorine dioxide secondary water treatment system in July 2014, concurrent with plumbing system modifications – completed by September 2014
  • Water treatment company took over monitoring, including sampling program
  • Facility did not develop or implement a WMP
Case Study 1

• More Problems ...
  • Periodic water sampling performed by water treatment company over the next 12 months revealed a generally declining number of samples positive for *Legionella* coupled with reduced concentrations of *Legionella* in the positive samples.
  • However, in June 2015 sampling results indicated an increase of positive samples and concentrations
  • In July 2015, additional cases of residents hospitalized with pneumonia were reported and subsequent testing confirmed at least one case of LD
Case Study 1

Next Steps:

- Golder was reengaged in July 2015 to perform additional onsite assessments and sampling services.
- Initial assessment revealed systemic colonization (27% positives; 20/75) within the cold and hot water systems.
- 57% positives on pre-flush samples (13/23).
- Hyperchlorination was performed in August 2015.
- Almost 1/3 of the circuits setters were still not functioning properly.
- Decision was made to streamline HWR system by removing the room-by-room hot water recirculation pipe work (completed January 2016).
Case Study 1

Final Monitoring Results:

- Periodic water sampling since the hyperchlorination event in August 2015, coupled with HWR system modifications, resulted in a significant decrease in the number of samples with detectable levels of *Legionella* and reduced concentrations of Legionella when detected
- Overall < 2% (9/508) samples had detectable *Legionella* vs. 27% (20/75) pre hyperchlorination
- Only 1 positive (1/210, < 0.5%) in the last 5 sampling rounds since completion of plumbing modifications
## Case Study 1

- **WMP Control Limits:**

<table>
<thead>
<tr>
<th>Processing Step</th>
<th>Operating Range</th>
<th>Critical Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water Storage Tanks</td>
<td>130 - 140°F</td>
<td>120 - 160°F</td>
</tr>
<tr>
<td>Distal Outlet Hot Water Temp.</td>
<td>110 - 120°F</td>
<td>105 - 125°F</td>
</tr>
<tr>
<td>Cold Water Booster Pumps</td>
<td>On</td>
<td>Off</td>
</tr>
<tr>
<td>Hot Water Recirculation Pumps</td>
<td>On</td>
<td>Off</td>
</tr>
<tr>
<td>ClO₂ at Distal Outlets</td>
<td>0.3 - 0.6 mg/L</td>
<td>0.2 - 0.8 mg/L</td>
</tr>
<tr>
<td>Incoming Cold Water Chlorine</td>
<td>0.5 – 2.0 mg/L</td>
<td>0.2 – 4.0 mg/L</td>
</tr>
</tbody>
</table>
Case Study 2

• **History:**
  • In June 2017, one case of LD was reported by local health department, suspected to be linked to the facility
  • Limited sampling by another consultant retained initially by the Facility indicated the presence of *Legionella pneumophila* in 80% of potable water samples collected (16/20) and measured chlorine levels at below 0.1 ppm
  • Facility also conducted hyperchlorination the day after the initial sampling
  • Significant debris and poor water flow in many areas was observed during the hyperchlorination event
  • Also removed most aerators from sinks and shower heads and installed POU filters in all occupied units and most of the unoccupied units
  • Golder retained to conduct a LRA in July 2017
Case Study 2

• **Important Building Information:**
  • Opened in late 2016 and was in operation less than a year
  • Two floors, with 90 units consisting of one or two bedroom units; 4 wings
  • Memory care units located in one wing on ground floor
  • Concerns regarding two oversized water softeners which reportedly “off-line” but filled with water for as long as six months prior to coming online.
  • 10 gas fired instantaneous tankless HW heaters, 7 set at 115 °F (residential) and 3 set at 140 °F (kitchen)
  • No thermostatic mixing valves at point of use fixtures, resulting in difficulties maintaining uniform HW temperatures in the HWR system
  • One main water supply line that had free chlorine levels ranging from 1.5 – 2 ppm
Case Study 2

• **Important Building Information continued:**
  • Building was not flushed prior to occupancy because there was no water meter installed?
  • Debris influx noted during Facility start-up and reportedly may have contributed to one of the hot water recirculation pumps failing
  • Redundant piping was installed in the first floor of the Facility in the Memory Care wing for future expansion purposes
  • The potable water distribution system was reportedly balanced at the time of turnover to current owner?
Case Study 2

• **Initial Findings:**
  • A total of 24 dead-legs in Memory Care units identified, almost 1,000 linear feet of dead leg piping (120 CFU/mL *Legionella*)
  • Free chlorine concentrations in the CW and HW were well below 0.5 ppm with water softeners on line
  • Some faucet aerator screens and shower head screens showed evidence of debris accumulation and biofilm
  • Two expansion tanks associated with the HW heaters did not have a purge valve
  • No flushing in vacant units
Case Study 2

- **Initial Findings continued:**
  - Temperature: CW was over 80°F; HW never exceeded 109°F at fixtures even after 3 min. flushing (Note: HW heaters were set to 115°F)
  - Four flow balancing/circuit setting devices located at distal points in the four wings within the interstitial space of the first floor ceilings
  - All three of the inspected devices were at identical settings of 6, inferring the system may not have been balanced
  - A commercial ice machine in the kitchen which had a charcoal filter installed tested positive for *Legionella* <1 CFU/ml)
  - Decorative fountain (not in use) located in courtyard of the Facility
Case Study 2

• **Initial Findings continued:**
  • Culture Analysis:
    • Only 5% (3/60) samples collected during Golder’s initial LRA were positive:
      • One of the water softeners (< 1 CFU/mL)
      • One of two commercial ice machines (< 1 CFU/mL)
      • Dead leg piping in Memory Care (120 CFU/mL)
      • No positives (0/20) of post-hyperchlorination sampling
Case Study 2

• **Recommendations:**
  • Increase set point temperature of residential HW heaters to 140°F
  • Isolate or remove all dead leg piping sections located in the Memory Care units
  • Consult with water softener manufacturer regarding chlorine reduction concern and only bring back on line after properly disinfecting/flushing
  • Removal and replacement of all remaining sink aerators and showerheads (including flex hose) and Installing POU filters
  • Clean and sanitize all ice makers according to the manufacturer’s recommended guidelines; replace filters with non-carbon containing cartridges
  • Install purge valves on the two expansion tanks
  • Verify balancing of HWR system
  • Develop and implement a site-specific WMP
  • Implement a routine flushing program, especially for vacant units
Case Study 2

• Follow-up Actions:
  • Plumbing modifications were completed by September 2017
  • This included installing thermostatic mixing valves under all sinks
  • Initial hyperchlorination worked but concerns about possible rebound was raised by local health department based on Golder’s initial LRA sampling results
  • A WMP was developed following the initial LRA
Case Study 2

• Follow-up Sampling Results:
  • Since the July 207 sampling, Golder has conducted a total of 8 additional sampling rounds, with the last one in April 2018
  • Results indicted a persistent presence of positive sample results, ranging from 2 – 50% positives per round or overall 13% positives (34/277)
  • Most positives are pre-flush samples, ranging from < 1 – 750 CFU/mL
  • Two main concerns were:
    • Water softener removing chlorine
    • Biofilm associated with flow controlling devices, including distal circuit setters, shut-off valves below each sink, and shower flow controllers
Case Study 2

**Next Steps:**

- Continued use of POU filters
- In May 2018, Facility solicited competitive bids for secondary disinfection system
- RFP did not specify Chlorine Dioxide system but all except one bid recommended it
- Bids ranged significantly in costs from $70,000 to > $200,000 over 5 years; mostly lease options
- System was installed in October 2018, with a baseline hyperchlorination completed just before turning system on
- Water softeners were also replaced with correctly sized units
**Case Study 2**

- **On-going Monitoring Results:**
  - Baseline post hyperchlorination sampling conducted in November 2018 was 100% negative for treated systems (0/44)
  - One positive was the decorative fountain in the courtyard which Facility forgot to shock (3 CFU/mL; 0.29 ppm Free Chlorine)
  - Conducted 1st round of sampling following 4 weeks of “normal operating” conditions of the Chlorine Dioxide System in January 2019 (results pending)
  - Recommended at least 2 “clean” rounds of sampling before discontinuing POU filters.
Conclusions

- ALFs pose some unique challenges, including highly susceptible population
- Recent standards and guidance documents may have put more emphasis on proactive risk management
- Information regarding and expertise in plumbing systems is key
- Incoming water with Free Chlorine of > 0.5 ppm may not be sufficient to control Legionella amplification
- Water softeners can remove significant chlorine!
- Construction activities nearby and/or improper commissioning of new facilities can pose a risk regarding sediment infiltration and bacteria amplification in water systems
Conclusions

- Challenge of budget constraints limiting proper assessments, especially related to sufficient sampling
- State health departments have inconsistent approaches and expectations regarding LRA and controls
- Clients expect immediate answers and controls
- Independent validation of any control plan should be conducted
- Periodic review and updates of WMP
- Potential health effects of disinfection byproduct beyond chlorite?
- Time from the initial reported case to “Normal Operating Conditions” can take a very long time (years!)
References


• 2015 AIHA Guideline: *Recognition, Evaluation, and Control of Legionella in Building Water Systems*


Questions?

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