Chlorine Dioxide Feed System for Pre-Oxidation at an 8 MGD WTP

Results from 1 Year of Full Scale Demonstration Testing

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Aqua Pennsylvania, Inc.
Bristol Water Treatment Plant

Background

- Owned and operated by Aqua, PA
- Located in Bucks County, PA
- Serves approx. 125,000 customers from Bristol Borough, Bristol Twp., and Bensalem Twp.
- Max. Capacity – 8.0 MGD
- Avg. Operating Flowrate – 5.0 MGD
Bristol Water Treatment Plant

Background
Bristol Water Treatment Plant

Background
Distribution System

Background

- Total chlorine residual of less than 0.2 mg/L
- Chloramination practice results in occurrence of nitrification in distribution system.
- A significant amount of disinfection byproduct (DBPs) formation at the entry point rather than in the distribution system
Evaluate the effectiveness of Chlorine Dioxide as a pre-oxidant to improve water quality in the distribution system.
Potential Benefits
Demonstration Study Hypotheses

- Oxidation of pre-cursors before the filters may allow the chlorine dosage applied to the filter influent to be reduced.
- Reduction of the chlorine dose at the filter influent may result in reductions in DBP formation in the distribution system.
- Chlorine dioxide breaks down to form the chlorite ion. Studies have shown that the presence of the chlorite ion in finished water results in better control of organisms in the distribution system, especially those which cause nitrification.
- Chlorine dioxide also may improve coagulation via microflocculation.
# Testing Objectives and Performance Goals

## Secondary Disinfection

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>GOAL</th>
<th>BENEFIT POTENTIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Chlorine Residual</td>
<td>&gt;0.2mg/L</td>
<td>Improve Water Quality in Distribution System</td>
</tr>
</tbody>
</table>
| ATP*  
HPC**             | 5 pg/mL  
n/a                | Reduce Nitrification                                       |
| Chlorite           | MCL= 1 mg/L  
>0.1 mg/L         | Reduce Nitrification                                       |
| Chlorate           | <840 ug/L                   | Improve Water Quality in Distribution System               |

*A: Adenosine Triphosphate (ATP)  
**: Heterotrophic Plate Count (HPC)

## Testing Objectives and Performance Goals

Disinfection By-Product (DBPs)

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<th>PARAMETER</th>
<th>GOAL</th>
<th>BENEFIT POTENTIAL</th>
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<tbody>
<tr>
<td>TTHMs*</td>
<td>Reduction at entry point</td>
<td>DBP reduction</td>
</tr>
<tr>
<td>HAAs**</td>
<td>Reduction at entry point</td>
<td>DBP reduction</td>
</tr>
<tr>
<td>TOC, DOC, UV254, Specific UV Absorbance***</td>
<td>n/a</td>
<td>Removal of DBP precursors during microflocculation</td>
</tr>
</tbody>
</table>

*Total Trihalomethanes (TTHMs)
**Haloacetic Acids (HAAs)
***Total Organic Carbon (TOC)
Dissolved Organic Carbon (DOC)
Description of the Demonstration Unit
Chlorine Dioxide System

- Chlorine gas (Cl\(_{(g)}\)): supplied using existing system
- Sodium Chlorite (NaClO\(_2\)) (25% strength): delivered and stored on site in 330 gallon totes (2)
- Unit operates manually based on desired chlorine dioxide feed rate (ppd)
  - Rotameters for each chemical are adjusted by operators
Description of the Demonstration Unit
Chlorine Dioxide Generator System

Power Requirements:
230VAC / 3Phase / 30Amp
(All Boxes to be mounted thru back of box and polyboard)

1 1/2" Motive Water Inlet
3/8" Frame Mounting Holes
(TYP @ 4 Locations)
1" Raw Water Flush Inlet
or Low Point Drain

3/8" Sample Port
1 1/2" Outlet to Application
## Description of the Demonstration Unit

### Capabilities

<table>
<thead>
<tr>
<th>CHLORINE DIOXIDE SYSTEM</th>
<th>BWTP</th>
<th>MAXIMUM UTILIZATION</th>
<th>AVERAGE UTILIZATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRODUCTION (ppd)</strong></td>
<td>15-150</td>
<td>134</td>
<td>67</td>
</tr>
<tr>
<td><strong>DOSE (mg/L)</strong></td>
<td>2.0</td>
<td>2.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Testing Protocol
Application Points and Sampling Locations

Application Points:
1. Application Point 1
2. Application Point 2
3. Application Point 3
4. Application Point 4 (Not Used)

Sampling Locations:
- Basin Inlet Sample

Diagram showing the flow of water through various treatment stages and sampling points.
Testing Protocol
Sampling Locations
Testing Protocol

Schedule

Application Point 1
Raw Water

Application Point 2
Pre-Rapid Mix

Application Point 3
Pre-Sedimentation
Testing Protocol
Daily Data Measured at Plant

Daily samples taken at the BWTP include:

- Plant flow
- Chlorine (ppd) and sodium chlorite (gpd) supplied to the chlorine dioxide generator
- Chlorine dioxide dose (mg/L)
- Chlorine dioxide and chlorite residuals at the basin inlet, plant effluent, and entry point

Other samples taken at the BWTP include:

- Generator efficiency (samples beginning in November 2015, taken at least once a month)
- % removal of TOC, DOC, UV254 based on values for the raw water and combined filter effluent (samples taken at least once a week)
Testing Protocol
Corrosion Monitoring

- Process Research Solutions (PRS) Monitoring Station
Testing Protocol
Distribution System Samples

- 5 Sampling Locations based on Water Age
  - 3 High
  - 1 Average
  - 1 Low
Testing Protocol
Weekly Data Measured in Distribution System

- Free and Total Chlorine (mg/L)
- pH
- Nitrite
- ATP
- HPC
- TTHM
- HAA5
- Temperature (°C)
- Chlorite (mg/L)
- Chlorate (mg/L)
Analysis of Data

Analysis

- Graphical and statistical analysis to understand trends over time and assess the precision of data
- Optimum chlorine dioxide dose: 0.6 mg/L
Analysis of Data and Results
Chlorine Residuals at Entry Point

• Challenges exist in maintaining the residual in the entry point feeding the distribution system during summer months

• Results: Chlorine residuals stabilize to a higher overall higher concentration at entry point. Most locations in the distribution system are above 0.2 mg/L.
Analysis of Data and Results
Chlorite Residuals in WTP

- Chlorite most prominent at basin inlet, but degrade at entry point
- Stabilization of chlorite levels since start of study, to overall lower level.
- Result: Average level is 0.31 mg/L – beneficial level to minimize nitrification
Analysis of Data and Results
Chlorate Residuals in WTP

- Although there are no regulations, Chlorate is a potential contaminant of concern.

- Result: Average at entry point: 100-300 ug/L
Analysis of Data and Results
TOC, DOC, UV254 Removal

• Percent (%) removal overall higher than historically.

• Result: Addition of chlorine dioxide has a positive impact on coagulation and microflocculation
Analysis of Data and Results

Generator Efficiency

• 94-100%

• Preliminary findings indicate erratic chlorine to sodium chlorite ratio.

• Stabilized once optimum dose was reached.

• Result: As study progresses, performance of the system became more efficient.
Analysis of Data and Results
DBP Reduction: Distribution System

• Reduction in TTHMs and HAAs
• Result: Reduction of DBPs
Analysis of Data and Results

Nitrification: Distribution System

- HPC and ATP generally decrease from start of study
- Result: Reduction in nitrification
Conclusions

- Effective dose: 0.6 mg/L
- Reduce nitrification
- Reduce DBPs
- Higher overall chlorine residual
- 3 application points – provide operational flexibility
Future Improvements

- In process – create more automated permanent system at BWTP (May 2017)
- Move Demonstration Study and Chlorine Dioxide Generator System to Ridley WTP
  - Raw Water Source: Ridley & Chester Creeks
Acknowledgements

Mott MacDonald
John Civardi
Jason Marie

Aqua Pennsylvania, Inc.
Jeff Bickel
Dave Hughes
Matt Miller
Eric Damon

Chemours/LANXESS
Rick Sutherland
Mike Morris
Ferndando Galarza
Thank you

Aqua Pennsylvania, Inc.