Wyoming Clean Water Plant –
Diffuser Health: How much Can It Affect Your Efficiency?

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REDMON ENGINEERING
Dave Redmon, P.E.
Background
Wyoming Clean Water Plant

- Average flow 13 MGD
- Design flow 24 MGD
- EBPR activated sludge facility
- Major upgrade in 2006
Wyoming Clean Water Plant

- Aeration system
  - 3 basins operating
  - 3 MG each
  - 5,100 ceramic diffusers in each tank
  - 5 – 500 HP blowers
  - DO setpoint control

- Electrical Usage
  - $660,000 annual aeration cost (50% of facility electrical usage)
Aeration Evaluation
Aeration Evaluation

- Focus on identifying energy-saving improvements

- Assess current flows and loadings

- Compare process aeration requirements with actual air supplied

- Evaluate existing blowers

- Evaluate aeration blower and control systems to identify upgrade alternatives
Aeration Evaluation

● Motivating Issues
  ▪ Current loadings nearing rated capacity
  ▪ Consistently running 3 of 5 blowers
Oxygen Transfer Testing
Oxygen Transfer Testing

- Redmon Engineering
  - Dave Redmon – oxygen transfer specialist
  - Co-developer of offgas analysis equipment and methodology
  - Performs clean water and process water oxygen transfer testing (field and laboratory)
  - Provides laboratory diffuser analysis
Oxygen Transfer Testing

- Field Testing
  - Offgas analysis of ceramic disc diffusers
  - Field measurement of
    - Oxygen transfer efficiency
    - $\alpha F$ factor
Alpha & Fouling Factor

- **Wastewater Alpha (α):**
  - The ratio of oxygen transfer efficiency in wastewater to that in drinking water
- **Fouling Factor (F):**
  - Describes how much any fouling of the diffusers reduces the actual oxygen transfer efficiency
Offgas Analysis

- In the case of diffused aeration it involves capturing the gas bubbles as they break the liquid surface.
- The offgas is captured with a floating hood and is drawn to an analyzer where it is analyzed for the content of oxygen.
Offgas Analysis
Offgas Analysis

- Comparison of Gas-Phase oxygen content of supply air & offgas
- Measures oxygen transfer efficiency directly
- OTE = Mass $O_2$ in – Mass $O_2$ out /Mass $O_2$ in
Offgas Analysis

- Multiple locations are tested to get a representative sampling of the basin.
- Each location measures OTE, gas flow, & dissolved oxygen.
- The field values of OTE are corrected to standard conditions (SOTEpw).
- In addition alpha and oxygen uptake rate are computed for each location.
<table>
<thead>
<tr>
<th>BASIN</th>
<th>CELL</th>
<th>Ave. DO (mg/l)</th>
<th>Airflow/Diffuser (scfm)</th>
<th>OTEf (%)</th>
<th>SOTEpw (%)</th>
<th>Alpha(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
<td>0.56</td>
<td>1.30</td>
<td>7.23</td>
<td>7.94</td>
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<td>Overall</td>
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<td>1.39</td>
<td>8.88</td>
<td>11.02</td>
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</table>
Field Off-Gas Testing

Initial Field Measurement of alphaF

<table>
<thead>
<tr>
<th>Sample Location Along Tank</th>
<th>Tank 5</th>
<th>Tank 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front of Tank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baffle Wall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back of Tank</td>
<td></td>
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</tbody>
</table>

Typical Front alphaF = 0.26

Front alphaF = 0.26

Typical Back alphaF

Back alphaF = 0.37

Overall alphaF = 0.32
## Diffuser Data

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>DWP 0.5 (in wc)</th>
<th>DWP 1.0 (in wc)</th>
<th>DWP 2.0 (in wc)</th>
<th>DWP 3.0 (in wc)</th>
<th>SOTEcw (%)</th>
<th>Fouling Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>New</td>
<td>5.30</td>
<td>5.60</td>
<td>6.40</td>
<td>7.30</td>
<td>19.35</td>
<td>1.00</td>
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<tr>
<td>Cell 1 Fouled</td>
<td>9.60</td>
<td>11.60</td>
<td>20.15</td>
<td>32.50</td>
<td>13.95</td>
<td>0.72</td>
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<tr>
<td>Cell 2 Fouled</td>
<td>9.30</td>
<td>10.50</td>
<td>15.50</td>
<td>22.10</td>
<td>16.45</td>
<td>0.85</td>
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</tbody>
</table>
Fouled Cell 1 Diffuser
Fouled Cell 2 Diffuser
Lab Testing – Diffuser Headloss

Increased Headloss Indicates Fouling
Lab Testing – Diffuser Cleaning

- High pressure spraying of diffuser surface at 2,500 psi cleans the top few grain depths of the diffuser.
- Liquid muriatic acid (14%) can be applied directly onto the diffusers in a drained basin.

Lab cleaning showed that diffusers fouling could not be fully reversed.
Identified Project

- On the basins of the laboratory testing it was recommended to replace all ceramic diffusers with membrane diffusers
  - New diffusers will restore fouling factor F

<table>
<thead>
<tr>
<th>Initial Estimated Project Values</th>
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</thead>
<tbody>
<tr>
<td><strong>Project Cost</strong></td>
</tr>
<tr>
<td>Diffuser Replacement</td>
</tr>
</tbody>
</table>
Overview of Diffusers

• **Ceramic Diffusers**
  - Long Life
  - Requires Regular Maintenance
  - Fouling Increase by Power Outages

• **Membrane Diffusers**
  - Shorter Life
  - Easier Physical Cleaning
  - More Resistant to Fouling
Insitu Diffuser Cleaning
BEFORE

AFTER
Results
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<tr>
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<tr>
<td>4</td>
<td>1</td>
<td>0.53</td>
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<td>9.08</td>
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<tr>
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<tr>
<td>5</td>
<td>2</td>
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<td>13.09</td>
<td>18.97</td>
<td>0.58</td>
</tr>
<tr>
<td>5</td>
<td>Overall</td>
<td>2.06</td>
<td>1.55</td>
<td>13.06</td>
<td>16.70</td>
<td>0.51</td>
</tr>
</tbody>
</table>
Follow-up Testing

Field Measurement of alphaF

- Front of Tank
- Baffle Wall
- Back of Tank

New Membranes

Ceramics

Tank 5 Oct 2016
Tank 4 Oct 2016
Results

- Power monitors installed since August for verification
- Diffusers in two remaining aeration basins were installed in late October

<table>
<thead>
<tr>
<th>Revised Project Values</th>
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<tbody>
<tr>
<td><strong>Diffuser Replacement</strong></td>
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<tr>
<td></td>
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Testing Benefits

- Offgas analysis in combination with laboratory diffuser testing is a powerful tool in optimizing fine bubble aeration system performance.

- Diffuser testing can identify the impact of service life on performance and aid in developing an optimum cleaning frequency and cleaning methodology.
Economic Benefits