Process Aeration
Improving Treatment Plant Efficiency

Joe Hebert, Ottawa County Public Utilities
Bubble Size Relationship

Course = ≥10 mm
Medium = 4-9 mm
Fine = 1-3 mm
Ultra-Fine = 1 mm
Micro = <0.5 mm
Bubble Size Relationship

1 cu ft = 1 bubble  
10mm = 5.4 \times 10^4  
1mm = 5.4 \times 10^7
Theory and Performance
Bubble Size Effects

- The smaller the bubbles, the larger the A / V ratio and thus the greater the oxygen transfer
- Smaller bubbles also provide for a slower bubble rise rate

\[
\frac{A}{V} = \frac{4\pi r^2}{\frac{4}{3} \pi r^3} = \frac{3}{r}
\]

Note: A / V – interfacial transfer area per unit volume of input gas
Terminology and Formulas

**Oxygen Transfer Rate of Diffuser = Oxygenation Rate**

**OTR** Approximately = scfm air \((1.036)\) SOTE = lb O²/hr

Example Airflow = 200 scfm & diffuser efficiency 22%
OTR = 200 scfm air \((1.036)\) 0.22 = 45.58 lb O²/hr

**Oxygen Transfer Efficiency**

Efficiency/Meter as % = Em

\(\text{Em} = \% \text{ SOTE/meter submergence}\)

\(\text{gram/m}^3 \text{ air per m submergence} = 1.036 \times (\text{Em}) \times 1000 / 2.206 (1.7)\)

\(\text{Em as} \% = \text{gram/m}^3 \text{ air per meter} \times (2.2046) 1.7 / 1.036 (1000)\)

\(\text{Em} = \text{SOTE/Ft submergence} (3.2808)\)
## Typical Oxygen Transfer Values

*(in clean water)*

<table>
<thead>
<tr>
<th>System</th>
<th>Oxygen Transfer Efficiency&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Oxygen Transfer Rate&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro Bubble Generators</td>
<td></td>
<td>10.9-27</td>
</tr>
<tr>
<td>Fine Bubble Diffusers (total floor coverage)</td>
<td>22-32</td>
<td>6.0-6.5</td>
</tr>
<tr>
<td>Fine Bubble Diffusers (side wall installation)</td>
<td>18-20</td>
<td>3.5-4.5</td>
</tr>
<tr>
<td>Jet Aerators (fine bubble)</td>
<td>18-25</td>
<td>3.0-3.5</td>
</tr>
<tr>
<td>Static Aerators (medium bubble)</td>
<td>10-12</td>
<td>2.3-2.8</td>
</tr>
<tr>
<td>Mechanical Surface Aerators</td>
<td></td>
<td>2.5-3.5</td>
</tr>
<tr>
<td>Coarse Bubble Diffusers (wide band pattern)</td>
<td>8-12</td>
<td>2.0-3.0</td>
</tr>
<tr>
<td>Coarse Bubble Diffusers (narrow band pattern)</td>
<td>6-8</td>
<td>1.5-2.0</td>
</tr>
</tbody>
</table>

<sup>a</sup> at 15 feet submergence

<sup>b</sup> 1 lb/hp-hr = 0.61 kg/kW-hr
Aeration Options

Surface Aerators
Aeration Options

Brush/Disk Aerators
Aeration Options

Aspirating Mixers
Aeration Options

Jet Aeration
Aeration Options

Course Bubble Diffusers
Aeration Options

Fine Bubble Diffusers
Aeration Options

Ultra-Fine Diffusers
Aeration Options

Micro Bubble Generator
Menominee, Michigan

4 MGD Activated Sludge Plant

2009 - EDI Mini Panel Fine Bubble Diffuser Retrofit
Existing Design

- Ceramic Disk Diffusers
- 100 hp blower operating at 91 amps, 460v, (97 hp electrical draw)
- 7.8 psi discharge
- D.O. @ 5 – 7 mg/l (measured intermittently)
2009 Retrofit/Upgrade

Installed EDI Mini Panel Fine Bubble Diffusers
2009 Retrofit/Upgrade

Installed EDI Mini Panel Fine Bubble Diffusers

**New Operating Conditions**

- 60 hp blower, VFD @ 40 Hz, (electrical draw @ 43 hp)
- 7.2 psi discharge pressure
- D.O. @ 5.7 mg/l (measured with an on-line probe)
- 55% Energy Cost Savings
2009 Retrofit/Upgrade

Installed EDI Mini Panel Fine Bubble Diffusers

**Optimized Operating Conditions**

- 60 hp blower, VFD @ 30 Hz, (electrical draw @ 31 hp)
- 7.0 psi discharge pressure
- D.O. @ 2.3 mg/l (measured with an on-line probe)
- 68% Energy Cost Savings (D.O./VFD control)
2009 Retrofit/Upgrade

The Bottom Line

Installation Cost: $150,000
Annual Energy Savings @ 0.075/KWH $26,000 – $32,000
Payback period: 4½ - 6 years
Ypsilanti Community Utilities Authority

Wastewater Treatment Plant

Solids Blending Tank Improvement - 2010

- 45.9 MGD capacity
- Serving 227,000 people in 10 communities
- Tertiary Treatment Plant with Biological Phosphorus Removal
- Sludge thickening with belt presses before incineration
The Problem

- Phosphorus being released in anoxic sludge blending tank
- 750 mg/l Phosphorus in filtrate pumped back to head of plant
- Additional $250,000 annually of Al$_2$(SO$_4$)$_3$ to control Phosphorus release
- 50 mg/l H$_2$S in Belt Press Room
- Additional $300,000 annually of VX-456 to control H$_2$S
The Solution

- Removed two 20 hp mixers from Sludge Blending Tank
- Installed two 40 hp MTS Aspirating Mixers in Blending Tank
Ypsilanti Community Utilities Authority
Wastewater Treatment Plant

The Result

• Filtrate phosphorus was reduced from 750 mg/l to 200 mg/l
• $\text{Al}_2(\text{SO}_4)_3$ to control phosphorus was reduced by 1,700 gpd
• Savings of $213,000 annually
• $\text{H}_2\text{S}$ in Belt Press Room was reduced to near zero (without VX-456)
• Savings of $300,000 annually
Termo-eléctrica Tula Power Plant
Hidalgo, Mexico
(Francisco Perez Rios Power Plant)

1,546 MWe Oil Fired Electrical Generation

Wastewater Treatment Plant Aeration Upgrade – 2010
Tula Power Plant Wastewater Treatment - Hidalgo, Mexico

Existing Design

• 16 MGD
• Activated Sludge Biological Treatment
• 12 Low Speed Mechanical Surface Aerators @ 75 hp each (900 hp)
• Current aeration system limited treatment to 5.7 MGD
• Provides reuse water to Power Plant’s Cooling Towers
Tula Power Plant Wastewater Treatment - Hidalgo, Mexico

2010 Aeration Upgrade

Selected for installation:

Parkson HiOx Ultra-Flex aeration panels
Theory and Performance
HiOx® UltraFlex versus Disc Diffuser

- Low flux rates = high efficiency
- High floor coverage allows low flux rates

**SOTE vs. Flux Rate HiOx & 9” Discs**
Typical System Designs @ SWD = 15'

**Note:**
(1) Typical HiOx Performance (~ 45 - 55% Floor Coverage)
(2) Typical 9” Disc Performance (~ 15 - 20% Floor Coverage)
HiOx® Product Features
Active Membrane Area

HiOx® incorporates an efficient footprint design

• Higher floor coverage potential
  - (1) HiOx® panel = approx (100) 9” discs in terms of membrane area
  - Only 52 discs will fit by arranging discs side by side in 4’x12’ area

• Results in fewer diffusers and less piping to install
Theory and Performance
Ultrafine versus Fine Bubbles

- Ultrafine bubbles have three times more air bubble surface area than competing fine bubble diffusers
- Ultrafine bubbles have 800% lower buoyancy which results in significantly longer contact time

<table>
<thead>
<tr>
<th>Bubble Size (φ)</th>
<th># of Bubbles</th>
<th>Total Bubble Surface Area</th>
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<tbody>
<tr>
<td>15 mm</td>
<td>$5.66 \times 10^5$</td>
<td>400 m$^2$</td>
</tr>
<tr>
<td>10 mm</td>
<td>$1.91 \times 10^6$</td>
<td>600 m$^2$</td>
</tr>
<tr>
<td>3 mm</td>
<td>$7.07 \times 10^7$</td>
<td>2,000 m$^2$</td>
</tr>
<tr>
<td>1 mm</td>
<td>$1.91 \times 10^9$</td>
<td>6,000 m$^2$</td>
</tr>
</tbody>
</table>

Benefits

- High A/V ratio
  - Increased bubble surface area for given SCFM
  - Means, improved mass transfer & higher SOTE
  - Means, less air requirement (smaller V)
  - Less head loss & less power consumption Generally about 20-30% energy efficient than typical disc or tube diffusers
Tula Power Plant Wastewater Treatment - Hidalgo, Mexico

2010 Aeration Upgrade

The Solution

• Removed 12 - 75 hp mechanical surface aerators (900 hp)
• Installed Parkson HiOx panels (Ultra-Fine Bubble aeration)
• Installed two 350 hp centrifugal blowers (700 hp)
The Result

• Increased capacity to over 13.7 MGD (140% increase)
• Reduced horsepower by 22% during peak flow
• Reduced horsepower by 61% during off peak flow
• Annual energy savings of $180,000 - $480,000
Thank you!

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