ENERGY SAVINGS THROUGH IMPROVED AERATION EFFICIENCY

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TYPICAL WWTP ENERGY USE

- HVAC - 11%
- PUMPING AND OTHER – 34%
- AERATION – 55%

- Aeration is the largest energy use for most WWTP’s
Prior to the 1970’s energy was cheap (approx. 2.0¢ kwh), as a result, many aeration systems were inefficient.

Consequently Mechanical and Coarse Bubble Aeration Systems which have relatively low maintenance requirements were very prevalent.

In 1974 the Arab oil embargo hit, resulting in:

• rising energy costs
• movement towards more energy efficient aeration systems.
1978 LA COUNTY CLEAN WATER TESTING

Testing of various generic diffused aeration systems. The goal was to identify those systems that would be energy efficient for the next 20 years.

Systems Tested:

- Norton Ceramic Domes - Grid
- FMC/ Pearlcomb Tubes – Spiral Roll
- Penberthy Jets – Cluster and Directional Mix
- Kenics Static Tubes – Grid Placement
- Sanitaire Coarse Bubble – Grid and Spiral Roll
- FMC Coarse Bubble – Spiral Roll
- Envirex Coarse Bubble – Spiral Roll
- Bauer Coarse Bubble – Spiral Roll
LA COUNTY CLEAN WATER TESTING.

- At Whittier Narrows, CA in 20x20 ft test tank, at 10, 15, 20 and 25 ft depths
- Three power levels between 0.3 and 1.5 HP/1000-cuft.
- Results presented in Houston at the 1980 WWEMA meeting.
Whittier Narrows Clean Water

WHITTIER NARROWS CLEAN WATER TEST RESULTS AT THE 15 FT DEPTH
STANDARD OXYGEN TRANSFER EFFICIENCY VS DELIVERED POWER DENSITY

DELIVERED POWER DENSITY (HP/1000 FT³)

STANDARD OXYGEN TRANSFER EFF (%)
WHITTIER NARROWS CLEAN WATER TEST RESULTS AT THE 15 FT DEPTH
STANDARD AERATION EFFICIENCY VS DELIVERED POWER DENSITY

DELIVERED POWER DENSITY (HP/1000 FT3)

STANDARD WIRE AERATION EFFICIENCY (LBS O2/WIRE HP-HR)

NORTON
KENICS
PENTECH
FMC TUBE
SANITAIRE
BAUER
ENVIREX
FMC CB
RECENT HISTORY

LA COUNTY PROCESS WATER TESTING

- Fine Bubble Grid
- Fine Bubble Tubes
- Jet Aeration

The winner was the FINE BUBBLE GRID.

Ceramic Disc Diffusers became the equipment of choice for Los Angeles County.
WHITTIER NARROWS – FINE BUBBLE
Norton & Sanitaire introduced ceramic grid aeration systems in U.S. in late 1970’s & early 1980’s

- Main problems were related to diffuser fouling

Parkson Corporation introduced flexible tube diffusers in early 1980’s.

- Early problems with plasticized PVC
- Later switched to polyurethane
- Changed the marketplace
RECENT HISTORY

Mid 1980’s thru 1990’s numerous vendors introduced membrane diffusers.

- Parkson, Sanitaire, EDI, Envirex, EIMCO, Wilfley Weber
- Membrane formulations evolved
- By late 1990’s membranes were taking over the fine bubble market
- The switch to membranes was driven by fouling issues related to porous media diffusers.
RECENT TRENDS IN AERATION

- Away from mechanical & coarse bubble systems
- Toward fine bubble full-floor coverage systems
- General movement away from porous (ceramic) media fine bubble systems
- Movement toward fine bubble membrane diffuser systems
- Movement toward higher density fine bubble layouts for increased energy efficiency
BENEFITS OF HIGH DENSITY LAYOUTS

- High density layouts operate at lower diffuser fluxes
  - As the diffuser flux (airflow / unit area) is decreased, bubble size decreases.

- High density layouts reduce density gradients
  - As diffuser density is increased, vertical liquid velocities are decreased.
EFFECT OF BUBBLE SIZE

- The smaller the bubbles the larger the A / V ratio.

- The smaller the bubbles the slower the bubble rise rate.

Smaller bubbles have greater surface area and longer residence time in the liquid, both of which increase the clean water oxygen transfer.
A/V RATIO VS BUBBLE SIZE

AREA/VOLUME RATIO VS BUBBLE SIZE

A/V RATIO   VS   BUBBLE SIZE

BUBBLE DIAMETER (MM)
FINE BUBBLE GRID – SOTE VS DIFFUSER FLUX AND DENSITY

FINE BUBBLE GRID - 15.0 FT SWD
SOTE VS DIFFUSER FLUX

DIFFUSER FLUX (SCFM/FT²)

SOTE (DECIMAL)

24.6 DIFFUSER DENSITY
16.7% DIFFUSER DENSITY
12.55% DIFFUSER DENSITY
9.85% DIFFUSER DENSITY
6.55% DIFFUSER DENSITY
4.90% DIFFUSER DENSITY
4.10% DIFFUSER DENSITY
THE IMPACT OF DIFFUSER DENSITY ON WATER CIRCULATION AND BUBBLE RISE VELOCITY

LOW DENSITY – HIGH CIRCULATION VELOCITY & SHORT BUBBLE RETENTION TIME

HIGH DENSITY – LOW CIRCULATION VELOCITY & LONG BUBBLE RETENTION TIME
STATE OF THE ART – HIGH DENSITY FINE BUBBLE SYSTEMS

Initially available from two suppliers in U.S.
- Parkson Corporation
- Aero Strip Corporation

Other suppliers now in the market place
- OTT Group
- ITT / Sanitaire
- EDI
- SSI
POLYURETHANE STRIP DIFFUSERS

Characteristics:

- Polyurethane Membrane Media
- Micro-perforations
- Diffuser Densities up to 70 – 80%
- Similar performance
POLYURETHANE MEMBRANE

- High strength polyurethane
- Precision cut perforations
- UV inhibitor
SANITAIRE STRIP DIFFUSERS - GOLD SERIES
AERO STRIP DIFFUSERS – RICHLAND, WA
AERO STRIP DIFFUSERS AT RICHLAND, WA – OFFGAS TESTING
Parkson HiOx
Ultra-Fine Bubble Diffusers
OTT TUBES IN HIGH DENSITY CONFIGURATION
OTT TUBES IN A HIGH DENSITY CONFIGURATION
<table>
<thead>
<tr>
<th>AERATOR TYPE</th>
<th>SAE CLEAN WATER</th>
<th>ALPHA - HIGH SRT SYSTEMS</th>
<th>SAE PROCESS WATER</th>
<th>AVE. SAE lbs O2/hp-hr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lbs O2/hp-hr</td>
<td>DO CONC mg/l</td>
<td>lbs O2/hp-hr</td>
<td></td>
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<tr>
<td>High Speed Surface</td>
<td>1.5 - 2.3</td>
<td>0.85</td>
<td>2</td>
<td>1.0 - 1.5</td>
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<tr>
<td>Low Speed Surface</td>
<td>2.5 - 3.5</td>
<td>0.85</td>
<td>2</td>
<td>1.65 - 2.3</td>
</tr>
<tr>
<td>Disc Aerator Surface</td>
<td>1.8 - 2.8</td>
<td>0.85</td>
<td>2</td>
<td>1.2 - 1.85</td>
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<tr>
<td>Turbine</td>
<td>2.0 - 3.0</td>
<td>0.75</td>
<td>2</td>
<td>1.2 - 1.8</td>
</tr>
<tr>
<td>Coarse Bubble Roll</td>
<td>2.2 - 3.2</td>
<td>0.65</td>
<td>2</td>
<td>1.15 - 1.65</td>
</tr>
<tr>
<td>Coarse Bubble Grid</td>
<td>2.7 - 3.7</td>
<td>0.65</td>
<td>2</td>
<td>1.4 - 1.9</td>
</tr>
<tr>
<td>Aspirator No Blower</td>
<td>0.8 - 1.2</td>
<td>0.6</td>
<td>2</td>
<td>0.4 - 0.6</td>
</tr>
<tr>
<td>Aspirator With Blower</td>
<td>1.2 - 1.9</td>
<td>0.6</td>
<td>2</td>
<td>0.55 - 0.9</td>
</tr>
<tr>
<td>Fine Bubble Grid Standard</td>
<td>5.7 - 8.0</td>
<td>0.6</td>
<td>2</td>
<td>2.75 - 3.9</td>
</tr>
<tr>
<td>Fine Bubble Grid Hi Density</td>
<td>7.0 - 12.0</td>
<td>0.6</td>
<td>2</td>
<td>3.4 - 5.8</td>
</tr>
</tbody>
</table>
FUTURE TRENDS – LARGE PLANTS

- As energy costs rise, these plants will move toward high density systems.
- Plants will move toward more sophisticated DO control systems.
- Plants will move toward the newer more energy efficient blowers.
STANDARD DENSITY VERSUS HIGH DENSITY

- COMPARING AN 8% DENSITY SYSTEM VERSUS A 35% DENSITY SYSTEM
- BOD 200; N 35; LOADING 30 #/d/kcf; SRT 15 days

- At 8 cents/kwh payback is 5.6 years
- At 10 cents/kwh payback is 4.5 years
- At 12 cents/kwh payback is 3.8 years.
FUTURE TREND – SMALL PLANTS

Convert from surface aeration (disc aerators, slow speed surface units, and aspirators) to fine bubble grids and mixers.

- This trend has already started. Several oxidation ditch systems have converted to fine bubble diffusers with mixers to propel the fluid around the loop.

- Energy reductions are in the order of 30 to 50%.