Technology for the Treatment/Reuse of Refinery Wastewater

Joseph Sebastian
Biological Treatment
Typical Applications and Operating Conditions

- Designed primarily for removal of biodegradable organic matter, nitrogen and phosphorus compounds
- Normally applied after primary treatment where inert solids and oils are removed from the wastewater
- Used to achieve effluent BOD and TSS concentrations of 30 ppm or less
- Effluent COD concentrations are dependent upon the application.
Biological Treatment
Principals of Operation

Bacteria

Organic Chemicals

Carbon Dioxide

Oxygen

Nutrients

Cell Mass

Carbon Dioxide

Cell Mass

Oxygen

Nutrients

Organic Chemicals
Biological Treatment
 Principals of Operation

[Diagram showing the flow of water through a biological treatment system, including Influent, Air Diffusers, Secondary Clarifier, Effluent, Waste Sludge, and Return Activated Sludge]
Market Dynamics - Background

- Industrial Wastewater
  - Treatment of Refractory Organics
  - Need for water conservation/sustainability
- Wastewater discharge regulations tightening
- Water shortages
- Existing technology not reliable / too costly
Needs

- Increased contaminants removal efficiency
  - Existing or stricter discharge standards
- Reuse of wastewater:
- Reliable, small footprint
From PACT® to MBR Alternatives

**Petro™ MBR Technology** = Siemens O&G MBR Design

**Petro™ PAC MBR** = Powdered Activated Carbon in Aeration + MOS Tank

**EcoRight™ MBR** = Granular Activated Carbon in Aeration Tank ONLY
Advantages

Carbon assisted MBR Advantages

- Small footprint
- High COD and TOC removal efficiency
- Bio-refractory organics removal
- No gravity clarification
  - More stable – less upsets
- Wastewater reuse pretreatment
- Lower capital, operating & maintenance costs for equivalent effluent quality
Testing

Saudi Aramco Powdered Activated Carbon PAC (MBR) Testing

- Complex refinery WW
  - Highly variable
  - High concentrations of refractory organics
  - Effluent compliance difficult
- Side-by-side test with MBR
Testing

PAC MBR Pilot Test Unit
Testing

Petro(tm)MBR Effluent  PAC Petro(tm)MBR Effluent

Refinery Wastewater Blend MBR Effluent
Testing

COD – Influent and Effluent

Refinery WW - COD Removal
PAC Petro™ MBR

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<th>Date</th>
<th>COD, mg/L</th>
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### Testing

<table>
<thead>
<tr>
<th>Test Results</th>
<th>Feed</th>
<th>MBR Removal %</th>
<th>PAC MBR Removal %</th>
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<tr>
<td>BOD</td>
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<td>(~4 mg/L) 99%</td>
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<td>~750 mg/L</td>
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<td>~200 mg/L</td>
<td>(27 mg/L) 86%</td>
<td>(11 mg/L) 94%</td>
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</table>
Testing

PAC MBR Results - Summary

- Excellent refractory removal
- Excellent effluent quality – feed to an RO
- Very stable
- No MBR membrane fouling
- Significant abrasion
  - Up to 40% reduction in life expectancy
* Improvements in membrane materials have reduced, but not eliminated, membrane abrasion.
Testing

Saudi Aramco invented & patented GAC MBR
All advantages of PAC MBR
Solves the problems

- GAC vs. PAC
  - GAC can be pre-separated from membrane tank – No membrane abrasion from carbon contact
  - GAC attrition is minimized
EcoRight™ MBR How it works

- Upstream system(s)
- Wastewater
- Sludge waste
- Biofilm
- Granular Activated Carbon
- Aeration Tank
- Isolation device
- Mixing device
- MOS Tank
- Membranes
- Effluent
- Return Line
- Sludge waste
Testing

EcoRight MBR Pilot Unit
Testing

*EcoRight™ MBR Pilot Samples*
Testing
EcoRight™ MBR Pilot Testing COD Removal Performance Following Acclimation

COD Removal Performance

Days Following Acclimation

Influent COD
Effluent COD
Testing
EcoRight™ MBR Pilot Testing Oil and Grease Removal Following Acclimation

Note - EcoRight MBR appears to respond much better to higher influent oil concentration than conventional biological treatment systems.
### Testing - EcoRight™ MBR Pilot Testing RO (Single Pass) Performance*

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<th>Data Collection Time HH:MM</th>
<th>Product Flow (gpm)</th>
<th>Reject Flow (gpm)</th>
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<th>Cartridge Filter Outlet Pressure (psig)</th>
<th>RO Inlet Pressure (psig)</th>
<th>RO Outlet Pressure (psig)</th>
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* Operating since June 28th with one maintenance cleaning cycle.
EcoRight™ MBR Testing

- Refractory organic feed
- Same operational advantages as PAC MBR
  - MBR – no clarifier
  - Improved refractory removal efficiency
  - Stable Operations - GAC acts as a buffer, adding stability to the system operation Lower EPS concentrations
- Biological regeneration of the GAC
Testing

Development together with Saudi Aramco

- Field pilot confirmation
  - Completed at the Ras Tanura Refinery and Juaymah Gas Plant in Saudi Arabia (both SA facilities)
- Applications (Refinery/ Gas plant)
  - Eliminate /reduce surface discharge
  - Reuse WW – reduce desalination costs
  - Reduce groundwater consumption
Thank you for your attention!