Advances in Reverse Osmosis Membrane Technology

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Advances in Reverse Osmosis Technology

- High area membrane
- Energy reduction in sea water membranes
- Biostatic spacer
- Vented seal carrier
Higher Membrane Area
Higher Membrane Area

- More membrane area is added in the membrane without changing dimensions and feed spacer thickness.
- Reduction in capital or operation cost
Energy Reduction in SWRO

Technology Contribution to Energy Minimization

![Energy Savings Chart]

- Split Permeate
- Low-Pressure Pretreatment
- Pressure Center
- Energy Recovery
- Membrane Advancements
- Energy Required

Energy Required vs. Energy Savings Over Time:
- 1970: 25 kWh/m³
- 1980: 20 kWh/m³
- 1990: 15 kWh/m³
- 2000: 10 kWh/m³
- 2007: 5 kWh/m³

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New High Performance Seawater Membranes

High performance seawater membranes

99.8% Salt Rejection
Feed Spacer Design with Biostatic Properties

2. Escherichia coli NCTC 8196

Biostatic Brine Spacer

Conventional Brine Spacer
Cell Test: Exposure of Membrane to Wastewater Stream

Bacteria Count Attached to Membrane or Spacer

![Graph showing bacteria count Comparison between Convent’l Attached on memb., Biostatic Attached on memb., Convent’l Attached on spacer, and Biostatic Attached on spacer.]
Cell Test: Exposure of Membrane to Wastewater Stream

Imaging Analysis of Bacteria on Membrane Surface

- Conventional
- Bio Static
  - green: live bacteria (SYTO9)
  - red: died bacteria (PI)
  - magnitude: $\times 1,000$
  - (140 $\mu$m $\times$ 140 $\mu$m)

Biostatic
Field Studies on Biofouling Feedwater

Samples of Membrane and Spacer from Side by Side Lead Elements After 6 Months of Operation on a Biofouling Surface Water
Biofouling Studies with Test Modules

25 C Waste water

Primary Treatment

Activated Sludge

Pressurized UF Treatment

Element with Standard Spacer

Permeate

Element with Biostatic Spacer

Permeate

Typical Wastewater Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDS</td>
<td>mg/l</td>
<td>862</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>7.4</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>&lt;0.1</td>
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<tr>
<td>TOC</td>
<td>mg/l</td>
<td>15.5</td>
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<tr>
<td>COD</td>
<td>mg/l</td>
<td>39</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>mg/l</td>
<td>18</td>
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<tr>
<td>Organic Nitrogen</td>
<td>mg/l</td>
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<tr>
<td>Ammonia</td>
<td>mg/l</td>
<td>30</td>
</tr>
<tr>
<td>Nitrate Nitrogen</td>
<td>mg/l as N</td>
<td>&lt;.1</td>
</tr>
</tbody>
</table>
Accelerated Biofouling Pilot Test

Single Mini-Element Testing
Feed: Secondary Municipal Effluent → UF Filtrate
Chloramines = 0 mg/L
Duration: Ten days

2nd Generation Low Fouling RO Element

Standard RO Element
Accelerated Biofouling Pilot Test

Differential Pressure (Normalized)

- No biospacer
- Required cleaning = 3 days
- With biospacer

2x

10 days

23-May-11 to 6-Jun-11

psi

NITTO DENKO

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Case Study 1: Reclaimed Wastewater

- Pre-treatment: Activated Sludge $\rightarrow$ Clarification $\rightarrow$ Ultrafiltration
- RO system design: 2 trains, single stage, 6M PV
- Flux 16 lmh (10 gfd), 55% recovery.
- The feedwater does not contain ammonia, so no chloramine disinfection
- Operational upset occurred after the first two months of operation, causing a rise in differential pressure (dP) in both trains and a loss of normalized flux.
Performance of Standard and Biostatic Spacer at a Power Plant

Feed: Secondary Effluent
Na = 195 ppm
Cl = 201 ppm
SiO2 = 15 ppm

Pretreatment
UF hollow fiber.

Membrane with biostatic spacer

Same Spacer Thickness

Membrane with standard spacer

Conventional 1st Generation Elements
Analysis of Side by Side Lead Elements from High Fouling System

- Three months of operation on reclaimed wastewater
- Elements removed from lead positions after biofouling event
- Drained and weighed

<table>
<thead>
<tr>
<th>Brine Spacer Type</th>
<th>Approximate Initial Weight (lbs)</th>
<th>Weight After Operation (lbs)</th>
<th>Biomass (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biostatic spacer</td>
<td>35</td>
<td>35.6</td>
<td>0.6</td>
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<tr>
<td>Conventional Element</td>
<td>35</td>
<td>41.5</td>
<td>6.5</td>
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</tbody>
</table>

- 10 x more biomass on the conventional element
Analysis of Biofouling on the Membrane Leaves

**Biostatic spacer**
Minimal bioslime/foulant at feed end of brine spacer and membrane surface.

**Conventional 1st Generation Low Fouling**
Significantly more bioslime/foulant at feed end of brine spacer and membrane surface.
New Vented ATD Design

Patented Design
Prevents accidental pressure shocks to element shell

Possible to release air between element and vessel

Reduce element burst risk
# Pressure behavior in vessel

New ATD design can prevent from occurrence of pressure difference around elements.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Conventional Flush cut type element</th>
<th>New ATD</th>
</tr>
</thead>
</table>

- **Pressure behavior in vessel**
  - **Pin**: Feed
  - **P1**: Outer shell of 1st. Ele.
  - **P2**: Outer shell of 2nd. Ele.

- **Graphs**:
  - **Conventional Flush cut type element**
    - Pin >> P1, P2
  - **New ATD**
    - Pin ≈ P1 ≈ P2

- **Graph details**:
  - Elapsed time (sec): 0 to 100
  - Pressure (MPa): 0 to 2
Demonstration of Vented Seal Carrier
Air release effect of special ATD

Vessel

1st Element

2nd Element

3rd Element

ATD

Diff. Press. At Outer shell (internal > external)

Pin

P1

P2

Residual Air

High flow

Air

Water

Special ATD

Conventional Membrane
<table>
<thead>
<tr>
<th></th>
<th>Special ATD</th>
<th>Conventional Membrane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial (0sec)</td>
<td><img src="image" alt="Special ATD Initial" /></td>
<td><img src="image" alt="Conventional Membrane Initial" /></td>
</tr>
<tr>
<td>7 sec later</td>
<td><img src="image" alt="Special ATD 7 sec later" /></td>
<td><img src="image" alt="Conventional Membrane 7 sec later" /></td>
</tr>
</tbody>
</table>
Special ATD

Conventional Membrane

10 sec later

14 sec later
Thank You

Solutions You Need. Technologies You Trust.