Applications Using Membrane Filtration as RO Pretreatment
Introduction

- Drivers for Continuous Membrane Filtration (CMF)

- Membrane Filtration is:
  - Reliable
  - Established
  - Simple
  - Compact
  - Flexible

- Many successful applications of Membrane Filtration
  - Potable water from surface and ground waters
  - Filtration of secondary and tertiary wastewater
  - Separation of biomass in activated sludge process
  - RO pretreatment from surface and waste waters
Conventional Filter Effluent Quality…

**Drivers**
- Reliable
- Established
- Simple
- Compact
- Flexible

**SAWEA 2005**
...Affects RO Performance

Drivers
- Reliable
- Established
- Simple
- Compact
- Flexible

Declining RO Flow Rates

- Frequent cleanings
- Declining flow
- Unreliable capacity
- Costly down-time
- Improve reliability
- Reduce operating costs
- Reduce wastewater
- Reduce chemicals

Reverse Osmosis requires better pretreatment ➔ CMF
CMF provides consistent effluent quality independent of feed

CMF: Predictable Performance

Drivers

- Reliable
- Established
- Simple
- Compact
- Flexible

Granular Filters
- Relies on random:
  - Collisions
  - Sieving
  - Entrapment

Membrane Filters
- Relies on pore size of membrane
  - < 0.1 NTU typical
  - < 2.0 SDI typical
Outside-in flow path prevents plugging of fibers
Monolithic membrane structure will not delaminate
Secure bonding of fibers will not detach from potting
High test pressure assures membrane integrity

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Established</th>
<th>Reliable</th>
<th>Simple</th>
<th>Compact</th>
<th>Flexible</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

CMF Physical Data

<table>
<thead>
<tr>
<th>Material</th>
<th>PVDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pore Size</td>
<td>0.04 - 0.1 micron</td>
</tr>
</tbody>
</table>

Memcor® Established in 1983
CMF Replaces Multiple Steps

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conventional Process</th>
<th>Membrane Filtration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Steps</td>
<td>Multiple</td>
<td>1</td>
</tr>
<tr>
<td>Waste Steps</td>
<td>Multiple</td>
<td>1</td>
</tr>
</tbody>
</table>

Drivers
- Reliable
- Established
- Simple
- Compact
- Flexible

- Same flow rate, more reliable and easier to operate

CMF reduces operating costs and complexities
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conventional</th>
<th>Membrane Filtration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footprint</td>
<td>500 gal / day / ft² (0.85 m³ / hr / m²)</td>
<td>2,500 gal / day / ft² (4.25 m³ / hr / m²)</td>
</tr>
</tbody>
</table>

- Same flow rate, better quality in 20% of floor space

CMF saves valuable plant space for expansion & other needs
<table>
<thead>
<tr>
<th>Drivers</th>
<th>Pressurized</th>
<th>Submerged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliable</td>
<td>Pressure driven filtrate</td>
<td>Suction driven filtrate</td>
</tr>
<tr>
<td>Established</td>
<td>Requires membrane pressure vessels</td>
<td>Membrane pressure vessels not required</td>
</tr>
<tr>
<td>Simple</td>
<td>Can be installed in pressurized line</td>
<td>Gravity fed system</td>
</tr>
<tr>
<td>Compact</td>
<td>Economical for low flows</td>
<td>Economical for large flows</td>
</tr>
</tbody>
</table>

**Choice depends on your needs, not want company sells**

**SAWEA 2005**
Applications in RO Pretreatment

- **Surface Waters**: Nuclear power plant replaces clarifiers and filters with membrane filtration.
- **Waste Waters**: Coal fired plant utilizes treated municipal sewage for boiler feedwater.
- **Waste Waters**: Large-scale membrane filtration systems replenish aquifers and serve industries.
**Surface Water**

- Existing process costly to operate and unreliable

**Process**
- Clarifier and filter replaced with Membrane Filtration

**Performance**

<table>
<thead>
<tr>
<th>Client</th>
<th>Point Beach Nuclear</th>
<th>Flow</th>
<th>400 gpm</th>
<th>Start-Up</th>
<th>2004</th>
</tr>
</thead>
</table>

**Others**

**CMF chosen based on proven performance**
### Surface Water

<table>
<thead>
<tr>
<th>Process</th>
<th>Performance</th>
<th>Results</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>Feed</td>
<td>Conventional</td>
<td>CMF Treated</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>1 - 70</td>
<td>1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>2 - 500</td>
<td>2 - 3</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>SDI</td>
<td>Not measured</td>
<td>3 – 5+</td>
<td>1 - 2</td>
</tr>
</tbody>
</table>

**Graph:**
- **RO Feed SDI**

**Legend:**
- 0.1 micron PVDF provides consistent RO feedwater quality

**Dates:**
- Dec-04 to May-05
## Surface Water

### Process Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conventional</th>
<th>CMF Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flux (GFD)</td>
<td>15.6</td>
<td>15.6</td>
</tr>
<tr>
<td>CIP (weeks)</td>
<td>&lt; 12</td>
<td>&gt;52</td>
</tr>
<tr>
<td>Life (years)</td>
<td>&lt; 3</td>
<td>???</td>
</tr>
</tbody>
</table>

### Others

Variations due to demand only

**RO Flow Rates**

CMF solves RO performance problems at this plant
### Surface Water

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Conventional</th>
<th>MF Treated</th>
<th>Yearly Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>$122,000</td>
<td>$24,000</td>
<td>$98,000</td>
</tr>
<tr>
<td>Consumables</td>
<td>$9,000</td>
<td>$2,000</td>
<td>$7,000</td>
</tr>
<tr>
<td>Labor</td>
<td>$525,000</td>
<td>$65,000</td>
<td>$460,000</td>
</tr>
<tr>
<td>Waste</td>
<td>$54,000</td>
<td>$5,000</td>
<td>$49,000</td>
</tr>
<tr>
<td>Total</td>
<td>$710,000</td>
<td>$96,000</td>
<td>$614,000</td>
</tr>
</tbody>
</table>

**CMF requires less chemicals and labor, generates less waste**
Surface Water

- Chemical manufacturing relies on CMF/RO
  - Client: Dow-Netherlands
  - Flow: 6,250 gpm
  - Start-Up: 2001

- Another nuclear plant will rely on CMF/RO soon
  - Client: Kewanee Nuclear
  - Flow: 215 gpm

Many possibilities for surface water sources
Applications in RO Pretreatment

**Surface Waters**
Nuclear power plant replaces clarifiers and filters with membrane filtration

**Waste Waters**
Coal fired plant utilizes treated municipal sewage for boiler feedwater

**Waste Waters**
Large-scale membrane filtration systems replenish aquifers and serve industries
Sanitary Wastewater

- Existing water source expensive with limited supply
- Utilize wastewater with CMF/RO for boiler feedwater

<table>
<thead>
<tr>
<th>Process</th>
<th>Performance</th>
<th>Results</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Client**: Eraring Power, NSW
- **Flow**: 380 gpm, 190 gpm
- **Start-Up**: 1995
- **Phase 2**: 2000

**Partnership with municipality critical for success**
Sanitary Wastewater

- **Process**
  - Plant in operation for over 9 years

- **Performance**
  - **Criteria**
    - RO Feedwater
    - MF Recovery
    - RO Recovery
  - **Performance**
    - < 2.0 SDI
    - 90%
    - 80%

- **Results**

- **Others**
  - 0.2 micron PP membranes provide excellent RO feed water
Sanitary Wastewater

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF life</td>
<td>8.5 years</td>
</tr>
<tr>
<td>MF CIP</td>
<td>Every 4 weeks</td>
</tr>
<tr>
<td>RO life</td>
<td>10 years</td>
</tr>
<tr>
<td>RO CIP</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>$800,000</td>
</tr>
</tbody>
</table>

- Lower TDS in feedwater to DI system saves money
- Elimination of potable water for non-potable use saves money
- Redirecting treated sewage to power plant saved city $4M
### Semiconductor manufacturing relies on CMF/RO

<table>
<thead>
<tr>
<th>Client</th>
<th>Flow</th>
<th>Start-Up</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kranji-Singapore</td>
<td>1,840 gpm</td>
<td>2000</td>
<td>2002</td>
</tr>
<tr>
<td></td>
<td>7,290 gpm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Zero liquid discharge for paper mill relies on CMF/RO

<table>
<thead>
<tr>
<th>Client</th>
<th>Flow</th>
<th>Start-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>McKinley Paper, USA</td>
<td>350 gpm</td>
<td>1994</td>
</tr>
</tbody>
</table>

CMF filters bio-mass effectively for RO pretreatment
Applications in RO Pretreatment

- **Surface Waters**: Nuclear power plant replaces clarifiers and filters with membrane filtration.
- **Waste Waters**: Coal fired plant utilizes treated municipal sewage for boiler feedwater.
- **Waste Waters**: Large-scale membrane filtration systems replenish aquifers and serve industries.
Sanitary Wastewater

- Existing process very expensive to operate

- New process economical and reliable

<table>
<thead>
<tr>
<th>Client</th>
<th>Flow</th>
<th>CMF Pilot</th>
<th>CMF-S Pilot</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange County, USA</td>
<td>500 gpm</td>
<td>160 gpm</td>
<td>4,200 gpm</td>
<td>55,000 gpm</td>
<td>1994</td>
</tr>
</tbody>
</table>

New process studied and tested for years: CMF selected
### Sanitary Wastewater

#### Performance

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<th>Parameter</th>
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</tr>
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<tbody>
<tr>
<td>Turbidity (NTU)</td>
<td>2 – 5</td>
<td>1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>5 – 10</td>
<td>2 – 3</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>SDI</td>
<td>&gt; 6</td>
<td>5 – 6</td>
<td>1 - 2</td>
</tr>
</tbody>
</table>

#### Others

Fiber and system integrity critical to application
<table>
<thead>
<tr>
<th>Process</th>
<th>Parameter</th>
<th>Conventional Treatment</th>
<th>CMF Treated</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulose Acetate RO system</td>
<td>Flux (GFD)</td>
<td>10</td>
<td>12</td>
<td>20% improvement</td>
</tr>
<tr>
<td></td>
<td>CIP (weeks)</td>
<td>4</td>
<td>16</td>
<td>400% improvement</td>
</tr>
<tr>
<td>Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyamide RO system</td>
<td>Flux (GFD)</td>
<td>10.4</td>
<td>10.4</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>CIP (weeks)</td>
<td>6</td>
<td>36</td>
<td>600% improvement</td>
</tr>
<tr>
<td></td>
<td>Life (years)</td>
<td>5</td>
<td>7</td>
<td>140% improvement</td>
</tr>
</tbody>
</table>

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CMF = higher flux, fewer cleanings and longer life of RO
Sanitary Wastewater

- Petroleum refineries rely on CMF/RO
  - Chemical and co-generation plants rely on CMF/RO

High-quality RO feedwater from sanitary wastewaters

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**Process**

**Performance**

**Results**

**Others**

- **Client** West Basin, USA
  - Flow: 12,500 gpm
  - Start-Up: 1998

- **Client** Honouliuli, USA
  - Flow: 2,300 gpm
  - Start-Up: 2000
### Applications in RO Pretreatment

**Surface Waters**
- Consistently low SDI in RO feedwater
- Elimination of solid waste handling
- Saved $614,000 annually

**Waste Waters**
- Saved community drinking water supply
- Plant utilized “cheap” water source
- Plant saved $800,000 annually

**Waste Waters**
- Simpler to operate and maintain
- Reduced O & M costs
- Utilized alternative water source

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CMF has been used successfully for RO pretreatment
Conclusion

- Membrane filtration is reliable and established
  - Over 700 plants in operation around the globe
  - Some of the world's largest filtration plants utilize membranes

- Membrane filtration is simple and compact
  - Replaces several process steps with one
  - Saves valuable plant space for other uses

- Membrane filtration has many benefits and uses
  - Improve performance of RO systems
  - Reduce operating costs of boiler feedwater systems
  - Take advantage of less expensive (alternate) water
  - Potable water for plant employees

How can CMF improve the performance of your RO system?
Contact:

Bob Wenta
301 W. Military Rd.
Rothschild, WI 54474
Phone: (715) 355-3330
Mobile: (262) 617-3781
Email: wentab@usfilter.com

Thank you very much for your attention.