Reverse Osmosis and Nano-filtration Innovation for Water Re-use

5th Water Arabia Conference and Exhibition

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Agenda

- The Water Energy-Nexus
- Dow Water and Process Solutions Mission
- Global References
- Key Takeaways
By 2030, the world’s population will reach 8.3 billion

50% more Food
45% more Energy
30% more Water

Nearly half the global population could be facing water scarcity – demand could outstrip supply by 40%

By 2050, manufacturing’s water demands will increase by 400%
Dow’s Business is about Addressing World Challenges

- **Resource Scarcity**: By 2030, water needs are expected to grow by 50%. 35% of the world’s population will live in water scarce regions by 2020.

- **Population Growth**: There will be 1 billion more mouths to feed by 2025. Global food demand will increase by 70% between 2000 and 2050.

- **Energy Consumption**: GDP growth will continue to drive energy consumption. Demand should increase by 30% in the next 15 years.

Linear economy model: “take, make and dispose” of raw materials.

Circular economy model: “reduced, reused and reclaimed” raw materials.
More from Every Drop: Reduce Cost, Increase Value

point-of-source
RE-CLAIM
Source reclaimed water

Industrial Customer

on-site
RE-CYCLE
Increase number of cycles

Industrial Customer

discharge
RE-NEW
Upgrade for alternate use

RE-DUCE
Reduce intake fresh water
Industrial Wastewater Treatment Top Needs

Primary Wastewater Needs
- Clean-in-Place...
- Water Recovery
- Durability
- Energy
- Salt Rejection

MLD Needs
- Water Recovery
- Operation Reliability
- RO Energy...
- Salt Rejection

Cost of Water Recovery ($/m³)

Primary RO

Secondary RO

Boil

Reduce cost of water

Primary Wastewater Reuse

Minimal Liquid Discharge (MLD)

ZLD

Water Recovery (%)

TDS (ppm)

2000 6,666 40,000 200,000

Reduce cost of water
DOW FILMTEC™ FORTILIFE™ and UHPRO (Ultra-High Pressure) RO Elements

*Designed for a Challenge.*

DOW FILMTEC™ FORTILIFE™ RO Elements and the support of seasoned Dow experts help industrial end users tackle the most challenging waters and applications enabling:

- Reliable performance
- Reduce water costs
- Achievable sustainability goals
- Minimal biofouling problems
- Minimal Liquid Discharge (MLD)

**FORTILIFE™ CR100**
**FORTILIFE™ XC70**
**FORTILIFE™ XC80**
**FORTILIFE™ XC-N**
Wastewater Treatment Design Recommendations

1. **Primary Wastewater Reuse**
   - High biofouling potential
   - FORTILIFE™ CR100
   - TDS Range 0-15,000 ppm
   - TDS Range 15,000-70,000+ ppm

2. **2**
   - High biofouling potential
   - High recovery
   - Low energy
   - FORTILIFE™ CR100
   - TDS Range 0-15,000 ppm
   - FORTILIFE™ XC70 (1st stage)
   - FORTILIFE™ XC80 (2nd Stage)

3. **Minimal Liquid Discharge**
   - Brine recovery
   - Minimize waste salts
   - FORTILIFE™ CR100
   - TDS Range 0-15,000 ppm
   - TDS Range 15,000-80,000 ppm
   - FORTILIFE™ XC70 (1st stage)
   - FORTILIFE™ XC80 (2nd stage)

4. **4**
   - High biofouling potential
   - Max recovery
   - FORTILIFE™ CR100
   - TDS Range 0-15,000 ppm
   - TDS Range 15,000-80,000+ ppm
   - FORTILIFE™ XC70 (1st stage)
   - FORTILIFE™ XC80 (2nd stage)
   - Dow UHP RO (Ultra High Pressure)
Dow Solutions for Industrial Water Reuse – Minimal Liquid Discharge

- **Precipitation Processes** (e.g. Lime and/or Iron, optional)
- **Filtration Processes** (e.g. Sand, GAC, optional)
- **Dow Ultrafiltration** (Particle removal)
- **Dow Ion Exchange** (Scaling prevention)

Industrial WW

- **RO 1**
  - Dow FORTILIFE CR100
  - 0.05 – 1% TDS

- **RO 2**
  - Dow FORTILIFE XC70/XC80
  - 1 – 4% TDS

- **Ultra High Pressure RO**
  - Dow Specialty Membranes
  - 5 – 8% TDS

- **Ion selective membrane**
  - Dow FORTILIFE
  - 6 – 10% TDS

- **Purified brine**
  - For further use
  - 4 – 6% TDS

- **To discharge, post treatment or further use**
  - 1 – 8% TDS
  - 10 – 20% TDS

Water reuse:
- < 100 mg/L TDS
- < 400 mg/L TDS
- < 1000 mg/L TDS

TDS:
- 1 – 4%
- 5 – 8%
- 5 – 8%
- 6 – 10%
- 5 – 8%
- 4 – 6%
- 1 – 8%
- 10 – 20%
Evaluation of two banks of 6 x 4” elements in series operated with matching flux and recovery. RO Feed: TDS = 1700 mg/L; TOC = 5.9 mg/L; ATP = 46 ng/L; Nitrate = 24.9 mg/L; Phosphate = 0.4 mg/L

→ 29% reduction in CIP frequency
**Industrial Wastewater:** FORTILIFE™ XC70 Brine Concentration

To improve system reliability, **Competitor SWRO** elements in **RO3** were replaced with **FORTILIFE™ XC70**

### Pretreatment: Feed TDS: 4500 ppm NaCl

- Lime + Fe₂SO₄ Coagulation - Biological Treatment – C/F – Clarifier – Sand Filter – UF

### RO3 Feed:
- Feed TDS: ~31,000 ppm
- Feed COD: 800 ppm
- Total Hardness: 800 ppm
- pH: 7.1

### CIP practice with SWRO installed:
- **Daily Caustic Cleaning** at the end of the day. (15 mins)
- **Short CIP with Caustic** followed by Acid after every 3 days (60 mins)
- **Long CIP with EDTA + STPP + Caustic** followed by acid after every 10 days. (120-150 mins)

**Combined permeate <300 ppm**

**TEXTILE Plant in Egypt**
Industrial Wastewater: FORTILIFE™ XC70 Brine Concentration
first 100 days of operation providing improved system reliability

CIP practice with FORTILIFE™ XC70:
• one CIP after 90 days of operation
Industrial Wastewater: FORTILIFE™ XC70 Separation Performance

XC70 provides excellent stable permeate quality
Guodian Hanchuan Power Plant in Asia
Salt Separation and Brine Concentration followed by ZLD

- This power plant is in one of the five largest national power groups in Asia.
- It is chosen as the pioneer power end user to establish Fuel Gas Desulfurization (FGD) wastewater Zero Liquid Discharge (ZLD) technology.
- Six months of close cooperation between DOW and a local Original Equipment Manufacturer (OEM) – NJ Lucency succeeded in piloting a new process while validating the performance of the FORTILIFE XCN and XC80 products.

Process and photo by courtesy of EPC (Engineering Procurement Construction) contractor: Beijing Lucency Environmental Tech Co, Nanjing Branch
**Guodian Hanchuan Power Plant in Asia**
Salt Separation and Brine Concentration followed by ZLD

1) High salinity wastewater;
2) High suspended solids;
3) High fluoride & hardness, low alkalinity

<table>
<thead>
<tr>
<th>Unit</th>
<th>Product Type</th>
<th>Elements Amount (pcs)</th>
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<tbody>
<tr>
<td>Ion Separation</td>
<td>FORTILIFE™ XC-N</td>
<td>80</td>
</tr>
<tr>
<td>Brine concentration</td>
<td>FORTILIFE™ XC80</td>
<td>78</td>
</tr>
<tr>
<td>BWRO</td>
<td>BW30-400</td>
<td>36</td>
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Process and photo by courtesy of EPC (Engineering Procurement Construction) contractor: Beijing Lucency Environmental Tech Co, Nanjing Branch
Guodian Hanchuan Power Plant in Asia
Salt Separation and Brine Concentration followed by ZLD

<table>
<thead>
<tr>
<th>Raw FGD wastewater composition</th>
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<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>TDS</td>
</tr>
<tr>
<td>Conductivity</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td>Turbidity</td>
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<tr>
<td>SS</td>
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<tr>
<td>COD</td>
</tr>
<tr>
<td>TOC</td>
</tr>
<tr>
<td>Alkalinity</td>
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</tbody>
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Wastewater challenges:
1) High salinity wastewater;
2) High suspended solids;
3) High fluoride & hardness, low alkalinity;

<table>
<thead>
<tr>
<th>Piloting time and cleaning frequency</th>
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<tbody>
<tr>
<td>System</td>
</tr>
<tr>
<td>TMF</td>
</tr>
<tr>
<td>NF</td>
</tr>
<tr>
<td>RO</td>
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<tr>
<td>DTRO</td>
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Cited from Sunup presentation, Tsingdao CDA conference, 2016

Low fouling, reliable performance
(NH₄)₂SO₄ Recovery from Industrial WW: DOW™ Specialty Membranes ultra-high pressure RO

Feed 2:
TDS: 4,500 mg/L(NH₄)₂SO₄
140 m³/h

FORTILIFE™ XC70
75%

FORTILIFE™ XC70
68%

DOW™ UHPRO
70%

ROₚ
90%

Second pass permeate
<10µS/cm

Feed 2:
TDS: 40,000 mg/L(NH₄)₂SO₄
20 m³/h

UHPRO Reject:
TDS: 140,000 mg/L
13 m³/h

Crystalline (NH₄)₂SO₄ as fertilizer
Key Takeaways

- DOW FILMTEC™ FORTILIFE™ family are designed with the challenges of MLD in mind to provide the best membrane options for achieving reliable high water recovery at low energy.

- DOW FILMTEC™ FORTILIFE™ CR100 offers 30–50% less cleanings

- This is observed in three waters and fouling resistant elements
Thank You.
Let’s *discuss*.
DOW FILMTEC™ FORTILIFE™ Product Line

Membranes to stand up to today’s water challenges.

DOW FILMTEC™ Fouling Resistant Membranes

a Track Record of Leading Innovation to Tackle Challenging Water

FORTILIFE™ CR100
FORTILIFE™ XC80
FORTILIFE™ XC70
FORTILIFE™ XC-N

Gen 2
BW30XFR

Gen 1
BW30FR

BW30
2001

DW30
2010

Increasing Water Treatment Challenge

Membrane chemistry
Innovations

Module design
Innovations
Back up slides
Partnering to Address Waste Water Challenges

Bringing it all together takes partnership
• Innovation: Global and Regional
• External Partnerships: Global and Regional
  o Chemistry/Science/Components Engineering
  o Systems Engineering
  o End users: wide range of applications from Industrial, Institutional to Municipal
  o Regional Water Knowledge and Engagement
DOW™ UHPRO (Ultra-High Pressure) reducing total treatment cost

DOW™ Specialty Membranes ultra-high pressure RO (XUS1808-series)

- Max operation pressure: 120 bar / 1740 psi (@ max 30°C); 83 bar @ 45°C
- Membrane area (8"): 285 sqft / 27m²
- 34 mil feed spacer

Distinctive element construction including polysulfone permeate water tube
High pressure DOW FILMTEC™ SW30 flat sheet
Available in 8040, 4040 and 2540 design
Fits into standard size pressure vessels with 120 bar specification

Dow UHPRO reducing total treatment cost

**FO**: forward osmosis
**EDR**: Electro Dialysis Reverse
**MVR**: Mechanical Recompression

Salinities in mg/l NaCl

- 40,000
- 80,000
- 115,000

DOW™ Specialty Membranes ultra-high pressure RO (XUS1808-series)
Challenging water recovery: general schematic

Approximate TDS range:
- 0.05-1%: FORTILIFE™ CR100
- 2-3%: FORTILIFE™ XC70/XC80
- 6-8%: FORTILIFE™ XC-N
- 10-20%: DOW™ UHP RO

Pretreatment
- UF
- IX

MAXIMIZE
- Water for recycle
- Pure Brine for re-use

MINIMIZE
- Waste Solids

Evaporator