Koch Membrane Systems History

1963 - ABCOR founded to commercialize separation technologies developed at MIT
1970 - ABCOR develops tubular ultrafiltration (UF) products
1977 - Koch Industries acquires 100% of equity in ABCOR
1980 - ABCOR introduces spiral wound UF products for food/dairy applications
1985 - ABCOR renamed Koch Membrane Systems, Inc. (KMS)
1991 - KMS acquires Romicon supplier of hollow-fiber UF technology
1996 - KMS acquires MPW supplier of specialty nanofiltration (NF) technology
1998 - KMS acquires Fluid Systems supplier of RO and NF spiral elements
2003 - KMS introduces 10” TARGA® UF and 18” MegaMagnum® RO elements
2004 - KMS acquires Puron® MBR (submerged) products
2006 - 1st large scale MegaMagnum System sold (66 MLD)
### KMS Overview

**Employment** 600 +

**Revenue** $100 + Million USA

**Facilities**
- Wilmington, MA: Corporate Headquarters, Membrane and System Manufacturing, Research and Development
- San Diego, CA: RO/NF Membrane Manufacturing
- Aachen, Germany: PURON Membrane Manufacturing

**Sales Offices**
- England, Germany, France, Italy, Spain, China, Bahrain, Singapore, India, Brazil, Australia

**Markets**
- Industrial and municipal MF/UF/NF/RO membranes, chemicals, systems and services. Tubular, pressurized and submerged hollow-fiber and spiral
KMS Overview
KMS Business Focus

• Water and Wastewater (48%)
  – Feed water and effluent treatment
  – Process water recovery and reuse
• Food, Dairy and Beverage (33%)
  – In-process applications for consumable products
  – All products in this focus area are FDA approved
• Specialty Applications (19%)
  – In-process applications for industrial processes
Membrane Separations

<table>
<thead>
<tr>
<th>Process</th>
<th>Micron Range</th>
<th>Components Removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microfiltration</td>
<td>0.1 to 1.0</td>
<td>Water, Monovalent Metals, Multivalent Metals, Surfactants, Oil &amp; Grease</td>
</tr>
<tr>
<td>Ultrafiltration</td>
<td>0.005 to 0.1</td>
<td>Water, Monovalent Metals, Multivalent Metals, Surfactants, Oil &amp; Grease</td>
</tr>
<tr>
<td>Nanofiltration</td>
<td></td>
<td>Water, Monovalent Metals, Multivalent Metals, Surfactants, Oil &amp; Grease</td>
</tr>
<tr>
<td>Reverse Osmosis</td>
<td>0.0005</td>
<td>Water, Monovalent Metals, Multivalent Metals, Surfactants, Oil &amp; Grease</td>
</tr>
</tbody>
</table>

Precipitated Metals
Membrane Chemistries

• Membrane Chemistries:
  – Polysulfone (PSF)
  – Polyethersulfone (PES)
  – Polyacrylonitrile (PAN)
  – Polyvinylidene fluoride (PVDF)
  – Cellulose Acetate (CA)
  – Polypropylene (PP)
Membrane Configurations

- Membrane Product Configurations:
  - Tubular
  - Spiral wound
  - Hollow fiber
    - Pressurized
    - Submersible
Membrane Configurations

Open, Wide Feed Channel

TUBULAR

FEG™
ULTRACOR™
SUPERCOR™

Narrow, Thin Feed Channel

HOLLOW FIBER
Pressurized
Submerged

Spiral Wound
High Flow
Standard Flow
Thin Channel

Relative Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Tubular</th>
<th>Hollow Fiber</th>
<th>Spiral Wound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Channel Size</td>
<td></td>
<td>Decreasing</td>
<td></td>
</tr>
<tr>
<td>Membrane packing density</td>
<td></td>
<td>Increasing</td>
<td></td>
</tr>
<tr>
<td>Concentrate Solids</td>
<td></td>
<td>Decreasing</td>
<td></td>
</tr>
<tr>
<td>System Footprint</td>
<td></td>
<td>Decreasing</td>
<td></td>
</tr>
</tbody>
</table>
Tubular Products

Product Characteristics

- Processes a variety of streams with high suspended solids
- Proprietary PVDF (MF) and PES (UF) membrane formulation
- Available in 1 inch and ½ inch ID tubes
- Sanitary and industrial product designs
Hollow Fibers (Pressurized)

Product Characteristics
- Propriety modified PS membranes
- Inside to Outside permeate flow direction
- Available in 10,000 and 100,000 MWCO
- Available in 35 mil (0.9 mm) and 43 mil (1.1 mm) fiber ID
- Modular Designs for Future Expansions
- Larger Size Cartridges reduce Capital and Operating Costs
Hollow Fiber (Vacuum)

Product Characteristics

• Proprietary PES reinforced hollow-fiber membrane
• Single header design to minimize sludge buildup
• Efficient air sparging for high energy efficiency
Sanitary Spirals

Product Characteristics

• Proprietary TFC formulations
• MF, UF, NF and RO membranes
• High area elements for reduced capital expenditure
• Sanitary element with net outer wrap
• 31 mil and 46 mil feed spacer
• High temperature options
Water Spirals

Product Characteristics

• Proprietary TFC membrane formulations
• NF and RO membranes
• High area elements for reduced capital expenditure
• Hard outer wrap for element structural integrity
• 28 and 31 mil feed spacers
• High salt rejection options
Product Characteristics

- Proprietary membrane formulation
- Stable at high acid and caustic concentrations
- Stable in organic solvents
- UF and NF membranes
- Spiral configurations
Membrane Bioreactor (MBR)

Raw wastewater

Combination of biological step and solid liquid separation

- S = Step screen
- GF = Grit and fat removal
- PC = Primary clarifier
- BS = Biological step
- ST = Sedimentation tank
- TC = Third cleaning step (e.g. filtration + disinfection ozone or UV)
- MT = Membrane technology

Permeate

Effluent
PURON Product Concept

- Central air injection
- Fiber cage
- Individually sealed hollow fibers
- One side potting
- Reduced clogging and sludging
- Reduced energy consumption for aeration

Main advantages:

- Permeate
- Fiber cage
- Module-element
- Air injection

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PURON Product Concept

- Membrane bundle
- Module row
- Technical module
PURON Module
Description

- Standard Sizes
  - 30 m²
  - 250 m²
  - 500 m²
  - 1500 m²
- Integrated permeate and aeration headers
- Available hardware to permit easy installation with both DIN and US piping
RO Terminology

- Membrane: plastic cast on flat sheet support material
- Element: spiral wound device
- Pressure Vessel (Tube): element housing
- Bank (stage): pressure vessels arranged in parallel
- Array: configuration of vessels by bank; i.e., 4:2:1
- Two Pass: RO permeate treated in two elements in series
RO Terminology

Process Flows

Feed → Concentrate, Reject, Brine → Product, Permeate, Filtrate
RO Terminology

% Recovery =
Percentage of feed water that becomes product water

\[
\frac{\text{Permeate flow}}{\text{Feed flow}} \times 100
\]

Example:
Permeate flow = 90 gpm
Feed flow = 100 gpm
Recovery = 90%
RO Terminology

% Salt Rejection =
Percentage of salt in feed that does not pass across membrane

\[
1 - \frac{\text{Permeate TDS}}{\text{Feed TDS}} \times 100
\]

Examples:

Feed TDS = 35,000 ppm
Permeate TDS = 200 ppm
% Rejection = 99.4%

Permeate TDS = 400
% Rejection = 98.9%
RO Terminology

\[
\text{\% Salt Passage} = \frac{\text{Permeate TDS} \times 100}{\text{Feed TDS}}
\]

Permeate TDS = 200 ppm  
Feed TDS = 35,000 ppm  
\% Rejection = 99.4% 
\% Salt Passage = 0.57%

Permeate TDS = 400 ppm  
Feed TDS = 35,000 ppm  
\% Rejection = 98.9% 
\% Salt Passage = 1.14%
Stage and Arrays (2/1 array)

Each stage increases water recovery

Feed 100 gpm

High Pressure Pump

1st Stage

50 gpm

2nd Stage

50 gpm 25 gpm

75 gpm Permeate

25 gpm Concentrate

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RO Terminology

Two Pass System

Each pass improves product water quality

Feed → Permeate (20 ppm) → Permeate (0.2 ppm) → Concentrate

1st Pass

2nd Pass

2,000 ppm
RO Terminology

Flux =
Permeate produced per unit time per unit membrane area

Permeate Flow (gal/day) = gfd
Membrane Area (ft²)

Permeate Flow (liters/hour) = lmh
Membrane Area (m²)

LMH = GFD * 0.59
RO Terminology

Rate of fouling is a function of flux
Maximum sustainable flux is a function of the feed water properties (water source)

<table>
<thead>
<tr>
<th>Water Source</th>
<th>Average Flux, GFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>RO Permeate</td>
<td>20 - 30</td>
</tr>
<tr>
<td>Deep Well</td>
<td>17 - 20</td>
</tr>
<tr>
<td>Lake</td>
<td>12 - 16</td>
</tr>
<tr>
<td>Canal/River</td>
<td>10 - 14</td>
</tr>
<tr>
<td>Wastewater</td>
<td>8 - 12</td>
</tr>
</tbody>
</table>
## RO Terminology

Flux and production rate sets number of elements (membrane area)

System recovery defines the array

<table>
<thead>
<tr>
<th>Recovery</th>
<th>Banks</th>
<th>Array</th>
<th>Element/Vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
<td>1 bank</td>
<td>1 bank</td>
<td>6 vessels</td>
</tr>
<tr>
<td>75%</td>
<td>2 banks</td>
<td>2:1 array</td>
<td>6 vessels</td>
</tr>
<tr>
<td>82%</td>
<td>2 banks</td>
<td>2:1 array</td>
<td>7 vessels</td>
</tr>
<tr>
<td>90%</td>
<td>3 banks</td>
<td>4:2:1 array</td>
<td>6/7 vessels</td>
</tr>
</tbody>
</table>
MegaMagnum®
Element Area Comparison
# Large Diameter RO Element Comparison

<table>
<thead>
<tr>
<th>Nominal Diameter (inches)</th>
<th>Element OD (inches)</th>
<th>Core OD (inches)</th>
<th>Available Area (inches²)</th>
<th>Area Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.00</td>
<td>17.2</td>
<td>3.5</td>
<td>223</td>
<td>5.1</td>
</tr>
<tr>
<td>17.25</td>
<td>16.4</td>
<td>3.5</td>
<td>201</td>
<td>4.5</td>
</tr>
<tr>
<td>16.00</td>
<td>15.2</td>
<td>3.5</td>
<td>172</td>
<td>3.9</td>
</tr>
<tr>
<td>12.75</td>
<td>11.6</td>
<td>2.5</td>
<td>101</td>
<td>2.3</td>
</tr>
<tr>
<td>8.00</td>
<td>7.65</td>
<td>1.62</td>
<td>44</td>
<td>1</td>
</tr>
</tbody>
</table>

18 inch comparison: Factor of five scaling compared to 8 inch
Nominal 30% more membrane area than 16 inch
MegaMagnum® Membrane
8” versus 18” Element Comparison

8” x 40” x seven long typical elements

Typical seven long vessel = one KMS MegaMagnum element

One KMS MegaMagnum vessel = five typical 8” vessels

18” x 61” x 5 long per KMS MegaMagnum vessel
Projects

MBR/RO System
Joe White Malting, Australia

03/05/2006
Projects

**MBR/RO System**

*Joe White Malting, Australia*
Projects

MBR/RO System
Joe White Malting, Australia
Projects

MBR/RO System
Joe White Malting, Australia
### Projects

#### Western Corridor Recycled Water Project

**Application:** Recycle municipal wastewater  
**Recycle Capacity:** 232,000 m³/day (~ 60 MGD)  
**Project Budget:** $1.6 billion USA  
**Project Overview:**  
- Construction of ~ 200 km large diameter pipelines and associated infrastructure  
- Construction of three new advanced water treatment plants (AWTP)  
  - Bundamba: 66,000 m³/day (17.4 MGD)  
  - Gibson Island: 100,000 m³/day (26.4 MGD)  
  - Luggage Point: 66,000 m³/day (17.4 MGD)
Project Implementation

Recycle water from the Bundamba AWTP is pumped to and used as cooling tower and boiler makeup water at the Swanbank and Tarong Power Stations.

Recycled water replaces water that is otherwise removed from municipal water reservoirs; thereby replenishing the local drinking water supply.
Projects

Project Implementation
Projects

Project Description

Feed Water: Secondary clarified sewage (flocculation)
Multi-stage advanced treatment process
  Microfiltration (MF)
  Reverse osmosis (RO)
  Advanced oxidation (UV/Peroxide)
Disinfection and Stabilization
Bundamba Project

Process Flow Sheet
Projects

RO Membrane System
Bundamba Project (Phase 1A)
Projects

Element Loading

Bundamba Project (Phase 1A)
Projects

MF Membrane System
Bundamba Project (Phase 1A)
Projects

RO Membrane System
Bundamba Project (Phase 1A)
Ashkelon SWRO Project

Project Overview

Largest SWRO Plant in World

Provides ~ 15% of domestic consumer demand

Start-Up => December 2005

Capacity => 330,000 m³/day (~ 87 MGD)

BOT project (25 years)

Facility transfers to Israel Government at end of term
Projects

Ashkelon SWRO Project

Project Finances

Project cost ~ $212 million

Funding => 23.5% equity/76.5% debt

Water tariff => $0.527/m3 (~ $2.00/kgal)

Tariff based on fixed (58%) and variable (42%) costs

Fixed cost covers capital expenditures

Variable costs covers energy, membrane, chemicals
Projects

Ashkelon SWRO Project

SWRO Plant Description

- Dedicated 80 MW gas turbine power plant
- Open seawater intake
- Dual media gravity filtration
- Two autonomous plants with shared seawater intake
  - 165,000 m³/day each plant
- 40,700 RO elements (total)/seawater and brackish type
Projects

Ashkelon SWRO Project

SWRO Plant Water Specifications
(Before Post-treatment)

< 80 ppm TDS
< 20 ppm Chloride
< 40 ppm Sodium
< 0.4 ppm Boron
Projects

Ashkelon SWRO Project

*Overview of RO Facility*

http://www.water-technology.net/projects
Projects

Ashkelon SWRO Project
8 inch Pressure Vessels
http://www.water-technology.net/projects
Projects

Ashkelon SWRO Project
DWEER Energy Recovery Device
http://www.water-technology.net/projects