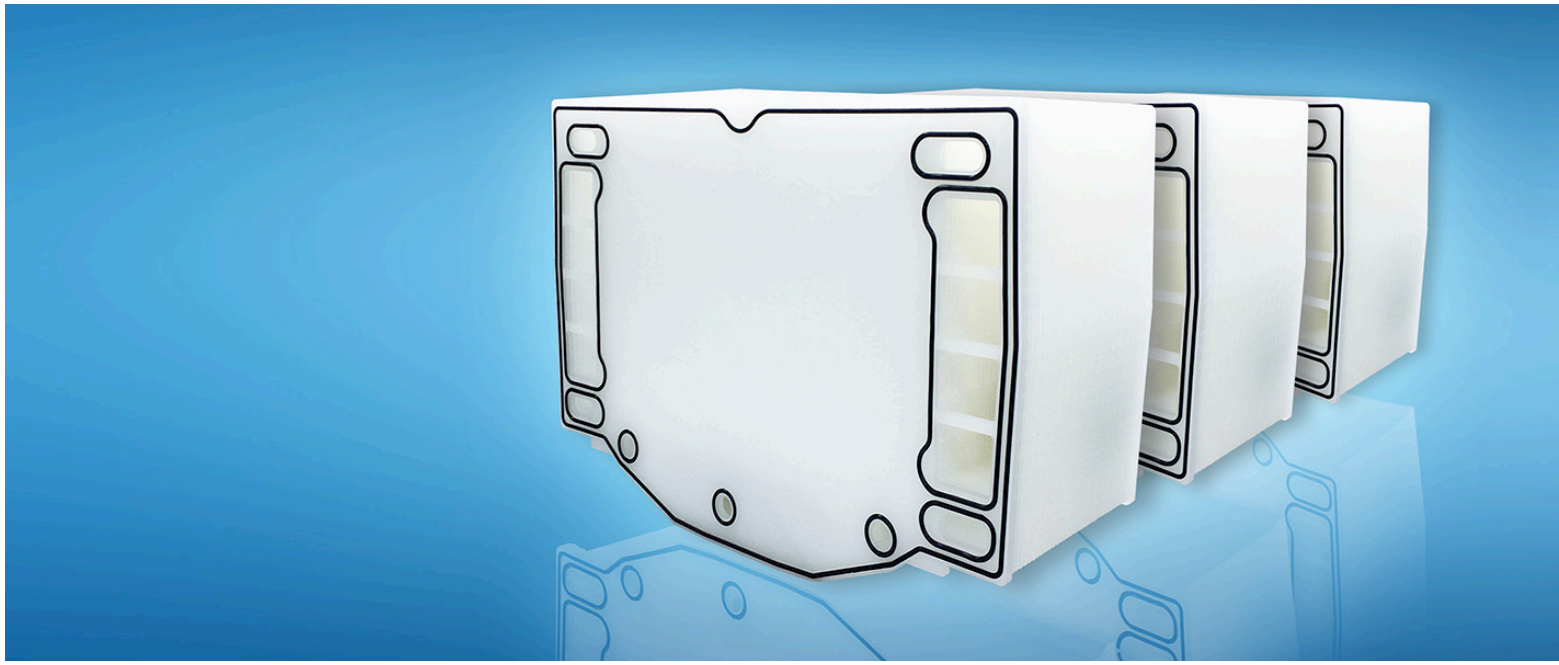
memsys®
thermal separation processes

FAQ – frequently asked questions

The memsys process of thermal membrane distillation



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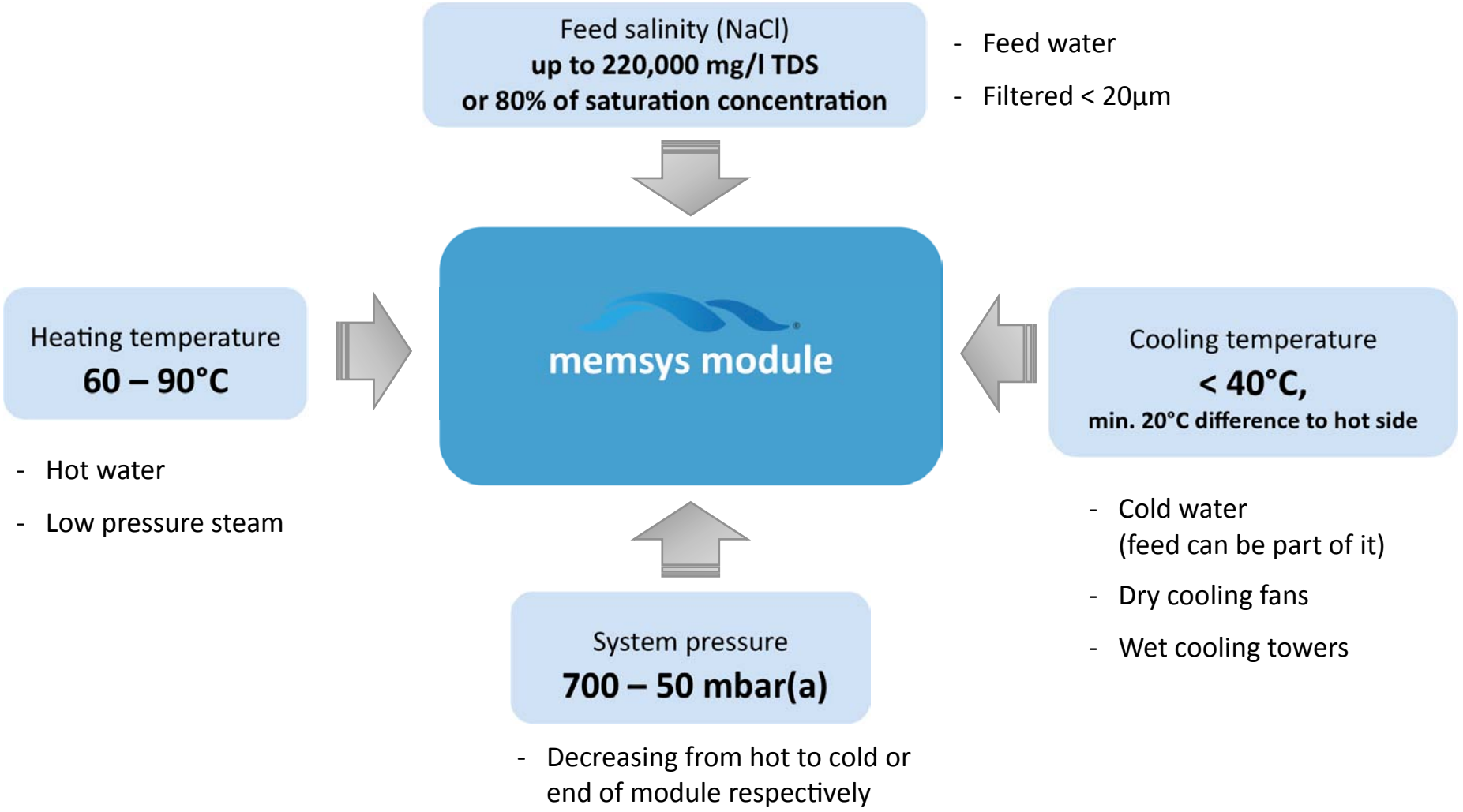
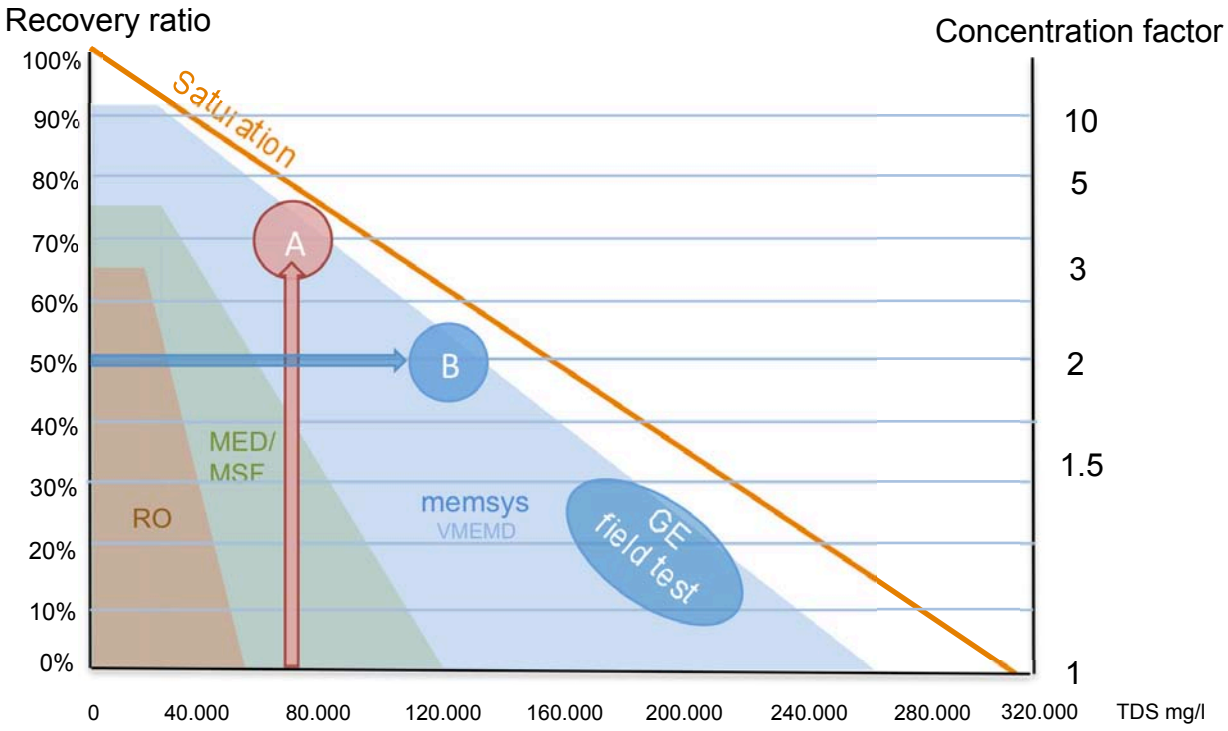
What are the process requirements?



What are typical concentrations and recovery rates?



- **memsys achieves recovery rates resulting in brine concentrations close to saturation**
- **Maximum achievable RR decreases with higher salt content of feed**

What is a recovery rate (RR)?

- Recovery rate is the ratio of distillate output versus feed input

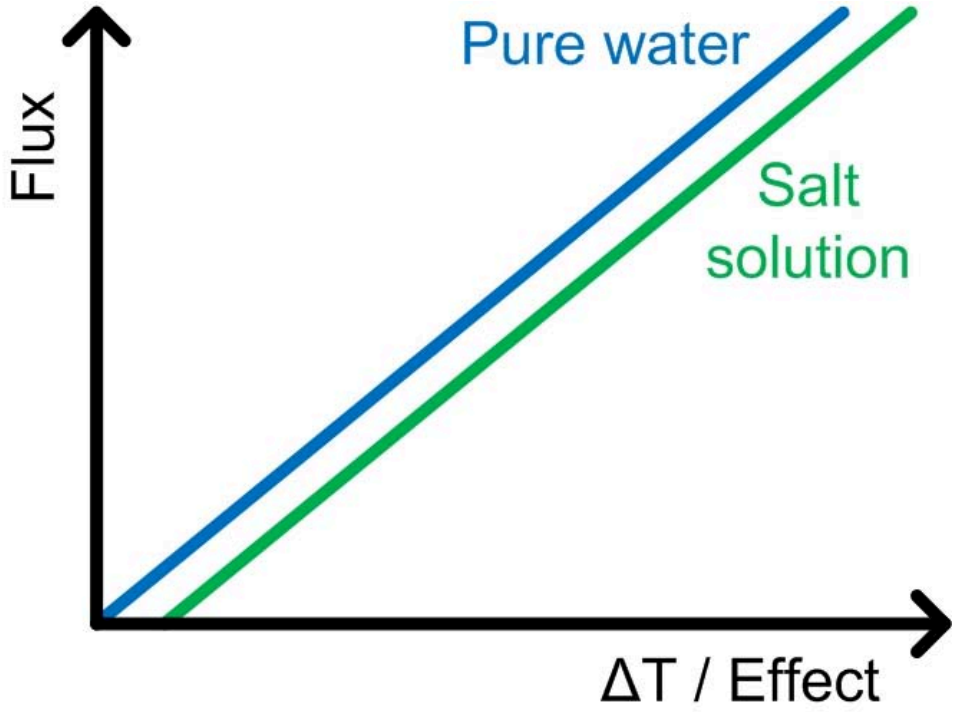
How to use the diagram?

- Examples:

A: Further concentration of RO-brine from 80.000 mg/l
=> RR of > 70% is possible

B: Desired RR: 50%
=> Inlet feed concentration can be up to 125'000 mg/l

What is the relation of flux and temperature delta?



- **Flux requires a temperature difference (ΔT)**
- **Higher flux at higher temperature difference**

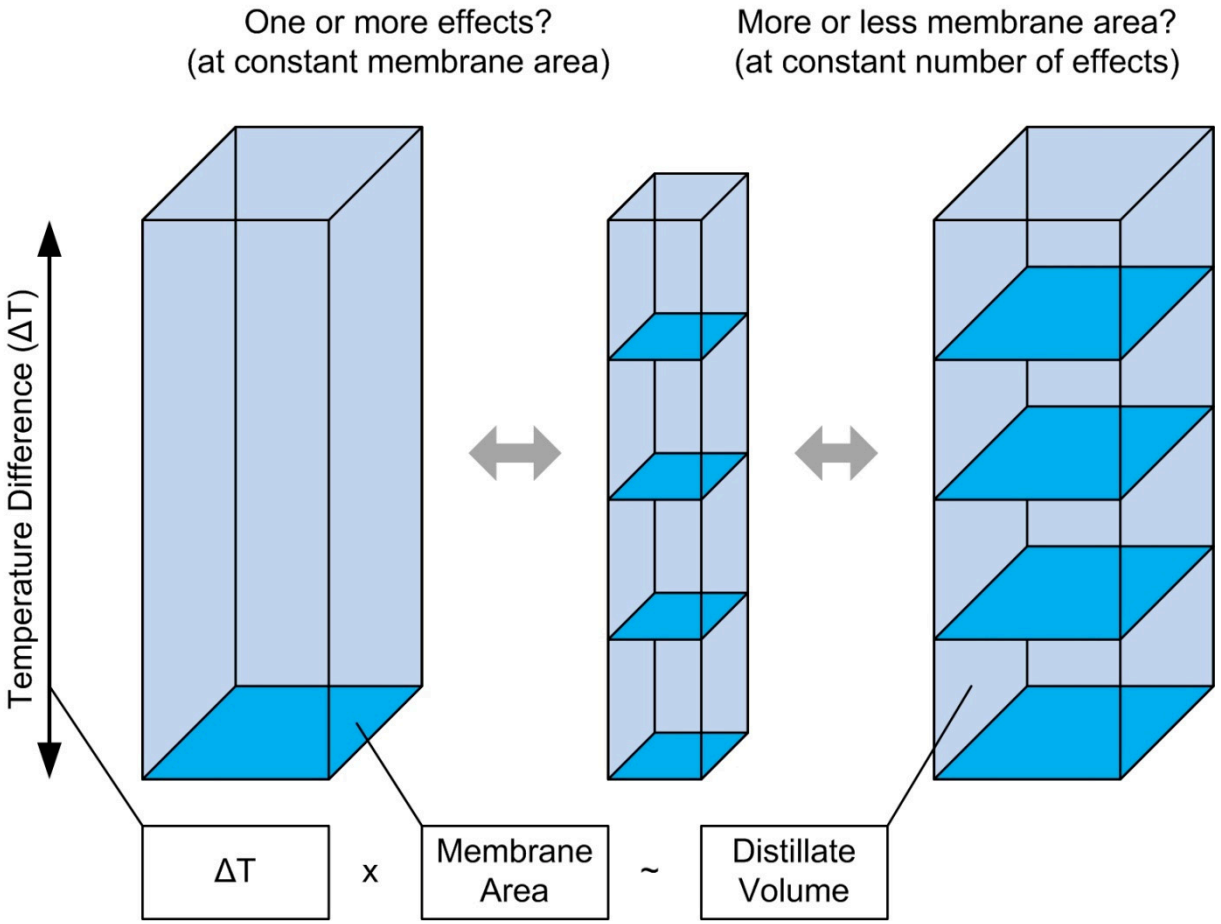
What is Flux?

- Flux is the specific distillate output flow per membrane area; unit: kg /(m²*h) (also l/(m²*h) or lmh)

Is there a difference with salty feed?

- Salt water starts boiling at higher temperatures compared to pure water
- Higher salt concentrations in the feed require a higher delta T to generate the same flux as with pure water

What are the relations of distillate production and membrane area?



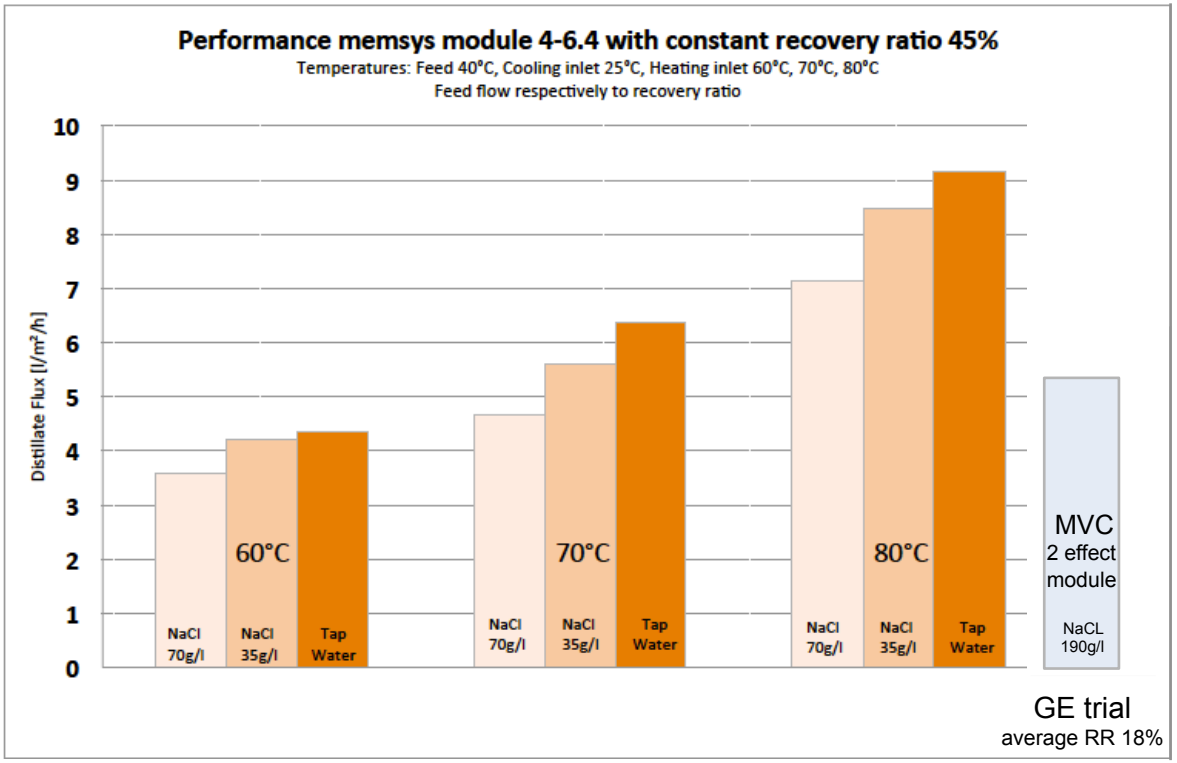
More effects at constant membrane area?

- The required energy is reused more often with more effects
  => better energy efficiency
  => less distillate output

More effects and more membrane area?

- The distillate output can be increased with larger membrane area
  => higher energy efficiency
  => higher distillate output

What is the relation of TDS and flux?

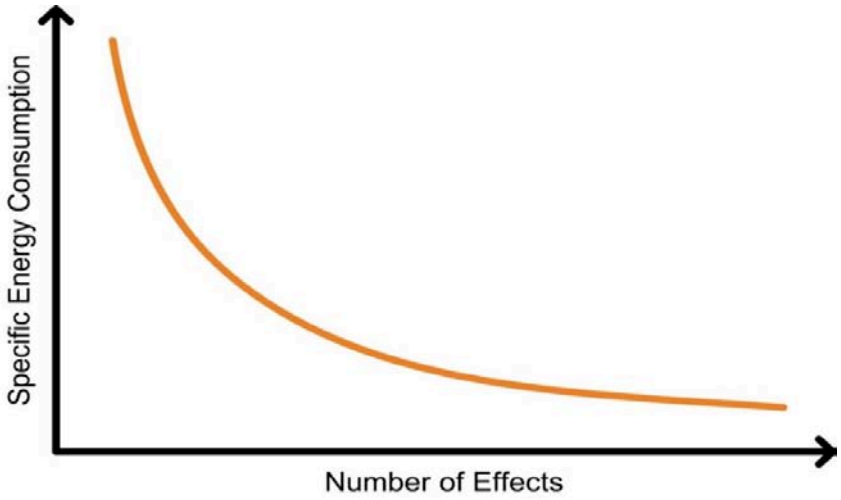


- **Fluxes of up to 10 l/(m²h) can be achieved**
- **Higher TDS lead to lower fluxes**

What does the diagram show?

- The diagram shows results of flux of a memsys module in operation in dependence of the temperature on the hot side of the module and the salt concentration of the feed
- At higher heating temperature a higher flux is achieved
- The flux is reduced with increased salt concentration of the feed

What is the energy consumption of the process?



Specific energy demand: (depending on boundary conditions and size of system):

- **80…250 kWh/m³ thermal energy**
  (related to an electrical equivalent of 12.7 … 39.8 kWh/m³)
- **1.0…2.2 kWh/m³ additional electrical energy demand (aux.)**

At MVC operation:

10 …18 kWh/m³ isentropic (~el.) energy demand

(with optimal compressor)

Specific energy consumption

- is the energy needed to produce one m³ distillate
- Thermal (heat) and electrical energy is used to generate distillate at VMEMD
- Only electrical energy is needed if operated with a vapor compressor (e.g. GE)
- More effects lead to lower thermal energy demand for the process
- TVC further reduces the thermal energy demand

What is the footprint of MD compared to other technologies?

- **Footprint for 6-fold stacked multiple train systems: 10 – 15 (m^3/d) /m^2**
- **Footprint for containerized small systems (50 m^3/d) 2 – 4 (m^3/d)/m^2**

Typical footprint of desalination systems (plant dimension, incl. service area, without pretreatment)

Sea water reverse osmosis:

- 5 (m^3/d)/m^2 for small containerized R.O. units up to 28 (m^3/d)/m^2 for large plants (e.g. Barcelona Llobregat)

MED/MSF:

- 10 to 25 (m^3/d)/m^2
- Depending on size and design (tower system, parallel vessels)

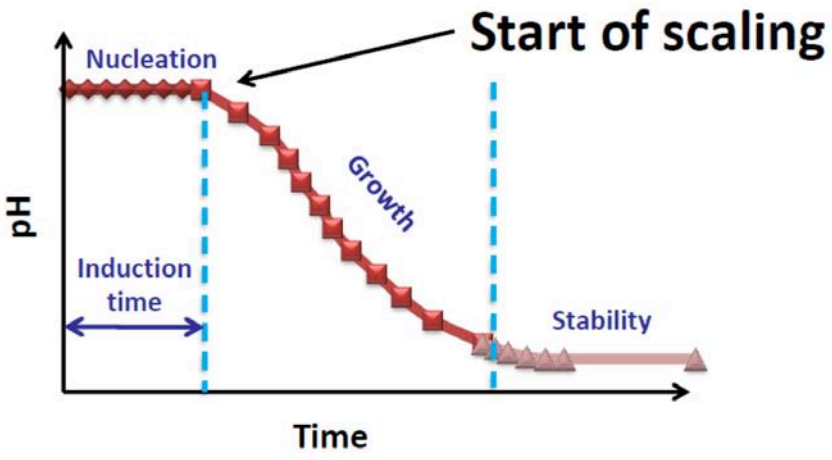
What are scaling experiences?

- **Only vapor passes the membrane, no liquids flow towards pores**
- **Cleaning procedures lead to full membrane recovery**

Scaling is limited in the memsys VMEMD process:

- Liquids do not pass the membrane, but flow along the surface
- Surface of membrane and frame is polymer and not polar => no adherence
- Cleaning dissolves scaling
- PTFE membrane is not affected by chemicals (e.g. acids, antiscalants)

What are scaling experiences (2)?



- **In case of over-saturation during feed concentration, created precipitants need to be held in solution or precipitated upstream of the MD process**
- **Marketready antiscalants have been tested and successfully prevented scaling without affecting the membrane**
- **Feedflow regulation enables reduction of scaling potential by concentration polarization**

Effect of antiscalants if required

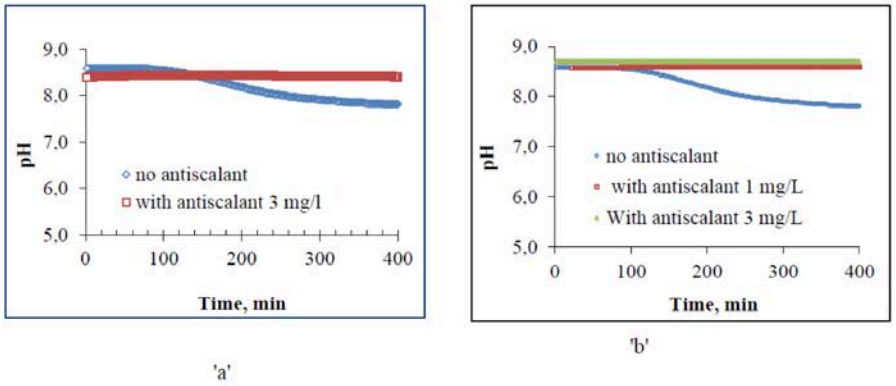
- Induction time is prolonged
- Antiscalants show effect on inhibiting the crystal growth process
- Cleaning agents can dissolve scaling in most cases
- Retarded scaling decreases scaling potential in the unit

Sources: **Aquaver; Conference talk on 1st International conference on desalination using membrane technology, 7th - 10th April 2013,** Mélia Sitges Hotel Congress Centre; Aquaver: *The International Desalination Association World Congress on Desalination and Water Reuse 2013 / Tianjin, China REF:* ***IDAWC/TIAN13-Dhakal***
memsys: Internal studies

What are scaling experiences (3)?

Test of antiscalants

- Scaling potential calculation with PHREEQC showed that North Sea Water while operating at 70% recovery and 70°C supersaturated with aragonite ($CaCO_3$), Calcite ($CaCO_3$), Dolomite $CaMg(CO_3)_2$, Magnesite ($MgCO_3$)
- The addition of antiscalants (BWA 2030 and COSUN bio based) prolongs the induction time of $CaCO_3$ at a feed dose of 3 mg/L in a tested range of S&DSI from 1.77 to 2.35 for more than 200 and 400 minutes, respectively
- Antiscalant COSUN bio based was found best as compared to BWA 2030. With this antiscalant even at a lower dose of 1 mg/L prolongs the induction time of $CaCO_3$ for S&DSI of 1.77 for more than 400 minutes



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What chemicals are critical for the modules or the membrane?

- **PTFE and PP are widely resistant against nearly all chemicals, extreme acids or bases.**
- **Only minimal restrictions for feedwater content**

Feed liquids should <u>not contain</u> large amounts of (harmfull for PP/PTFE)**:**

- Free chlorine, bromine
- Benzol, chlorobenzene
- Chromium-Tri-Oxide
- Cyclohexanon
- Dekahydronaphtalin
- Diisopropylether
- Amylacetate, Butylacetate
- Concentrated nitric acid
- Tetrachlorethane, Xylol
- Ethylene oxide, propylene oxide
- Bromtriflourid, chlortriflouride,
  - Substances decreasing the surface tension of water. e.g. surfactants, oil (100 ppm), strong organic solvents can cause wetting of the membrane

What are fouling experiences?

- **Thermal and surface conditions limit microbiological growth**
- **Cleaning procedures achieve full membrane recovery**

Bio-fouling is limited in memsys VMEMD:

- Temperature of feed is always higher than 60 – 80°C
  => microorganisms are not surviving these thermal conditions
- The membrane is resistive against anti-fouling chemicals

What is the demand for pretreatment?

What are the pretreatment requirements?

- Very limited need for pre-treatment due to membrane properties (PTFE)
- 20 µm filtering mostly sufficient
- pH adjustment for keeping carbonates in solution if necessary
- Membrane and frames resistant towards most chemical cleaning agents
- Limited amount of oil and surfactants
- Precipitation / flocculation in the unit must be avoided by according **pre-treatment upstream**

- **Suspended solids should be filtered, oil and surfactants need to be reduced to 100 ppm**
- **Tested cleaning procedures lead to full membrane recovery**

What are life time experiences?

Full recovery of wetted membrane indicates long life time without degradation

Experiences to date indicate:
5 years+ lifetime in sea water desalination and
2 years+ in organic waste water treatment and WPA

Membrane life is influenced by

- **Mechanical stress**
  (too high pressure differences
  => not applicable here)
- **Chemical influences**
  PTFE membrane not sensitive against chemical attack
- **Aging**
  influence can only be investigated after many years of operation