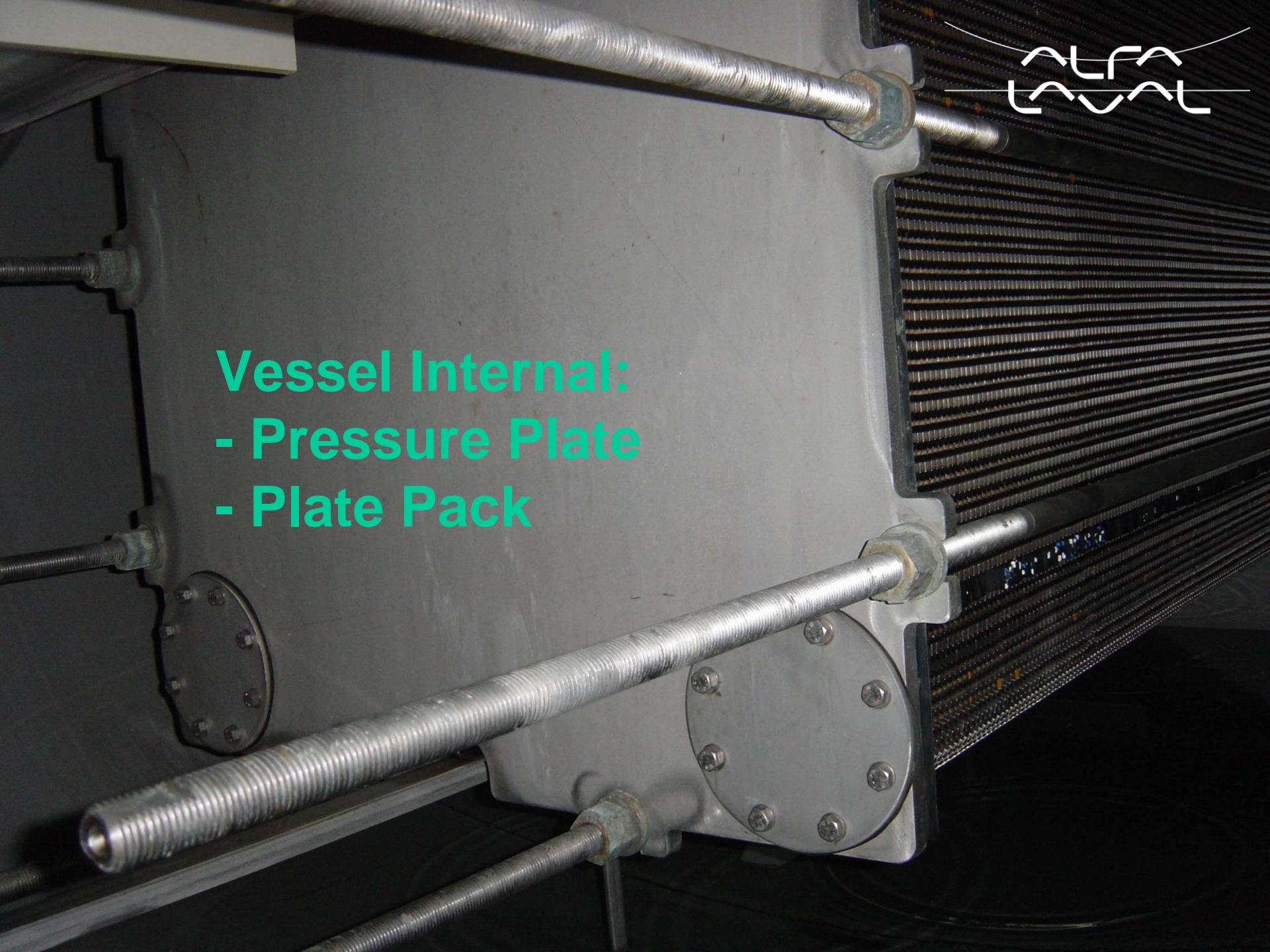


# Vessel Internal and Plate Pack



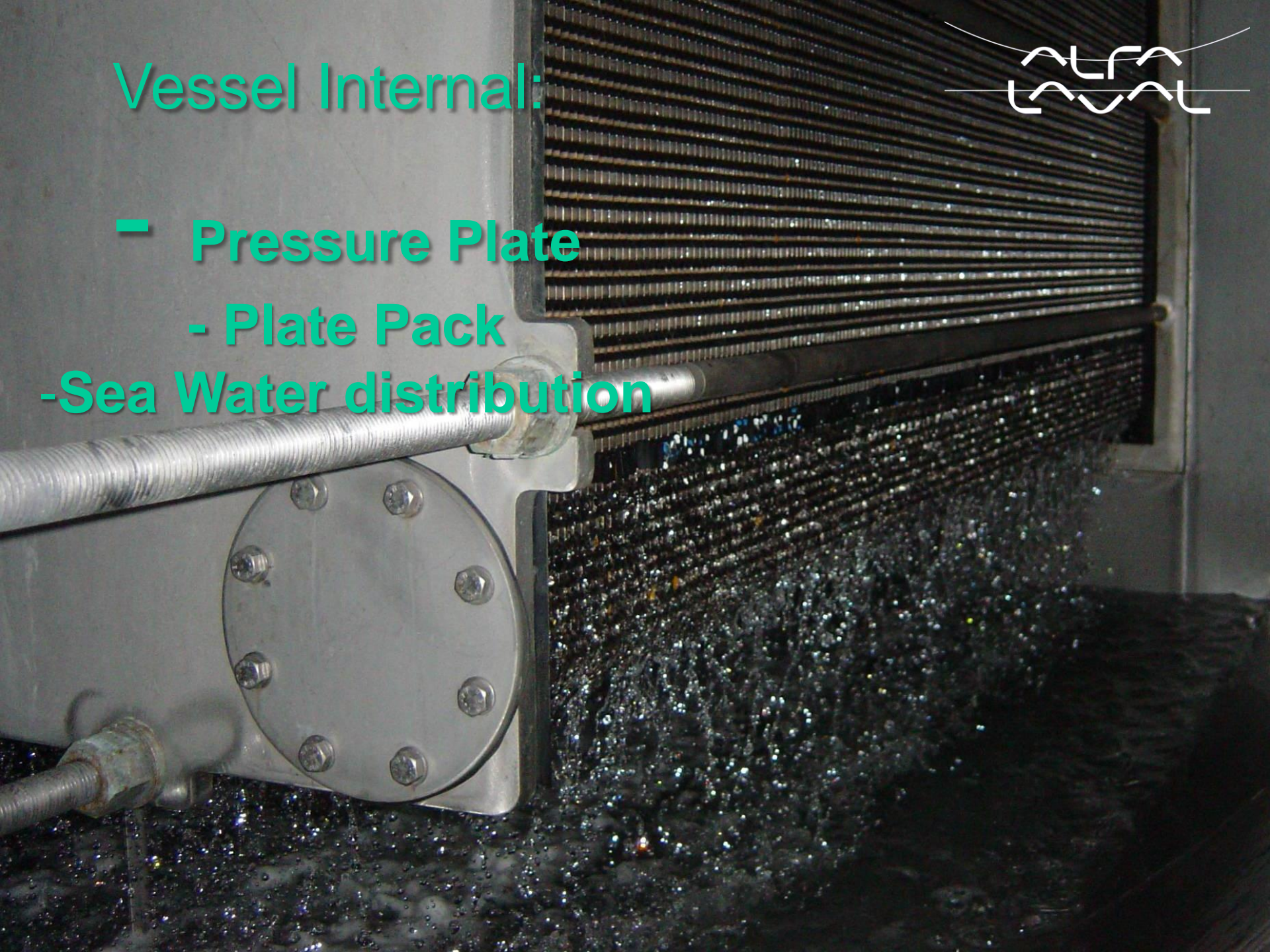
**Vessel Internal:**  
**- Pressure Plate**  
**- Plate Pack**



# Vessel Internal:



- Pressure Plate
- Plate Pack
- Sea Water distribution



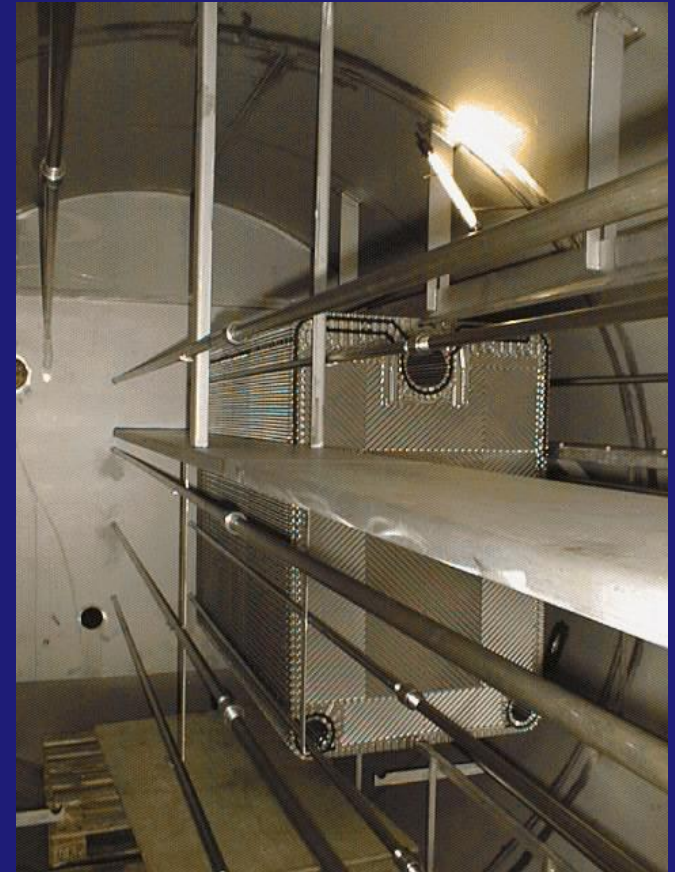
# Multiple Effect Distillation (MED) is becoming state-of-the-art in thermal desalination

- **20-30 % lower capital investment compared to MSF**
- **50 % lower electrical power consumption vs. MSF**
- **Lower corrosion risk due to lower operation temperature**
- **No contamination of distillate by leakage in the heat transfer surface.**
- **Faster response and flexibility in start-up and operation**

# Modular Plate Pack arrangements

Modular design to meet  
specific project  
performance requirements

Efficient and compact  
plate pack design in  
high grade titanium



# Plate mounting in vessel



Full Access to Heat  
Transfer Surfaces  
... if needed

# Main advantages - PHE design



- 1. Truly modular design**  
design for any capacity based on known conditions
- 2. High thermal efficiency**  
less volume & weight, compared to any other MED types
- 3. Best material against corrosion**  
Titanium Grade 1 evaporators and non-coated materials
- 4. Controlled thin falling film**  
avoiding dry spots, thereby avoiding scaling
- 5. Short residence time of media**  
faster process response for start-up and less scaling
- 6. Direct manual access to all surfaces**  
high flexibility and 100% capacity recovery after cleaning

# Alfa Laval Technology Added Value

High Reliability – Uptime

Low maintenance cost (Life Cycle Cost (LCC))

High quality non-coated materials (Titanium, AISI 316/Duplex)

*No Copper release to contamination of the distillate from CuNi materials*

Compact design

High water quality (Salinity below 5 ppm)

Automatic operation (PLC controlled)

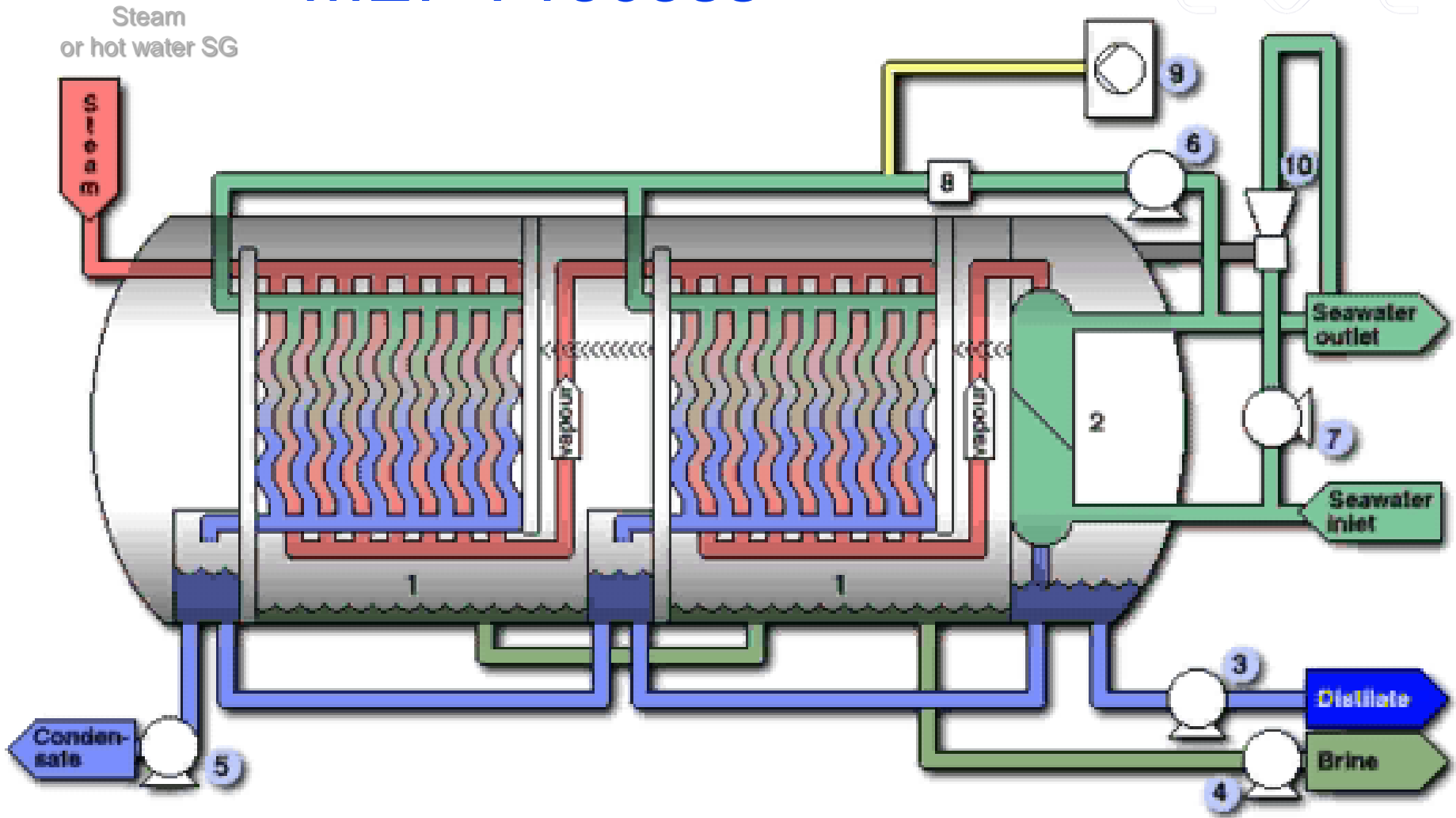
Local service available

Proven design / Extensive track record

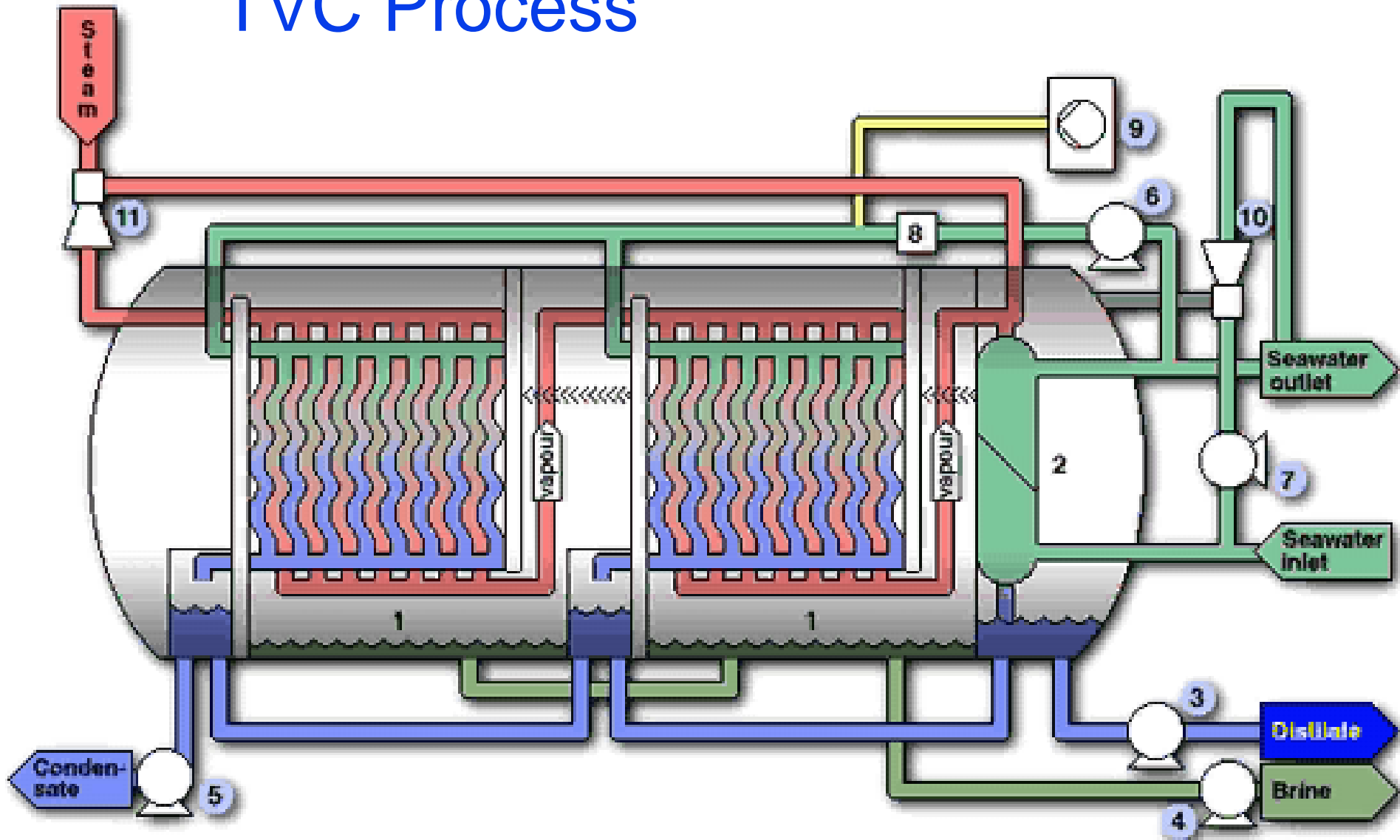
Minimized impact on marine life / environment

*Only one single anti-scale chemical, potable water production approved*

# MEP Process



# TVC Process



# Main Process - VVC

## Electrically Driven Units

- VVC: Vacuum Vapour Compression

# VVC units

- Based on Vacuum Vapour Compression technology
- Capacity: 20 - 70 m<sup>3</sup>/day “ORCA”  
300 - >1000 m<sup>3</sup>/day “VVC”
  - Water quality: TDS < 5 ppm
  - Fully automatic (PLC controlled)  
easy operation for start, stop, load control
- Plate technology combined with process control enables less frequent maintenance
  - Superior uptime ( > 95%)
- Energy efficient (11-18 kWh/m<sup>3</sup>\_freshwater)



# VVC units

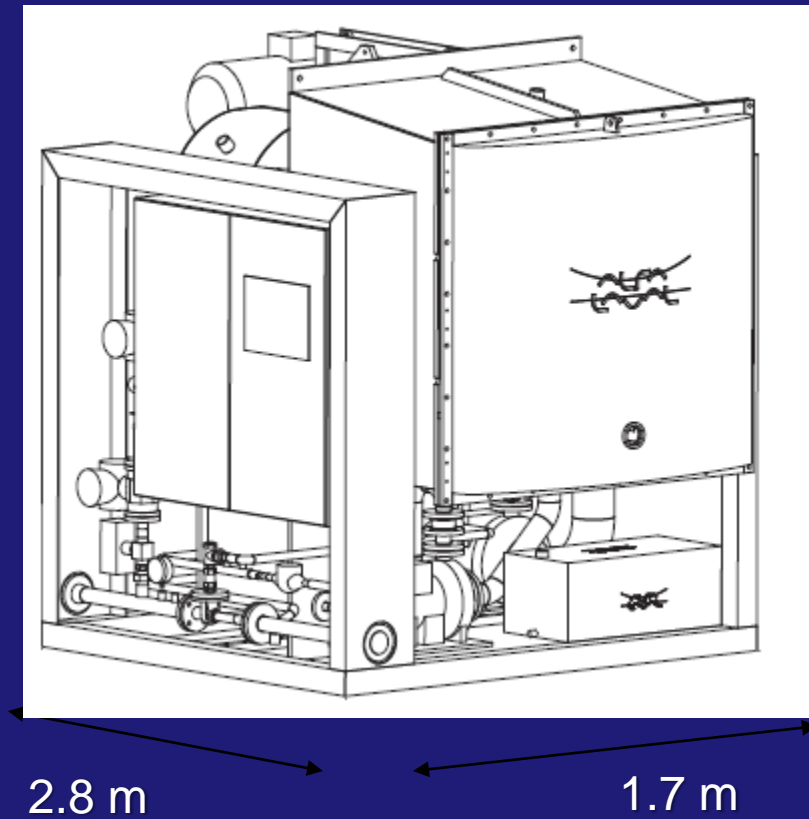
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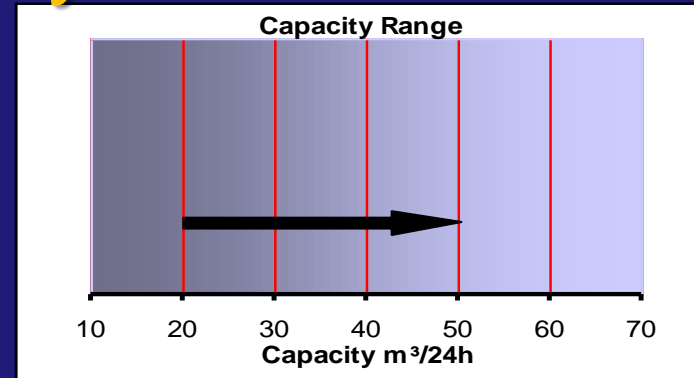
# ORCA Vessel internals



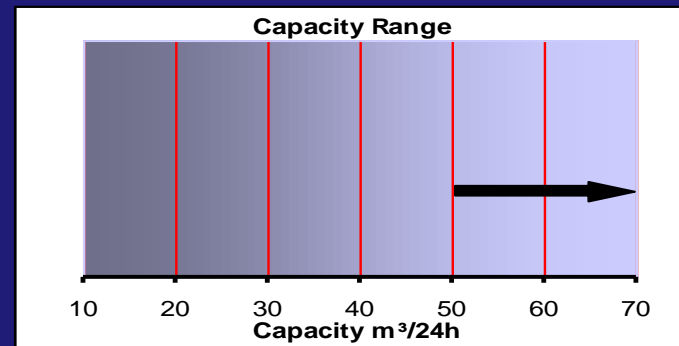
# "ORCA" VVC: Dimensions & capacity



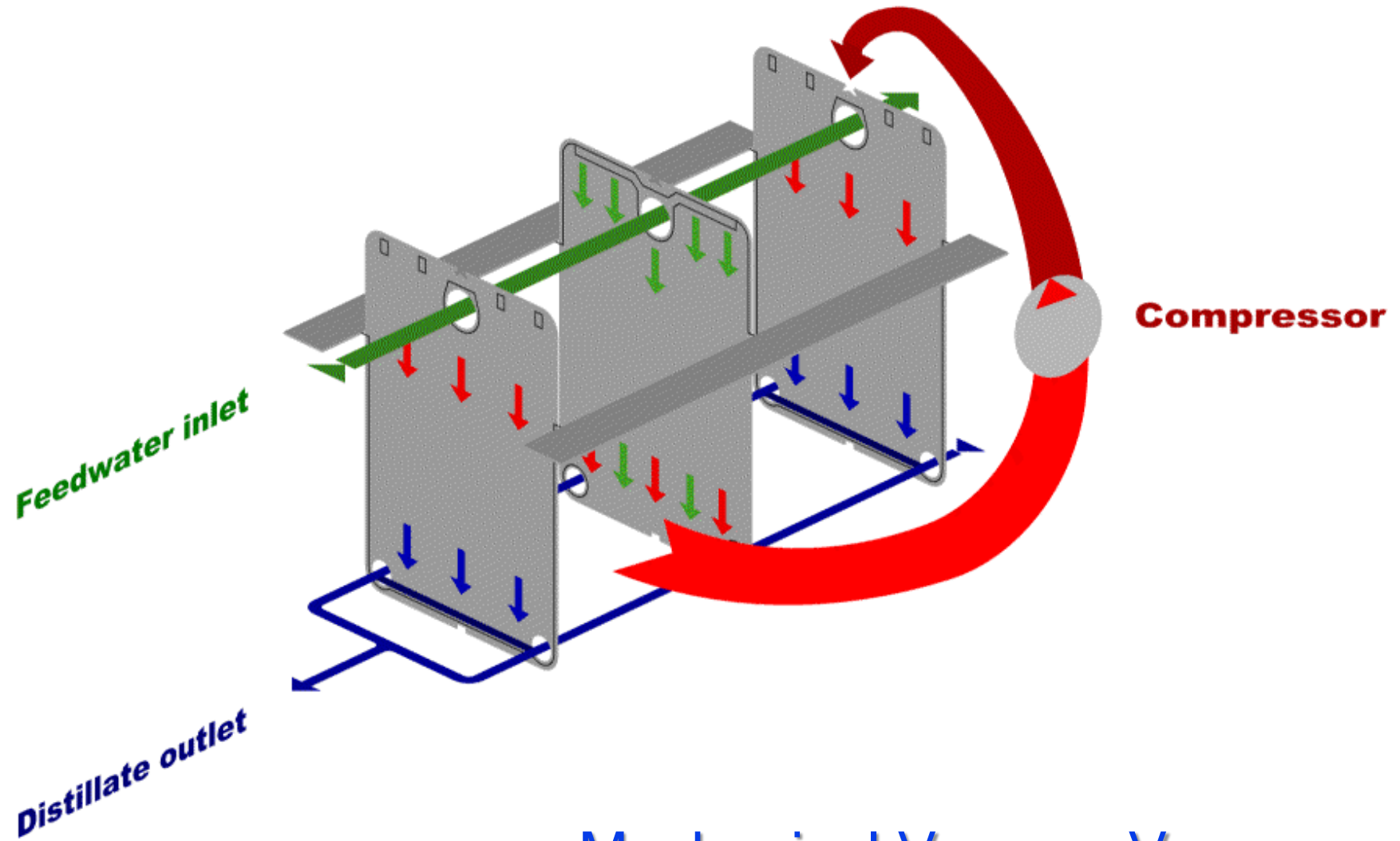
ORCA 20-50



ORCA 50-70



# VVC Process



Mechanical Vacuum Vapour  
Compression

# Itabo – Dominican Republic

## VVC-600; 600 m<sup>3</sup>/day + EDI Polisher

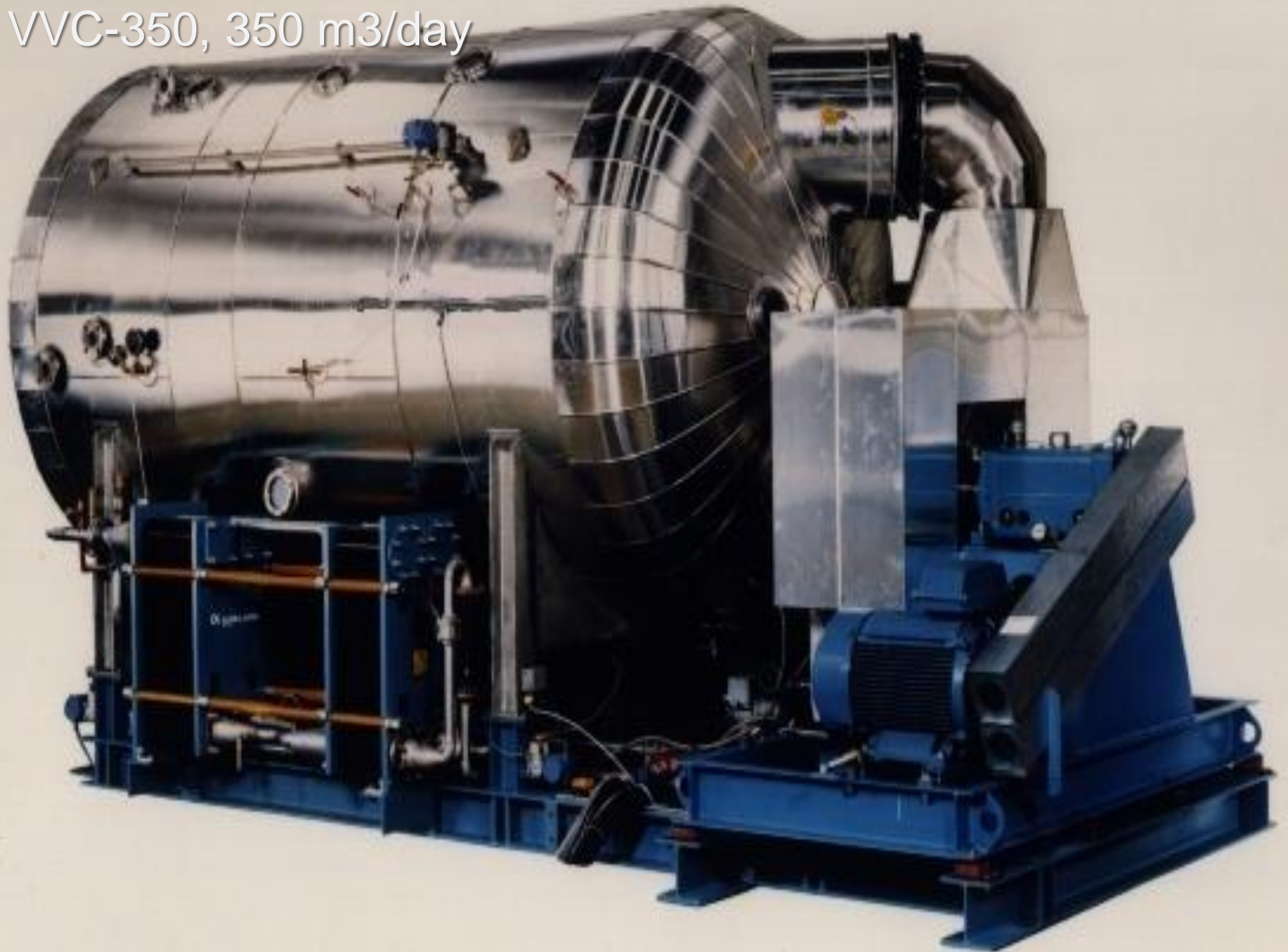


Two VVC 50 units build in Titanium  
for off-shore applications

 Alfa Laval

Oseberg Sør, Norway

Noumea, New Caledonia  
VVC-350, 350 m<sup>3</sup>/day



# Binzagr CoRo, Jeddah, Saudi Arabia

## VVC-350 and VVC-125: Total 475 m<sup>3</sup>/day



Binzagr CO-RO produce soft drinks and beverages using freshwater distilled from underground water, which has a higher salinity chemical complexity than the Red Sea



1995

# Semiri Crishi CCGT Power Plant by Edison, Italy VVC 400 year 2006



Installed 2006 as a second hand unit

# UTE CTCC Barcelona by TECNICAS REUNIDAS - and GE: GT PP for Gas Natural – 2xVVC-600 - 2009



# CFE Power Co. Mexico

## La Paz, Baja California Sur 2006 and 2013



### MVC installations:

- 2013: 1 unit type VVC-240
- 2005: 2 units type ORCA-60

# Kyushu Electric Power Co. Genkai Nuclear Power Station: VVC800 installed 2011



# Easy transport & installation



## Industrial Processing Plants



## Main applications

### Cargo and Cruise vessels

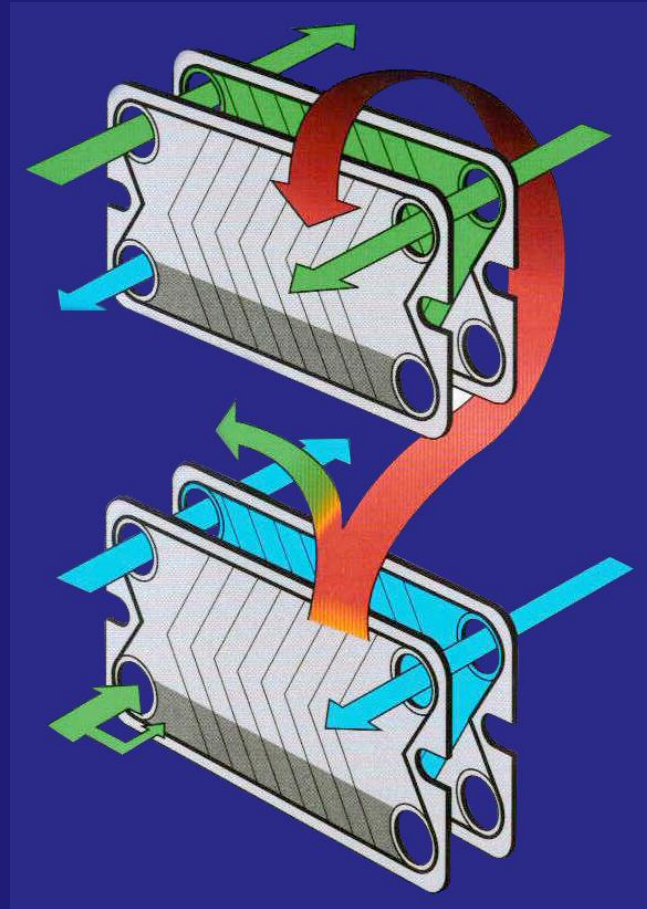


## Power Generation Plants



## Off-shore Drilling & Production

# Principle



- Controlled evaporation
- Use of waste heat
- Thermal efficient plate heat exchanger

# Multi Stage Flash (MSF)

- Operates with flash evaporation under vacuum over a number of stages
- The feed stream is heated to a temperature (e.g.  $> 90$  deg. C) higher than the evaporation temperature of the first stage, where it is released and some of the water evaporates instantly by “flashing”
- Then the water proceeds to the next stage which has a slightly lower pressure (temperature) and the flash process is repeated.
- The steam generated is lead to a combined feed water pre-heater and condenser were it condenses into pure water.
- As the carrier of energy is the feed water, the feed flow has to be rather high, for energy saving purposes brine recycling is often used.
- Requires external heat energy, 70-500 kWh/m<sup>3</sup>, EI: 3-7 kWh/m<sup>3</sup>
- Typical recovery: Sea Water / Feed Water: 10 - 15 %

# MED versus MSF (S&T)

Multiple Effect Distillation (MED)

is becoming state-of-the-art in thermal desalination

- **20-30 % lower capital investment compared to MSF**
- **50 % lower electrical power consumption vs. MSF**
- **Lower corrosion risk due to lower operation temperature**
- **No contamination of distillate by leakage in the heat transfer surface.**
- **Faster response and flexibility in start-up and operation**

# Scale



- Scale a natural phenomena in a desalination process
- Fouling will disturb the evaporation process and cause scale formation
- Soft scale can be removed by safe acid
- Hard scale require mechanical cleaning

# TYPES OF SCALING

## Soft Scaling

- $\text{CaCO}_3$
- $\text{MgOH}$  at pH 8,3
- $\text{Ca}(\text{HCO}_3)$

## Hard Scaling

- $\text{CaSO}_4$  (anhydrate)
- $\text{CaSO}_4$  ( $\frac{1}{2}$   $\text{H}_2\text{O}$  hemihydrate)
- $\text{CaSO}_4$  ( $2\text{H}_2\text{O}$  Gypsum)

# How to avoid Scaling ?

Four Factors influencing scale:

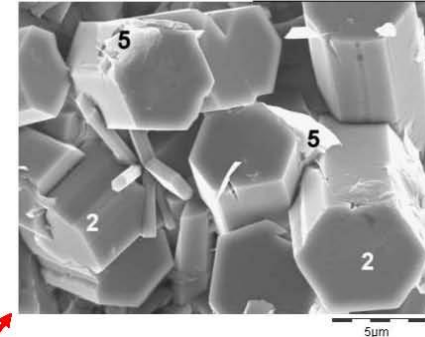
- CONCENTRATION
- TEMPERATURE
- RESIDENCE TIME
- NUCLEATION

# Problem of Scale Formation in MED Distillers

Scale formation in multiple-effect distillers (MED)

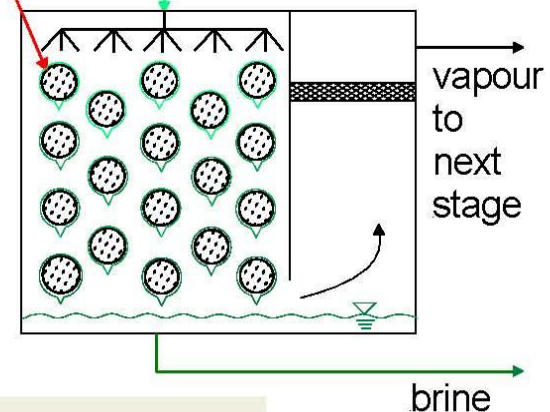
- hinders **heat transfer process**
- increases **specific energy consumption**
- reduces **production capacity**
- creates capital, operating and maintenance **costs** due to
  - allowance for scale formation by over-sizing heat transfer surface area
  - scale prevention methods, cleaning methods, production losses during plant shutdown
- is on the **outside of the tubes**
  - what prevents use of mechanical cleaning methods such as ball cleaning system

➔ **Essential to incorporate effective scale control technique**



scale on the outside of the tubes

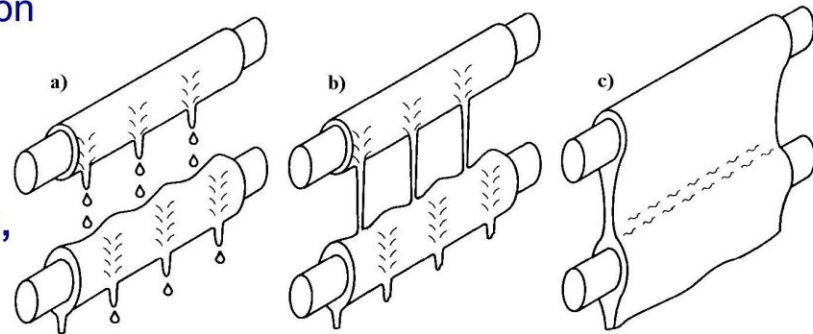
seawater



# Importance of the Wetting Rate

## Critical design parameter

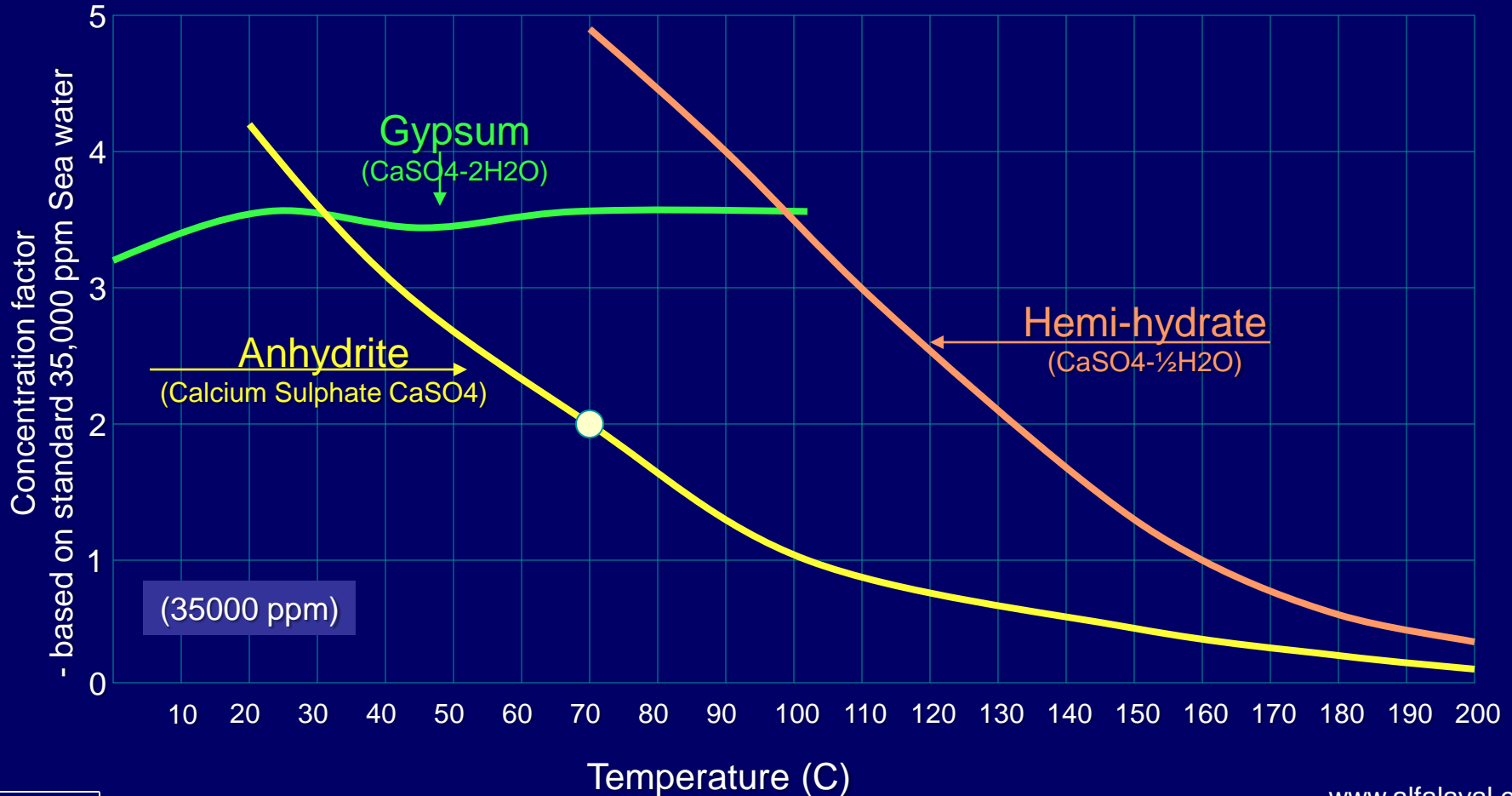
- Complete coverage of tube surface with water or **breakdown of thin film (dry patches)**
- **Film thickness** and flow regime on tubes (**laminar, laminar wavy, turbulent**)
- Pattern of liquid flow between adjacent tubes (**droplet dripping, liquid jets, liquid sheets**)
- **Heat transfer, required area**
- **Tube bundle design**
- **Scale formation**
- **Capital cost of a plant**
- **Operational flexibility**



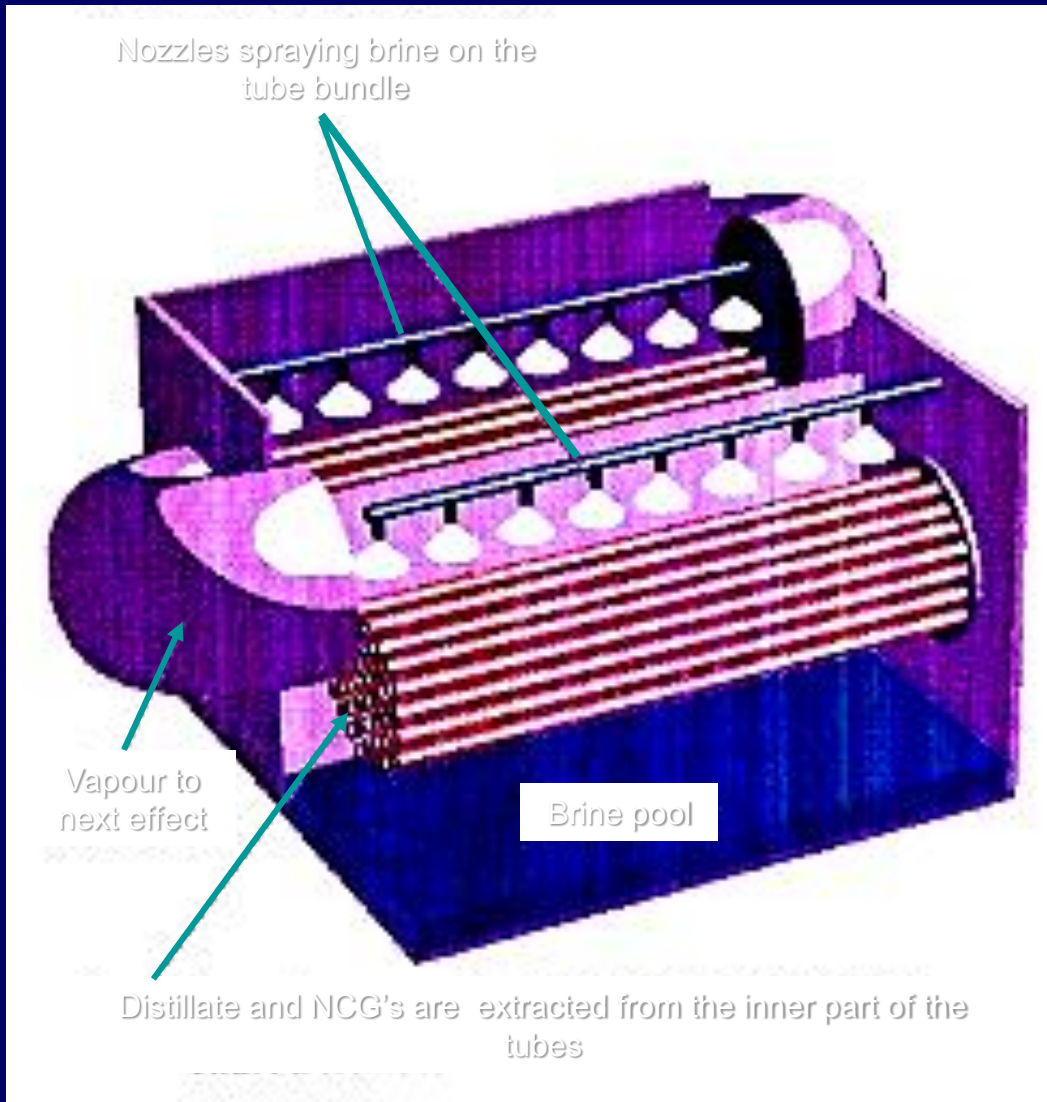
# Hard scaling

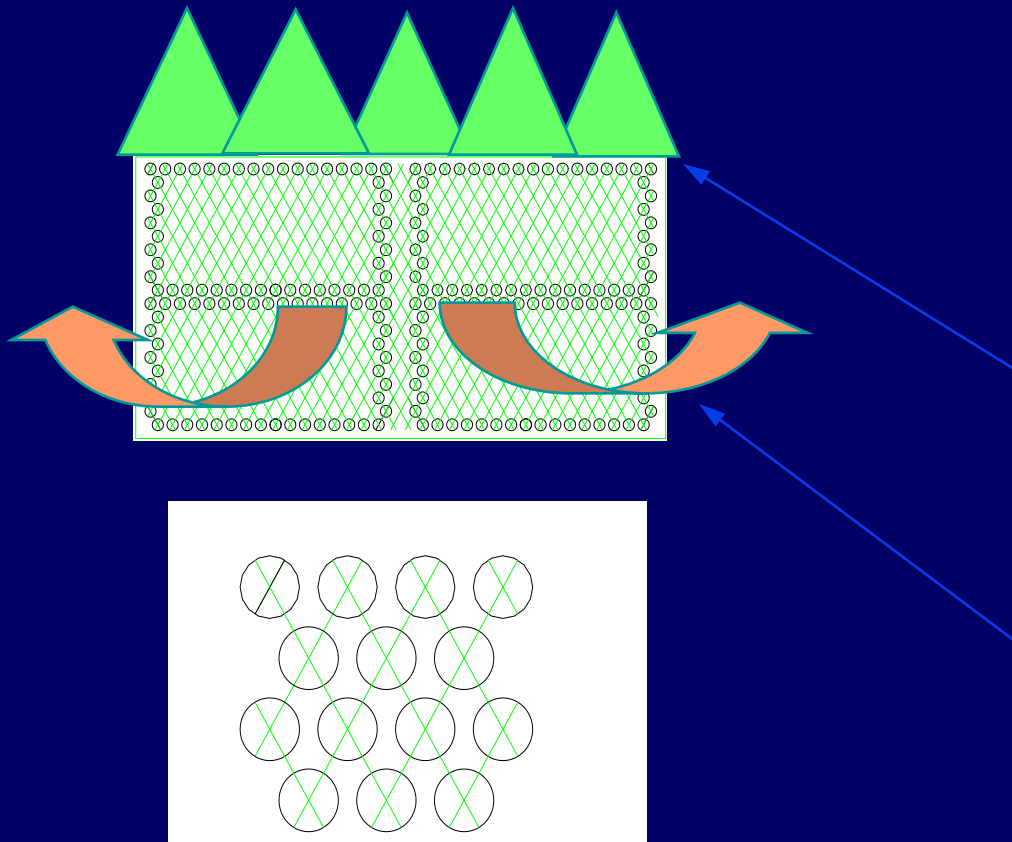


## Solubility Limits for Calcium Sulphates derivatives of Gypsum



# Horizontal Tube Falling Film (HTFF) Configuration





In the HTFF configuration has make-up losses due to :

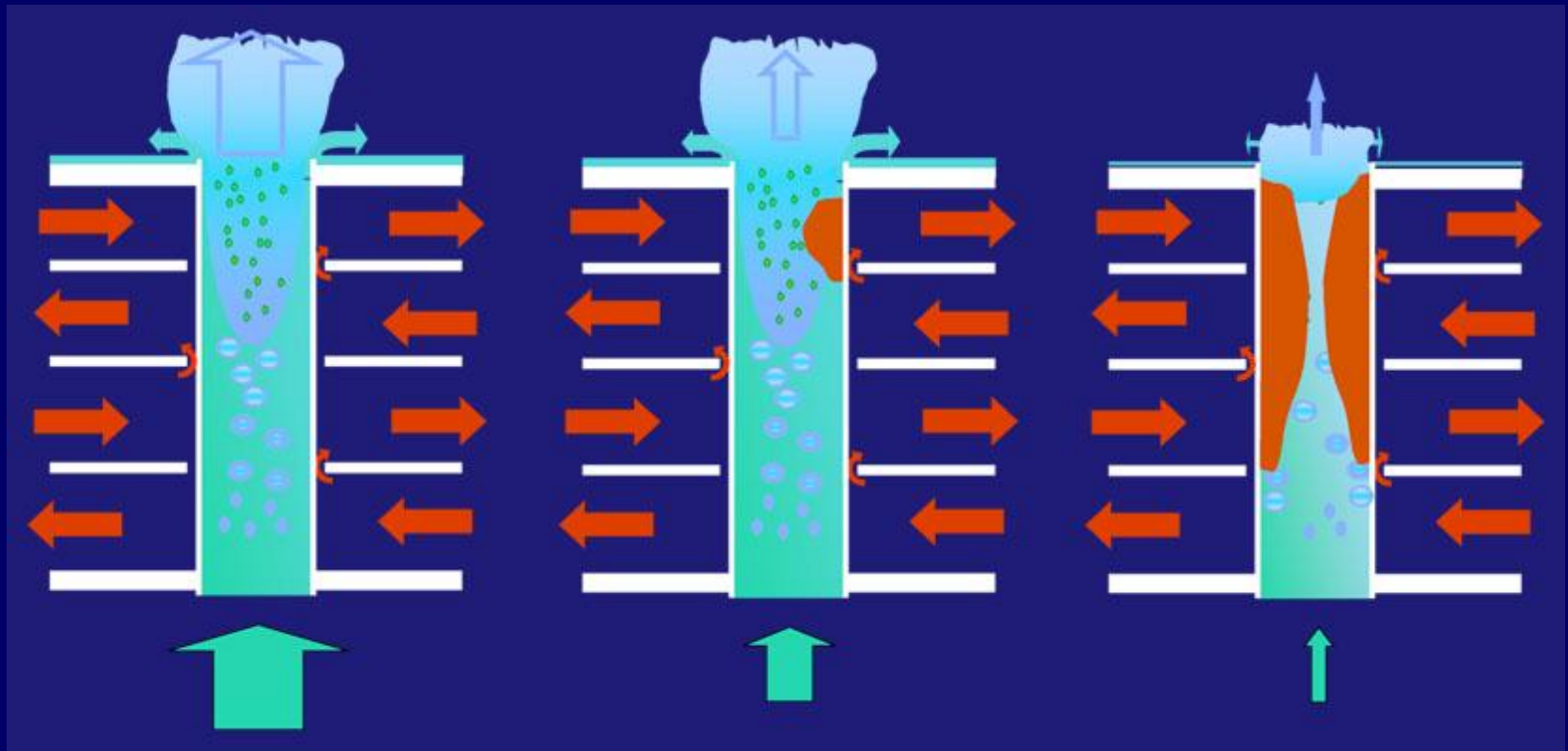
“over spray”

and

“reflection”

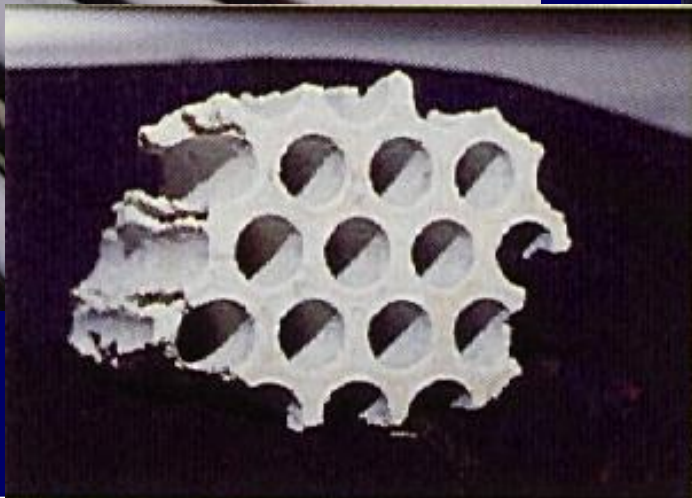
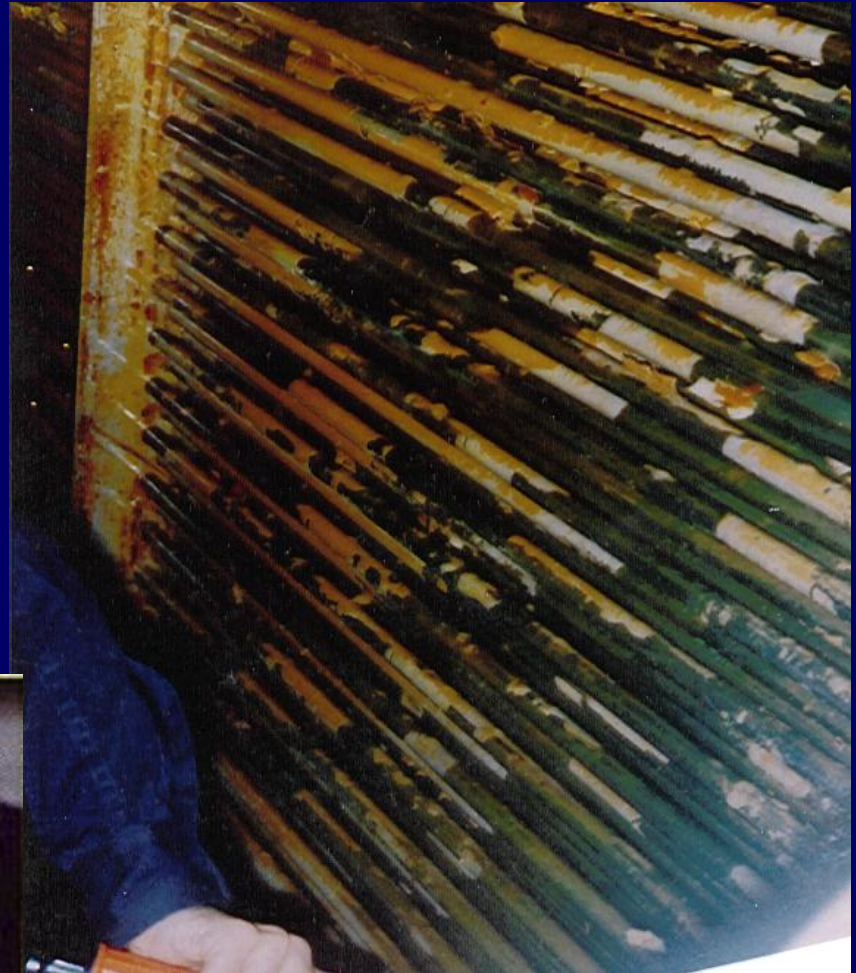
Resulting in localised over concentration

# Scale building up

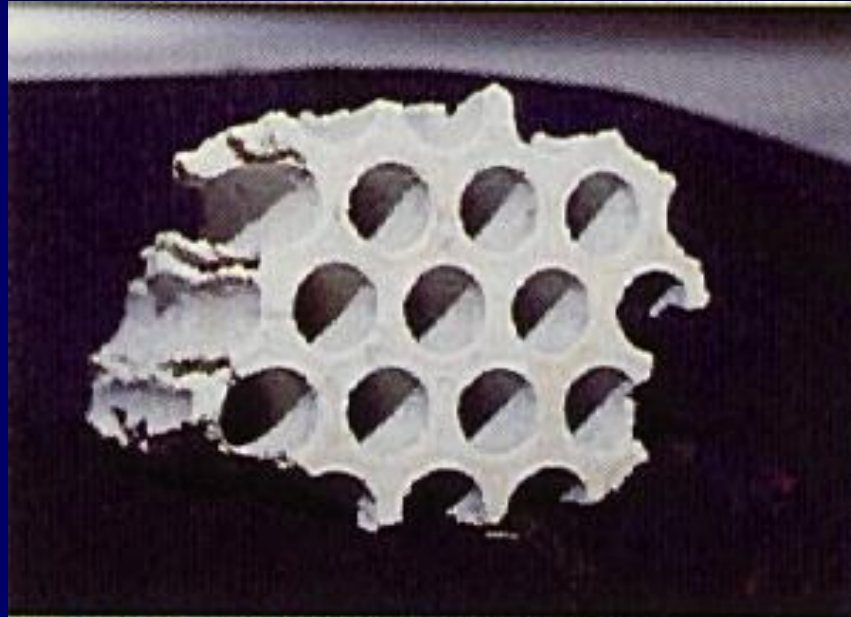


Scale is CaSO<sub>4</sub> on HTFF

Result of 8 hours of CIP with Na-EDTA followed by thermal shock



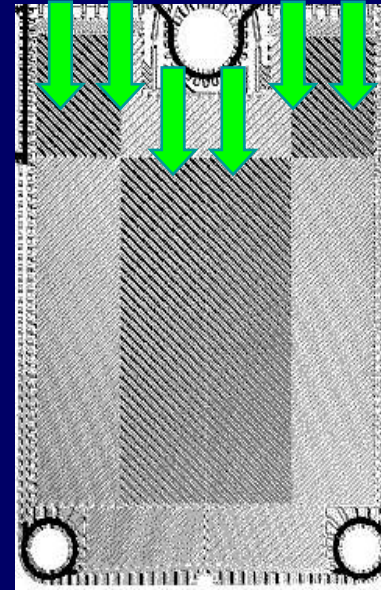
# CaSO<sub>4</sub> scale on HTFF MED



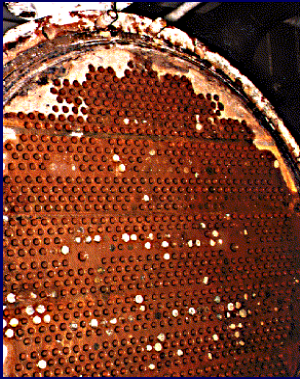
# Controlled Falling Film to avoid scaling



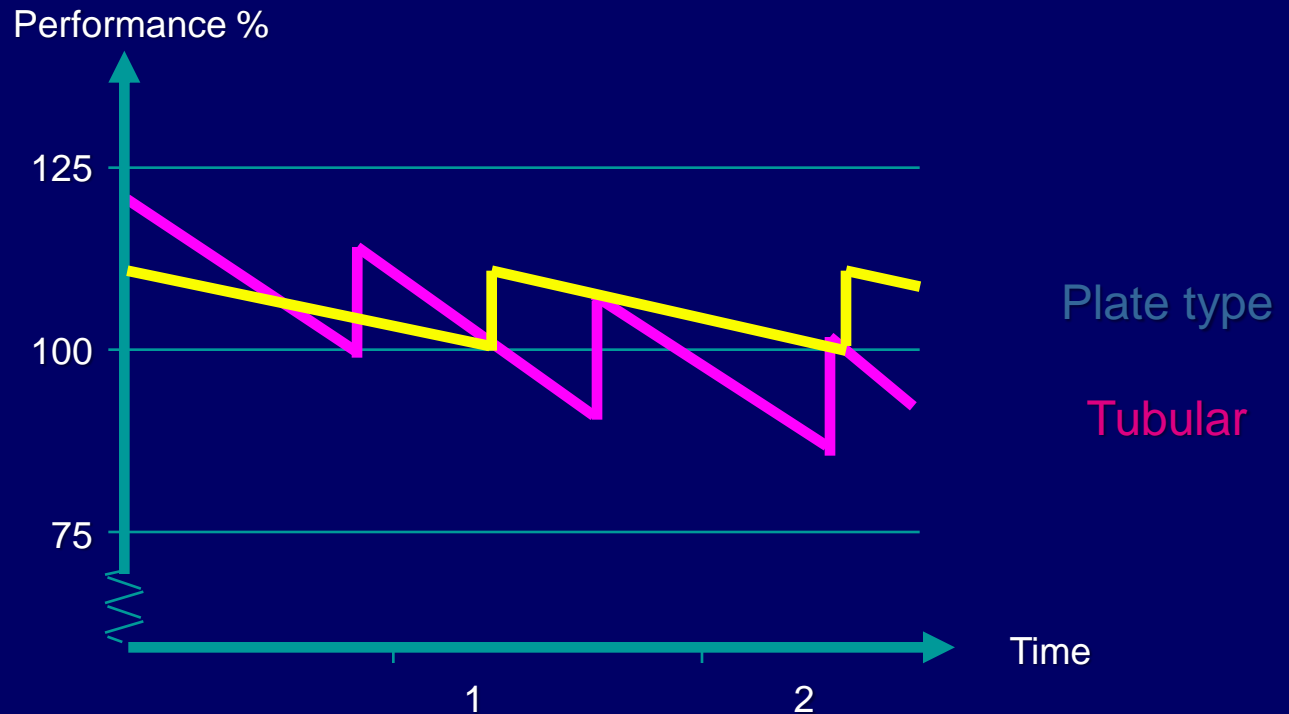
- Integrated seawater distribution for each individual plate evaporator channel with distribution part
- Even and controlled falling film in contact with the entire heat transfer surface to ensure high thermal efficiency
- Uninterrupted wetting surface to avoid risk of localized super-concentration and dry spots, i.e. reduced risk of scaling



# Performance through time



Alfa Laval Plate type evaporators can be cleaned 100%  
Tubular evaporators gradually decrease performance of capacity and efficiency (GOR) because of “irreversible” scaling/fouling



CIP cleaning can remove alkaline soft scaling, and hard scaling can also be removed 100% in a PHE type desalination unit. [www.alfalaval.com](http://www.alfalaval.com)

# Maintenance

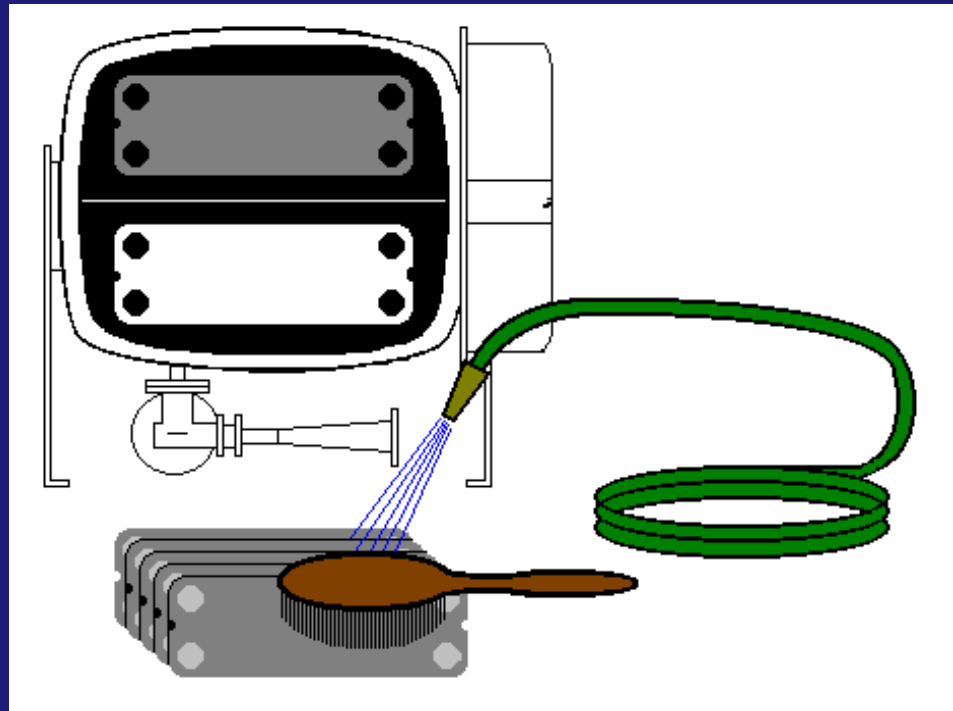


# Cleaning

Open the cover

Remove all  
condenser Plates

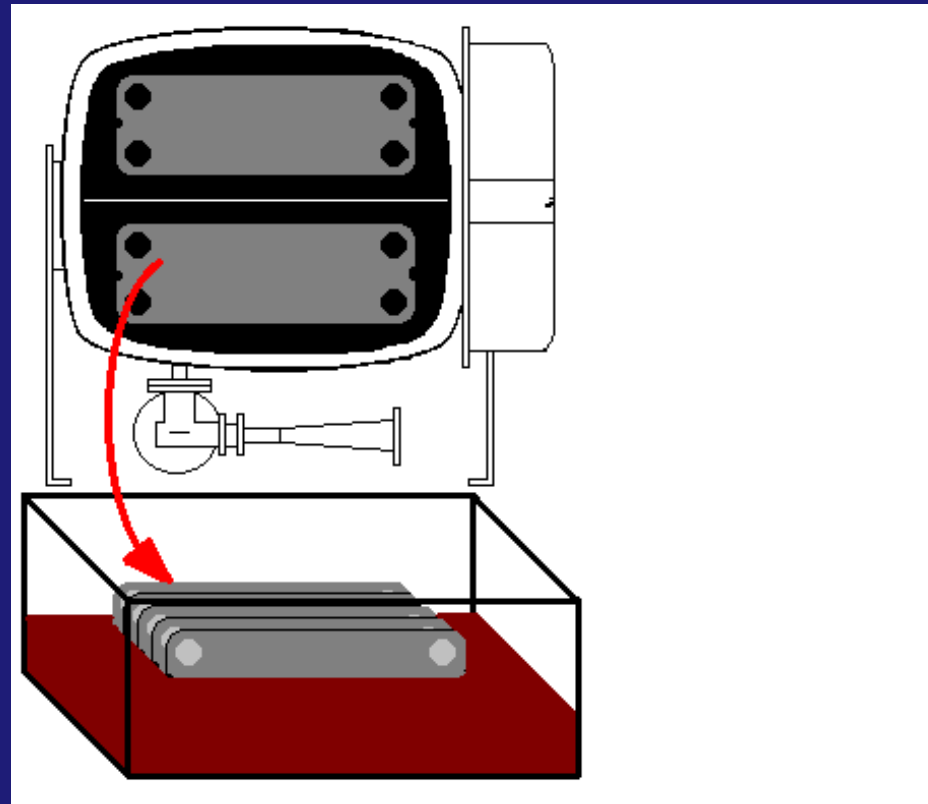
Rinse in fresh water  
and clean with soft  
bristle brush



# Cleaning

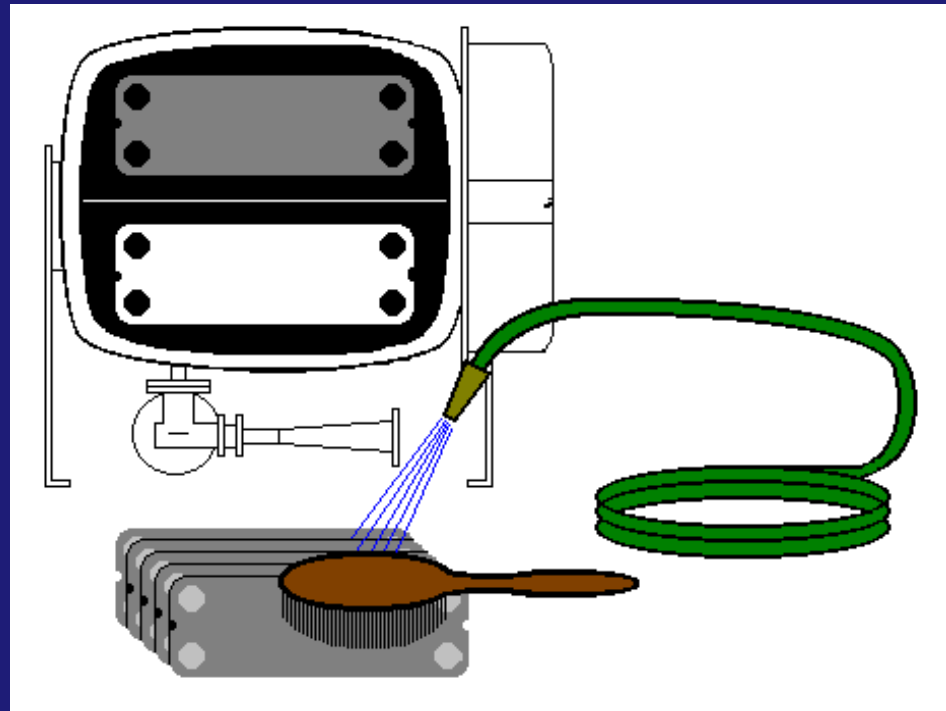
**Remove all  
evaporator plates  
and shake off heavy  
deposits**

**Soak in inhibited  
sulfamic acid for 2 to  
4 hours**



# Cleaning

Rinse with fresh  
water



# Plate mounting in vessel



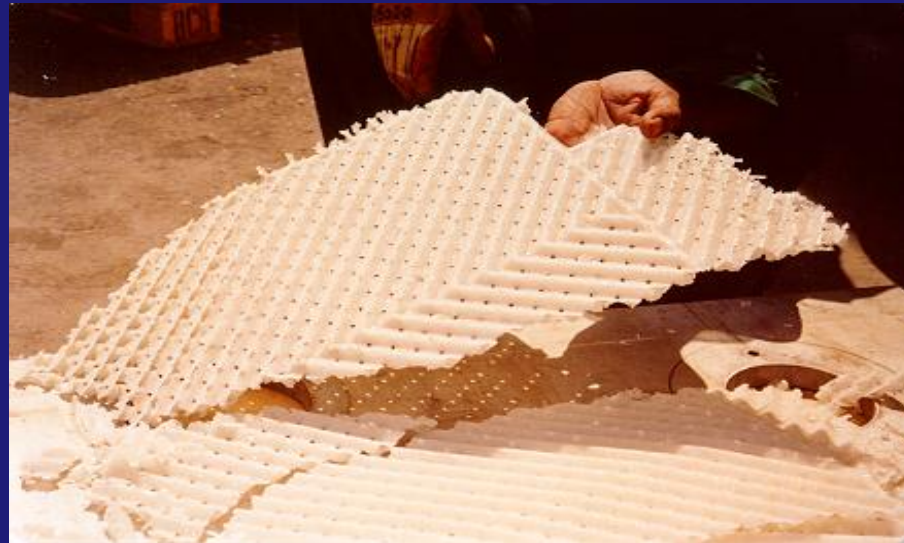
Full Access to Heat  
Transfer Surfaces  
... if needed

# Controlled scaling TEST



NORMAL cleaning: CIP cleaning 1-2 times per year  
Manual opening & cleaning after 9-12 years of operation

TEST of manual cleaning:  
Pieces of Hard Scaling formation is easily removed if needed

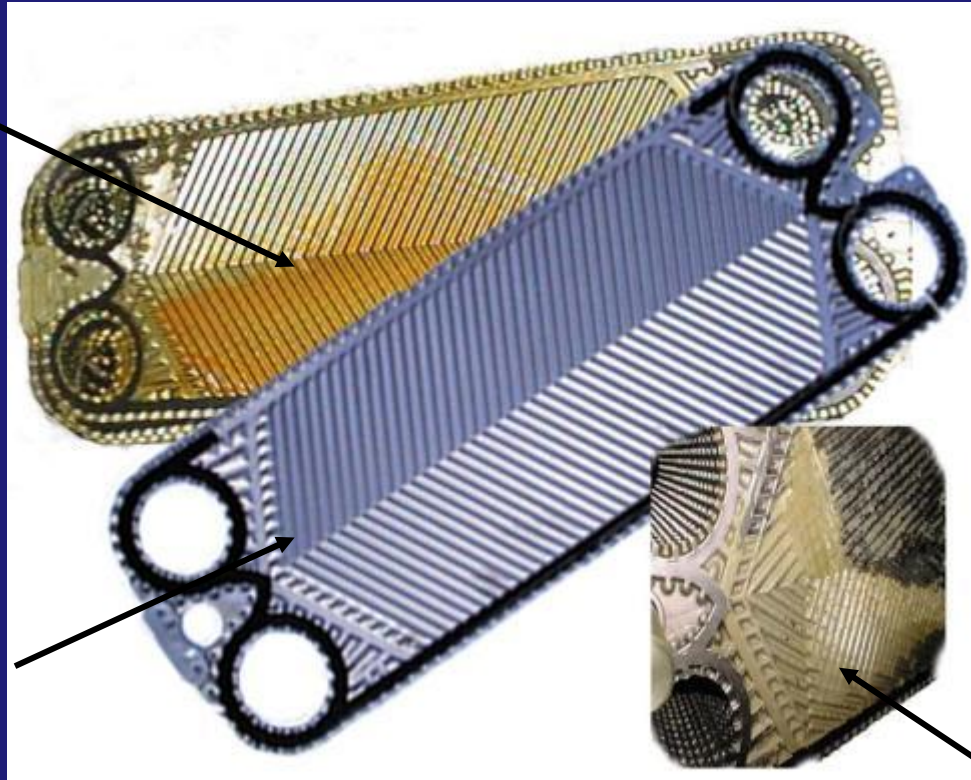


Operator holding calcium sulphate scaling removed in one piece  
after test by deliberate forced over-concentration for TEST of cleaning

# De-scaling

## Plate heat exchanger

Fouling and soft scale



After cleaning  
in safe acid  
bath

Hard scale is easy  
removed on an  
open surface

# CIP with Acid to remove soft scale

- Soft scaling is removed by acid cleaning (CIP = Clean In Place) with an Inhibited Sulfamic Acid solution of 4-6% at 50 deg. C (eg. SAF ACID). pH approx. 1,1 mix with clean fresh water.
- Stronger Acids should NOT be used to avoid corrosion damages!
- IMPORTANT: The Sulfamic Acid must be inhibited, otherwise it will corrode the metal parts.
- Inhibited Sulphamic Acid is an acidic powder with a sulphamic acid base and a corrosion inhibitor which protects the metal surfaces from corrosion during the acid cleaning process.

# CIP cleaning with Sulfamic Acid

1. When adding the acid, the immediate pH value measured is approx. 1 - 1,1 (pH value of the 6% acid solution).
2. Due to the dissolvment of the scale (i.e. a more alkaline solution as most basic salts) the pH value will increase gradually.
3. When the pH value has increased to 2,5 - 3, then more inhibited Sulfamic Acid can be added (max. 3 times totally).
4. If the pH value still increase to 2,5-3, then the acid solution must be replaced with a new inhibited Sulfamic Acid solution.
5. When the pH value no longer increase, then this cleaning procedure is finished.