

Multiple Effect Distillation

Processes for Sea
Water Desalination



WATER TECHNOLOGIES

The technology

SIDEM / ENTROPIE is the world leader in sea water desalination through low temperature distillation processes such as:

- Multiple Effect Distillation (MED)
- Multiple Effect Distillation with Thermal Vapour Compression (MED-TVC)
- Multiple Effect Distillation with Mechanical Vapour Compression (MED-MVC)

BASICS ON THE MED PROCESS

An MED evaporator consists of several consecutive cells (or effects) maintained at decreasing levels of pressure (and temperature) from the first (hot) cell to the last one (cold). Each cell mainly consists in a horizontal tubes bundle. The top of the bundle is sprayed with sea water make-up that flows down from tube to tube by gravity (see sketch 1).

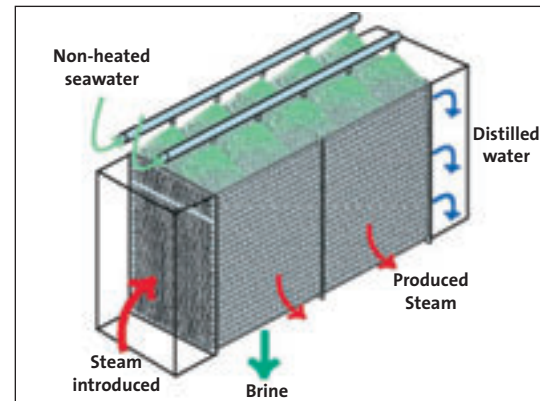
Heating steam is introduced inside the tubes. Since tubes are cooled externally by make-up flow, steam condenses into distillate (fresh water) inside the tubes. At the same time sea water warms up and partly evaporates by recovering the condensation heat (latent heat). Due to evaporation sea water slightly concentrates when flowing down the bundle and gives brine at the bottom of the cell. The vapour raised by sea water evaporation is at a lower temperature than heating steam. However it can still be used as heating media for the next effect where the process is repeated. The decreasing pressure from one cell to the next one allows brine and distillate to be drawn to the next cell where they will flash and release additional amounts of vapour at the lower pressure. This additional vapour will condense into distillate inside the next cell.

This process is repeated in a series of effects (Multiple Effect Distillation) (see sketch 2 with 3 effects). In the last cell, the produced steam condenses on a conventional shell and tubes heat exchanger. This exchanger, called “distillate condenser” is cooled by sea-water. At the outlet of this condenser, part of the warmed sea-water is used as make-up of the unit, the other part is rejected to the sea. Brine and distillate are collected from cell to cell till the last one from where they are extracted by centrifugal pumps

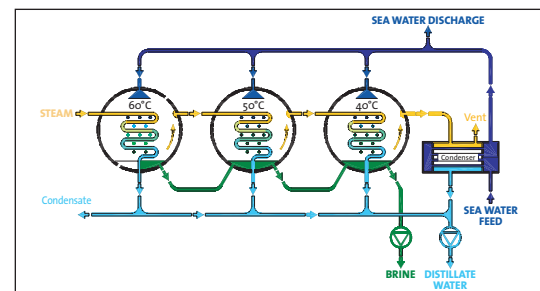
The thermal efficiency of such evaporator can be quantified as the number of kilos of distillate produced per one kilo of steam introduced in the system. Such number is called the **Gain Output Ratio (GOR)**.

The GOR of the evaporator in sketch 2 can be enhanced by addition of a thermo-compressor between one of the cells and the hot one. Using LP or MP steam this static compressor will take part of the vapour raised in one of the cells and recycle it into higher pressure vapour to be used as heating media for the first one. **Sketch 3** shows the typical arrangement of an MED evaporator with thermocompression (**MED-TVC**). Whereas the GOR of the evaporator in sketch 2 would be in the range of 3 (using LLP steam) the GOR of sketch 3 would rather reach 6 (using LP or MP steam).

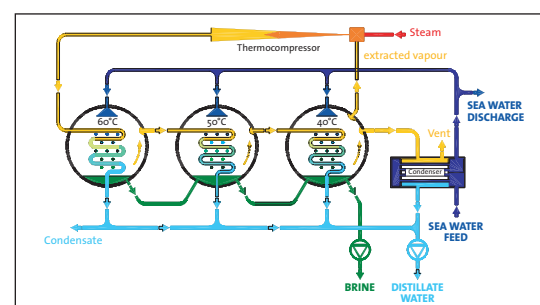
When no steam is available, it is still possible to use the MED process with a Mechanical Vapour Compressor (**MED-MVC**). In such case the vapour is recycled from the cold cell to the hot one by means of a centrifugal compressor driven by an electrical engine (**Sketch 4**). The electrical consumption of such system is in the range of 8 to 15 kWh/m³. Due to current limitation in compressors technology the maximum capacity of MED-MVC units is 5000 m³/day.



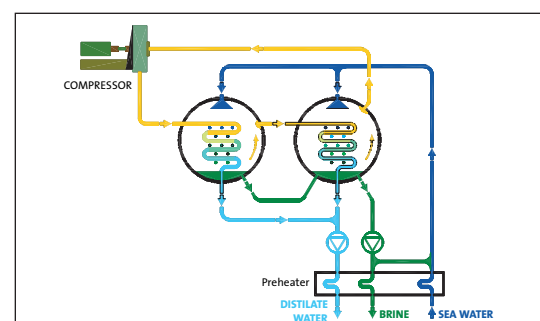
Sketch 1



Sketch 2



Sketch 3



Sketch 4

Advantages of the MED processes

MED & MED-TVC

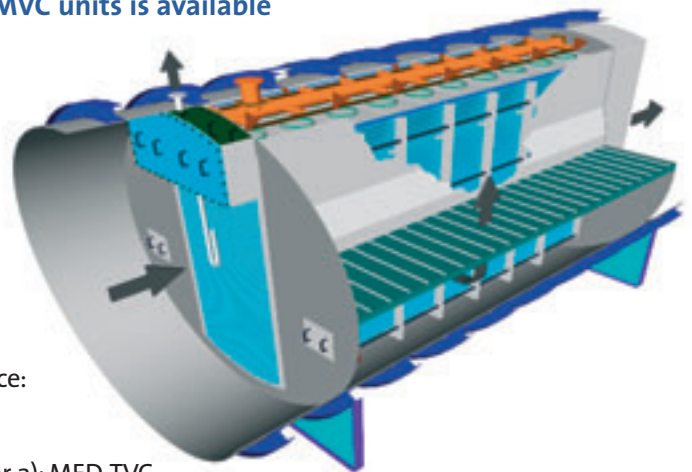
- > **Very low electrical consumption (1.5 kWh/m³)** compared to other thermal processes such as Multi Stage Flash (MSF) or membrane processes (Reverse Osmosis)
- > **Operate at low temperature (< 70C°) and at low concentration (<1.5)** to avoid corrosion and scaling
- > **Produce steadily high purity distillate**
- > **Do not need complex pre-treatment of sea water and tolerant to variations of sea water conditions**
- > **Are highly reliable and simple to operate**
- > **Reduce civil works cost** thanks to reduced foot print
- > **Are simple to install** with the packaged unit mounted on skids and delivered ready for use, after simple installation
- > **Have a low maintenance cost** (No rotating parts except low pressure pumps)
- > **Operate 24 hours a day with minimum supervision**
- > **Ideal for coupling with power plants**, steam can be used at any pressure from 0.35 to 40 bar abs
- > **Can be adapted to any heat source** including hot water
- > **Allow very high thermal efficiencies and savings in fuel costs**
- > **Range up to 15 MIGD (68 000m³/day)**

MED-MVC

- > **Range up to 5000 m³/day**
- > **Are environmentally clean:** 100% electrical process (no external heat source)
- > **Have high energy efficiency:** electrical energy consumption ranging from 8 to 15 kWh/m³
- > **Sea water consumption is reduced** with only make up water necessary

Characteristics of SIDEM-ENTROPIE MED design

- > Water spray through large opening nozzles or dismantable perforated plates:
 - Better water distribution - No risk of plugging
 - Allows final degasing of sea water
- > Low vapour velocities:
 - Low pressure losses
 - Better quality of distillate (< 2 ppm TDS)
- > Knitted stainless steel wire high efficiency demisters
- > Tubes expanded in tube plates: guarantee of a constant purity of distillate
- > Easy access to the evaporator internals
- > High quality selected materials
- > Factory assembled and tested (for capacities <2500 m³/day) on skid, with all auxiliaries, so that installation on site is minimized
- > A complete range of standard MED-TVC and MVC units is available up to 3000 m³/day.



ENERGY SOURCES FLEXIBILITY

MED can be powered by almost any kind of heat source:

- > Very low Pressure (LLP) steam (0,35 to 1 bar a): MED
- > Low or medium Pressure (LP or MP) steam (over 2 bar a): MED-TVC
- > Hot water sources above 60°C: MED
- > Electricity: MED-MVC

Steam or heat is available from:

- > Steam turbines
- > Gas turbine power plants (open and combined cycle)
- > Diesel generators
- > Heat recovery on flue gas cleaning and waste incinerators
- > Heat recovery on exothermal industrial processes
- > Geothermal waters

SIDEM-ENTROPIE

standard MED materials list

EVAPORATOR CELLS

Shell and tube plate:	316 L or Duplex SS
Tubes:	
Upper rows:	Titanium grade 2 SW 0.4 mm th. or 90/10 Copper Nickel 1 mm th.
Other rows:	Aluminium Brass 0.7 mm th. or Cu-Ni 90/10 0.7 mm th.
Vapour boxes:	316 L or Duplex SS
Demister:	316
Spraying plates:	316 L or Duplex SS
Spray nozzles:	Polypropylene

SEA WATER, BRINE, DISTILLATE AND CONDENSATE PUMPS

Impeller:	ASTM A351 CD4 MCu (or CF3M for distillate and condensate)
Casing:	ASTM A351 CD4 Mcu (or CF3M for distillate and condensate)

CONDENSER AND PREHEATERS

Shell and tube plates:	316 L or Duplex SS
Tubes:	Titanium grade 2 SW 0.4 mm th. or 90/10 Copper Nickel 1 mm th.
Water boxes:	316 L or Duplex SS

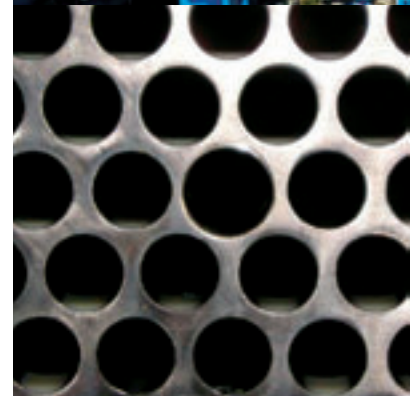
VACUUM SYSTEM CONDENSERS

Shell & tube plates:	316 L or Duplex SS or High Grade SS
Tubes:	Titanium grade 2 SW 0.4 mm th. or 90/10 Copper Nickel 1 mm th.
Water boxes:	316 L or Duplex SS

EJECTORS

Thermocompressors:	316 L or Duplex SS
Vacuum ejectors:	316 L or Duplex SS or High Grade SS

Other materials can be proposed on case by case basis.



Industrial references

The high purity of produced water (<2 ppm TDS) allows for direct use in industrial applications, with or without minor polishing. These industrial applications include the production of boiler feed water, process water and water for closed loop cooling systems for the following industries:

- > Cement Plants
- > Petrochemical Complexes
- > Oil Refineries
- > Mining Applications and Mineral Processing Plants
- > Methanol Plants
- > LNG Plants
- > Sugar Refineries
- > Power Plants
- > Chemical Plants



Capacity: 2 x 216 m³ product water per day

MVC Process

- > Client: JV Kellogg, Technicas Reunidas & JGC
- > Site: Damietta (Egypt)
- > Number of cells: 1
- > End user: Segas Egypt LNG
- > Contract date: September 2002

MED-TVC Process

- > Client: Technip & Snamprogetti
- > Site: Oman
- > Number of cells: 2
- > Top brine temperature: 70°C
- > End user: Omifco fertilizer complex
- > Contract date: September 2003



Capacity: 3 x 2 400 m³/d



Capacity: 1 440 m³/day

MED-TVC Process

- > Client: Man Ferrostaal
- > Site: GL2Z Arzew (Algeria)
- > Number of cells: 2
- > End user: Sonatrach
- > Application: Petrochemical
- > Contract date: 2003

In the case where potable water is required, the pure product water can be blended with raw water in order to achieve adequate potable water at low price. If necessary a remineralisation plant can be included in the package.



Capacity: 4 x 12 300 m³/d

MED-TVC Process

- > Client: Technip
- > Site: Coke Calcining Plant in Bahrain
- > Number of cells: 4
- > GOR: 7,5
- > Application: distillate for boiler feed and potable water
- > End user: Aluminium of Bahrain
- > Year of contract: June 1999

MED-TVC Process

- > Client: Hitachi
- > Site: Peru
- > Number of cells: 2
- > Top brine temperature: 70°C
- > Application: Power station
- > End user: Enersur
- > Contract date: December 1997



Capacity: 2 x 1 300 m³/day



Capacity: 2 x 2 500 m³/day

MED-TVC Process

- > Client: YANBU CEMENT Co
- > Site: YANBU CEMENT Complex (Saudi Arabia)
- > Number of cells: 4
- > Top brine temperature: 66°C
- > Application: Cement factory
- > End user: Yanbu cement
- > Contract date: December 1994

Municipal references

The low electrical consumption, the high reliability and simplicity of operation together with its ability to be efficiently combined with power production make MED a first choice for large desalination plant producing drinking water for municipal applications.

The following references are a few examples of MED successes over the past few years.



MED-TVC Process

- > Client: TPL Italia
- > Site: Trapani (Sicily)
- > Number of cells: 12
- > End user: Sicilacque, for Sicily Region
- > Contract date: 1990
- > Particulars: the largest MED plant in the world when built in 1992. GOR 16,3.

MED-TVC or MED Process

- > Client: AQUALECTRA (formerly KAE)
- > Site: Curacao Island
- > Number of cells: 12
- > Contract date: 1994
- > Particulars: In winter the unit is driven by 2,45 bar abs LP steam at the thermocompressor nozzle (GOR 13,4). In summer it is fed by 0,35 bar abs LLP steam to cell 1 (GOR 9,8).





Capacity: 3 x 13 330 m³/day

MED-TVC Process

- > Client: General Electric Company of Libya (GECOL)
- > Site: Tobruk (Libya)
- > Number of cells: 6
- > Contract date: 1997
- > Particulars: The first large MED plant in Libya for municipal application. GOR 9,75.

MED-TVC Process

- > Client: Abu Dhabi Water and Electricity Authority (ADWEA)
- > Site: Umm Al Nar Power Station (Abu Dhabi)
- > Number of cells: 6
- > Contract date: 1998
- > Particulars: Fed with 2,75 bar abs LP steam recovered from the power plant. A steam transformer is used to keep distillate free from any hydrazine contamination. GOR 7,9.



Capacity: 2 x 16 500 m³/day



Capacity: 2 x 22 700 m³/day

MED-TVC Process

- > Client: Sharjah Electricity and Water Authority (SEWA)
- > Site: Layyah Power Station (Sharjah UAE)
- > Number of cells: 5
- > Contract date: 1999
- > Particulars: Combined with the power plant, these units are fed with MP steam at 16 bar abs through a steam transformer. GOR 8,4.

Municipal references

MED-TVC Process

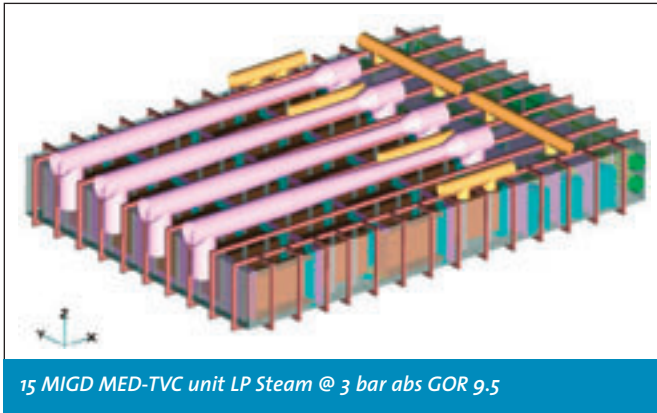
- > Client: Total Tractebel EPC Company
- > Site: Taweelah Power and Desalination Plant (Abu Dhabi - UAE)
- > Number of cells par unit: 6
- > Contract date: 2000
- > Particulars: Fed with 2,75 bar abs LP steam recovered from the power plant through steam transformers (GOR 8). The largest MED plant in the world with 240 000 m³/day.



MED-TVC Process

- > Client: Sharjah Electricity and Water Authority (SEWA)
- > Site: Layyah Power Station (Sharjah UAE)
- > Number of cells: 5
- > Contract date: January 2005
- > Particulars: Combined with the power plant this unit is fed with MP steam at 16 bar abs through a steam transformer (GOR 8,4). The largest MED unit in the world with a compact design that allows this 8 MIGD MED-TVC unit to fit into the space allocation of a 5 MIGD MSF plant.

The future of MED technology



R&D efforts towards the increase of MED units capacities have resulted in the key technologies being available for large plant such as 15 MIGD per single unit.

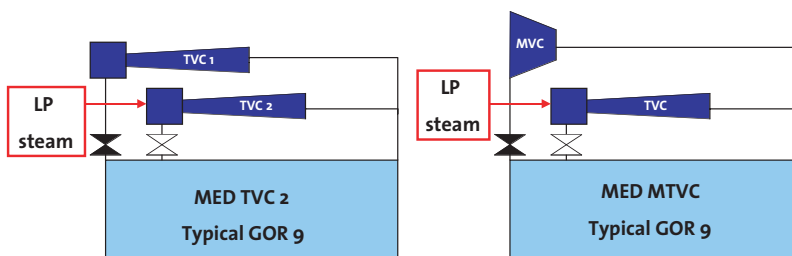
The basic design beside shows the outlook of such plant:

In addition MED-TVC allows unparalleled **flexibility** when combined with power plants thanks to the **HYBRID MED concept**. This concept provides two types of MED units:

- The MED-TVC2 can be fed with two types of steam pressure depending on the load factor of the power plant. When electrical demand is high a lot of LP steam is available, when it is low the steam extracted from the turbines is a limited quantity of MP steam.
- The MED-MTVC units can be driven by LP steam during high electrical demand, and with electrical power when electrical demand is low. Such unit provides a mechanical vapour compression system to be installed in parallel with the LP thermocompressor.

An HYBRID MED system can use both types of units or one only, in all cases it brings very important savings on the production cost of fresh water.

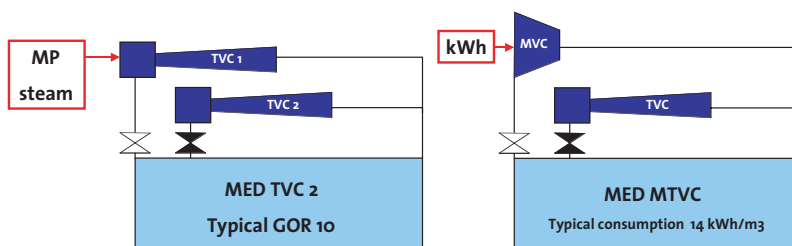
HYBRID MED in summer mode



TVC : Thermal Vapour Compressor

MVC : Mechanical Vapour Compressor (Industrial Fans System)

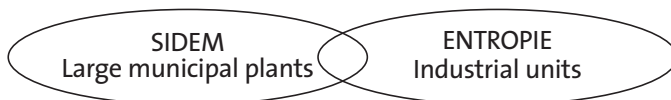
HYBRID MED in winter mode





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collaboration scheme



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| Aqualectra (Curacao) | QP (Qatar) |
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