Advanced Water Treatment
(DESALINATION)

EENV 5330 **معالجة مياه متقدمة**

PART 2

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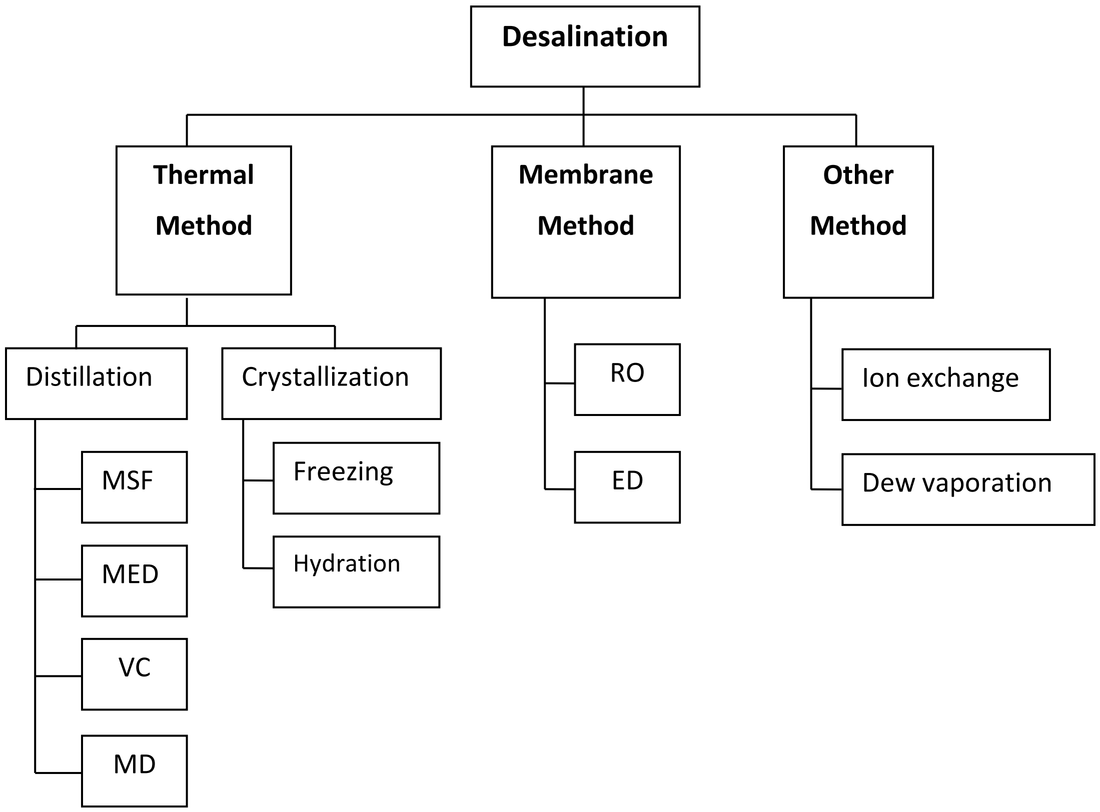
❖ Thermal Desalination

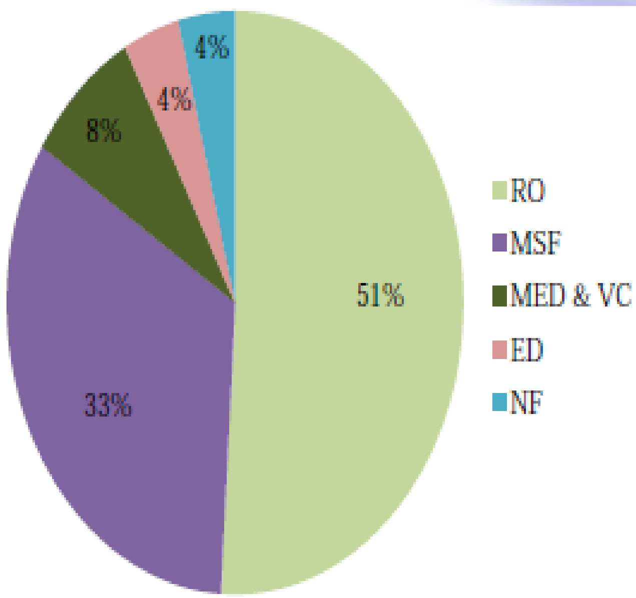
❑ Overview:

- All thermal desalination technologies apply distillation (i.e., are based on heating the source water) to produce water vapor, which is then condensed into a low-salinity water.

- Since the energy for water evaporation is practically not dependent on the source water salinity concentration, thermal evaporation is very suitable for desalination of high-salinity waters and brine.

Desalination Technologies





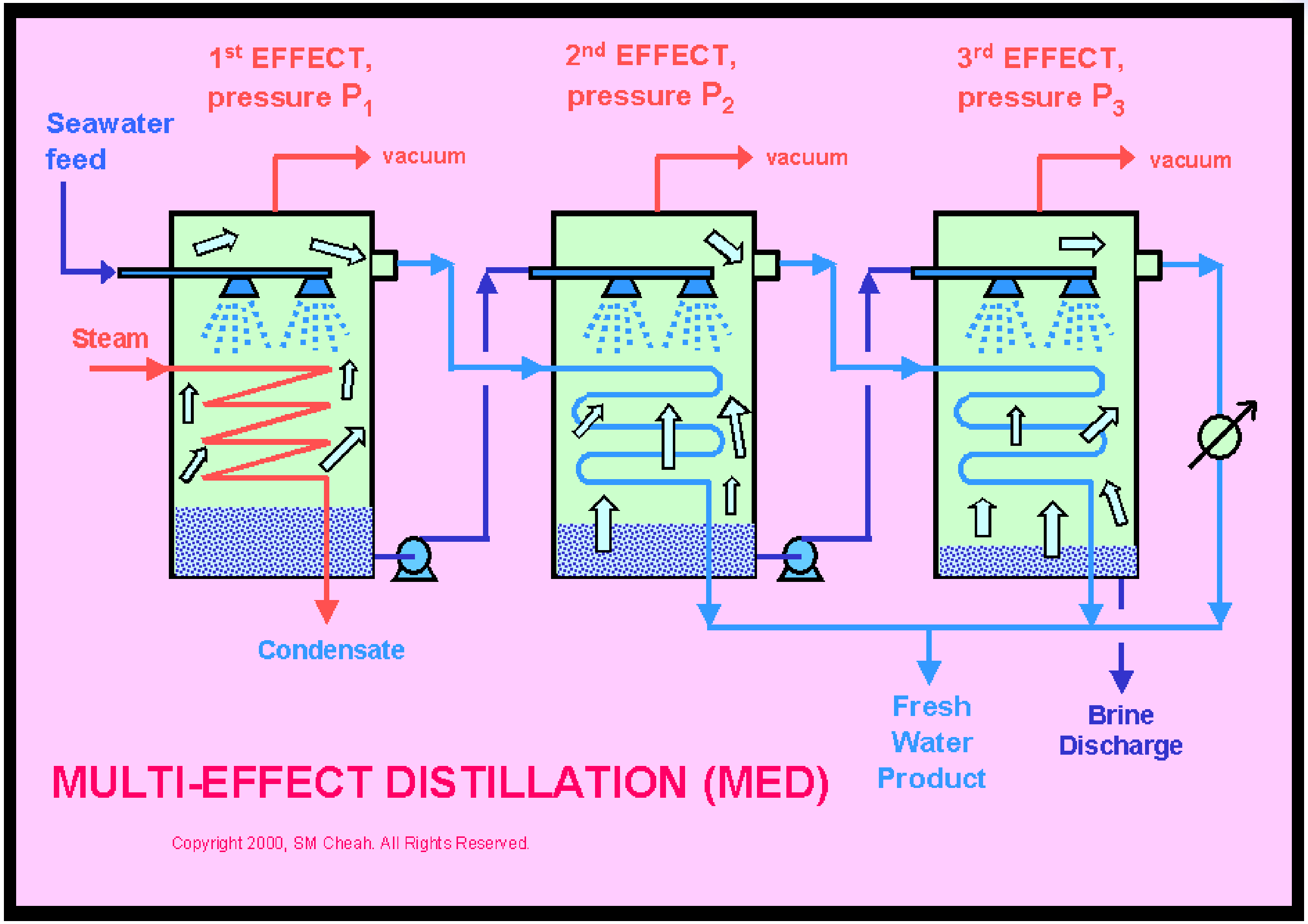
Thermal Processes

- Salty water is heated producing water vapor which condensed to form fresh water free of salts. Fresh water is mineralized to suit human consumption.
- Temperature relative to its ambient pressure as well as sufficient energy for vaporization & scale formation control are the main factors to be considered for any thermal process.
- For some economic reasons linked to energy consumption, some regions may not consider thermal process as viable desalination process.

Multi Effect Distillation (MED)

- Series of evaporators, so called effects where the MED process takes place and uses ambient pressure reduction in the various effects principally.
- This process allow saline feed water to undergo multiple boiling without any need to supply extra heating after first effect takes place.
- Feed water flows in the first effect and raised to reach boiling point after being preheated in tubes.
- Rapid evaporation is then promoted by spraying feed water onto the evaporator surface.
- Configurations of MED plants include vertical or horizontal tubes. The tubes are heated by external supplying steam from dual purpose power plant.
- Steam is condensed on one side of the tube with heat transfer causing evaporation of saline water on the other side. In each effect (or stage), pressure is sequentially reduced due to the temperature decline.

Multi Effect Distillation (MED)



Multi Effect Distillation (MED)

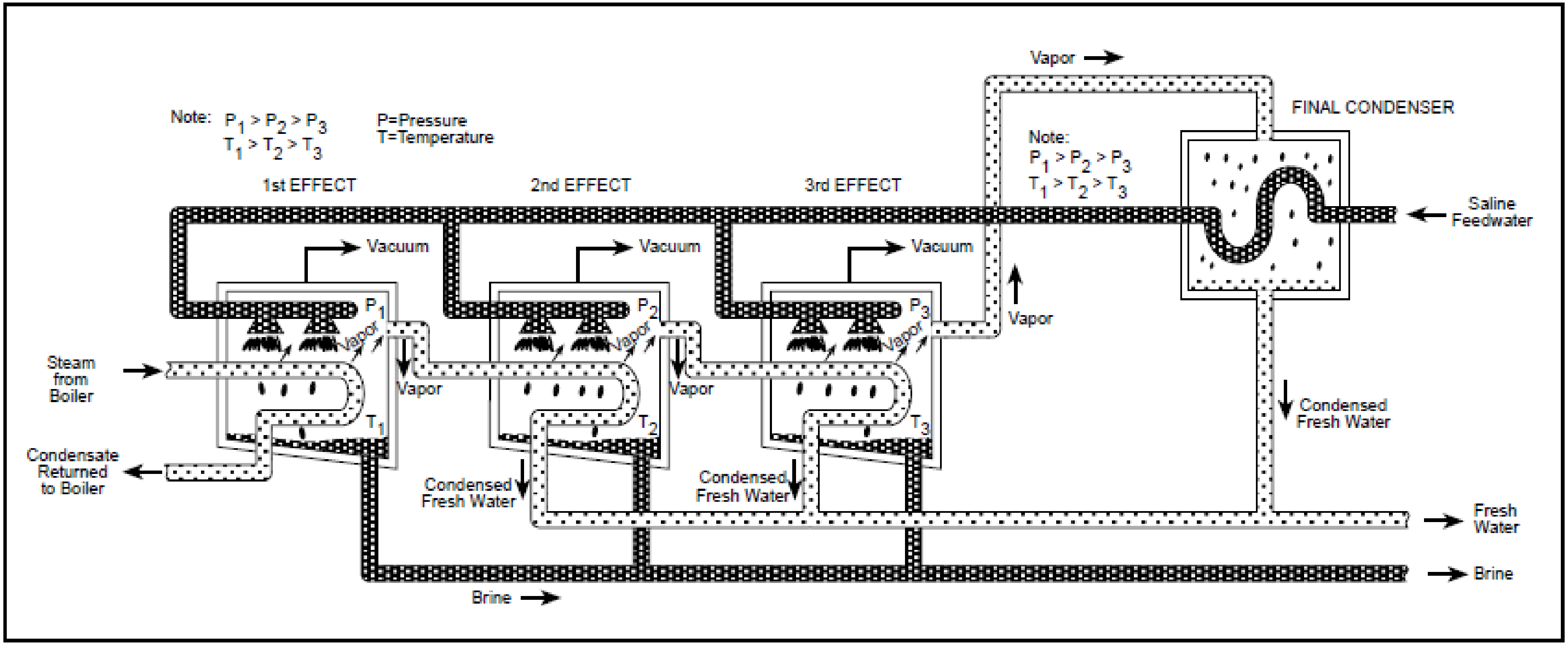
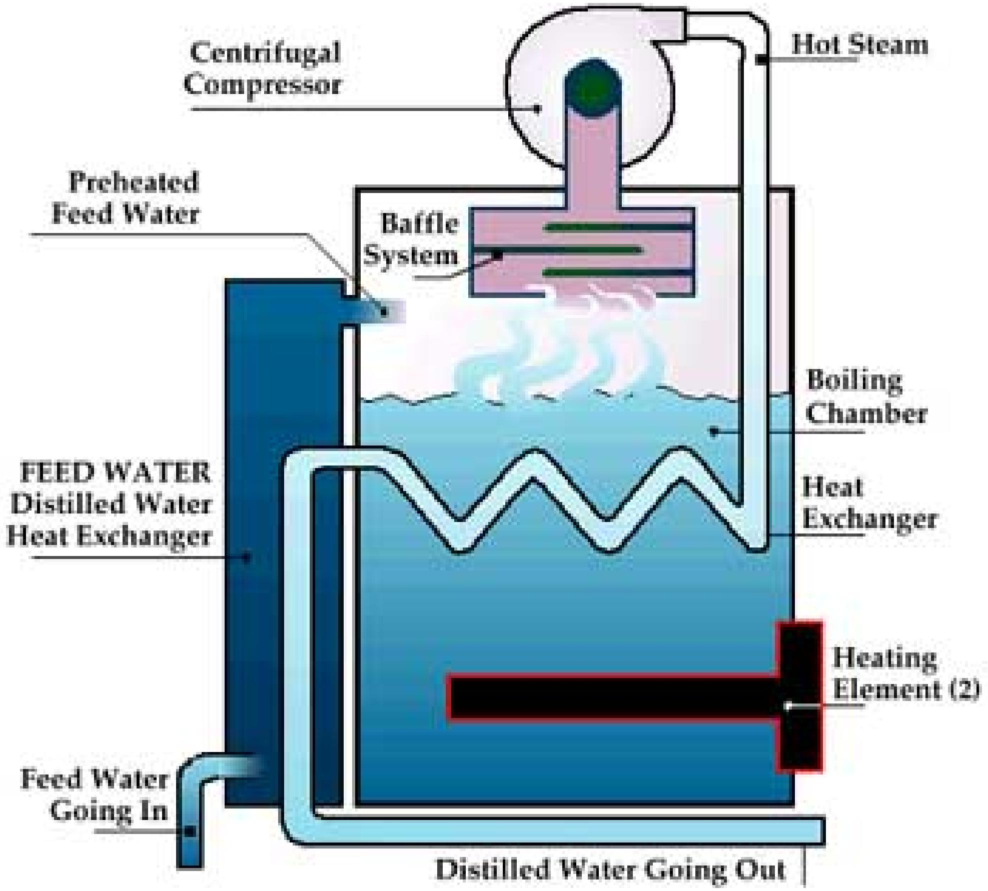


Diagram of a Multi-Effect plant with horizontal tubes. *USAID*

Vapor Compression (VC)

- Vapor compression system is functioning by compressing water vapor which raises its temperature and causes condensation on a heat transfer surface.
- This allows the condensation heat transporting to brine on the other side of surface and resulting in vaporization.
- The compressor, however, is driven by steam, which considers as medium scale desalination system. Such system is simple when compared to MED.
- The energy consumption required for VC is less than required for MED but cost of water produced remains higher for VC than MED due to the fact that unit capacity in VC is smaller.
- The environmental impacts of VC are relatively low with respect to concentrate effect, as the concentration of production is less than 10 mg/l of TDS but heating sources and maintenance procedures which resulted in high CO_2 emissions attribute to global warming.

Vapor Compression (VC)



http://www.aquatechnology.net/vaporcompressiondistillers.html

Vapor Compression (VC)

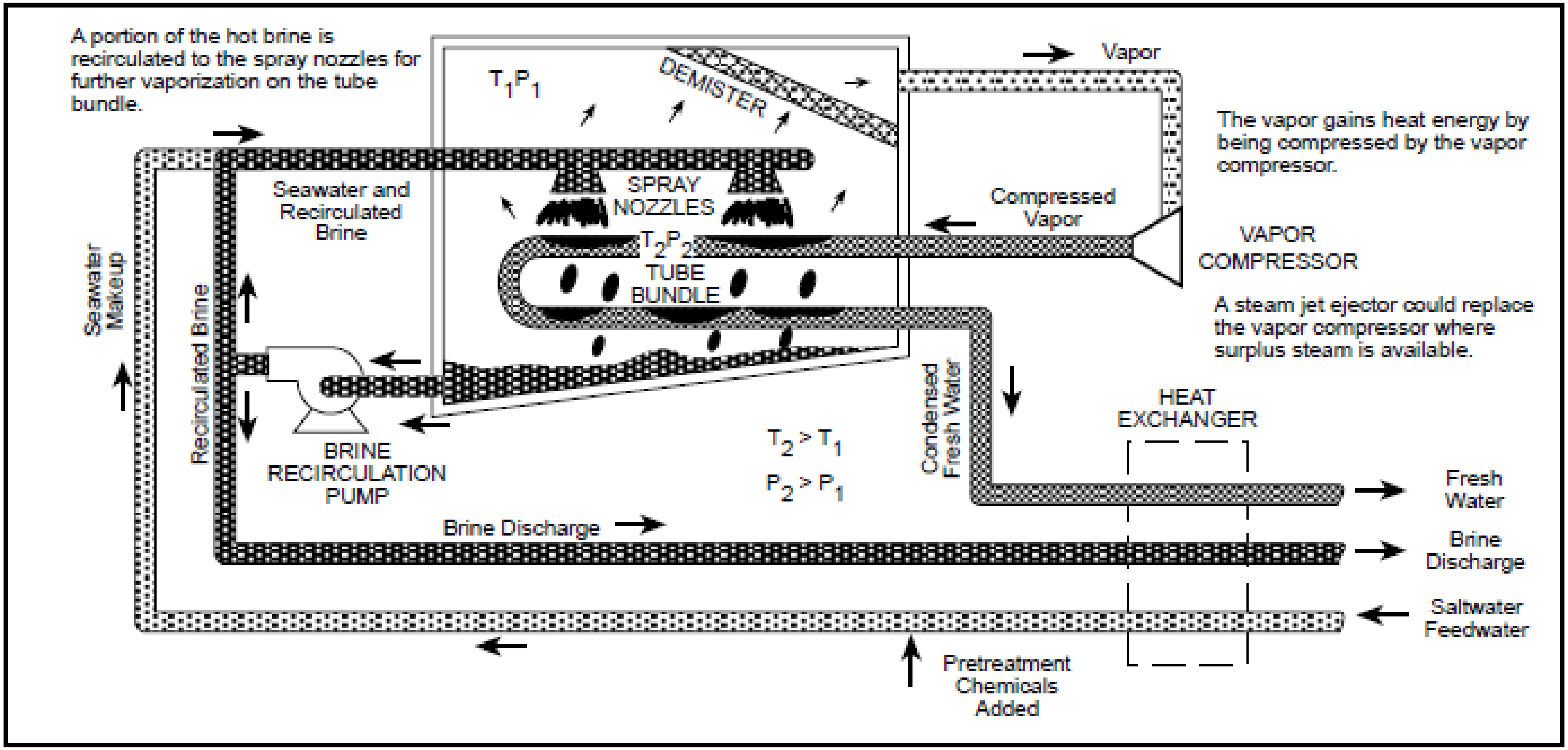


Diagram of a mechanical vapor compression unit *USAID*

Vapor Compression (VC)

Thermal vapor compression unit in Saudi Arabia

Photo — Weir Westgarth

Vapor Compression (VC)

- The mechanical VC units are produced in capacities ranging from a few liters up to 3,000 m^3/d.
- They generally have an energy consumption of about 7 to 12 kWh/m^3.
- VC desalination has found applications mostly in small municipal and resort water supply systems, as well as industrial applications.
- Their simplicity and reliability of operation make them an attractive unit for small installations.

Technologies comparison

Method of desalination	Advantages	Disadvantages
Multi-effect desalination (MED)	High production capacity Low capital cost High purity (< 30ppm) Energy input independent on salinity Minimal skilled operator	Dependence of output on local power availability Long construction period Difficult to control water quality Low conversion of feed water (30%-40%) Labor-intensive Large space and material requirements
Reverse osmosis (RO)	Suitable for both sea and brackish water Flexibility in water quantity and quality Low power requirement compared with MED and VC Flexibility in site location Flexibility in operation start-up and shut-off Simple operation	Low quality (250-500 ppm) Requires high quality feed water Relatively high capital and operating costs High pressure requirements Long construction time for large scale plants
Vapor compression (VC)	High water quality (20 ppm) High operational load Short construction period Operation and production flexibility	High operational costs High energy consumption Lack of water quality control
Electrodialysis (ED)	Low operating and capital costs Flexible energy source High conversion ratio (80%) Low energy consumption Low space and material requirements	Low to medium brackish water capability (3000ppm) Requires careful pretreatment of feed water Low production capacity Purity affected by quality of feed water
Multi-stage flash	Flexibility in salinity of feed water High purity production (< 30ppm) High production capacity Low skill requirement Production of both water and electricity High energy input	Labor intensive Low conversion ratio (30%-40%) High operating costs High construction requirements Limited potential for improvement