



# MSF & MED



Lecture 2

# Thermal Processes

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- ▶ Over 60% of the world's desalted water are produced with heat to distill fresh water from sea water.
- ▶ The distillation process mimics the natural water cycle in that **saline water is heated** producing **water vapor** that is in turn **condensed to form fresh water**.
- ▶ The distillation desalting process usually uses multiple boiling in successive vessels, each operating at a lower temperature and pressure.

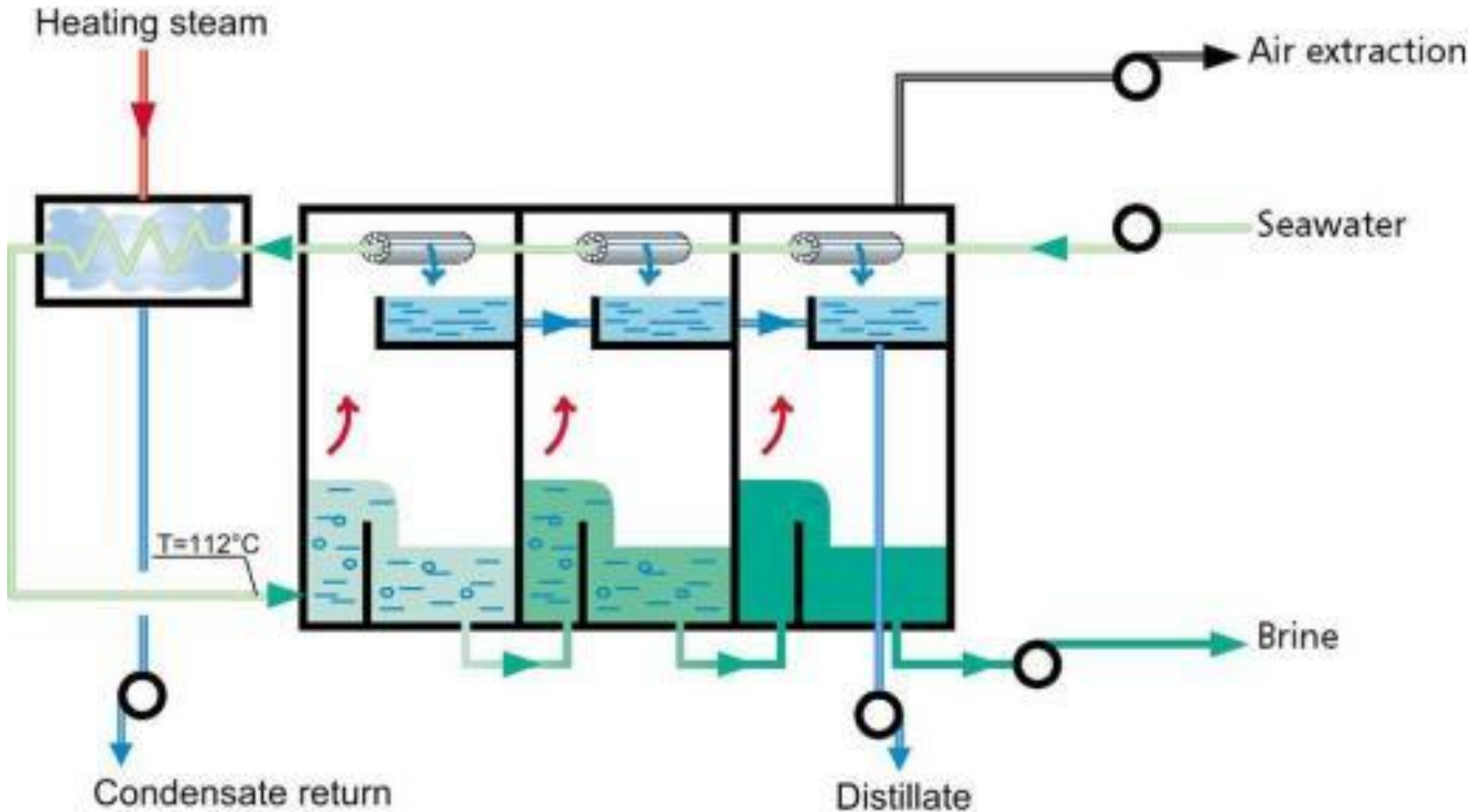
# Thermal processes

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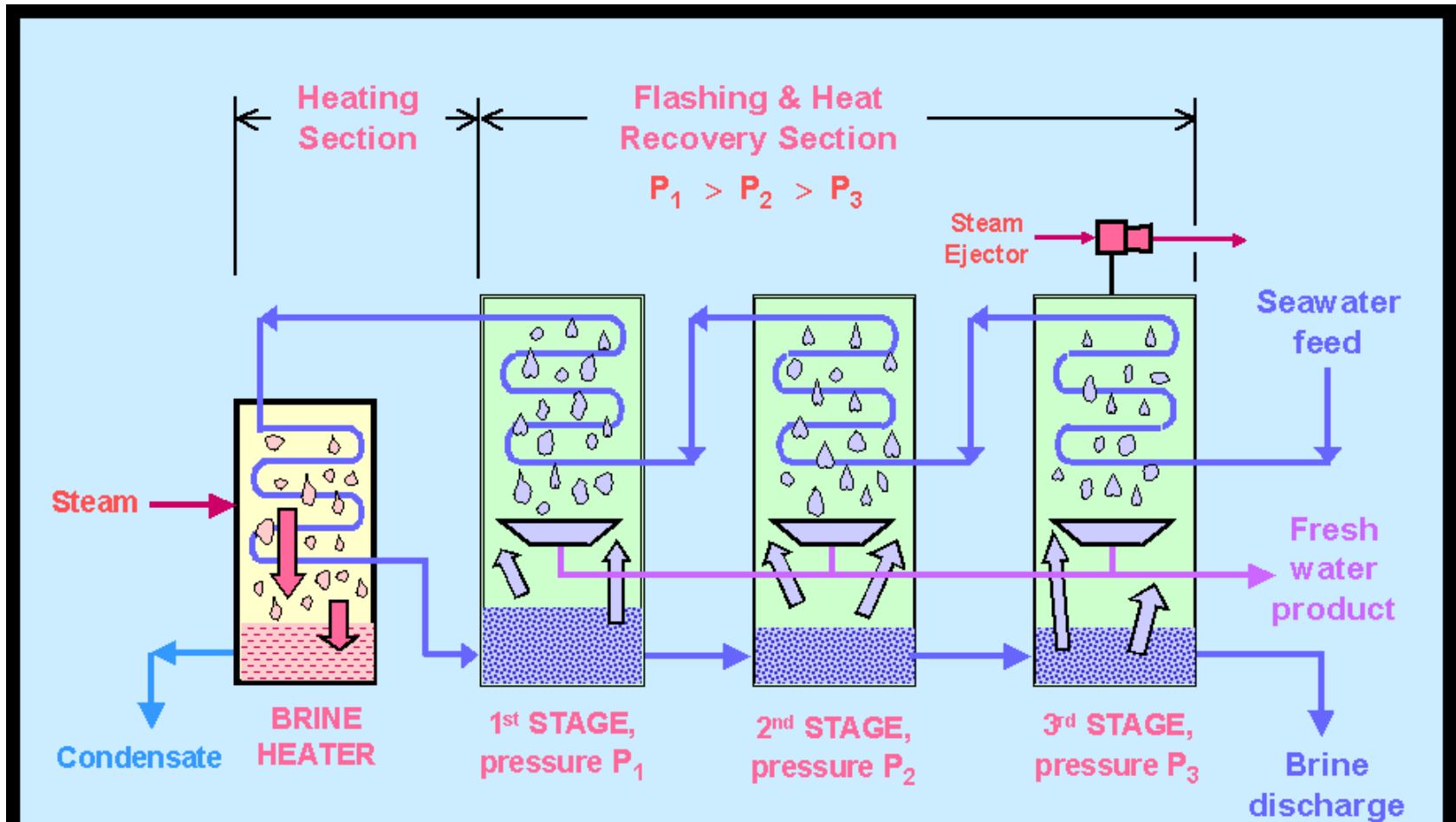
The following table indicates the reduction in temperature with the reduction of pressure which is a **natural phenomenon** takes place with the rising-up above sea level.

Pressure	1 bar	0.47bar	0.32 bar (top of Everest)	0.25	0.1
Boiling point	100°C	80°C	70°C	65°C	45°C

# MSF Distillation



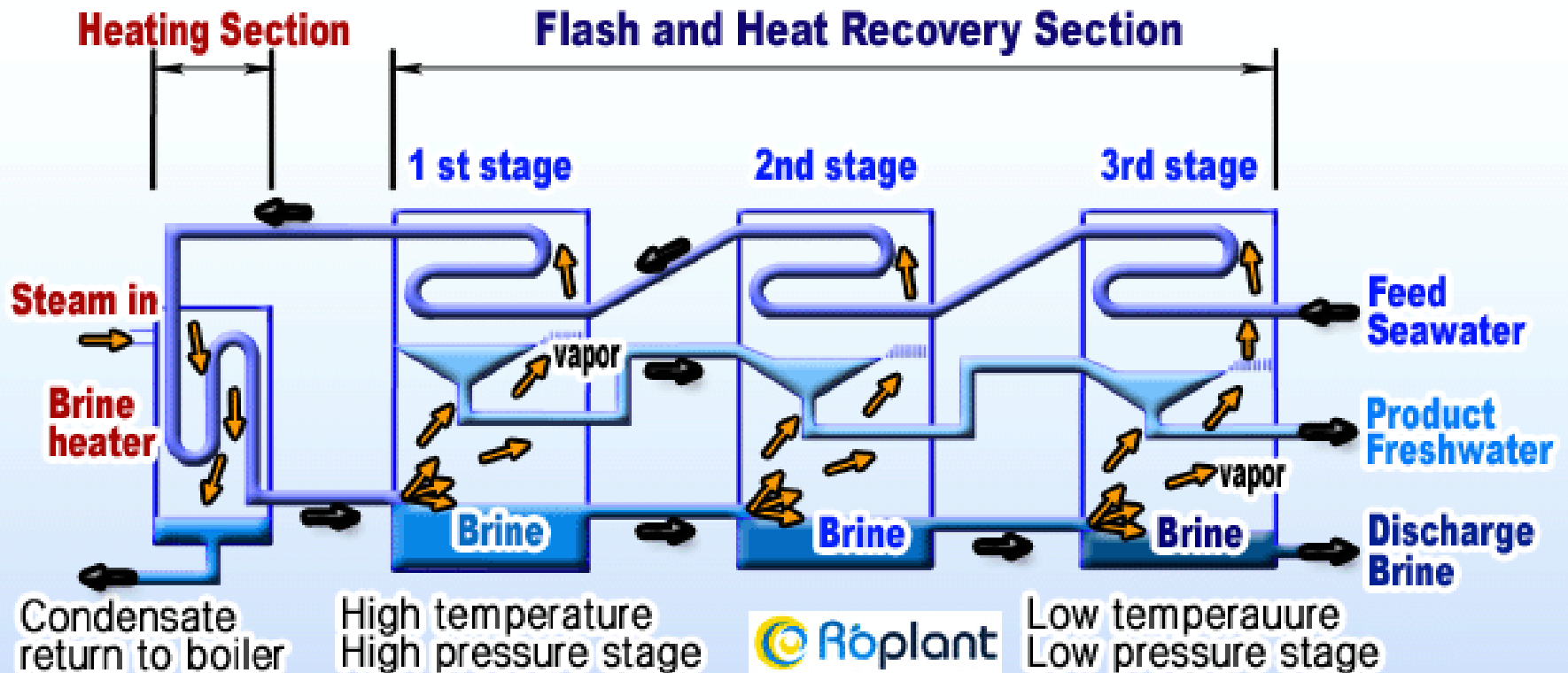
# MSF Distillation



## MULTI-STAGE FLASH DISTILLATION (MSF)

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# MSF Distillation



< Multi-Stage Flash Distillation(MSF)>

# MSF Distillation

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# MSF Distillation

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- ▶ In MSF process, sea water is heated in a vessel called the **brine heater**.
- ▶ The heating is done by condensing **steam on a bank of tubes** that passes through the vessel which in turn heats the sea water.
- ▶ This heated sea water then follows into another vessel, called **stage**, where the ambient pressure is such that the water will immediately boil.
- ▶ The sudden introduction of the heated water into the chamber causes it to boil rapidly, almost exploding or **flashing into steam**.



# MSF Distillation

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- ▶ Generally, only a small percentage of this water is converted to steam (water vapor), depending on the pressure maintained in this stage since boiling will continue only until the water cools to the boiling point (furnishing the heat of vaporization).
- ▶ The concept of distilling water with a vessel operating at a reduced pressure is not new and has been used for well over a century.
- ▶ In the 1950's, a unit that used a series of stages set at increasingly lower atmospheric pressures was developed.

# MSF Distillation

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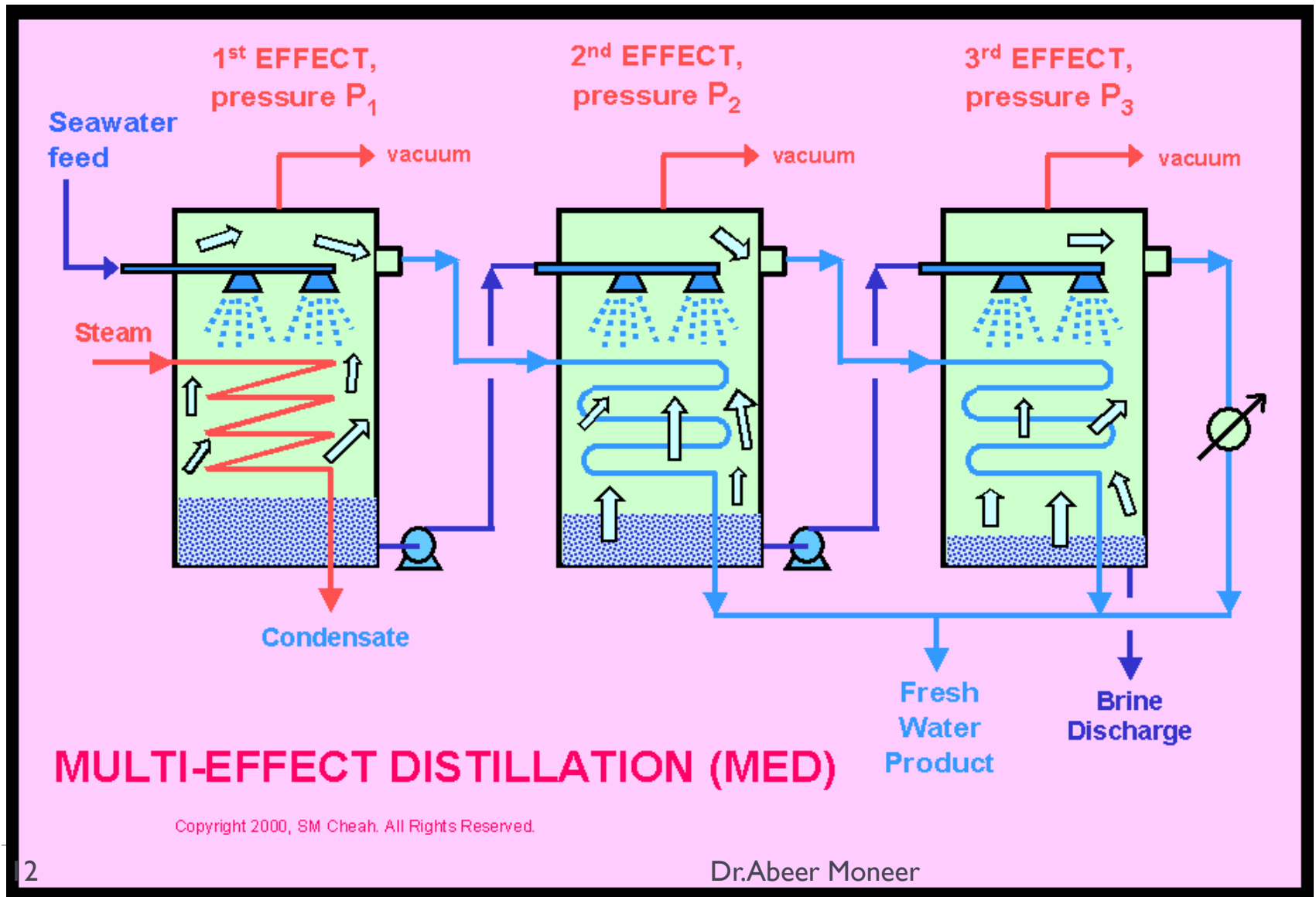
- ▶ In this unit, the feed water could pass from one stage to another and be boiled repeatedly without adding more heat.
- ▶ Typically, an MSF plant can contain from 4 to about 40 stages.
- ▶ The steam generated by flashing is converted to fresh water by being condensed on tubes of heat exchangers that run through each stage.
- ▶ The tubes are **cooled by the incoming feed water** going to the brine heater.
- ▶ This in turn, warms up the feed water so that the amount of thermal energy needed in the brine heater to raise the temperature of the sea water is reduced.

# MSF Distillation

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- ▶ MSF plants have been built commercially since the 1950's.
- ▶ They are generally built in units of about 4,000 to 30,000 m<sup>3</sup>/day (1-8 MGD).
- ▶ The MSF plants usually operate at the top feed temperatures (after the brine heater) of 90-120°C.
- ▶ One of the factors that affect the thermal efficiency of the plant is the difference in temperature from the brine heater to the condenser on the cold end of the plant.
- ▶ Operating a plant at a higher temperature limits of 120°C tends to increase the efficiency, but it also increases the potential for detrimental scale formation and accelerated corrosion of metal surface.

# Multi-effect Distillation (MED)



# Multi-effect Distillation (MED)

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## **History:**

- ▶ It has been used for industrial water for a long time.
- ▶ One popular use for this process is the evaporation of juice from sugar-cane in a production of sugar, or for production of salt with evaporative process.
- ▶ Early distillation plants used the MED process which was later displaced by the MSF units because of cost factors and their apparent higher efficiency.
- ▶ However, in the past three decades, interest in the MED process has been renewed.
- ▶ A number of new design have been built around the concept of operating at lower temperatures.

# Multi-effect Distillation (MED)

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## Operation:

- ▶ Like the MSF process, MED takes place in a series of vessels (effects) and uses the principle of reducing the ambient pressure in the various effects which permits the sea water feed to undergo multiple boiling without supplying additional heat to the first effect.

# Multi-effect Distillation (MED)

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## **Steps:**

1. Sea water enters the first effect and is raised to the boiling point after being preheated in tubes (steam chest).
2. The sea water is either sprayed or otherwise distributed onto the surface of evaporator tubes in a thin film to promote rapid boiling and evaporation.
3. The tubes are heated by steam from a boiler or other source, which is condensed on the opposite side of the tubes.

# Multi-effect Distillation (MED)

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4. The condensate from the steam chest is recycled to the boiler for reuse.
5. Only a portion of the sea water applied to the tubes in the first effect is evaporated.
6. The remaining feed water is fed to the second effect, where it is again applied to a tube bundle.
7. These tubes are in turn being heated by the vapors created in the first effect.
8. This vapor is condensed to fresh water product, while giving up heat to evaporate a portion of the remaining sea water feed in the next effect.



# Multi-effect Distillation (MED)

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9. These continue for several effects, with 8 or 16 effects being found in a typical large plant.
10. Usually, the remaining sea water in each effect must be pumped to the next effect so as to apply it to the next tube bundle.

# Multi-effect Distillation (MED)

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## **Advantages:**

- ▶ MED plants are typically built in units of 2,000 to 10,000m<sup>3</sup>/D.
- ▶ Some the more recent plants has been built to operate with a top temperature (in the first effect) of about 70° C, which reduced the potential for scaling of sea water within the plants but in turn increases the need for additional heat transfer area in the form of tubes.
- ▶ [MED Desalination Process - YouTube.mp4](#)

# Questions

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▶ **Answer with Yes or No and correct the false statements:**

1. MSF process can contain from 4 to 20 stages only.
2. In MSF distillation, sea water flows counter currently to the distilled water.
3. In MSF, the stage undergo successive decrease in temperature and increase in pressure.
4. A large percentage of salty water is converted to water vapor in each stage in MSF process.
5. In MSF plant, external heat must be added to each stage in order to compensate heat losses.

# Questions

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▶ **Choose the correct answer:**

- I. MED can be used in the:
- A) Evaporation of juice from sugar cane in the production of sugar.
  - B) Evaporation of water from aqueous acetic acid to produce glacial acetic acid.
  - C) Evaporation of water from sulfuric acid-water mixture.

# Questions

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▶ **Choose the correct answer:**

2. In MED plant:

- A) All the sea water applied to the tubes in the first effect is evaporated.
- B) Half of the sea water applied to the tubes in the first effect is evaporated.
- C) A portion of the sea water applied to the tubes in the first effect is evaporated.

# Questions

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▶ **Choose the correct answer:**

3. In MED, the tubes in the  $n^{\text{th}}$  effect are heated by the vapors created in the:

- A)  $(n-2)$  effect.
- B)  $(n-1)$  effect.
- C)  $(n+1)$  effect.

4. In MED plant, vacuum is applied to:

- A) The  $n^{\text{th}}$  effect only.
- B) Alternating effects only.
- C) Each effect.