General Comparison of Reverse Osmosis to Vapor Compression Distillers

Technical Application Publication

Reverse Osmosis to Vapor Compression Distillers

1.0 Introduction
Reverse Osmosis, RO, and Vapor Compression Distillers, VCD, are two types of seawater desalination processes used to make potable water. The two process use very different methods to separate the dissolved salt and other impurities from the water.

2.0 RO Process
RO systems require a pretreatment stage to remove paticulates in the water to prevent physical damage to the membrane surface and blockage of water flow across the membrane. There are various methods used to capture the particulates such as filter elements, media filters and centrifugal separators. The type and complexity of the pretreatment system depends on the quality of the water source. A system operating in open ocean (blue water) contains much less particulates then near shore water and would require much less filtration.
The RO process uses a high pressure pump to pressurize sea water above the osmotic pressure. The seawater is then pumped across a semi permeable membrane. Typically about 20 to 30% of the water will pass through the membrane.
The purified water that has passed through the membrane is now called permeate or product water. The water on the seawater side of the membrane gets higher in concentrations of salinity and other contaminants as it flows across the membrane. This water now is called brine or reject water. The continuous flow of water and maintaining the correct flux rate keeps the membranes from scaling. See Figure 1.

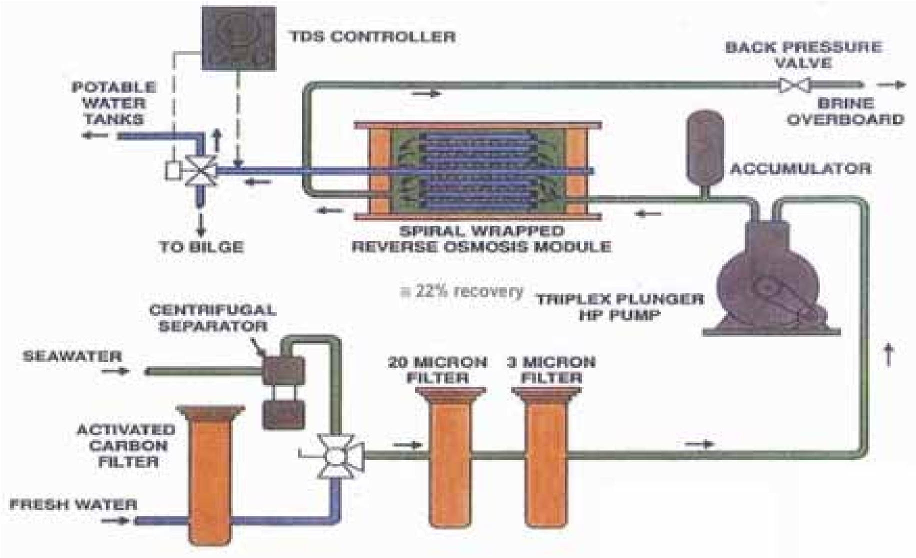

Figure 1 Typical RO Diagram

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2.1 RO Energy Requirements

The pump is the main source of energy consumption on the equipment. The correct type of pump and its efficiency for the pressure and flows of the system will have the most effect on the energy costs to operate the system.

Calculated power requirements to run a 12,000 GPD RO HP pump is as follows:

RO potable water: 12,000 gpd
Seawater feed flow rate: 40.5 gpm
Product water flow rate; 8.3 gpm
Pump Discharge pressure: 800 psig

Brake horse power from ref. 1 (Reference: Mark's Standard handbook for Mechanical Engineers, ninth Ed., E. Avallone editor, McGraw-Hill, Inc 1987)

Bhp = Q x (Pd-Ps)/(1714 x Effp)

Where

Q = Seawater Flow rate through the pump = 40.5 gpm
(Pd-Ps) = Pressure added to the water by the pump = 800 psi
Effp = Positive displacement pump and motor efficiency = .90 (pump) x .95 (motor) = .86

Bhp = 40.5 x (800) / (1714 x .86) = 22 Bhp

Converting the to KW

22 Bhp x (.7457) = 16.39 KW

12,000 gpd = 500 gph

Calculated Power required per gallon of potable water produced

16.39/500 = **.0328 KWh/gallon**

RO advantages over VCD

RO membranes and systems work very well on sea water. The RO systems have been tested by the US Navy and have been in service for over 20 years, replacing the distilling units.

- The RO system uses less energy
- The RO does not require acid descaling
- Lower maintenance and corrosive chemical handling due to the acid descaling
- Lower heat in the machinery space
- Smaller size and weight
- Lower initial costs
- Lower operating (energy) costs

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3.0 VCD Process

The VCD system is basically a distiller that evaporates water and captures the condensate as potable water. The added heat exchangers are used to capture some of the latent heat of vaporization that is produced when the water changes phase. The VCD system uses a vapor compressor to drive the process and heating elements to start and maintain it.

Heated seawater is sprayed onto a heat exchanger in an evaporator chamber. The water changes to steam when it hits the surface of the evaporator heat exchanger tubes. The steam is then taken up in the vapor compressor where it is pressurized and sent through the evaporator heat exchanger tubes. When the steam is compressed it raises the temperature of the steam which is higher then the seawater temperature in the evaporator chamber. The steam under goes another phase change as it condenses into water. The condensed water passes though another heat exchanger where it heats the incoming seawater that is sprayed in the evaporator. The condensed water is now discharged out of the unit as distilled water. The heating elements are used to heat the water up to allow the evaporation to start and to maintain the correct temperatures. See Figure 2.

The VCD evaporation process leaves minerals in the water chamber that builds up over time. The minerals will come out of solution and start scaling the chamber if it is not periodically de-scaled with an acid.

The VCD uses heat exchangers and the vapor compressor to recover some of the latent heat that is generated during condensation.

The Vapor Compression Distillers use about .12 KWh/gallon (from Ref. 2) of distilled water produced.

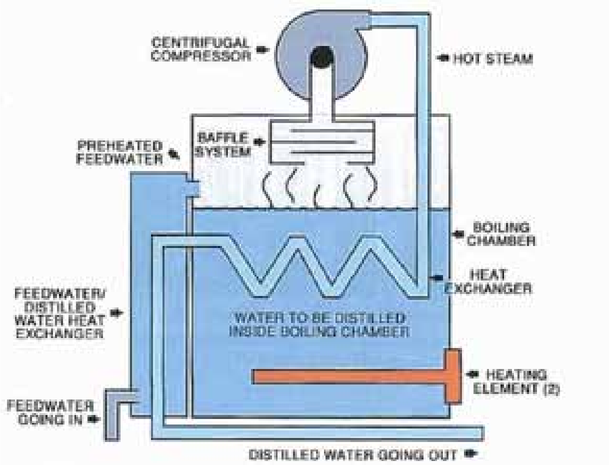

Figure 2 Diagram of a Typical Vapor Compression Distiller, from Ref. 2
(Reference: Water Distillation, B. Kucera, Scranton Gillette Communications, Sept 2005)

VCD advantages over RO

A VCD may have an energy advantage over an RO system in very specific situations where the right amount of waste heat is available and distilled water is required. This would have to be weighed against the added periodic maintenance of descaling the VCD system.

- Produces distilled water, higher quality then a 1st pass only RO.
- Can be designed to run off of a waste heat source.
- Less reject water produced.
- Lower feed water filtration requirements.

4.0 Summary

The RO system has a lower initial cost, lower energy cost and lower maintenance cost than a VCD system for a typical marine potable water installation. The reasons for this is that the power requirement to pressurize the water in an RO system is much less then the power needed to vaporize water as required by a VCD. The RO process maintains a continuous flow stream across the membranes that helps prevent fouling of the membranes, where as a VCD tends to concentrate contaminates in the evaporator chamber.