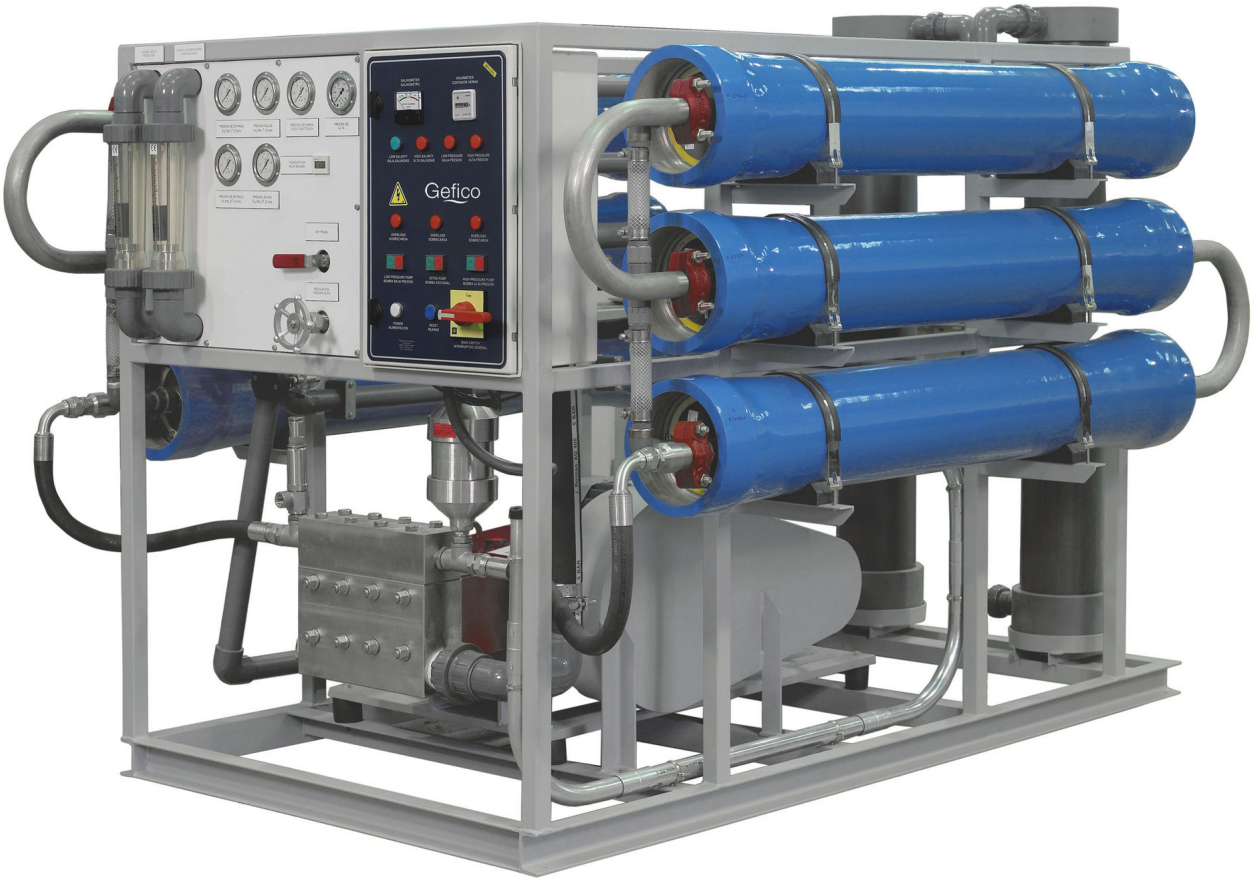
Reverse Osmosis - DieselShip



Reverse osmosis is one of the most desalination processes that is used widely on most ships and also for household water production. RO plant is considered one of the most successful method of desalination as the size of the system can be reduced or increased to suit the requirement varying from a house hold process to an industrial process with larger output.

Let us first understand what is Osmosis?

Osmosis is a natural process involving fluid flow across a membrane which is a semi permeable one. The direction and relative quantities of fluid flow is determined by the chemical potential which is a function of pressure, temperature and concentration of dissolved solids.

When two solutions of different concentrations are separated by a semi permeable membrane, water from the less concentrated solution will, due to the natural phenomenon of osmosis, pass through the membrane to dilute the more concentrated solution to make it an equivalent concentration to itself.

> In simple words: If a container separated in to two by a semi-permeable membrane is filled with fresh water one side and sea water on the other side, the fresh water will diffuse through the membrane and move towards sea water side to equal the concentrations on both the sides.

Osmotic Pressure:
This is one of the important factors in Osmosis & Reverse Osmosis process. if the hydraulics of this process are taken into account, as the water passes from the less concentrated solutions into the more concentrated solution to dilute it, the static head of the more concentrated solution increases and the one of the less concentrated solution decreases thus giving a net pressure.

Equilibrium of the two solutions occurs when the pressure differential is sufficiently high to

Stop the fluid flow across the membrane – this pressure is called the **osmotic pressure**.

We have seen what Osmosis is! Now, what is Reverse Osmosis?

Reverse Osmosis is the use of this natural process in the reverse direction. Pressure is exerted on the more concentrated side of the membrane to overcome the natural osmotic pressure and force water 'out of' the concentrated solution and through the membrane.

Particles, bacteria and the larger organics are blocked by molecular filtering, however RO also involves an Ionic repulsion process, where by only water is allowed to pass through the semipermeable membrane, whilst virtually all dissolved molecules are rejected. The semipermeable membrane rejects multi charged ions such as calcium and sulphate at rates exceeding 99% while single charged ions such as sodium are rejected at rates from 90-96%

Semi-Permeable membrane stack usually used on RO plants.

Permeate??
The fresh water produced through such membranes is called Permeate. According USPH rules and regulations, such water until treated with required PPM of Chlorine and pH correction made to maintain the pH value not more than 7.8 may not be called as potable water; hence it's called a 'Permeate'.

Reverse Osmosis process flow chart.

Flowchart Description
Now let use get deeper into each process charted down in the flow chart.

1. **Feed Water**: This is typically the water that needs to be desalinated. Feed water is supplied to the system using a feed pump. Feed is passed through a strainer. The same pump is used to back wash the Sand filters which we will see in next steps.
2. **Sand Filtration:** This process is for the removal of relatively large suspended solids that may be present in the raw water. Sand filtration is carried out by a filter vessels (Usually 2 in numbers or more depending upon quality of feed water) which typically contains a combination of different dimension grits stored in layers with coarse sand.

Empty space is intentionally left above the grit media to allow space for bed expansion during filter backwashing. The design throughput of the filter is such that they will provide sufficient filtered water for correct operation of the R O Plant. The total design flow rate of filters in parallel is set to a required value,

this flow should not be exceeded as the filtration rate for optimum performance will be exceeded which in turn could mean a vastly reduced quality filtrate.

> Backwashing:
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> Backwashing of the filters is carried out to remove the accumulated solid particulates from the filtering media layers; it involves reversing the normal flow and discharging it to waste.
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> Backwashing is carried out on a set frequent depending upon the feed quality or if the differential pressure increases by 1.0 bar between the inlet to the outlet.
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> The backwash flow rate will vary depending upon the feed water temperature. It is critical that the correct flow rate is used; a satisfactory wash may not be achieved if it is too low or, on the other hand, media may be washed away if the wash water flow rate is too high.
>
> The next step is the Anti-scalant Dosing!

ANTISCALANT DOSING

Seawater contains sparingly soluble salts of Calcium, Barium, etc. These salts naturally have no tendency to precipitate, however, as the seawater passes through the plant and permeate is removed, the concentration of salts increases to such a degree that precipitation on the membrane surface can occur and thereby reduce their performance.

To suppress the precipitation of these salts a solution of a proprietary antiscalant compound is dosed into the feed water which acts as a scaling inhibitor, thus allowing more efficient operation.

The Next step is CARTRIDGE FILTRATION

The feed water free from large suspended solids and dosed with antiscalant is passed through a 10 micron absolute rated cartridge filter, this ensures that the feed water to the RO membrane elements is free from any fine particulate matter ensuring maximum performance from the RO membrane elements, the filter also protects the HP pump in the event of a sand filter lateral failure.

The next step is the Feed Pumps, As RO process involves pressure exerted on the fluid with the higher concentration to overcome the ‘Osmotic Pressure’.

HP FEED PUMPS AND ASSOCIATED EQUIPMENT

The high pressure pump supplies the pressure needed to push water through the membrane, even as the membrane rejects the passage of salt through it.

Typical pressures

1. For brackish water range from 225 to 375 psi (15.5 to 26 bar, or 1.6 to 2.6 MPa).
2. For seawater, pressure range from 800 to 1,180 psi (55 to 81.5 bar or 6 to 8 MPa).

Such high pressure is achieved by one or more HP pumps running in parallel. Usually these are axial piston pump.

Energy Recovery Unit

> ENERGY RECOVERY
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> Desalination, the product of potable water for seawater, has been done for centuries. Until now, however, desalination has been considered a costly alternative because of the high energy consumption in the process.
>
> Early desalination plants relied on evaporation technology. The most advanced seawater evaporation desalination plants using multiple stages have an energy consumption of over 9 kW/m³ of potable water produced. For this reason large plants were initially constructed in Places with cheap abundant energy such as the Middle East.
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> The device recovers hydraulic energy from the high pressure reject stream and transfers that energy to the feed stream. In real terms, for example, the high pressure pumps would only need to delivery 16.75 m³/h at 59.5 bar instead of 16.75 m³/h at 74 bar.

Next step & Final step is MEMBRANE ARRAY;

Filtered, pressurised water is passed to the RO membrane elements and is desalinated. Within each stream feed water enters the first vessel and is split into two flows, permeate (high quality, potable water) and reject (concentrated feed water). The reject from the first vessel then feeds the second vessel where again it is split into two flows, permeate and reject.

This process is the same in each of the remaining streams. Reject from the last vessel in each of the three streams is manifolded together then flows through the reject control valve and to waste. The reject control valve is used to regulate the pressure within the membrane stack, which in turn regulates the permeate flow rate and quality.