

The Process of Reverse Osmosis

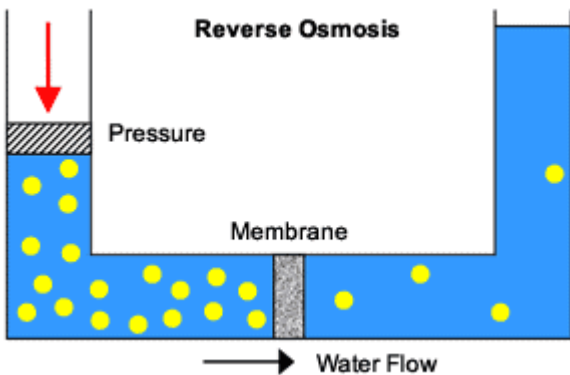
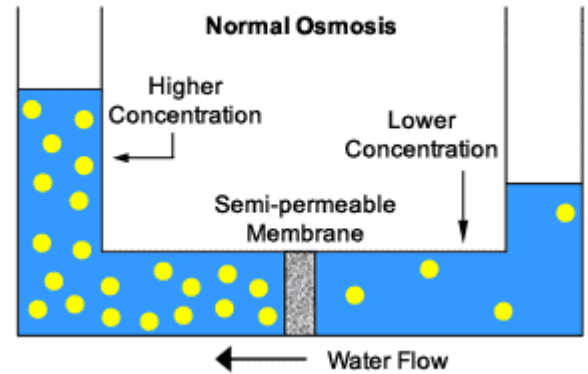
Keep reading to discover the how and why of reverse osmosis or jump to:

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To understand how reverse osmosis purifies water, you must first understand the process of osmosis.

Osmosis is a physical force. It is the natural tendency of water with a low concentration of dissolved particles to move across a semi-permeable membrane to an area of water with a high concentration of dissolved particles. The water will try to reach an equilibrium on both sides. I.e. both sides of the semi-permeable membrane will have the same concentration of dissolved particles. This is how plants absorb nutrients from the soil.

Picture a tea bag placed in a mug of hot water. (The tea bag is the semi-permeable membrane). At first, the water is free of tea. However, with time, the tea will appear to seep from the tea bag into the mug. This is the process of osmosis. If you were to leave the tea bag in the mug for long enough, the concentration of tea inside the teabag would equal the concentration of tea outside the teabag.



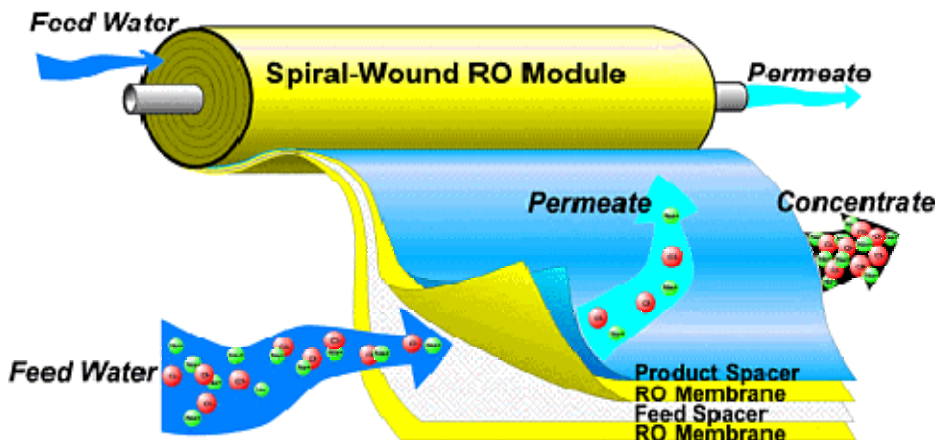
Now for reverse osmosis

The process of **reverse osmosis** requires that the water be forced through a semi-permeable membrane (the tea bag from the previous example) in the opposite direction of the natural osmotic flow; leaving the dissolved particles in the more highly concentrated solution.

In order for reverse osmosis to occur, the amount of force or pressure applied must exceed the osmotic pressure.

A semi-permeable membrane is at the heart of a reverse osmosis system

Reverse osmosis works through a technique called *membrane separation*. The membrane is permeable only to water molecules.



Two types of Membranes:

CTA membrane - cellulose triacetate

TFC membrane - thin film composite

[Click here to see the difference.](#)

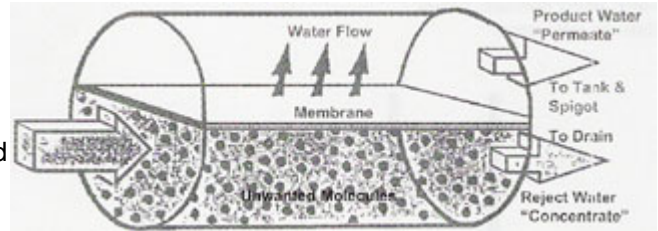
Raw water enters a module housing the membrane system. The water is forced against the semi-permeable membrane and only clean water molecules pass through the pores in the membrane. Impurities are rejected and flushed away.

Crossflow Filtration

While the principles of reverse osmosis are simple the process can not run indefinitely unless steps are taken to ensure the membrane does not become clogged by impurities.

To significantly reduce the rate of membrane fouling, reverse osmosis systems employ **crossflow filtration**.

In conventional filtration, the entire water solution to be filtered is pumped through the filter media and all contaminants too large to pass through the pores of the membrane are trapped or retained on the surface.



In crossflow filtration, two exit streams are generated -- a "concentrate" stream (reject water) containing those material which are rejected or do not pass through the membrane, and the "permeate" stream (product water) which has been pumped through the membrane, and passes to the tank.

The comparative size of particles

Various mineral salts, heavy metals, particular matter, some organic molecules, bacteria and even viruses are rejected or repelled by the membrane surface based on their molecular or atomic weight. A second barrier, such as ultraviolet light, should be used if bacteria are present.

The ability of the membrane to reject or repel dissolved particles, while allowing water to readily permeate, is based on the incredibly small size of the multitude of pores that penetrate its surface. **Such pores are able to reject substances as small as 0.0005 microns.**

A micron (*m*) is a metric unit of length equal to a millionth of a meter, or 0.00003937 inch. A human hair is approximately 75 *m* in diameter. The smallest particle that can be seen with the naked eye is 40 *m* across The smallest bacteria is about 0.22 *m* while a virus is even smaller at 0.01 *m*.

Reverse Osmosis will remove the following contaminants:

Contaminant	% nominal rejection	Contaminant	% nominal rejection
Aluminum	96-98	Ammonium	80-90
Bacteria	99+	Borate	30-50
Boron	50-70	Bromide	90-95
Cadmium	93-97	Calcium	93-98
Chloride	92-95	Chromate	85-95
Copper	96-98	Cyanide	85-95
Fluoride	92-95	Hardness Ca & Mg	93-97
Iron	96-98	Lead	95-98
Manganese	96-98	Magnesium	93-98
Mercury	94-97	Nickel	96-98
Nitrate	90-95	Orthophosphate	96-98
Phosphate	95-98	Polyphosphate	96-98
Potassium	93-97	Radioactivity	93-97
Silica	80-90	Silicate	92-95
Silver	93-96	Sodium	92-98
Sulfate	96-98	Thioisulfate	96-98
Zinc	96-98		

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Selecting a Reverse Osmosis System

When selecting a reverse osmosis system, the following factors must be considered:

Is the water supply potable?

An RO system should be used with water that is already deemed bacteriologically safe for human consumption or is adequately disinfected or sterilized on a continuous basis. RO systems can include ultraviolet lights.

Is the feed water supply chlorinated or unchlorinated?

If the water is unchlorinated, a TFC membrane should be chosen due to its greater resistance to bacterial attack. If the water is chlorinated, a CTA membrane that is not chlorine sensitive may be chosen or a TFC membrane that is sensitive to chlorine may be used with the addition of a carbon pre filter. The membrane will need to be replaced approximately every 2 years, depending on the water quality and quantity. Most systems use TFC membranes.

What is the daily quantity of pure water required?

A suitable residential system should be capable of producing in excess of a minimum of 1/2 gallon of drinking water per person per day. Residential systems typically produce 15 to 25 US gallons per day of pure drinking water.

Commercial/Industrial units can produce up to 40000 US gallons per day of pure drinking water and should be sized according to their application.

Is the water supply adequately pretreated?

If present, any contaminant such as iron, manganese or hydrogen sulfide must be adequately reduced or removed by pretreatment in accordance with membrane tolerances. If necessary, the feed water should be treated to reduce hardness to a maximum of 10 gpg to prevent premature fouling of the membrane.

What is the level of TDS (total dissolved solids)?

Drinking water should have a TDS of below 500. City water on the West Coast of Canada has a low TDS of 25, while many other areas have a TDS of 200+. Well water can have a TDS of 1000 to 5000. Sea water has a TDS of 40 000 and the Black Sea can be up to 60 000 TDS. Residential RO units can tolerate up to 2000 TDS. Brackish water RO units can take up to 6000 TDS. Desal RO units are used for higher levels and the membrane pressure vessel will run at approximately 900 psi.

What is the pH of the feed water?

The pH in most city water supplies is 6.9 to 7.5. In many West Coast cities the water can have a low natural pH level, as low as 5.5, making the water very corrosive to copper piping. pH is a logarithmic scale. For example, a pH of 6.9 is ten times more acidic than a pH of 7.0

Is a booster pump required?

A booster pump may be required if your incoming water pressure is less than 50 psi, or you have a TDS count of over 1000, or the inlet water temperature is very low.

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Factors affecting performance of reverse osmosis units

Outlined below are three of the primary factors that have the greatest potential impact on the quality and quantity of reverse osmosis water that an individual system will produce.

TDS of Feed Water

Osmotic pressure is the force binding water molecules to dissolved ions or solids. The higher the TDS, the higher the molecular forces. Before water molecules can start to separate and pass through the membrane, these forces must be broken with the application of pressure. Every 100 mg/l of TDS requires 1 psi (pounds per square inch) just to overcome osmotic pressure.

Water Pressure or Feed Pressure

Net pressure across the membrane is a major factor in determining how much water is produced. As the pressure increases, so does the rate of water production. The minimum water pressure required for a residential RO unit is 50 psi. A booster pump can be added to any RO unit which will operate with inlet pressure of as low 10 psi.

Temperature of Feed Water

Water temperature greatly affects the actual rate of production. Membranes are rated in terms of production in gallons per day (GPD) at 77 degrees Fahrenheit. The cooler the water, the lower the rate of production. Water production increases or decreases for CTA membrane - 1.5% per °F and for TFC membranes 2.0% per °F above or below 77 °F. For high output RO units, temperature is an important design factor.