WaterReview
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What Is . . Reverse Osmosis

Anyone who has sat through a high school science class will likely be familiar with the term osmosis. This process was first described by a French scientist in 1748, who noted that water spontaneously diffused through a pig bladder membrane into alcohol. Over 200 years later, a modification of this process known as reverse osmosis allows people throughout the world to affordably convert undesirable water into water that is virtually free of health or aesthetic contaminants. Reverse osmosis systems can be found providing treated water from the kitchen counter in a private residence to installations used in manned spacecraft. Typical uses of reverse osmosis include:

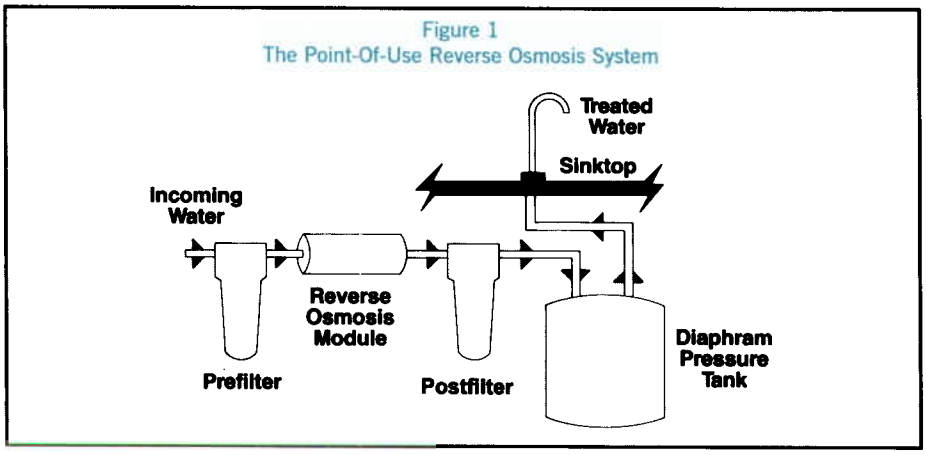
- Drinking Water
- Humidification
- Ice-Making
- Car Wash Water Reclamation
- Rinse Waters
- Bio-Medical
- Laboratories
- Photography
- Pharmaceuticals
- Kidney Dialysis
- Chemical Process Water
- Cosmetics
- Animal Feed
- Hatcheries
- Restaurants
- Greenhouses
- Metal Plating
- Wastewater Treatment
- Boiler Water
- Battery Water
- Semiconductor Industry
- Hemodialysis

How Reverse Osmosis Works

A semipermeable membrane, like the membrane of a cell wall or a bladder, is selective about what it allows to pass through. It generally allows water to pass through easily while limiting the passage of other contaminants. Water will typically be present on both sides of the membrane, with each side having a different concentration of dissolved minerals. Since the water in the less concentrated solution seeks to dilute the more concentrated solution, water will pass through the membrane from the lower concentration side to the greater concentration side. Eventually, osmotic pressure, or the difference in the two water levels, will become great enough to counter the diffusion process forming an equilibrium.

The process of reverse osmosis forces water with a greater concentration of contaminants (the source water) into a tank containing water with an extremely low concentration of contaminants (the processed water). High water pressure on the source side is used to "reverse" the natural osmotic process, with the semipermeable membrane still permitting the passage of water while rejecting most of the other contaminants. The specific process through which this occurs is known as ion exclusion, where a concentration of ions at the membrane surface form a barrier that allows other water molecules to pass through while excluding other substances.

Figure 1
The Point-Of-Use Reverse Osmosis System



Semipermeable membranes have come a long way from the natural pig bladders used in the earlier osmosis experiments. Before the 1960s, these membranes were too inefficient, expensive, and unreliable for practical applications outside the laboratory. Modern advances in synthetic materials have generally solved these problems, allowing membranes to be highly efficient at rejecting contaminants while making them tough enough to withstand the greater pressures necessary for efficient operation.

Even with these advances, the "reject" water on the source side of a reverse osmosis (RO) system must be periodically flushed in order to keep it from becoming so concentrated that it forms a scale on the membrane. RO systems also typically require a carbon prefilter for the reduction of chlorine, which can damage an RO membrane, and a sediment prefilter is always required to ensure that fine suspended materials in the source water do not permanently clog the membrane. Hardness reduction, either through the use of water softening for residential units or chemical softening for industrial use, may also be desirable in hard water areas.

Low Pressure (Residential) Systems

Low pressure RO systems generally refer to those systems with a water feed pressure of less than 100 psig. These are the typical countertop or undersink residential systems that rely primarily on the natural water pressure to make the reverse osmosis process function (see Figure 1).

Countertop units typically have an unpressurized water storage tank which is maintained at atmospheric pressure. Undersink units typically have a pressur-

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Reverse Osmosis

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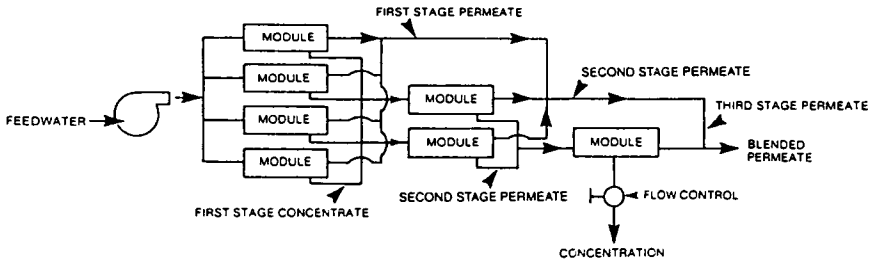
ized accumulator storage tank where the water pressure tends to increase as the tank fills. This provides sufficient pressure to get the water from the undersink storage tank to the faucet. Unfortunately, this also creates a back pressure against the membrane which decreases its efficiency. Some units overcome this by using unpressurized tanks with a pump to get the treated water where its needed.

Figure 2
Commerical RO System With Reject Staging



Low pressure units typically provide between 2 and 15 gallons per day of water with an efficiency of 2-4 gallons of reject water per gallon of treated water. Water purity can be as high as 95 percent. These systems can be highly affordable, with countertop units starting at about US$150 and undersink units at US$500. They produce water for a cost as low as 10 cents per gallon after maintenance and water costs are factored in. Maintenance usually requires replacing any pre- or postfilters as required (typically one to four times per year) and the reverse osmosis membrane cartridge about once every two to three years. Look for the WQA Gold Seal (S-300) to find products that have been successfully tested to industry performance standards; and to Certified Water Specialists (CWS I-V), Certified Sales Representatives (CSR), and Certified Installers (CI) for advice on your water needs and equipment installation.

High Pressure (Commercial/Industrial) Systems

High pressure systems typically operate at pressures between 100 psig and 1,000 psig, depending on the membrane chosen and the water being treated. These systems are usually used in industrial and commercial applications where large volumes of treated water are required at a high level of purity.

Most commercial and industrial systems use multiple membranes arranged in parallel to provide the required quantity of water. The processed water from the first stage of treatment can then be passed through additional membrane modules to achieve greater levels of treatment for the finished water. The reject water can also be directed into successive membrane modules for greater efficiency (see Figure 2), though flushing will still likely be required when concentrations reach a level where fouling is likely to occur.

High pressure industrial units typically provide from 10 to thousands of gallons per day of water with an efficiency of 1-9 gallons of reject water per gallon of treated water. Water purity can be as high as 95 percent. These systems tend to be larger and more complicated then low pressure systems, which is reflected in their cost. Commercial and industrial units can range in cost from US$1,000 to tens of thousands of dollars for a large, multimodule unit that can provide desalinated drinking water for a resort facility or water bottling plant.

What Reverse Osmosis Treats

Reverse osmosis can treat for a wide variety of health and aesthetic contaminants. Effectively designed, RO equipment can treat for a wide variety of aesthetic contaminants that cause unpleasant taste, color, or odor problems like a salty or soda taste caused by chlorides or sulfates.

RO can also be effective for treating health contaminants like arsenic, asbestos, atrazine (herbicides/pesticides), fluoride, lead, mercury, nitrate, and radium. When using appropriate carbon prefiltering (common with most RO systems), additional treatment can also be provided for such "volatile" contaminants as benzene, trichloroethylene, trihalomethanes, and radon. Some RO equipment is also capable of treating for biological contaminants, like cryptosporidium. The Water Quality Association (WQA) cautions, however, that while RO membranes typicially remove virtually all known microorganisms and most other health contaminants, due to design considerations, they may not offer foolproof protection when incorporated into a consumer drinking water system.

When looking for a product to treat for a health contaminant, care should be used to find products that have been tested successfully for such purposes at a quality testing laboratory.

Conclusion

Reverse osmosis is a relatively new, but very effective, application of an established scientific process. Whether it is used to meet the needs of a typical family of four, or the needs of an industrial operation requiring thousands of gallons per day, it can be a cost-effective way to provide the required quantity of highly treated water. With continual advances in system and membrane design that boost efficiency and reliability, RO can be expected to play a major role in water treatment for years to come.

For more information on the benefits of water softening, contact your local Certified Water Specialist (CWS), Water Quality Association member company, or write to the:

Water Quality Association
4151 Naperville Road
Lisle Illinois 60532 USA □

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