Reverse Osmosis of Drinking Water

Basic Principle

Reverse osmosis is a membrane separation technique that utilizes permeable membranes to filter selected components from a liquid. The membrane selects molecules on the basis of shape and size. Hotels could potentially use this process to reduce the levels of heavy metals, volatile organic compounds (VOCs), and chlorine in the drinking water.

Reverse osmosis is a very refined filtration method and utilizes a membrane with smaller pores than are used with microfiltration or ultrafiltration, two other methods of membrane separation. This system allows compounds smaller than 5–20 angstroms to pass through, while retaining larger compounds.

System Description

In a reverse osmosis system, water is circulated under pressure, in contact with a specially constructed polymeric film. Some dissolved matter passes through while other contaminants, such as heavy metals and chlorine, do not. The systems are modular, each designed as a self-contained pressure vessel containing the membranes and fluid distribution system. The systems typically operate at pressures of 200–1500 psi.

Four basic module designs or configurations exist:

- Tubular: The least susceptible to plugging, but the most expensive
- Flat plate: Compact and less costly, with greater maintenance requirements
- Spiral wound: Compact, low capital cost per unit, but requires more prefiltration and makes leak detection more difficult
- Hollow fiber: Relatively low capital cost, but requires prefiltration and has limited operating pressures

In all these configurations, solids build up on the membrane, usually because only hydrogen-bonding substances (e.g., water, ammonia) are allowed to pass through the membrane. The remedy for this membrane fouling involves either rinsing or back-flushing the membrane.

In rinsing, the membrane is flushed with feedwater at reduced pressures and increased velocity (two or three times normal). The turbulent action of the fluid loosens the particles and carries them away. Additives such as dilute hydrochloric acid, citric acid, dilute caustic soda, sodium hypochlorite, or detergent can assist in loosening the particles.

In back-flushing, the flow of the permeate (high-quality water) is reversed through the membrane. This process loosens and lifts particles from the membrane and washes them away with the concentrate (rejected particle stream). This ensures high filtration rates over long periods of time.

Reverse Osmosis Unit

Source: Culligan International Company

Advantages

- Low energy requirements: Membrane filtration systems require less energy than conventional phase-change processes.
- Limited maintenance requirements: There are no moving parts, which reduces the need for maintenance.
- Systems are modular and compact: The reverse osmosis system requires less space than most other water treatment systems, and can be added onto existing water treatment processes.
- Cost savings: In general, membrane filtration systems cost a fraction of phase-change systems.

Disadvantages

- Reverse osmosis membranes are susceptible to damage by a variety of organic and inorganic compounds.
- Fouling occurs when particles collect on the membrane surface.

Commercial Status

Reverse osmosis systems for water treatment are now commercially available in numerous sizes, ranging from small units for home drinking supplies to large units for hotel water treatment. It would, however, be expensive for a hotel to treat all of its water with reverse osmosis, and to treat only drinking water would require a separate piping system for distribution. Many hotels might find installation of a separate piping system too expensive, whether done at the time of hotel construction or retrofit later. A hotel wanting to provide this type of "ultra-pure" drinking water for its guests could use reverse osmosis to treat its restaurant/kitchen water and/or to treat the water used in hotel ice machines. Alternatively, a reverse osmosis unit could be installed on each floor of the hotel for easy guest access.

Cost and Electrical Requirements

Capital and operating costs depend primarily on the type of membrane and its specific

Reverse Osmosis System Characteristics

Capacity	0.1–100 gal/min
Approximate Size	Length: 15–210" Width: 10–70" Height: 30–90"
Approximate Weight	70–5200 lb
Power Rating	0.2–30 kW
Energy Consumption	0.5–4 kWh/100 gal of water
Key Inputs	
Power	Electricity
Other	Membrane replacement (once every 1–3 years)
Key Outputs	
Solid Waste	Heavy metal, salts
Air Emissions	None
Water Effluent	Drinking water supply
Cost	
Purchase	$3300–$100,000
Installation	10% of purchase cost
Other Supplies	$1–$3/1000 gal of feed rate

application. A reverse osmosis system processing 5 gallons of water per minute would cost $15,000–$30,000. This system might be appropriate for a medium-sized hotel that processes all of its drinking water.

Electricity requirements depend on the type of application, membrane, area, permeability, temperature, pressure, and feed flow rate. Electricity is required for pumping water through the system. Units ranging in size from 0.1–100 gallons per minute (gpm) require 0.2–30 kW of energy, respectively. Therefore, for most systems, the electricity requirement for a reverse osmosis unit would be 0.5–4 kWh per 100 gallons of water.

EPRI

Technology Profile

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