Reverse Osmosis: Explained & Simplified

1. What is reverse osmosis? What's the simplest way to explain it?

Reverse Osmosis (RO) is a pressure-driven membrane process used for purification of water. In all pressure-driven membrane processes, water passes through the membranes more easily than the contaminants that are being removed. However, not all of the water supplied to an RO membrane passes through the membrane. The two water streams of differing water quality are produced in the RO process:

Stream 1: The water stream that passes through the membrane is purified and is referred to as "permeate".

Stream 2: As the feed water stream passes along the membrane and loses water to the permeate stream, the concentration of contaminants on the feed water side increases. For this reason, the feed stream quality declines along the membrane and is often referred to as "concentrate" when it exits the membranes.

The membranes used in RO are generally composed of a non-porous polymeric film underlain by porous support layers. The openings in this polymeric film are very small, which allows RO the unique ability to remove most dissolved solids from water. Specifically, RO is capable of rejecting viruses, bacteria, salts, sugars, proteins, particles, dyes, heavy metals, dissolved organics and other contaminants that are dissolved in water.

2. What is TDS?

Total Dissolved Solids (TDS) is a measure of the combined content of all inorganic and organic chemicals dissolved in water. These components could be in molecular, ionized or micro-granular suspended form. Examples of inorganic chemicals that commonly contribute to a measurement of TDS include calcium, magnesium, potassium, sodium, bicarbonate, chloride, and sulfate. Organic chemicals that may contribute to TDS can derive from land application of chemicals, industrial release of chemicals to the environment, vegetable matter, and/or animal matter. In a laboratory setting, TDS is measured by weighing the mass of solids remaining when water is evaporated completely. In practice, handheld meters are often used to approximate the TDS in water based upon a conductivity measurement. TDS varies widely from region to region (and store to store) and is generally determined by the water source (groundwater or surface water) and geologic make-up of the region.

3. What is hardness?

As water percolates over and through soil and rock, a variety of minerals may dissolve and enter into solution. Of these dissolved solids, calcium and magnesium are the two chemicals that make water "hard."

Hard water causes the formation of scale in equipment when it encounters changes in temperature or concentration. Specifically, scale is formed when calcium and/or magnesium precipitates out of solution and onto the surfaces of the equipment. For example, scale forms in a coffee brewer because calcium/magnesium precipitates (crystalizes) out of the water as it encounters the brewer's heating elements. The hardness of water is reported in Milligrams per Liter (mg/L), or Parts Per Million (ppm).

Reverse Osmosis is the only pressure driven membrane process that can protect equipment from mineral scale. This is because only RO membranes have small enough openings to hold back calcium and magnesium from crossing the membrane into the permeate.

4. What other water problems can RO solve?

Beyond scale prevention, Reverse Osmosis can be used to control corrosion by reducing the conductivity of water (TDS) and by removing chloride ions and or sulfate. However, blending some filtered tap water with RO permeate is often necessary to ensure that water supplied to equipment is not too pure. For example, blending is often used to meet an equipment manufacturer's (coffee, espresso, steamer, etc.) water specification for TDS.

5. What does RO not do?

RO is not typically designed for biological purification of water. Minor defects in the membrane structure may allow passage of microbes without a significant impact on its ability to remove dissolved solids.

RO is not capable of removing chlorine from water. Chlorine can damage the non-porous films that allow removal of dissolved solids; so, carbon must be placed upstream of Reverse Osmosis to ensure good membrane performance.

RO is capable of removing some undissolved solids (dirt); however, it is not designed for this purpose, and using it in this manner will often reduce the lifetime of the membranes. As such, particulate filtration is recommended upstream of RO.

6. Why is RO necessary or preferred? What's wrong with the existing filtration system for fountain, ice, and coffee?

Existing filtration systems are designed to remove particles, chlorine, and dissolved organics (fertilizers, pesticides, and organics of animal or vegetable origin). They are not, however, capable of removing many dissolved contaminants including calcium, magnesium, sodium, and potassium salts. Dissolved mineral salts in the tap water can cause scale to build up on faucets, internal surfaces of pipes, water heaters, brewing equipment, and ice machines. This scale buildup often results in expensive repairs and losses of equipment efficiencies. For example, mineral deposits (scale) tend to create a thermal barrier that coats heating elements of machines that produce hot water, thus extending heating time increasing energy consumption.

Beyond scale formation, salts (dissolved minerals) can impact the taste of brewed and other beverages. By removing these contaminants, RO water allows the full essence of espresso, coffee, and/or tea to come through while brewing.

7. Recovery or efficiency and rejection- what are they and why does RO send some water to drain?

The recovery or efficiency of an RO system refers to the amount of pure water obtained relative to the amount of feed water used. As described above, an RO membrane retains dissolved solids on the feed side of the membrane. As more water passes through the membrane, the concentration of dissolved solids increases on the feed side. If this were allowed to continue, the concentration of dissolved solids would increase beyond the solubility of certain mineral salts. In turn, minerals would precipitate on the surface of the membrane, and the productivity of the membrane would be compromised. To avoid this loss of productivity, some of the concentrate produced by the RO process must be sent to the drain during normal operation, thus washing dissolved solids away from the membrane during the production of low TDS water. Rejection of an RO membrane refers to the percentage of dissolved solids removed from feed water by the RO membrane. As such, rejection tells how well a membrane can purify a given feed water.

8. Why does RO technology cost more than standard fountain filtration?

The non-porous film common to most RO membranes is much tighter than the pores encountered in the filtration that is commonly used prior to fountain dispensers. As a result, more pressure is necessary to produce RO permeate, and the rate of water production with RO is much slower than is possible with sub-micron filtration. These differences require additional pump capacity and water storage relative to sub-micron filtration.

RO membranes also require more sophisticated techniques to ensure that the membranes function in different water qualities to produce the desired output water quality. As a result, efficient RO systems demand more expensive controls and monitoring.

9. How does RO pay for itself?

Reverse Osmosis pays for itself by protecting the equipment that it supplies with high-quality water. By preventing the formation of scale deposits on equipment, the function and energy efficiency of water using equipment is maximized. In turn, this means more “equipment up time” available to produce saleable product and reduced utility costs. Further, the continuous equipment protection that is afforded by Reverse Osmosis ensures the fewest possible service calls for equipment.

10. Does every commercial kitchen need RO? Why not?

No. Water quality, as measured by a broad number of variables, varies widely throughout the world. As such, some waters have high concentrations of TDS and are likely to produce scale in water using equipment, while other waters have very low concentrations of TDS and pose no significant threat to equipment. Similarly, some waters have optimal TDS concentrations for the flavor of brewed beverages while others do not.

Based on this variability, RO should only be applied when the TDS or hardness in a feed water is high enough to either generate scale in equipment or have a negative impact on the quality of beverages produced from said water.

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