Reverse Osmosis

INTRODUCTION

To understand the concept of reverse osmosis it is first necessary to understand osmosis. Dictionary.com defines osmosis as:

1. Diffusion of fluid through a semi-permeable membrane from a solution with a low solute concentration to a solution with a higher solute concentration until there is an equal concentration of fluid on both sides of the membrane.
2. The tendency of fluids to diffuse in such a manner.

This concept is shown in Figure 1.

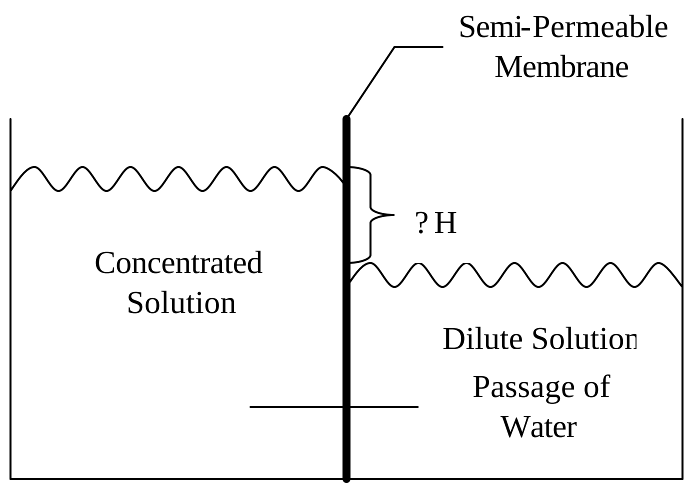

Figure 1

The height ? H is the osmotic pressure. This pressure is defined as:

> n : (physical chemistry) the pressure exerted by a solution necessary to prevent osmosis into that solution when it is separated from the pure solvent by a semi-permeable membrane.

In other words, when the pressure exerted on the semi-permeable membrane as measured by the height ? H exceeds the pressure necessary to prevent osmosis, the flow of pure solvent from the dilute solution to the concentrated solution stops.

In reverse osmosis the process as described above is reversed. In this process a high pressure is applied to the concentrated solution thereby forcing the pure solvent to pass through the semi-permeable membrane from the concentrated solution to the dilute solution. This process is shown in figure 2. When applied to water purification the concentrated stream is the reject water and the dilute stream is the product or permeate water.

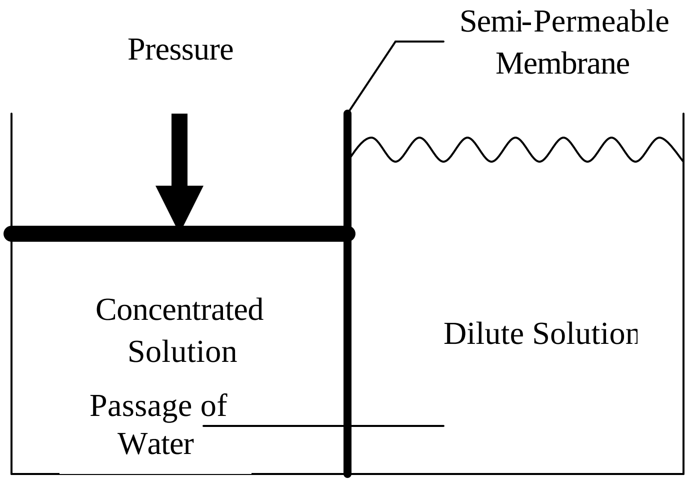

Figure 2

The amount of dissolved solids rejected by the membrane is expressed as a percentage. Rejection rates of 90% to 98% are typical for today's membranes. A rejection rate of 90% means that 90% of the total dissolved solids (TDS) will be rejected by the membrane and 10% will pass through the membrane. The % reduction can be calculated by use of the following equation:

$$\%\text{Rejection} = \frac{\text{Feed TDS} - \text{Product TDS}}{\text{Feed TDS}} \times 100$$

The amount of pure water produced as a percentage of the total water supplied to the RO machine is called the % Recovery. The % recovery is calculated by using the following equation:

$$\%\ \text{Recovery} = \frac{\text{Product Water Flow Rate}}{\text{Feed Water Flow Rate}} \times 100$$

Recovery rates from 25% to 80% are common in today's RO systems. Recovery rates are determined by the material of the membrane and the pressure and temperature of the feedwater. For an under-the-counter point-of-use systems commonly found in homes the feedwater operates at the utility supply pressure of 40 to 80 psi. With this supply pressure the recovery is typically 25% to 33% and product water is produced at the rate of 10 to 50 gallons per day (GPD).

Light commercial systems have a feedwater booster pump to raise the pressure on the membrane to 150 to 250 psi. The pure water is produced at the rate of 150 to 2400 GPD at a recovery of 35 to 60%. Heavy commercial and industrial systems run from 2400

GPD up to 500,000 GPD product water production for standard systems and for custom designed systems the upper flow limit is only limited by cost and space. Recovery for these systems ranges from 50% to 80%.

A simple RO machine design includes a pump to provide the driving pressure required, the membranes or elements in housings, connecting piping, control valve(s) and instruments. Pressure gauges and motor controls are required, but the degree of instrumentation and other controls can and does vary tremendously. Roughing prefilter cartridges are usually included to reduce membrane fouling. Everything from simple on/of conductivity sensor lights to complex, sophisticated PLC and computer-controlled systems are employed today for RO machines.