WET USA Inc.
316 Roma Jean Pkwy, Streamwood, IL 60107
tel 630-540-2113 • fax 630-540-2117
www.wet-usa.com • info@wet-usa.com

TECHNICAL PUBLICATION

INFORMATION & STRATEGY FOR THE FACILITY MANAGER

Principles of Reverse Osmosis

A Reprint from Ecodyne

Reverse Osmosis is a process for removing dissolved mineral salts, organic molecules, and certain other impurities from water by forcing water under increased pressure to pass through a semi-permeable membrane. This process is the reverse of the natural osmotic process in which fluids with a low concentration of dissolved solids, pass through a membrane into an area of higher concentration. With reverse osmosis, water is made to pass from a state of high concentration to a state of low concentration.

Since reverse osmosis does not occur naturally, it must be created by applying pressure to the high solids water in order to force it through the membrane. Membranes must be strong and resistant enough to withstand the high pressures of RO operation — from 200 to 400 psi in most applications, 1000 or even 1200 psi for sea water desalination. The pressure applied to the feed side of the RO membrane must be much higher than the natural osmotic process to be reversed. High pressure pumps are used to create the pressure needed to produce product flow rates that are economically acceptable.

Design Considerations

The product flow of a RO is mainly a function of temperature and pressure. System recovery (product divided by feed) is limited by the characteristics of the feed water and can be controlled through the use of a recycle stream. Product quality is based on a percentage of dissolved solids feed to the membrane.

There should be an economic balance between product quality and system recovery. High recoveries increase concentrations of dissolved solids in the system which degrades quality, but high recoveries make the system more efficient and decrease waste.

RO units do not deliver to service all of the water that is fed to them. During operation, some of the incoming water is used to wash down the membrane, and only part becomes finished product water. The purified water is referred to as product, and waste water is referred to as concentrate. The percent of water delivered as product is called the recovery, and depends on the membrane and on total RO unit design considerations.

RO units are volume rated at 77° (25°C.) incoming water temperature. Adjustments must be made if the incoming water temperature varies. Often, for optimum RO unit performance, mixing valves or heaters are used to maintain feed water at the rated temperature.

Pretreatment

Pretreatment of water prior to the RO process is almost always required. Not only is chlorine removal commonly required but high hardness minerals should also be controlled by a softener or other suitable methods of treatment. Hard water scale build-up impairs RO unit performance. Turbidity, iron and other impurities must be controlled for optimum RO performance.

Reverse Osmosis Membranes

Several types of membranes have been developed for RO applications and two types are in wide use.

The membranes allow water to pass through the membrane while stopping the passage of dissolved and suspended matter. RO membranes also have excellent rejection of organic matter, colloids, and turbidity, although turbidity can foul them. The percent rejection of each impurity varies somewhat according to the type of impurity and the membrane. Rejection tables are available for each membrane.

Thin Film Composite

The membrane gaining wide acceptance is the composite membrane, usually called a thin film composite (TFC) membrane. TFC membranes are three layers of material — a thin (0.25um) barrier coating on the surface of a microporous layer of polysulfone, both supported by a polyester web. The barrier coating can be made of polymers such as polyamines, polyimines, or polyethers.

TFC membranes have high salt rejection rates, usually operate at lower pressures than CA or HF, and have exhibited good performance under wide ranging pH and temperature conditions. They are not degradable by micro-organisms, and hold their flux rates over long periods of time. They have low chlorine tolerance so chlorine removal is needed as a pretreatment step. TFC membranes are produced in spiral wound module configuration.

Cellulose Acetate

Another type of commonly available membrane capable of high salt rejections is made of cellulose acetate. These elements are more chlorine tolerant than the TFC composite. Cellulose acetate (CA) membranes are asymmetric, that is, they consist of a thin dense salt barrier attached to a thicker microporous layer, manufactured in on step so that it is essentially only layer. CA membranes are usually fabricated in spiral wound module configurations, with a fabric support, to provide a lot of membrane area in a small space. As water is forced against the barrier layer, the dissolved salts are rejected and low solids product water passes through to an inner cylinder, or tube, and then to service.

Cellulose triacetate (CTA) is also used in RO applications. It has a higher rejection of slat than regular cellulose acetate, is more resistant to chlorine, and can operate at high pH values, up to 8.5. Blends are also used, combining cellulose diacetate and cellulose triacetate. This blend has good resistance and salt rejection, but with higher flux than cellulose acetate. Flux is the rate at which water is transported through the membrane.

System Engineering

RO units are often used to provide low Solids feed water to deionizers. This lengthens the deionizer service cycle and lowers regeneration frequency. Considerable money can be saved through reduction of regenerant chemicals. Systems engineering of water treatment problems takes on added significance as RO and DI processes are designed and operated together as a system.