Tech Manual Excerpt

Basics of Reverse Osmosis
Desalination Technologies and FIltration Processes

Desalination Technologies and Filtration Processes

FilmTec™ reverse osmosis (RO) and nanofiltration (NF) membrane technologies are widely recognized to offer highly effective and economical process options. From small-scale systems, through to very large-scale desalination, RO and NF can handle most naturally occurring sources of brackish and seawaters. Permeate waters produced satisfy most currently applicable standards for the quality of drinking waters.

RO and NF can reduce regeneration costs and waste when used independently, in combination or with other processes, such as ion exchange. They can also produce very high quality water, or, when paired with thermal distillation processes, can improve asset utilization in power generation and water production against demand.

Figure 1 gives an approximate representation of the salinity range to which the main desalination processes can be generally applied economically.

The most typical operating range of the four major desalination processes is shown in Figure 1. Also shown is typical operating ranges for several generic FilmTec™ membrane types.

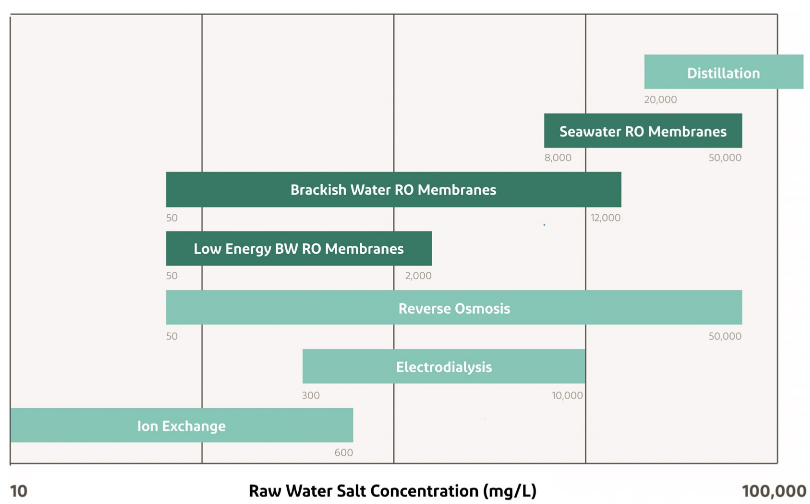

Figure 1: Major desalination processes

Desalination Technologies and Filtration Processes (Cont.)

The various filtration technologies which currently exist can be categorized on the basis of the size of particles removed from a feed stream. Conventional macrofiltration of suspended solids is accomplished by passing a feed solution through the filter media in a perpendicular direction. The entire solution passes through the media, creating only one exit stream. Examples of such filtration devices include cartridge filters, bag filters, sand filters, and multimedia filters. Macrofiltration separation capabilities are generally limited to undissolved particles greater than 1 micron.

For the removal of small particles and dissolved salts, crossflow membrane filtration is used. Crossflow membrane filtration (see Figure 2) uses a pressurized feed stream which flows parallel to the membrane surface. A portion of this stream passes through the membrane, leaving behind the rejected particles in the concentrated remainder of the stream. Since there is a continuous flow across the membrane surface, the rejected particles do not accumulate but instead are swept away by the concentrate stream. Thus, one feed stream is separated into two exit streams: the solution passing through the membrane surface (permeate) and the remaining concentrate stream.

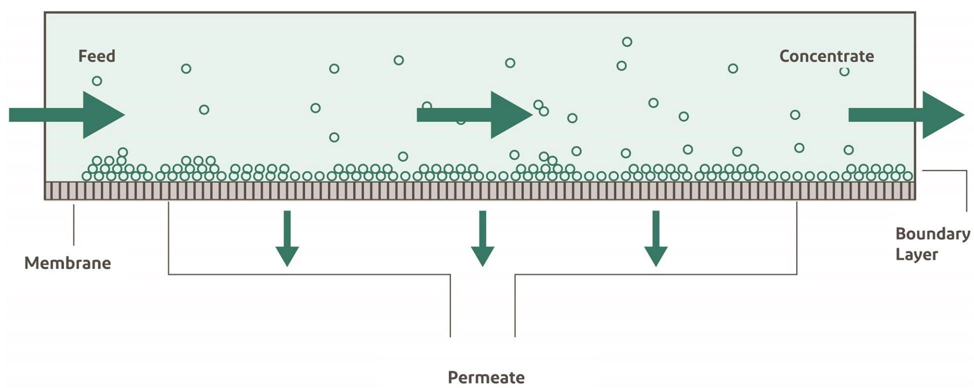

Figure 2: Crossflow membrane filtration

There are four general categories of crossflow membrane filtration: microfiltration, ultrafiltration, nanofiltration, and reverse osmosis.

Microfiltration (MF)

Microfiltration removes particles in the range of approximately 0.1 – 1 micron. In general, suspended particles and large colloids are rejected while macromolecules and dissolved solids pass through the MF membrane. Applications include removal of bacteria, flocculated materials, or TSS (total suspended solids). Transmembrane pressures are typically 10 psi (0.7 bar).

Desalination Technologies and Filtration Processes (Cont.)

Ultrafiltration (UF)

DuPont's ultrafiltration modules provide macro-molecular separation for particles ranging in size from approximately 20 – 1,000 Å (up to 0.1 micron). All dissolved salts and smaller molecules pass through the membrane. Items rejected by the membrane include colloids, proteins, microbiological contaminants, and large organic molecules. Most UF membranes have molecular weight cut-off values between 1,000 and 100,000. Transmembrane pressures are typically 15 – 100 psi (1 – 7 bar).

Nanofiltration (NF)

Nanofiltration refers to a speciality membrane process which rejects particles in the approximate size range of 1 nanometer (10 Å), hence the term "nanofiltration." NF operates in the realm between UF and reverse osmosis. Organic molecules with molecular weights greater than 200 – 400 are rejected. Also, dissolved salts are rejected in the range of 20 – 98%. Salts which have monovalent anions (e.g., sodium chloride or calcium chloride) have rejections of 20 – 80%, whereas salts with divalent anions (e.g., magnesium sulfate) have higher rejections of 90 – 98%. Typical applications include removal of color and total organic carbon (TOC) from surface water, removal of hardness or radium from well water, overall reduction of total dissolved solids (TDS), and the separation of organic from inorganic matter in specialty food and wastewater applications. Transmembrane pressures are typically 50 – 225 psi (3.5 – 16 bar).

Reverse Osmosis (RO)

Reverse osmosis is among the finest levels of filtration available. The RO membrane generally acts as a barrier to all dissolved salts and inorganic molecules, as well as organic molecules with a molecular weight greater than approximately 100. Water molecules, on the other hand, pass freely through the membrane creating a purified product stream. Rejection of dissolved salts is typically 95% to greater than 99%, depending on factors such as membrane type, feed composition, temperature, and system design.

The applications for RO are numerous and varied, and include desalination of seawater or brackish water for drinking purposes, wastewater recovery, food and beverage processing, biomedical separations, purification of home drinking water and industrial process water.

Also, RO is often used in the production of ultrapure water for use in the semiconductor industry, power industry (boiler feedwater), and medical/laboratory applications. Utilizing RO prior to ion exchange (IX) can substantially reduce operating costs and regeneration frequency of the IX system. Transmembrane pressures for RO typically range from 75 psig (5 bar) for brackish water to greater than 1,200 psig (84 bar) for seawater.

The normal range of filtration processes is shown in Figure 3.

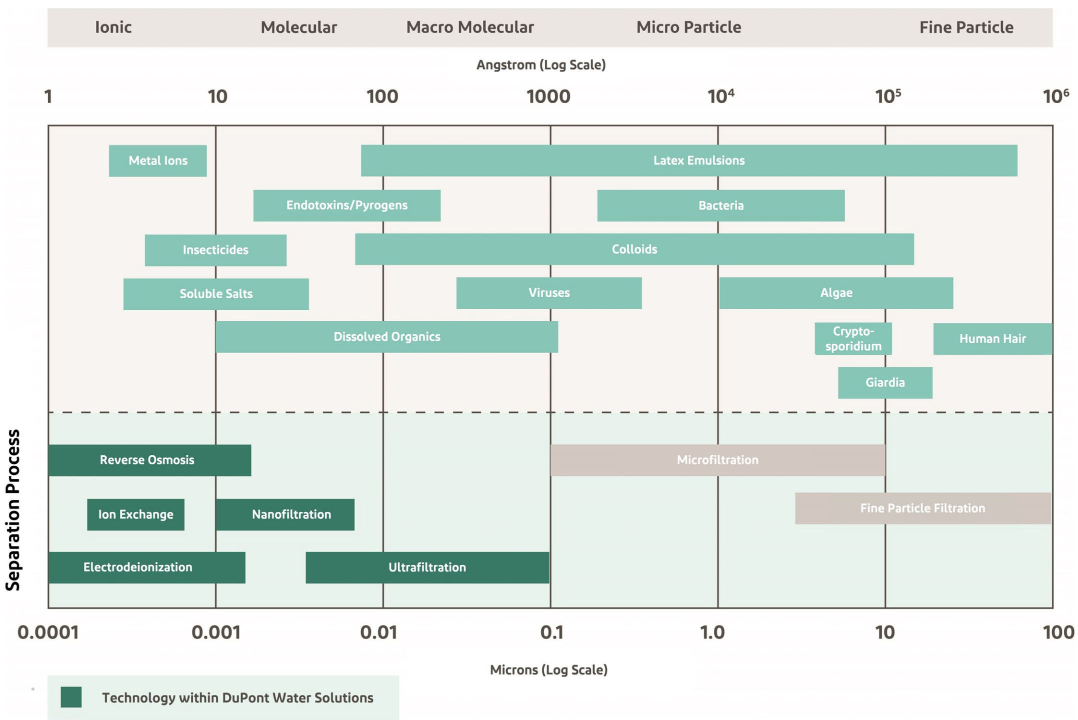

Figure 3: Ranges of filtration processes

Excerpt from FilmTec™ Reverse Osmosis Membranes Technical Manual (Form No. 45-D01504-en), Chapter 1, "Basics of Reverse Osmosis and Nanofiltration."

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