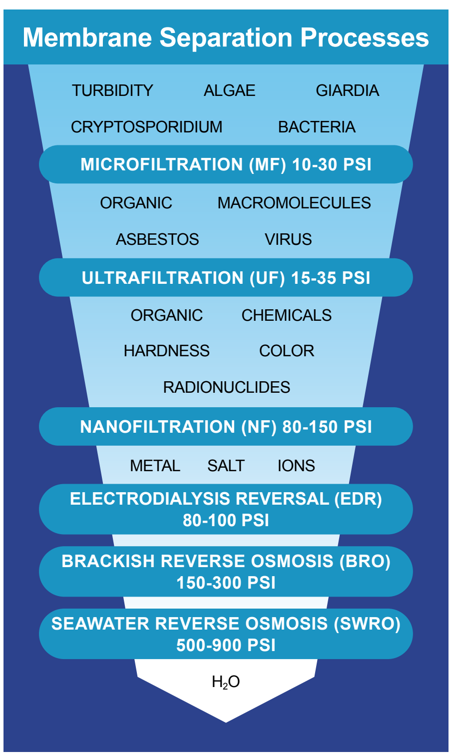
APPLICATION of Membrane Technologies

Membrane technologies have seen a significant growth and increase in application in the last two decades. Membrane systems are now available in several different forms and sizes, each uniquely fitting a particular need and application. This fact sheet provides a brief overview of membrane technologies with their general use and application.



Reverse osmosis (RO) membrane technology has been successfully used since the 1970s for brackish and seawater desalination. A lower pressure RO technology called **nanofiltration** (NF), also known as “membrane softening,” has also been widely used for treatment of hard, high color, and high organic content water.

In addition, RO systems are utilized for removal of inorganic contaminants such as radionuclides, nitrates, arsenic, and other contaminants such as pesticides.

A non-pressure, electric potential driven membrane called **Electrodialysis Reversal** (EDR) has also been widely used for removal of dissolved substances and contaminants.

RO is a physical separation process in which properly pretreated source water is delivered at moderate pressures against a semi-permeable membrane. The membrane rejects most dissolved ions and molecules, while allowing water of very low dissolved ion content to pass through. This process also works as an absolute barrier for cysts and most viruses. The process produces a concentrated reject stream in addition to the clean permeate product. By-product water—or the “concentrate”—may range from 10% to 60% of the raw water pumped to the reverse osmosis unit. For most brackish waters and ionic contaminant removal applications, the concentrate is in the 10 to 25% range, while for seawater, it could be as high as 60%.

Figure 1: Reverse Osmosis/Nanofiltration

Figure 2: Electrodialysis Reversal (EDR)

In the EDR process, electrical energy pulls ions through a membrane, with separate passes required for the positive and negative ions, leaving behind feed water with only the ions without a charge. Typically, RO/NF elements are in spiral wound element configuration **(Figure 1)**, while EDR is in stacks containing membrane sheets **(Figure 2)**.

During the last two decades, utilities nationwide have turned to low pressure membrane filtration to meet more stringent water quality requirements. Low pressure **microfiltration** (MF) and **ultrafiltration** (UF) membrane filtration technologies have emerged as viable options for addressing current and future drinking water regulations related to the treatment of surface water, groundwater under the influence, and water reuse applications for microbial and turbidity removal.

MF membranes remove only particulate matter and are capable of removing particles with sizes down to 0.1- 0.2 microns. Some UF processes have a lower cutoff rating of 0.005-0.01 microns. Pressure or vacuum may be used as the driving force to transport water across the membrane surface. Most MF/UF systems operate with high recoveries of 90 to 98%. Full-scale facilities have demonstrated the efficient performance of both MF and UF as feasible treatment alternatives to conventional granular media processes. Both systems have been shown to exceed the removal efficiencies required by the Surface Water Treatment Rule such as those for *Cryptosporidium* oocyst, *Giardia* cyst, and turbidity. MF and UF membrane systems generally use hollow fibers that can be operated in the outside-in or inside-out direction of flow. Pressure (5 to 35 psi) or vacuum (-3 to -12 psi for outside-in membranes only) can be used as the driving force across the membrane.

MF and UF membranes are most commonly made from various organic polymers such as different polysulfones and polyvinylidene fluoride (PVDF). Physical configurations include hollow fiber, spiral wound, cartridge, flat plate/sheet and tubular **(Figure 3)**.

Figure 3: Microfiltration/Ultrafiltration

Membrane bioreactor (MBR) and tertiary treatment systems are the best available technologies for treating wastewater for communities that are concerned about protecting the environment and preserving potable water supplies. Whether a community needs to improve the effluent quality from its existing conventional wastewater treatment plant or construct a new compact and highly efficient wastewater treatment system, MBRs provide cost-effective solutions that will meet or exceed discharge standards for years to come. Effluent from these systems is of such high quality that it can be safely discharged into the most sensitive aquatic environments or reused in irrigation, industrial processes, or groundwater recharge **(Figure 4)**.

Figure 4: Membrane Bioreactor (MBR)

With so many utilities facing the threat of contamination from an increasing number of sources, the need for new and better ways of treating and protecting our water supplies is paramount. Although there is no guarantee of complete protection against an attack, spill, or infiltration of natural or international contaminants, the multi-barrier approach, along with the other benefits of membrane technology, can reduce the potential for disasters substantially. Together, with all other safety and security measures recommended by national and federal guidelines, the installation of membrane systems in a facility provides water agencies with an effective multi-barrier system.

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Membrane technologies provide high quality treatment solutions for a wide range of situations, with multiple full-scale global applications in:

- Drinking Water
- Municipal Wastewater
- Industrial Wastewater
- Ultrapure Water
- Recovery/Reuse
- Agriculture
- Landfill Leachate
- Pharmaceutical
- Power Generation
- Pulp and Paper
- Semiconductor
- Specialty Chemicals
- and even Floating Plants!

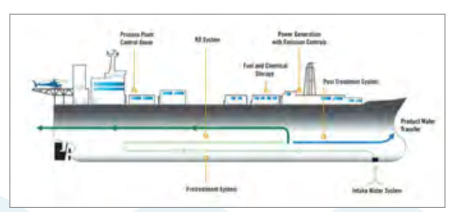

Figure 5: Seawater Desalination Vessel

This material has been prepared as an educational tool by the American Membrane Technology Association (AMTA). It is designed for dissemination to the public to further the understanding of the contribution that membrane water treatment technologies can make toward improving the quality of water supplies in the US and throughout the world.