Water Treatment and Dow Liquid Separations

Dow Liquid Separations is a leading global supplier of ion exchange resins and reverse osmosis (RO) and nanofiltration (NF) membrane elements. While these two technologies are based on different principles (see sidebars), they both deliver high level separations capabilities. Dow is the only manufacturer offering both membrane and ion exchange technologies.

Dow serves all major water treatment markets, including industrial water treatment (primarily boiler feedwater), municipal potable water treatment, seawater desalination, ultra pure water production for the semiconductor manufacturing industry, and commercial and home drinking water purification.

Water treatment products from Dow Liquid Separations include DOWEX* ion exchange resins and FILMTEC® reverse osmosis and nanofiltration membrane elements. These products make significant contributions to the quality of life for the world's population. For example, FILMTEC RO elements are utilized in desalination plants to provide potable water in Florida, the Middle East, Europe, the Caribbean, the Canary Islands, and other regions around the globe. FILMTEC nanofiltration elements are used to remove bacteria, pesticides, hardness ions, and other contaminants from potable ground and surface water supplies.

Dow water treatment technology also provides benefits in a host of industrial applications. DOWEX ion exchange resins are applied in process water treatment applications such as boiler feedwater demineralization and condensate polishing, reducing scale and lowering operating costs. DOWEX resins and FILMTEC elements are also used to produce the ultra pure water required to manufacture today's increasingly complex computer chips.

FILMTEC Membrane Elements

The FilmTec Corporation was established in 1977 with the introduction of the FT-30 reverse osmosis membrane, the first commercially viable thin-film composite polyamide membrane for brackish water treatment. This membrane offered several advantages over traditional cellulose acetate (CA) membranes. These advantages included better rejection of dissolved solids and organics, increased productivity at lower operating pressures, greater structural stability, and the ability to produce two to three times more purified water per unit area than CA membranes. As a result, the company quickly gained a significant share of the growing market for RO membrane elements.

FilmTec Corporation was purchased by The Dow Chemical Company in 1985, a move that leveraged Dow's sales and marketing strength plus its expertise in polymer and membrane research together with FilmTec's membrane research, manufacturing, and technical service resources. Operating today as a wholly owned subsidiary of The Dow Chemical Company, FilmTec manufactures a complete line of reverse osmosis and nanofiltration membrane elements.

FILMTEC elements are thin-film composite polyamide membranes packaged in a spiral-wound configuration. The FILMTEC FT-30 membrane consists of three layers: an ultrathin polyamide barrier layer, a microporous polysulfone interlayer, and a high-strength polyester support web (see Figure 1). Underlying structural support is given by the non-woven web. The polyamide barrier layer provides high water flux, rejects salt and silica, and resists chemical attack. The thick, microporous polysulfone support layer offers the necessary porosity and strength properties and resists compaction under RO and NF pressure conditions. While the original FT-30 membrane technology was introduced more than 20 years ago, it has been continuously refined since that time to provide higher rejection, improved membrane flux, and low fouling performance.

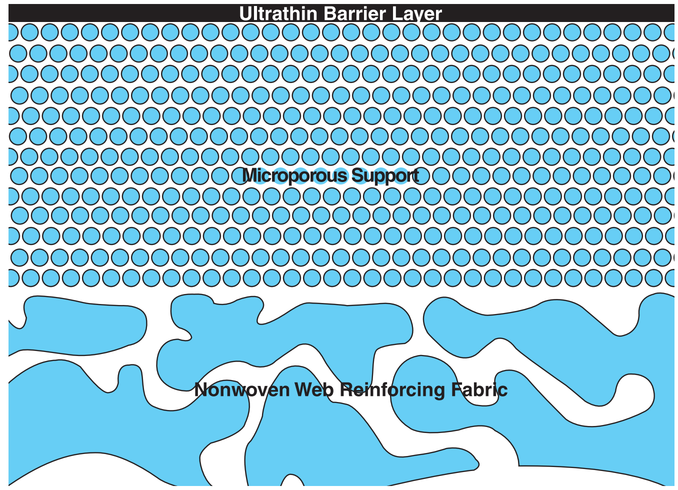

Figure 1. The FILMTEC FT-30 membrane consists of three layers: an ultrathin polyamide barrier layer, a microporous polysulfone interlayer, and a high-strength polyester support web.

FILMTEC RO and NF membrane elements have also benefited from continuous improvements. These improvements include high active surface area elements that furnish a larger active surface area and correspondingly greater productivity in the same amount of space as standard elements. Low-energy filter elements have also been introduced to address economic considerations in applications where energy costs are a critical factor. These low-energy elements also reduce capital investment and operating costs. Semiconductor grade elements that minimize potential contamination in ultra pure water processing have also been developed. And a new generation of NF elements designed to remove specific contaminants while permitting the passage of other desirable molecules are also available.

The FILMTEC element product line includes a variety of products for a range of applications. Brackish water RO elements are available for industrial water treatment and for home or commercial water systems. FILMTEC seawater elements include both standard and high rejection RO elements for seawater desalination. And low-pressure RO elements for home and commercial tapwater systems with low daily volume requirements are also available.

FILMTEC nanofiltration elements are used to treat ground and surface water supplies where high sodium rejection is not required but other salts such as calcium and magnesium must be removed. Municipalities in Florida and other areas use FILMTEC NF elements as an alternative to lime softening of surface and groundwater supplies. Nanofiltration removes most trihalomethane (THM) precursors; THM is a suspected cancer threat that can remain in raw water treated with lime. FILMTEC NF200B nanofiltration membranes combine high rejection of pesticides and other dissolved organics with high productivity and low energy consumption. These elements are now being used to purify surface water supplies providing drinking water to communities.

All FILMTEC elements are fabricated in an ISO 9002 certified manufacturing facility using precision manufacturing processes to ensure the highest product quality and performance. The exacting fabrication process yields highly productive, consistently reliable elements that resist fouling, are easily cleaned, and provide long service life.

DOWEX Ion Exchange Resins

DOWEX ion exchange resins include a broad line of cation and anion resins for use in multiple bed and mixed bed demineralization as well as other demanding applications. Dow's family of resin products provide highly efficient and effective dealkalization, softening, mineral acid removal, and/or total organic carbon (TOC) removal.

The majority of DOWEX resins are based on styrene copolymerized with divinylbenzene (DVB). Styrene/DVB structures are the preferred matrices for ion exchange resins because they offer significant capacity and stability advantages over acrylic, polyamine, and phenolic resin structures. Some DOWEX resins, however, have acrylic and epoxy-polyamine structures to take advantage of the specific properties and performance of these matrices.

The DOWEX resin line includes both gel (or microporous) and macroporous resins. Both types of resins have significant advantages if properly applied. Gel-based resins are typically the resins of choice for standard water treatment applications because of their inherently greater capacity and better regeneration efficiency. Macroporous resins are generally preferred in more aggressive applications where their highly cross-linked structure provides osmotic strength and thermal stability.

Uniform particle size (UPS) technology is available across the entire line of DOWEX ion exchange resins. Dow pioneered the use of UPS resins in the early 1980s with the development of their monodisperse resin production technology. Because they contain no large beads, DOWEX UPS resins provide more surface area per unit volume, resulting in improved resin bed kinetics and more efficient and effective resin rinses. And unlike conventional Gaussian (or polydisperse) resins, DOWEX UPS resins do not contain any very small beads that can be lost during backwashing, thereby reducing resin bed capacity. Dow has recently applied monodisperse resin technology to its macroporous DOWEX resins to produce the industry's only comprehensive line of macroporous UPS anion and cation resins.

DOWEX MONOSPHERE* and DOWEX MARATHON* UPS resins are available as strong base anion resins, strong acid cation resins, and as mixed resins. Certain DOWEX MONOSPHERE resins are used for condensate polishing in power plant boiler feedwater applications and in other mixed beds. Matched pairs of DOWEX MONOSPHERE anion and cation resins feature optimized particle sizes to ensure fast kinetics, short rinse times, more thorough regeneration, and longer resin life. DOWEX MARATHON resins utilize a small average bead diameter and a narrow particle size range to achieve longer operating runs and lower operating costs in multi-bed demineralization. DOWEX GUARDIAN* UPS resins meet the stringent iron removal and TOC cleanliness requirements of deep bed condensate polishing in pressurized water reactor nuclear power plants.

To improve the efficiency of multi-bed demineralizers, Dow offers the UPCORE* countercurrent regeneration system. The UPCORE system combines a downflow service, upflow regeneration design with DOWEX UPCORE UPS resins in packed bed ion exchanger vessels (Figure 2). When compared with fluidized beds or air and water hold-down systems, the UPCORE system offers significant productivity and economic advantages. This is because it uses regenerant chemicals more efficiently, significantly lowers wastewater volume, and minimizes effluent postprocessing efforts. And resin beds clean themselves with the UPCORE system, so downtime for resin transfers and backwash operations is eliminated, physical stress on resins is reduced, and resin loss is minimized.

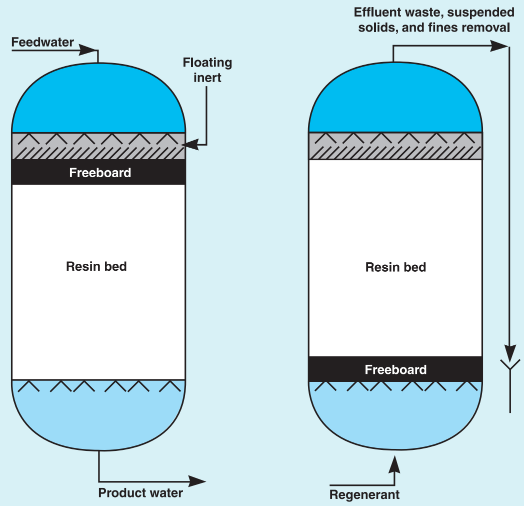

Figure 2. The top collector/distributor of a demineralizer bed incorporating the new UPCORE* system is surrounded by a layer of floating inert resin. This inert layer allows the compaction /regeneration effluent, along with any suspended solids and resin fines, to pass through while it restrains the passage of active DOWEX* UPCORE* uniform particle size resin beads.

Feedwater enters at the top of the distributor system and passes through the inert layer, through the ion exchange resin bed, and exits the vessel as demineralized water. At the end of the service cycle, water flows upward from the bottom distributor system, causing the resin bed to compact against the inert layer at the top of the vessel.

Immediately following compaction, the regenerant is passed upflow at a rate high enough to prevent decompaction. After the bed is regenerated, it is allowed to settle and is then returned to service.

DOWEX resins are made in advanced manufacturing plants with all process variables under computer control to ensure uniformity of the finished product. Dow backs each batch of DOWEX ion exchange resin with a written certificate of analysis based on testing of the material in that batch. The certificate quantifies properties such as physical stability, ion exchange capacity, water retention capacity, and classified density, permitting users to accurately predict how the resin will perform.

How Reverse Osmosis and Nanofiltration Membranes Work

The reverse osmosis and nanofiltration processes employ a semipermeable membrane and the cross-flow filtration principle to separate an extremely high percentage of unwanted organic and salt molecules from a feedwater stream. When this membrane is placed between pure water and a concentrated salt solution, pure water passes through it into the chamber containing the salt solution (Figure 3). This naturally occurring process is called osmosis, and it is caused by the pure water and the salt solution attempting to equalize their concentrations. As pure water flows through the membrane into the solution, the solution volume increases until the flow stops at a point of equilibrium. The difference between the volume of the salt solution and the pure water at the point of equilibrium is called the osmotic pressure.

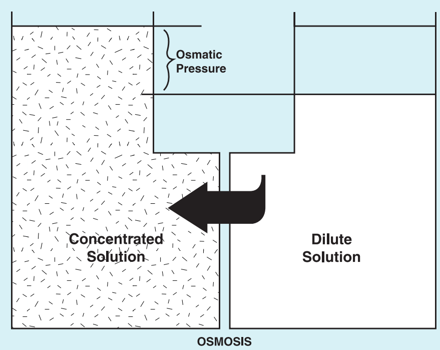

Figure 3. Pure water flows through the semipermeable membrane into salt solution.

Reverse osmosis and nanofiltration reverse the natural process of osmosis by applying pressure greater than the osmotic pressure to feedwater which is, in effect, the salt solution. As the feedwater flows across the membrane surface under pressure, pure water passes through the membrane, leaving behind a more concentrated solution (Figure 4) which is discharged as concentrate.

RO and NF systems employ cross-flow filtration to control membrane fouling. Feedwater flow parallel to the membrane surface allows pure water to pass through the membrane while the continuing flow of concentrated solution sweeps rejected molecules away from the membrane surface. This flow also maintains the osmotic pressure at a relatively constant level by preventing the solution in contact with the membrane from becoming too concentrated.

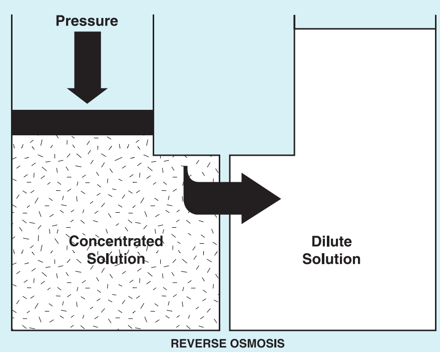

Figure 4. Pressure applied to the salt solution causes pure water to flow through the membrane fomr the solution side.

Semi-permeable membranes are categorized by the size of the dissolved solids that they remove. Reverse osmosis rejects dissolved solids larger than 1 angstrom in size Nanofiltration refers to a membrane process that rejects solutes approximately 1 nanometer (10 angstroms) in size with molecular weights above 200. Because they feature pore sizes larger than RO membranes, NF membranes remove organic compounds and selected salts at lower pressures than RO systems.

Greater Flexibility

As a supplier of both DOWEX ion exchange resins and FILMTEC elements, Dow Liquid Separations can provide integrated, optimized solutions taking advantage of the full performance capabilities of both technologies. As the only company that offers both resin and membrane technologies, Dow has an impartial perspective when assessing a user's separations needs and recommending a solution because the company is not tied exclusively to either technology.

How Ion Exchange Filtration Work

The ion exchange process removes unwanted ions from a water supply by transferring them to a solid material called an ion exchange resin, which accepts these ions while returning an equivalent number of a desirable species stored on the ion exchange resin skeleton. These reactions are predictable, they are reversible, they only occur if the molecules can be ionized, and the resin matrix is essentially unchanged from one reaction to the next.

An ion exchange system consists of a tank containing small beads of synthetic resin. The beads are chemically treated to selectively adsorb either cations or anions and exchange certain ions based on their relative activity in comparison to the resin. This ion exchange process will continue until all available exchange sites are filled, at which point the resin is exhausted and must be regenerated using appropriate chemicals.

The regeneration cycle involves displacing ions that were previously removed during the service cycle from the resin. This is accomplished with a solution (called the regenerant) containing the ion desired on the resin. The time required for regeneration and the associated waste neutralization must be kept to a minimum in order to maximize the service portion of the overall operating cycle.

Regeneration efficiency is the amount of regenerant consumed relative to the amount of regenerant supplied. Since regenerant efficiency is directly related to operating capacity or the number of functional sites that have been reactivated, it will ultimately affect the amount and purity of the treated water. Also affected is the amount of regenerant chemical consumed and the volume of waste chemical that must be processed as a result of each regeneration cycle.

The two basic deionizer configurations are two bed and mixed bed. Two-bed deionizers have separate tanks of anion and cation resins, and the process fluid passes the tanks sequentially. Mixed-bed deionizers contain a mixture of cation and anion resins within a single vessel. Mixed-bed systems generally produce higher quality water, but they have a lower overall capacity than two-bed systems. Multiple-bed systems are commonly used for demineralizers, while mixed beds are used in condensate polishing and other applications where higher water purity is required.

DOW*

Form No. 609-00277-1299AMS