PermaCare®

Glossary of Terms

Antiscalant	Chemical treatment added to increase the solubility of sparingly soluble salts. In RO systems $CaCO_3$, $CaSO_4$, $SrSO_4$, $BaSO_4$, CaF are the most common scales of concern.
Anti-telescoping Device	ATD - A plastic device on the ends of a membrane element which provides structural support to the membrane envelopes preventing unraveling and extension. See "Telescoping."
Array	The physical arrangement of pressure vessel (e.g., 4:3:1 - 3 stages with 8 total vessels; stage 1 has 4 pressure vessels, stage 2 has 3 pressure vessels and stage 3 has 1 pressure vessel.) The reject of each stage is the feed stream for the next successive stage.
Asymmetric	Membrane which is constructed of the same material (cellulose acetate or polyamide) that has an increase in porosity from surface to base. The surface has a dense thin barrier skin and a thick porous support layer.
Brackish Water	Technically is defined as Water of TDS levels up to 6,000 mg/L. For RO12™, any water less than 25,000 mg/ L is considered to be brackish.
Brine Seal	Plastic or rubber devices that seal the outside of one end of a spiral wound membrane element against the wall of the RO housing. These devices prevent bypassing of feedwater around the element.
Cellulose Acetate	An asymmetric polymer used in the construction of a membrane elements (others are Polyamide and Polysulfone). Originally CA membranes can be made of cellulose diacetate, cellulose triacetate or a blend. CA membranes need a residual of chlorine to protect them from biological attack. CA membranes have tight pH operating requirements. CA membranes are considered uncharged because their functional groups are not polar (PA and Polysulfone are) Because they are non-polar they do not attract foulants to the surfaces as easily. Less fouling is observed also due to a smother surface of a CA membrane. CA membranes are easily degraded by bio-fouling.

Compaction	Physical compression of the membrane. This compression results in a decrease in flux. The rate of compaction is directly proportional to an increase in temperature and pressure. Compaction occurs naturally over time requiring a greater feed pressure. Feed pumps are sized to the pressure requirements of the third year. Compaction is permanent and can occur quickly in CA membranes if operated at high pressures for any extended period of time. PA membrane have greater structural strength and can be operated at higher than normal pressures with little concern to compaction. Change as a result of compaction is expected for CA and TFC membranes during the first 200 hours of operation.
Concentration Factor (CF)	The degree that feedwater dissolved solids are concentrated in the brine. **Concentration Factor = 1/(1- Y)** Y ≡ Recovery as a decimal
Concentration Polarization	- Refers to the concentration gradient of salts on the high pressure side of the membrane surface created by the less than immediate re-dilution of salts left behind as water permeates through the membrane. The salt concentration in this boundary layer exceeds the concentration of the bulk water. This phenomenon impacts the performance of the process by increasing the osmotic pressure at the membrane's surface, reducing flux, increasing salt leakage and increasing the probability of scale development. Increasing the velocity (turbulence) of the brine stream helps to reduce concentration polarization.
Conversion	see "Recovery"
Cross Flow Separation	Filtration process with the feedwater stream running parallel to the filter media and a concentrate stream continuously removing contaminants from the surface media. Cross flow separation differs in that it has 3 streams associated with it compared to 2 streams found in dead head separation.
Elements	Often referred to as a module, elements are the physical devices that house the membrane. Spiral wound systems can have up to six elements per pressure vessel. Hollow fiber RO systems have only one element per pressure vessel.
Feed Channel Spacer	Found in spiral wound elements, feed channel spacers are a netting material placed between the flat sheets of a membrane to promote

	turbulence in the feed / concentrate stream. This material is referred to as "Vexar."
Feed Stream	Flow into the first stage of an RO system. The feed stream is separated into a permeate or product stream and a concentrated or brine stream. Feed Stream = Permeate + Concentrate
Flux	(Water Flux) Typically expressed as volume per area per unit of time, flux is used to express the rate at which water permeates a membrane. Typical units are gallons per square foot per day (i.e., GFD or GSFD) or liters per square meter per hour ($l/m^2/hr$). The flux of a membrane is directly proportional to temperature and pressure. As a rule of thumb, flux decreases 1.5% per 1^oF. Salt flux is the amount of TDS passed through a given area of membrane per unit of time. It is important to remember that Salt flux is a function of concentration gradient and not driving pressure. Therefore with increasing driving pressure, the concentration of salts in the permeate decreases due to constant salt leakage (e.g., milligrams) and increased water flux (e.g., liters). The net effect of increased drive pressure is to dilute a constant amount of slat with more pure water. Note: 1 GFD = 1.66 $l/m^2/hr$
Hollow Fiber Element	One of four possible membrane configurations (others are spiral wound, plate and frame, and tubular). Hollow fiber elements are made of extruded cellulose acetate or polyamide material. Pressurized feed water passes across the outside of the fibers. Pure water permeate the fibers and is collected at the end of the element. Hollow fibers were among the first RO systems. The hollow fiber element does not allow for turbulent flow or uniform flow across the fiber surface making these elements more prone to fouling and scaling. Once fouled they are more difficult to clean due to the inability to get the cleaning solution to the fouled area. Hollow fiber elements are mostly found in seawater desalination applications and limited brackish water applications where fouling potential is minimal.
Hydrolysis	Chemical breakdown of a membrane from exposure to low or high pH, bio-activity and temperature. Normally associated with CA membranes where the acetyl groups are replaced by hydroxyl groups. Hydrolysis in increased salt leakage (i.e., greater conductivity of the permeate) and a lower feed pressure requirement. Oxidants and temperature can cause hydrolysis in TFC elements.

(LSI)	Langlier Saturation Index is a measurement of CaCO3 potential. A positive LSI is indicates that CaCO3 can precipitate. A negative LSI indicates that the water is corrosive to steel.
Membrane	A membrane is a semipermeable material, that is, a material through which water passes relatively quickly, while other substances cannot (or do so relatively slowly). Membranes provide the barrier layer or interface for cross flow separation. Membranes are thin, porous material constructed of organic polymer (e.g., cellulose acetate, polyamide and charged polysulfone). RO membranes will typically reject contaminants with molecular weights greater than 200. Ultrafiltration membranes will reject contaminants with molecular weights between 10,000 and 0.1 micron.
Normalized Permeate Flow (NPF)	NPF is a calculation that allows the comparison of a measured permeate flow rate to a standard (or start up) condition. Permeate flow is a function of Net Driving Pressure (NDP), temperature and membrane condition. By normalizing measured permeate flow for observed NDP and temperature, a measure is obtained that can be used to compare the condition of the membrane to original start up conditions. A decrease in NPF of 10-15% indicates that membrane cleaning is required.
Net Driving Pressure	The difference between the feed pressure and the osmotic pressure. It is the measure of the actual driving pressure available to force the water through the membrane. As net driving pressure increases, the flux increases proportionally (given all other factors are held constant)
Nanofiltration	Similar to reverse osmosis but are not as effective at removing dissolved solids. Nanofilters are commonly referred to as membrane softeners because they will usually reject the double-positively charged hardness ions (i.e., calcium & magnesium) fairly well but cannot reject the single-positive charged soft ions (e.g., sodium & potassium). Nanofilters are most commonly used in the drinking water industry where the dissolved solids must be reduced to below 500 mg/L (Safe Drinking Water Act). The choice between nanofiltration in these applications comes down to economics. Nanofilters require less pumping pressure but would require a greater percentage of the total flow compared to RO systems which require greater feed water pressure but could be blended with the raw water due to the lower TDS level of the RO permeate.

O-rings	Used to seal the permeate water tube inter-connectors of adjacent elements. The prevent the intrusion of high pressure feedwater (poor quality) into the low pressure permeate water (good quality). A damaged O-ring will result in higher salt concentration of the permeate in that section of the system.
Osmotic Pressure	Is the pressure required to prevent the flow of water across a semipermeable membrane separating two solutions having different ionic strengths. For RO systems it is osmotic pressure that has to be overcome in order to produce permeate. A "rule of thumb" is for every 100 mg/L of TDS difference between feed and permeate, 1 psi of osmotic pressure exists.
Permeate	Often referred to as "product," permeate is the portion of the feedwater stream water which passes through the membrane. Permeate = Feedwater - Concentrate
Polyamide	Introduced in the early 1970's this asymmetric polymer is used in the construction of thin film composite (TFC) spiral wound membrane. Polyamide membrane are the most typical membrane construction material due to less pressure requirements and more flexible operating conditions. Polyamide membranes are oxidant (chlorine, chloramine, bromine, ozone etc.) intolerant. Also noteworthy is that surface of the polyamide membrane carries an anionic charge that makes it slightly more susceptible to fouling from contaminants carrying a cationic charge.
Pressure vessel	Tubular device which contains the membrane elements. For spiral wound elements the pressure vessel often is referred to as the pressure tube and can contain up to six membrane elements. In hollow fiber systems the pressure vessel is often referred to as the "permeator."
Product Channel Spacer	(A.K.A. Permeate Water Carrier) In the construction of a membrane element, the product channel spacer is placed between two layers of the flat sheet membrane. This spacer is a knit fabric called Tricot and is used to prevent the membrane from closing off on itself under the high pressure of operation. Permeate water will flow in a spiral path across the product channel spacer into the product collection tube.
Product Collection Tube	Collects the permeate water and directs to a product water header. The product collection tube is in the center of a spiral wound membrane element with the "membrane-product channel spacer - membrane- feedwater channel spacer" sandwich wrapped around it.

Product Stream	Same as permeate.
Recovery	Recovery is the percentage of the feedwater which is converted into permeate. (Sometimes referred to as conversion)
Salt Passage	The quantity of salt, as a percentage, which passes through the membrane into to the permeate stream. Salt passage is a function of temperature, velocity and concentration gradient (i.e., concentration of salt in the brine versus the permeate). Note Salt Passage = 1 - Salt Rejection Salt passage = $(TDS_{product}) / (TDS_{Feed}) \times 100$
Salt Rejection	The quantity of salt removed from the feedwater stream as a percentage. Note: Salt Rejection = 1 - Salt Passage Salt Rejection = $(TDS_{feed} - TDS_{product}) / (TDS_{Feed}) \times 100$
Silt Density Index (SDI)	SDI is an empirical test used to characterize the fouling potential of a feedwater stream. Test is based on the measuring the rate of plugging a 45 micron filter using a constant 30 psig feed pressure for specified period of time. SDI_{15} refers to a silt density index test which was run for 15 minutes. Typically spiral wound systems require an SDI < 5 and hollow fiber systems require an SDI < 3. Most deep well waters have an SDI of 3 and most surface water have SDI's greater than 6.
Spiral Wound Element	A membrane configuration which is comprised of "flat sheet membrane-permeate channel spacer - flat sheet membrane - feed channel spacer" combinations rolled up around a product collection tube.
Staging	"Reject Staging" refers to a technique where the reject from one group of RO pressure vessels becomes the feed stream of a second group of RO pressure vessels. Reject staging is used to increase the recovery of water. A one stage system typically could recover 50 - 60% of the feed water stream with 2 and 3 stage systems operating at 75 - 80% and greater than 85% respectively. "Product Staging" referred to as "multiple pass", is a technique where the product of the first group of RO pressure vessels becomes the feed water stream for a second stage. Product staging is used to increase the quality of the product water.

Telescoping	Longitudinal unraveling of spiral wound elements which results in the membrane leaves extending beyond the spacing material between the leaves. Can be caused by hydraulic surges or by temperature extremes. It is physically damaging to the construction of the membrane element. Most manufactures install anti-telescoping devices (ATD's) on their elements. Depending on severity, it may effect salt rejection.
Thin Film Composite (TFC)	Is a membrane composed of and manufactured as three layers bonded together. The two base layers of the asymmetric design have a thin skin (3rd) layer of either polyamide or charged polysulfone deposited on the surface. The thin film is the salt rejecting layer where the two base layers provide a porous structure whose function is strength.
Ultrafiltration	A cross flow separation technique used to remove colloidal, very fine particles and macromolecules from a water stream. Pore sizes in a UF system range from 0.001 to 0.1 micron. UF membrane systems are characterized by the molecular weight cut-off points (e.g., 3,000, 10,000, 20,000, and 80,000 Daltons). Unlike RO systems, UF does not remove dissolved salts from water.
Ultrapure Water	Term used to characterize electronic grade process water. Essentially this water is free of particles, colloids, organic and inorganic contaminants.