

Dow  
Liquid Separations



# **DOWEX** Ion Exchange Resins and **FILMTEC** Membranes

Glossary of Terms and Acronyms

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## A

**A-value:** Membrane water permeability coefficient.

**Adapter:** Cylindrical piece of plastic or metal that connects the product water tube of the element to the permeate piping of the water distribution system.

**Adsorption:** The attachment of compounds to the chemically active groups on the surface and in the pores of an ion exchange resin.

**Air mixing:** The process of mixing two ion exchange materials of different densities in a water slurry with air to yield a homogeneous mixed bed.

**Alkalinity:** Alkalinity may exist in three forms: caustic (or hydroxide), carbonate and bicarbonate. Alkalinity is commonly expressed as “P” and “M” in parts per million (ppm) as calcium carbonate (CaCO<sub>3</sub>). “P” represents the titration with a standard acid solution to a phenolphthalein end point. “M” represents the titration to a methyl orange end point. These values are used to calculate the caustic, carbonate and bicarbonate alkalinities. Standard practice assumes that (i) titration to a “P” end point determines all caustic and one-half of carbonate alkalinity and, (ii) titration to an “M” end point measures the sum of bicarbonate, carbonate and caustic alkalinity.

**Ammonia cycle:** Cation exchange resin operation in which the resin is run past the ammonia break.

**Antiscalant:** See *scale inhibitor*.

**Anti-telescoping device (ATD):** The ATD is a part of the end cap and keeps the envelopes in place. This inhibits telescoping.

**Array:** The series and/or parallel arrangement of pressure vessels within a reverse osmosis or nanofiltration system.

**Attrition:** The breakage and abrasion of resin beads.

## B

**B-value:** Salt diffusion coefficient.

**Backwashing:** The upward flow of water through an ion exchange resin bed to remove foreign material, reclassify the bed after exhaustion and prior to regeneration in co-current regenerated units. Also used to reduce compaction of the bed.

**Backpressure:** See *permeate backpressure*.

**Bank:** See *RO train*.

**Base exchange:** The exchange of cations between a solution and cation exchange resin.

**Batch operation:** A method of utilizing ion exchange resins in which the resin and the solution to be treated are mixed in a vessel and the liquid is decanted or filtered off after equilibrium is attained.

**Batch process:** Discontinuous processing of liquids, usually used for relatively small volumes.

**Bead count:** The evaluation of an ion exchange resin contained in a column or operating unit.

**Bed:** The ion exchange resin contained in a column or vessel (see *exchanger bed*).

**Bed depth:** The depth of ion exchange resin in a column or vessel.

**Bed expansion:** The separation and rise of ion exchange resin beads in a column or vessel during backwashing.

**Bed volume:** The volume of ion exchange material of specified ionic form contained in a column or operating unit, usually measured as the backwashed, settled and drained volume.

**Bed volume per hour:** The measure of the volume flow-rate through an ion exchange material contained in a column or operating unit, expressed as BV/hr, m<sup>3</sup>/hr/m<sup>3</sup> or gals/min/ft<sup>3</sup>.

**Bed warm-up:** The step just prior to regenerant injection where hot dilution water is added to the resin bed to heat the bed to the appropriate temperature. This is to enhance polymerized silica removal.

**Biofilm:** Growth of bacteria, algae, fungi, viruses and higher organisms on the membrane surface resulting in a film that is difficult to remove.

**Biofouling:** Degradation of RO/NF system performance due to formation of biological deposits by organisms present in the feed to the RO/NF system or in the system itself.

**Boiler feed water:** Water used in steam boilers and some industrial processes. Boiler feed water may possibly be raw water, treated water, condensate or mixtures, depending on the need.

**Booster pump:** Pump installed between two stages of an RO system, enabling to raise operating pressure for the subsequent array.

**Boundary layer:** Layer adhering to the membrane facing the feed/concentrate water.

**Brackish water:** (1) Water from a surface or ground water source with a salt content of less than 5,000-15,000 ppm. (2) The ASTM definition is: water that contains dissolved matter at an appropriate concentration range from 1000 to 30000 mg/liter.

**Breakthrough:** That volume of effluent where the concentration of the exchanging ion in the effluent reaches a predetermined limit. This point is usually the limit of the exhaustion cycle and the beginning of the regeneration cycle.

**Brine:** (1) Water that contains dissolved matter at an approximate concentration of more than 30,000 ppm. (2) See *concentrate*.

**Brine seal:** Ring made from flexible plastic material placed on element end cap in order to prevent flow bypass around the outside of an element.

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## C

**CADIX:** Computer Aided Design of Ion eXchange systems. A computer software for designing ion exchange resin plants.

**Capacity:** The number of equivalents of exchangeable ion per unit volume, unit wet weight, or dry weight of an ion exchange material in specified ionic form.

**Carboxylic:** A term describing the functionality of weak acid cation exchange resins.

**Caustic soda:** Also simply called caustic. This is the chemical sodium hydroxide (NaOH) which is used to regenerate anion exchange resins.

**Channeling:** The creation of isolated paths of lower resistance in an ion exchange resin bed caused by the introduction of air pockets, dirt or other factors which result in uneven pressure gradients in the bed. Channeling prevents the liquid being processed from uniformly contacting the entire resin bed.

**Chemical stability:** The ability of an ion exchange resin to resist changes in its physical properties when in contact with aggressive chemical solutions such as oxidizing agents. Also the ability of an ion exchange resin to resist inherent degradation due to the chemical structure of the resin.

**Chloride anion dealkalization:** An anion exchange system that is regenerated with salt and caustic and exchanges chloride ions for bicarbonate and sulfate ions in the water being treated.

**Classification:** Obtained by backwashing an ion exchange resin bed to obtain a bed which is graduated in resin bead size from coarse on the bottom to fine on the top.

**Clumping:** The formation of agglomerations in an ion exchange bed due to fouling or electrostatic charges.

**Co-current or Co-flow operation:** Ion exchange operation in which the process water and regenerant are passed through the bed in the same direction, normally downflow.

**Colloidal fouling:** Deposition of colloids on the membrane surface resulting in losses in system performance.

**Colloids:** Extremely small particles which are not removed by normal filtration.

**Color throw:** The imparting of color from an ion exchange resin to a liquid.

**Column operation:** The most common method for employing ion exchange in which the liquid to be treated passes through a fixed bed of ion exchange resin.

**Composite membrane:** Membrane obtained precipitating a thin desalinating layer on a porous carrier membrane.

**Concentrate:** The residual portion of an aqueous solution applied to a membrane, containing the retained salts. Also called retentate or brine.

**Concentration factor:** CF is the ratio of the feed quantity (or feed stream) over the concentrate quantity (or concentrate stream).

**Concentration polarization:** The development of a concentration gradient of the retained components across the boundary layer near the membrane surface. See also *concentration polarization ratio*.

**Condensate polisher:** The use of a cation resin or mixed bed unit to remove impurities from condensate.

**Conductivity or specific conductance:** The ability of a current to flow through water as a measure of its ionic concentration, measured in micromhos/cm or microSiemens/cm.

**Configuration:** See *membrane configuration*.

**Contact time:** The amount of time which the process liquid spends in the ion exchange bed, expressed in minutes. Determined by dividing the bed volume by the flow rate, using consistent units.

**Counter-current or Counter-flow operation:** An ion exchange operation in which the process liquid and regenerant flows are in opposite directions.

**Cross-linkage:** Binding of the linear polymer chains in the matrix of an ion exchange resin with a cross-linking agent that produces a three-dimensional, insoluble polymer.

## D

**Dalton (D):** Alternative unit for the indication of the molecular weight of a compound. 1D = 1 g/mol.

**Deaerator:** See *degasifier, vacuum*.

**Dealkalization:** A weak acid cation or alternatively an anion exchange process for the removal or reduction of alkalinity in a water supply.

**Decationization:** The exchange of cations for hydrogen ions by a strong acid cation exchange material in the hydrogen form (see *salt splitting*).

**Decrosslinking:** The alteration of the ion exchange structure by degradation of the cross-linkage by aggressive chemical attack or heat. This causes increased swelling of ion exchange materials.

**Degasifier, forced air:** Also called a decarbonator. Used to reduce carbon dioxide content of the effluent from hydrogen cation exchangers. Reduces CO<sub>2</sub> to about 5-10 ppm but saturates water with air.

**Degasifier, vacuum:** Actually a deaerator. Reduces oxygen as well as CO<sub>2</sub> and all other gases to a very low level. Preferred as a means of CO<sub>2</sub> reduction when demineralizing boiler water makeup. Eliminates water pollution and reduces corrosion problems when transferring water through steel equipment. Use usually results in longer anion exchange resin life.

**Degradation:** The physical or chemical reduction of ion exchange properties due to type of service, solution concentration used, heat or aggressive operating conditions. Some effects are capacity loss, particle size reduction, excessive swelling, or any combination of the above.

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**Deionization:** The removal of ionizable (soluble) constituents and silica from a solution by ion exchange processing. Normally performed by passing the solution through the hydrogen form of cation exchange resin and through the hydroxide form of an anion exchange resin, either as a two-step operation or as an operation in which a single bed containing a mixture of the two resins is employed.

**Deionized water:** When all of the ionic constituents dissolved in water are removed by ion exchange, the water is said to be deionized. Cation and anion exchange resins, when properly used, will deionize water.

**Delamination:** When the active layer peels off from the polyester support web as a consequence of mechanical or chemical membrane damage.

**Demineralization:** See *deionization*.

**Density:** The weight of an ion exchange material usually expressed as g/l or lbs/ft<sup>3</sup>.

**Desalination:** The removal of dissolved salts from a solution.

**Diffusion:** The process whereby ions, atoms, and molecules move in a mix. The movement is random, with the net effect being movement from a higher concentration zone to a lower concentration zone until the zones have equalized.

**Dissociate:** The process of ionization of an electrolyte or a salt upon being dissolved in water, forming cations and anions.

**Distributor:** The piping inside an ion exchange vessel which evenly distributes flow across the resin bed.

**Divinylbenzene (DVB):** A di-functional monomer used to cross-link polymers.

**Downflow:** The operation of an ion exchange column in which the regenerant enters the top of the ion exchange column and is withdrawn from the bottom. This is the conventional direction of water flow in a co-current operated ion exchange column.

**Double pass RO system:** RO System in which the permeate is further desalinated by a subsequent RO System.

**DVB copolymer:** A polymer containing styrene (vinyl benzene) cross linked with divinylbenzene.

## E

**Eductor:** A device that, by flow of water through it creating a vacuum, draws a solution into the water stream.

**Effective size:** The particle size expressed in millimeters which represents 90 percent of the ion exchange material from a screen analysis.

**Efficiency:** A measure of the quantity of regenerant required to effect the removal of a chemical equivalent weight of contaminant in the influent water. For a sodium softener, this will usually be expressed as pounds of salt per kilograin or kg salt per equivalent of hardness removed.

**Effluent:** The solution which emerges from an ion exchange column or vessel.

**Electronegativity:** A measurement of the relative attraction an atom has for electrons.

**Eluate:** The solution resulting from an elution process.

**Elution:** The stripping of sorbed ions from an ion exchange resin by passing solutions containing other ions in relatively high concentrations through the resin column.

**Envelope:** See *membrane envelope*.

**Epoxy wrapping:** See *fiberglass shell*.

**Exchange sites:** The reactive groups on an ion exchange resin.

**Exchanger bed:** Ion exchange resin contained in a suitable vessel; and supported by material, such as graded gravel, screen wrapped pipe, or perforated plate, which also act as liquid distribution systems.

**Exhaustion:** The step in an ion exchange cycle in which the undesirable ions are removed from the liquid being processed. When the supply of ions on the ion exchange resin being exchanged for the ions in the liquid being processed is almost depleted, the resin is said to be exhausted.

## F

**Fast rinse:** That portion of the rinse which follows the slow rinse; usually passed through the ion exchange bed at the service flow rate.

**Feed:** The liquid entering ion exchange or RO/NF system.

**Feed channel:** Spacer filled channel (see feed channel spacer) of about 25-60 mil (0.6-1.5 mm) height that allows the water to travel through the spiral wound RO element.

**Feed channel spacer:** Web or screen placed between two leaves of membrane that supports the membrane leaves and allows the water to pass from the feed to the concentrate end of a spiral wound RO element.

**Fiberglass shell:** Epoxy wrapping applied around envelope bundle supplying mechanical support.

**Fibertape wrapping:** Tape wrapping applied around envelope bundle supplying mechanical support.

**Film diffusion:** The movement of ions through the liquid film on the surface of an ion exchange particle.

**Fines:** Small particles of an ion exchange resin which are undesirable.

**Flatten:** To exhaust a resin bed (see *exhaustion*).

**Fouling:** (1) In ion exchange, this refers to any relatively insoluble deposit or film on an ion exchange material, which interferes with the ion exchange process. (2) In RO and NF, this refers to the deposition of foreign matter on the membrane surface and/or in its pores, resulting in changed element and/or system performance. The different types of fouling are scaling, colloidal fouling, organic fouling and biofouling.

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**Fouling factor (FF):** Ratio of permeate flow after substantial fouling has occurred to permeate flow at system start-up. When designing an RO system, the fouling factor enables taking into account potential fouling processes.

**Fouling-resistant membrane**

**element:** Modified surface chemistry and modified element design of this membrane element type make it the optimum choice to cope with high fouling tendency waters.

**Free mineral acidity (FMA):** Free mineral acidity is due to the presence of acids such as sulfuric, nitric, and hydrochloric.

**Freeboard:** The space provided above the resin bed in the vessel to accommodate the expansion of the resin particles during the backwashing operation.

**FT30:** Membrane chemistry upon which most FILMTEC membrane elements are based.

**Full-fit element:** A full-fit element is a spiral-wound membrane element designed to minimize or eliminate stagnant areas. Like all membrane elements it has an outerwrap, but rather than tape or fiberglass, a rigid polypropylene material gives the element structural support.

**Fulvic acid:** A high molecular weight polycarboxylic acid often found in surface water supplies. It frequently contributes to organic fouling of ion exchange materials.

**Functional group:** The atom or group of atoms on an ion exchange resin which give the resin its specific chemical characteristics.

**G**

**Gel:** A term applied to the bead structure of certain ion exchange resins which have a microporous matrix structure with small pores generally <10Å. Gel resins offer good operating capacity and regeneration efficiency. Porous gel resins also exhibit good resistance to organic fouling.

**Glue line:** Line at which two pieces of membrane leaf are glued together in order to form a membrane envelope.

**Grains per gallon:** The concentration of ions in solution usually expressed in terms of calcium carbonate equivalents. One grain per gallon is equal to 17.1 ppm.

**Greensands:** Naturally occurring materials which possess ion exchange properties. Greensand was the first ion exchange material used in softeners.

**H**

**Hardness, total:** In conformity with current practice, total hardness is defined as the sum of calcium and magnesium concentrations, both expressed as calcium carbonate in milligrams per liter.

**Head loss:** The loss in liquid pressure resulting from the passage of the solution through the bed of ion exchange resin (also known as pressure drop).

**Hollow fiber (HF) element:** This element type consists of a membrane that has been extruded into a hollow tube with a bore of 0.05-0.2 mm (2-10 mil) in its center. Hollow fiber elements offer highest surface area to volume ratio but are very prone to deterioration by scaling and fouling.

**Hot Zeolite softener:** A sodium zeolite softener operated at a temperature of 100-120°C (215-250°F). This unit will follow a hot lime softener.

**Humic acid:** A high molecular weight polycarboxylic acid found in surface water supplies which contributes to organic fouling in ion exchange materials.

**Hydraulic classification:** The tendency of small resin particles to rise to the top of, and large resin particles to settle to the bottom of the resin bed during a backwash operation.

**Hydrogen cation exchanger:** Term used to describe a cation resin regenerated with acid to exchange hydrogen (H<sup>+</sup>) ions for metal cations.

**Hydrogen cycle:** Cation exchange resin operation in which the regenerated ionic form of the resin is the hydrogen form.

**Hydrometer:** An instrument used for measuring the relative density (specific gravity) of liquids.

**Hydroxide cycle:** An anion exchange operation in which the regenerated form of the ion exchange material is in the hydroxide form.

**I**

**Influent:** The solution entering an ion exchange column or vessel.

**Inhibitor:** Additive able to suppress biological and chemical processes. Examples are scale inhibitors, growth inhibitors, corrosion inhibitors.

**Interconnector:** Piece of plastic used to connect the product water tube of various membrane elements within the same pressure vessel.

**Interstitial volume:** The space between the particles in an ion exchange resin bed.

**Ion exchange:** The process by which ionic impurities in water are attached to active groups on and in an ion exchange resin and more desirable ions are discharged into water.

**Ionic strength:** The ionic strength is defined as half of the sum of the product of ion concentrations and the square of their charges.

**Ionization:** The separation of part or all of the solute molecules into positive (cationic) and negative (anionic) ions in a dissociating media such as water.

**Iron:** Iron is often present in ground waters in a reduced, soluble form (such as ferrous bicarbonate) in quantities usually ranging from 0.5 to 10 ppm. Iron in solution is susceptible to oxidation, precipitating as a reddish-brown floc when contacted by air under normal well water conditions.

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## L

### **Langelier Saturation Index (LSI):**

An index calculated from total dissolved solids, calcium concentration, total alkalinity, pH and solution temperature that shows the tendency of a water solution to precipitate or dissolve  $\text{CaCO}_3$ . Should be used for the low TDS range, in the high TDS range, the Stiff & Davis saturation index (S&DSI) should be used.

**Layered bed:** Two ion exchange materials with weak and strong functionality (e.g., weak and strong anion resins) designed with sufficient difference in density and hydraulic characteristics to be layered in the same vessel, in place of two separate vessels.

**Leaf:** See *membrane leaf*.

**Leaf length:** Length of a membrane leaf in a spiral wound element. Should be minimized in order to assure homogeneous permeate flux distribution over membrane leaf.

**Leakage (hardness, sodium, silica, etc.):** Caused by incomplete regeneration of an ion exchange bed. Since complete regeneration is usually inefficient, most ion exchange processes operate at one half to one third of the total capacity of the ion exchanger.

**Low energy membrane element:** Membrane element designed to have lowest possible energy consumption and highest possible rejection.

**Lubrication:** The application of grease-type materials to components of an RO systems. The lubrication of interconnectors (with silicone grease Dow Corning 111) supports the sealing functionality of the o-rings; lubrication of the pressure vessel (with glycerin) supports smooth loading of membrane elements into the vessel.

## M

**Macroporous:** A term applied to the bead structure of certain ion exchange resins which have a tough, rigid structure with large discrete pores. The macroporous resins offer good resistance to physical, thermal and osmotic shock and chemical oxidation. Macroporous anion resins also exhibit good resistance to organic fouling.

**Macroreticular:** See *macroporous*.

**Membrane:** A thin sheet separating different streams, which contains active groups that have a selectivity for anions or cations but not both.

**Membrane configuration:** (1) The arrangement of individual elements and/or pressure vessels in a RO or nanofiltration plant. (2) Way in which the membrane sheet is arranged in a practical system. By far the most common RO configuration is the spiral wound element, other common configurations involve plate-and-frame, hollow fiber and tubular.

**Membrane envelope:** A membrane envelope consists out of two sheets of membrane separated by the permeate spacer. In a spiral wound element, the membrane envelope connects to the product water tube; all other ends are sealed off by a glue line.

**Membrane leaf:** (1) Alternatively for membrane sheet. (2) Alternatively for membrane envelope.

**Membrane performance:** The two main performance parameters for spiral wound membrane elements are rejection and flow.

**Membrane salt passage:** SPM is the concentration of a compound in the permeate related to its average concentration in the feed/concentrate side.

**Membrane sheet:** Flat sheet of membrane consisting of polyester support web, polysulfone interlayer and active polyamide barrier.

**Microfiltration:** Pressure-driven membrane process used to retain particles with a minimum diameter of about 0.2 micron (8 mil). Frequently used as a pretreatment to RO systems.

**Mixed bed:** The use of a mixture of cation and anion resins in the same column or vessel to produce water of extremely high quality.

**Modified Fouling Index (MFI):** Measure for the fouling potential of a water. See also *silt density index (SDI)*.

**Module:** Pressure vessel containing membrane element(s).

**Molality:** The number of gram-molecules weight of a solute per kg of solvent.

**Molarity:** The number of gram-molecules weight of a solute per l of solution.

**Molecular weight cut-off (MWCO):** Nominal measure of the separation potential of a membrane, defined as the molecular weight, of which 90 percent of the molecules are retained by the membrane.

**Monomeric silica:** The simplest form of silica (often described as  $\text{SiO}_2$ ) and referred to as dissolved or reactive silica.

**Nanofiltration (NF):** Pressure-driven membrane process, similar to RO, but with higher molecular weight cut-off and lower operating pressure.

**Nonionic:** Compounds that do not have a net positive or negative charge.

## O

**O-ring:** Ring from flexible plastic material placed on the inner or outer diameter of the interconnector in order to seal the product water off from the brine.

**Ohm:** The unit of resistance of a solution, often related to the electrolytic concentration.

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**Operating capacity:** The portion of the total exchange capacity of an ion exchange resin bed which is utilized in a practical ion exchange operation. Commonly expressed in kilograins per cubic foot (kgr/ft<sup>3</sup>) or equivalents per liter (eq/l).

**Operating cycle:** A complete ion exchange process consisting of a backwash, regeneration, rinse, and service run.

**Organic fouling:** (1) In ion exchange, the condition where a significant amount of organic molecules remain in the beads following a normal regeneration. (2) In RO/NF systems, this refers to the deposition of organic molecules on the membrane surface resulting in losses in system performance.

**Organic matter:** Organic matter is present in many ground and surface waters. It may come from natural sources such as swamps and be visible as color. Pollution by industrial wastes and household detergents are other sources of organic matter.

**Osmosis:** Phenomenon of solvent flow occurring between two cells containing solutions with different solute concentration separated by a membrane that is permeable to the solvent and impermeable to the solute.

**Osmotic shock:** The expansion or contraction of resin beads due to volume changes imposed by repeated applications of dilute and concentrated solutions.

**Osmotic stability:** The ability of an ion exchange material to resist physical degradation due to osmotic shock.

## P

**Particle diffusion:** The movement of ions within the ion exchange material toward exchange sites.

**Performance:** See *membrane performance*.

**Permeability:** The ability of an ion exchange membrane to pass ions under the influence of an electric current.

**Permeate:** The Portion of the feed which Passes through the membrane, also called product.

**Permeate backpressure:** Pressure applied to the permeate side of an RO system, either resulting from design of permeate piping and permeate tank, or applied by closing permeate valve in order to reduce net driving pressure in first array.

**Permeate channel:** Spacer filled channel (see *permeate channel spacer*) between two membrane leaves that allows the permeate to travel to the product water tube.

**Permeate channel spacer:** Web or screen placed between two leaves of membrane that supports the membrane leaves and allows the product water to exit from the membrane leaves to the product water tube of a spiral wound element.

**Permeate collector fabric:** See *permeate channel spacer*.

**Permeate flux:** Permeate flow rate per unit membrane area.

**Permeate staged system:** RO system where the permeate is subjected to more than one passes through an RO membrane.

**Permeate water carrier:** See *permeate channel spacer*.

**pH:** The negative logarithm (base 10) of the hydrogen ion concentration in water.

**Physical stability:** The ability of an ion exchange resin to resist breakage caused by physical manipulation or by volume changes due to either osmotic shock or iteration between two or more ionic forms.

**Plant capacity:** Production of permeate per unit time, expressed as m<sup>3</sup>/day or m<sup>3</sup>/h (GPD, MGD).

**Plate and frame configuration:** In plate-and-frame configuration, the RO or NF membrane is stacked between plates along with spacers that allow feed water in and permeate water out.

**Polar:** A molecular property in which the positive and negative electrical charges are permanently separated. Polar molecules ionize in solution and impart electrical conductivity.

**Polarity:** A molecular property in which the positive and negative electrical charges are permanently separated.

**Polisher:** A mixed bed ion exchange unit usually installed after a two bed deionizer system to remove the last traces of undesirable ions.

**Polymeric silica:** The larger molecular weight silica compounds which are a result of the chemical polymerization of monomeric silica.

**Porosity:** Used qualitatively to describe that property of an ion exchange resin which allows solutes to diffuse in and out of the resin particle. It is usually used with regard to large ions and molecules such as organic acids. Porosity is directly related to the water content and inversely related to the cross-linkage of a gel resin.

**Potable water:** Water meeting Health Department standards for use as drinking water. These waters may be hard, and may contain considerable salts in solution.

**Pressure drop:** (1) In membrane operations, the pressure drop (differential pressure) results from frictional pressure losses when the water flows through a membrane element, a stage, or the entire system. (2) For ion exchange systems, see *head loss*.

**Pressure vessel:** The vessel containing the individual elements.

**Pretreatment:** Includes flocculation, settling, filtration or any treatment water receives prior to an ion exchange or reverse osmosis system.

**Process water:** Any water mixed with a product, or becoming part of a product or used to wash a product. These supplies require various kind of treatment such as clarification and filtration, and in many cases ion exchange resins are used to soften, dealkalize or completely deionize the water.

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**Product water:** See *permeate*.

**Product water tube:** Perforated hollow tube around which the membrane leaves are wound spirally. Permeate exits from the permeate channel spacer to the product water tube and is collected from there.

## Q

**Quaternary ammonium:** A term describing the functionality of strong base anion exchange resins.

## R

**Raw water:** Untreated water from wells, surface sources or the sea.

**Reactive silica:** See *monomeric silica*.

**Recovery (Y):** (1) The ratio of product quantity (or stream) over the feed quantity (or stream), given as fraction or in percent. (2) Increasing the concentration of precious solutes in a solvent with membrane processes in order to recycle them.

**Regenerant:** The chemical used to convert an ion exchange resin to the desired ionic form for reuse.

**Regeneration:** The displacement from the ion exchange resin of the ions removed from the process solution. May be performed either co-currently or counter-currently. Lower ion leakages are typically obtained with counter-current regeneration at comparable regenerant dosages.

**Regeneration efficiency:** A measure of the amount of capacity of an ion exchange resin compared to the amount of regenerant applied. This is expressed as a ratio of equivalents of capacity to equivalents of regenerant and is therefore <100 percent. It is the reciprocal of Stoichiometry.

**Regeneration level:** (Regeneration Dosage) The amount of regenerant used per cycle. Commonly expressed in pounds per cubic foot of resin or grams per liter of resin.

**Rejection:** The ability of an RO/NF membrane/system to hinder solutes from passing through the membrane. Mathematically, it is the quantity of solutes in the feed water subtracted from the quantity of solutes passing through a semipermeable membrane, which is then divided by the quantity of solutes in the feed water, typically expressed as a percentage.

**Retentate:** See *concentrate*.

**Reverse osmosis:** A pressure-driven membrane operation in which the solvent is transferred through the membrane and the dissolved solutes are retained by the same membrane.

**Rinse:** The passage of water through an ion exchange resin bed to flush out excess regenerant.

**ROSA:** Reverse Osmosis System Analysis, software program enabling to design reverse osmosis and nanofiltration systems.

**RO train:** One of two or more complete RO installations operating in parallel.

**Run length or run time:** The time between regenerations or the duration of the service cycle.

## S

**Salt rejection:** The ability of an RO/NF membrane/system to hinder solutes from passing through the membrane. Mathematically, it is the quantity of solutes in the feed water subtracted from the quantity of solutes passing through a semi-permeable membrane, which is then divided by the quantity of solutes in the feed water, typically expressed as a percentage.

**Salt splitting:** The conversion of salts to their corresponding acids or bases by passage through strong acid cation or strong base anion exchange resins, respectively.

**Saturated:** The maximum amount of a substance that can be dissolved in a solvent.

**Saturation level:** The ion product of dissolved material in a solvent to its solubility. A material with a saturation level higher than 100 percent tends to precipitate and form deposits.

**Scale inhibitor:** Chemical additive able to suppress the formation of inorganic scales from supersaturated solutions.

**Scaling:** Deposition of solids on the membrane surface, due to exceeding the solubility product of the salt in question.

**Scavenger:** A polymer matrix or ion exchange material used to specifically remove organic species from the process liquid before the solution is deionized.

**Seawater:** Water from oceans, continental seas and nearby wells, with a TDS of about 25,000 to 60,000 ppm.

**Selectivity:** The difference in attraction of one ion over another by an ion exchange resin.

**Semipermeable membrane:** A membrane that is permeable to certain compounds and impermeable to other compounds. Most practically used RO membranes have a high permeability for water and a very low permeability for most solutes.

**Sheet:** See *membrane sheet*.

**Shimming:** The placement of shims on the adapter within the vessel minimizes movement of the individual membrane elements. This reduces wear-out and mechanical abrasion and subsequent o-ring leakage.

**Silica:** Silica is present in most water supplies. Well waters usually contain silica in solution while surface waters may contain soluble, colloidal and suspended silica.

**Silt Density Index (SDI):** Measure for the fouling potential of a water, measured by filtering a water sample through a micron filter. In RO systems, SDI should be maintained at or below 5.

**Slow rinse:** That portion of the rinse which follows the regenerant solution and is passed through the ion exchange material at the same flow rate as the regenerant.

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**Sluicing:** A method of transporting resin from one tank to another with water. This is usually found in mixed bed deionization systems with external regeneration systems.

**Sodium cation:** Cation exchange resin, regenerated with salt (NaCl). Exchanges sodium ions (Na<sup>+</sup>) for the metal cations (Mg<sup>++</sup>, Ca<sup>++</sup>, etc.), forming sodium salts (sulfates, carbonates, etc.).

**Spacer:** A sheet of woven fabric (also called web or screen) placed between two leaves of membrane supporting the membrane leaves and providing grooves (channels) for water to travel between the membrane sheets. See also *feed channel spacer* and *permeate channel spacer*.

**Specific gravity:** The picometric density of the resin material expressed as grams per unit volume in a specific ionic form.

**Sphericity:** A measure of the amount of ion exchange resin beads that are unbroken.

**Spiral wound (SW) element:** Configuration, in which the membrane sheet is wound spirally around the product water tube, resulting in a configuration with very high surface area per volume ratio and low fouling tendency.

**Stiff & Davis Saturation Index (S&DSI):** Measure for the saturation of CaCO<sub>3</sub> in high salinity waters. Should be used for waters with a TDS higher than 10,000 ppm; in the low TDS range, the Langelier saturation index (LSI) should be used.

**Stoichiometry:** A measure of the quantity of regenerant required compared to the resultant capacity of the ion exchange resin. This is expressed as a ratio of equivalents of regenerant to equivalents of capacity and is therefore >100 percent. It is the reciprocal of Regeneration Efficiency.

**Stratified bed:** See *layered bed*.

**Strong acid capacity:** That part of the total cation exchange capacity that is capable of converting neutral salts to their corresponding acids (also called salt splitting capacity).

**Strong acid cation resin:** Resins employed in softening and deionization systems. When regenerated with salt, the sodium ions on the resin will effectively exchange for divalent cations such as calcium and magnesium. When regenerated with sulfuric or hydrochloric acid the resin will split neutral salts converting the salt to its corresponding acid. The resin usually receives its exchange capacity from sulfonic groups.

**Strong base anion resin:** Resins employed in chloride anion dealkalizers and deionization systems. When regenerated with salt, the chloride ions will exchange for bicarbonate and sulfate anions. When regenerated with caustic soda, the resin will remove both strong and weak acids from cation exchange resin effluent. The resin usually receives its exchange capacity from quaternary ammonium groups.

**Strong base capacity:** That part of the total anion exchange capacity capable of converting neutral salts to their corresponding bases (also called salt splitting capacity).

**STY/DVB copolymer:** A polymer containing styrene (vinyl benzene) cross-linked with divinylbenzene.

**Sulfonic:** A term describing a specific group that imparts a strongly acidic exchange ability to some cation resins.

**Support media:** A graded particle size, high density material such as gravel, anthrafil, quartz, etc. Used to support the resin bed.

**Surface water:** Water taken directly from surface sources such as rivers, lakes and seas.

**System salt passage:** SPS is the concentration of a compound in the permeate related to its concentration in the feed water; also called apparent salt passage.

## T

**Telescoping:** (1) Length-wise displacement of the membrane inside the RO element. (2) Central product water tube and membrane envelopes are pushed outwardly and unravel as a consequence of high pressure drop and/or high cross-flow velocity.

**Tertiary ammonium:** A term describing the functionality of weak base anion exchange resins.

**Tertiary effluent:** Waste water from municipal water treatment plant. Has undergone sedimentation, biological treatment and advanced particle removal steps such as clarification and filtration. See also *waste water*.

**Throughput:** The amount of product water generated during the service cycle.

**Total capacity:** The maximum exchange ability of an ion exchange resin.

**Total dissolved solids (TDS):** The concentration of dissolved matter in water.

**Train:** A single ion exchange system capable of producing the treated water desired, such as a strong acid cation resin bed followed by a strong base anion resin bed, with multiple trains being duplicates of the single system.

**Tubular membrane element:** A tubular element consists of a piece of membrane on the inside of a fiberglass tube with internal diameter of about 0.5" (about 1 cm).

**Turbidity:** The reduction of transparency of a sample due to the presence of particulate matter.

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## U

**Ultrafiltration:** Pressure-driven membrane process used to retain macro solutes with a minimum molecular weight of 1000-1500 Dalton. Frequently used as a pretreatment to RO systems.

**Under drain:** The piping inside an ion exchange vessel which evenly collects the treated water after it has passed through the resin bed.

**Uniformity coefficient:** The volume or weight ratio of the 90 percent retention size (see *effective size*) and the 40 percent retention size in a screen analysis.

**Upflow:** The operation of an ion exchange column in which the regenerant enters the bottom of the ion exchange column and is withdrawn from the top. Regeneration efficiency and column leakage may be improved by this process.

## V

**Valence:** The number of positive or negative charges of an ion.

**Void volume:** See *interstitial volume*.

**Volume mean diameter:** The particle size expressed in microns or millimeters at which 50 percent by volume of the ion exchange material from a screen analysis has passed.

**Waste water:** Water discharged from a process as a result of its formation or its use in that process.

**Water carrier:** See *spacer, feed channel spacer, permeate channel spacer*.

**Water hammer:** Mechanical stress on membrane element in pressure vessel that occurs when feed flow and pressure are increased too sharply. May cause telescoping and cracking of element outer wrap.

**Water retention:** The amount of water, expressed as a percent of the wet weight, retained within a fully swollen and drained ion exchange material.

**Water softening:** To exchange sodium for the hardness in water by ion exchange.

**Weak acid cation resin:** These resins are used in dealkalization and desalination systems and in conjunction with strongly acidic cation resins for deionization. When regenerated with acid, the resin will split alkaline salts converting the salt to carbonic acid. This resin exhibits very high regeneration efficiency. It usually receives its exchange capacity from carboxylic groups.

**Weak base anion resin:** These resins are employed for partial deionization when silica removal is not required or used in combination with strong base anions to provide high capacity and chemical efficiency in full deionization operation. When regenerated with soda ash, ammonia or caustic soda, weak base resin will adsorb strong acids such as hydrochloric and sulfuric acids (FMA) from the cation bed effluent. The resin is usually functionalized with tertiary amine groups.

**Well water:** Generally this type of water refers to water from a ground water source that has been accessed via a well. When the well is close to a surface water, then significant portions of the water obtained may be provenient from that water source.

## Z

**Zeolite:** A mineral composed of hydrated silicates of aluminum, and sodium or calcium. The term is commonly used in connection with water softening by ion exchange (i.e., zeolite softener, hot lime zeolite, etc.).

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## Acronyms Common to Ion Exchange and Membranes

A&E: architect & engineer	OF: organic fouling
ASTM: American Society for Testing and Materials	OS: organic scavenger
ATD: Anti-telescoping device	ppb: Unit of concentration, parts per billion, equal to 1µg/L
AVT: all volatile treatment	ppm: Unit of concentration, parts per million, equal to 1 mg/L
BVH: Bed Volumes per Hour	PSI: pounds per square inch
BWR: boiling water reactor	PSIG: pounds per square inch gauge
CAC: Combined Available Chlorine	PWR: pressurized water reactor
CIP: Cleaning-in-place	RO: reverse osmosis
CP: condensate polishing	SAC: strong acid cation
CRC: Combined Residual Chlorine	SBA: strong base anion
D: Dalton	SBS: Sodium bisulfite
Degas: degasifier	SDI: Silt Density Index
Demin: demineralization	S&DSI: Stiff and Davis Saturation Index
DVB: divinylbenzene	SHMP: Sodium hexametaphosphate
FAC: Free Available Chlorine	SMBS: Sodium meta bisulfite
FB: Free base	Spec: specification
FF: Fouling factor	SSC: salt splitting capacity
FMA: Free Mineral Acidity	SW: Spiral wound or Sea Water
FRC: Free Residual Chlorine	TBC: Total Bacteria Count
GAC: Granular Activated Carbon	TDS: Total dissolved solids, usually expressed as mg/l or ppm (Parts per million)
GPM: gallons per minute	TEC: total exchange capacity
GrPG: grains per gallon	TOC: Total organic carbon
HF: Hollow fiber	TRC: Total Residual Chlorine
IX: ion exchange	TSS: Total suspended solids
Kgr: Kilograins	UPS: uniform particle size
LSI: Langelier Saturation Index	UPW: ultra pure water
ME: microscopic examination	URC: Ultrasonic Resin Cleaned
MFI: Modified fouling index	WAC: weak acid cation
MWCO: Molecular weight cut-off	WBA: weak base anion
NF: Nanofiltration	WBC: weak base capacity
OEM: original equipment manufacturer	WRC: water retention capacity

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**Warning:** Oxidizing agents such as nitric acid attack organic ion exchange resins under certain conditions. This could lead to anything from slight resin degradation to a violent exothermic reaction (explosion). Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

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