Cal Water
1961 Petra Lane, Placentia, CA 92870
(800) CAL-WATER (800) 225-9283
FAX: (714) 792-0794
Web Page / Email: www.cal-water.com

"a better solution.."

WATER PURIFICATION GLOSSARY

INTRODUCTION

Water purification has a lexicon of its own which has been developed over centuries. To the uninitiated it sounds like Greek. Until now the only way to learn it was either to get a degree in chemistry or work in the field for 20 years.

In an effort to illuminate water treatment-ese, we have prepared this Water Purification Glossary. to provide definitions for commonly used water treatment "slang."

Absolute: - (as opposed to Nominal) Refers to a cartridge filter's ability to live up to it's rating. An absolute 0.45 micron filter will remove at least 99.9% of all particles 0.45 microns in size or larger. A nominal 0.45 micron filter will only remove 95% of particles 0.45 microns and larger

Absorption: - The taking up of one substance into the body of another; water in a sponge for example.

Adsorption: - The adherence of a substance to the surface of a solid. Activated carbon adsorbs organics on to its surface.

Acid: - A substance with a low pH, typically a liquid. Acids most commonly used in water conditioning are HCl (Hydrochloric Acid) and H2SO4 (Sulfuric Acid). They are typically used to regenerate Cation Resins. CAUTION: HNO3 (Nitric Acid) is never used for regeneration because the combination of nitric acid and ion exchange resin can be explosive.

Acre Foot: - That amount of water which would cover an acre of land, one foot deep or 325,829 gallons.

Activated Carbon: - Carbon which has been subjected to high heat and steam injection or burned in the absence of oxygen. The resulting carbon is extremely porous with a total surface area of a teaspoon full being equivalent to the surface area of a football field. This surface area is what will trap organics by adsorption (not absorption).

While activated carbon will filter out some particulate matter, its main applications in water purification are the removal of organics and the reduction of chlorine. For these applications GAC is used. (Granular Activated Carbon)

The types and quantity of carbon media determines how much flow can be realized through the system as well as what contaminants are removed. Chlorine reduction can take place at a much greater flow rate than organic adsorption.

Alkali: - A basic substance. Typically a metal hydroxide with a high pH. NaOH, (Caustic Soda) for example.

Alum: - Aluminum sulfate ($Al(SO_4)$) is commonly used as a filter aid to agglomerate particles to make them easier to filter out.

Ammonia: - NH3, NH4OH -- A caustic chemical sometimes used in the regeneration of weak base anion resins.

Angstrom: - One ten-billionth of a meter. Usually used to measure the wavelength of electromagnetic radiation or molecular or atomic sizes. (See Nanometer)

Anions: - Negatively charged ions such as: Chlorides [Cl-], Sulfates [SO_4=], Nitrates [NO_3=], Carbonates [CO_3=], Silicates [SiO_2-]. (See Cations)

Anion Resin: - The anion exchange resin exchanges negatively charged impurities (See Anions), for the hydroxyl radical (OH-). The impurities attach themselves to sites on the ion exchange resin, eluting off hydroxyl radical (OH-). As soon as all the sites are taken up, the resin must be regenerated with caustic soda (NaOH). (See Ion Exchange Resin)

Anthracite: - A very hard coal used as a particle filter media and as underdrain material. Anthracite is unsuitable for activated carbon applications because it lacks the surface area required.

Aquifer: - An underground porous water bearing geological formation

ASTM: - American Society of Testing and Materials. An expensive, but sometimes necessary stamp of approval on pressure vessels.

Automatic Deionization: - (See Packaged Deionization.)

Base: - A chemical substance with a high pH. (See Alkali)

Backwash: - An up flow of water through an ion exchanger or filter to clean and re-stratify the media. It provides a physical cleaning only and does not regenerate an ion exchange unit.

Bacteriostatic: - A substance or process that will not support bacterial growth. If something is "bacteriostatic," it won't necessarily kill bacteria, but neither will it support it.

Baumè: - An obsolete scale based on specific gravity for measuring the strength of chemicals.
Formula:

$$\text{Baumè} = 145 - \frac{145}{\text{Specific Gravity}}$$

Bed: - A vessel containing ion exchange resin. (See Mixed bed, two bed, etc.) The term itself comes from observations made on the ion exchange properties of flower beds. The studies were made over 400 years ago, but somehow the term still hangs around today.

Biopure Water: – Water that is sterile, pyrogen free and has a TDS content of less than 1 ppm.

Bed Depth: - The depth of water purification media inside a tank. The amount of media in a water purification tank rarely fills the tank. Open space or "Freeboard" in the tank above the media is required to allow for backwash and/or expansion of the media.

BOD: - (Biochemical Oxygen Demand) A measure of the oxidizable substances in water. The substances typically referred to are food for bacteria. With a high BOD analysis, you either have a high bacteria count, or soon will. (See COD)

Biological Contamination: - Bacteria, viruses, algae, amoebae, molds, any micro-organism. (See: Uv, O3, Chlorine, Halogen.)

Brackish Water: - A subjective term that refers to a water with a salinity somewhere between fresh water (`500 ppm) and sea water (`35,000 ppm). "Brackish" water usually falls within the range of 5,000 to 10,000 ppm salinity.

Brine: - (1) Typically water that has a high concentration of sodium chloride salt in it (NaCl), used for the regeneration of water softeners. Saturated Brine: - Water that has as much salt in it as it can hold without precipitation, usually assumed to be 2.5 lb./gallon.

(2) The water that carries away impurities from a Reverse Osmosis system. It is the water that does not pass through an R.O. membrane and is directed to drain.
(3) Any salt dissolved in water, usually concentrated.

Brine Seal: - A rubber gasket fitted around a Reverse Osmosis module that prevents water from bypassing around the module forcing it to pass across the membrane.

Bubble Point Test: - Originally used to rate sub-micron membrane filter disks. The filter disks were wetted, placed in a housing and subjected to gradually increasing air pressure. The amount of air pressure required to finally displace the water on the disk (and "bubble" into a beaker of water on the other side of the filter disk) indicated the micron rating of the disk. (Eg: 50 psi bubble point = 0.20 microns) With very slow and careful monitoring procedures, under laboratory conditions, this technique can be used to test sub-micron filter cartridges of any size. Procedures of this type are best carried out by a computer with an A/D capability. (Software and hardware are available from Cal Water)

Buffer: – A solution that is capable of opposing small changes in chemical composition; particularly in pH. Buffers of pH 4, 7 and 10 are used in standardizing pH meters.

Carbon: - Please see Activated Carbon and Anthracite.

Cations: - Positively charged ions such as: Sodium [Na+], Calcium [Ca++], Magnesium [Mg++], Potassium [K+], Iron [Fe+++], Manganese [Mn++]. (See Anions)

Cation Resin: - The cation exchange resin exchanges positively charged impurities such as calcium (Ca++), magnesium (Mg++), sodium (Na+) and potassium (K+), for hydrogen (H+). The impurities attach themselves to sites on the ion exchange resin, eluting off hydrogen (+H). As soon as all the sites are taken up, the resin must be regenerated with an acid such as hydrochloric acid (HCl) or sulfuric acid (H2SO4). (See Ion Exchange Resin)

Caustic Soda: - (Sodium Hydroxide) Chemical Formula: NaOH
Commercial caustic soda is purchased in liquid form at a 50% concentration or in dry flake form. Caustic soda is used to regenerate Anion resin.

Cavitation: - A pump with an inadequate liquid feed supply can “cavitate.” Cavitation occurs when heat and vacuum cause bubbles of water vapor to form on a pump impeller. If the condition is allowed to continue, the pump impeller and casing can be seriously damaged.

Channeling: - Water takes the path of least resistance. When water is improperly distributed through a resin bed not all the resin beads come in contact with it. The water forms its own "channel" through the bed. Typical causes of channeling are too low a flow rate or an insufficient backwash resulting in "firm" strata which ruin the distribution of the water through the bed.

Chloramine: - A sterilizing agent use in place of chlorine by municipal water plants to prevent the growth of harmful organisms in drinking water. Chloramine is harmful to fish and can be deadly in kidney dialysis machines. Like chlorine, chloramine can be removed by GAC (Granular Activated Carbon), but a much longer contact time is required because the chloramine is adsorbed like an organic rather than destroyed in a chemical reaction as chlorine is.

Chlorine: - (Bleach) (ClO 12.5%) is a dissolved gas. It is an oxidizing substance that is used to kill micro-organisms in water that would other wise pose a threat to human health. At room temperature and atmospheric pressure it is a greenish yellow gas.
Note: - The fumes from chlorine are corrosive and unbreathable and can cause burns on contact with any part of the body. Mucous membranes of the eyes and upper respiratory tract are especially susceptible. NEVER inhale fumes given off by chlorine and provide good ventilation where the chlorine is being used. If chlorine contacts the skin, flush with cold water.

Chlorine Residual: - The amount of chlorine that remains in the water after the initial amount of chlorine has been used up destroying microorganisms. For example, it is possible to feed 10 ppm of chlorine to a contaminated water supply and end up with a 0.5 ppm residual. A rule of thumb states that if there is a chlorine residual in a water supply, then the water is safe to drink.

Chloride: - (Cl-) An anion commonly found in water. It has no sterilization properties and in normal concentrations, has no taste or odor.

COD: - (Chemical Oxygen Demand) Similar to BOD. A measure of the oxidizable substances in water. The substances typically referred to are food for bacteria. COD analysis is used in water conditioning in place of BOD analysis because it is a much easier and less expensive test to run. While not identical to BOD, COD is a good indicator of existing or potential bacterial problems. (See BOD)

Colloid: - A particle that is halfway between a solid particle and a molecule. Simple mechanical filtration will not do the job of colloid removal. Until the 80's the only effective colloid removal technique short of reverse osmosis was the injection of a polyelectrolyte into the colloid laden

water. The electrolyte was allowed a suitable contact time to collect the colloids, then multimedia filtration was used to remove the agglomerated colloids.

Current nanofiltration technology includes TFC membranes that have the ability to remove colloids.

Condensate: – Distillate just after it has been cooled from steam into the liquid state.

Conductivity: – The reciprocal of resistivity, it is a measure of the ability to conduct an electric current. Since ionized impurities increase the conductivity of water, it is also an accurate measure of ionic purity. To measure it, current is passed between two electrodes a fixed distance apart. Conductivity is normally expressed as microsiemens/cm, identical to micromhos/cm.

Conductivity Monitor: - Measures the dissolved solids in water by passing an electrical current through water. Readings from a conductivity monitor are in MICROSIEMENS or MICROMHOS. (See Resistivity Monitor.)

CTA Membrane: - (Cellulose Triacetate): - A type of reverse osmosis membrane that must be fed water with a chlorine residual because it is vulnerable to bacterial attack. It will operate in a pH range of 5-8, and will provide R.O. water of reasonable quality. CTA is the least expensive R.O. membrane available.

Deionization: - (D.I. for short) Demineralization of water through the use of ion exchange resins.

Deionized Water Quality: - Today's technology can provide a water purification system to meet any possible quality standard. In general the higher the quality deionized water required, the higher the cost, so it is best to choose the most economical system that will meet your requirements.

There are three basic types of deionizers that meet most requirements.

1. Two bed weak base systems produce high quality water for most applications. Weak base units typically produce a deionized water over 20,000 ohms/cm3 with a pH under 7. Weak base units do not remove silica or carbon dioxide from the water.

2. Two bed strong base systems produce high quality water over 50,000 ohms/cm3 with a pH over 7. Strong base units remove silica and carbon dioxide from the water.

3. Mixed bed deionizers contain both cation and strong base anion resins mixed together in a single vessel. They produce the highest quality water typically from 200,000 up to 18,000,000 ohms/cm3.

There are also multi-bed deionizer systems using any combination of cation, weak base, strong base and mixed bed units to meet specific volume and quality requirements.

Demineralization: - A process by which dissolved minerals are removed. Demineralization processes includes deionization, distillation, reverse osmosis and electrodialysis.

Desalination: - The removal of dissolved minerals from brackish or sea water. The most common desalination techniques are Vacuum Distillation and High Pressure Reverse Osmosis Membrane separation.

Dilution: – Lowering the concentration of a solution by adding more solvent.

Disinfection: – To destroy (but not necessarily all) of the harmful or objectionable microorganisms by means of chemicals, heat, ultraviolet light, etc. Also referred to as sanitization.

Dissolved Solids: – Also referred to as Total Dissolved Solids (TDS), it is the amount of nonvolatile matter dissolved in a water sample, and is usually expressed in parts-per-million by weight.

Displacement Rinse: - (Slow Rinse) The rinse of an ion exchange unit following the end of chemical injection. While it is called a rinse, it is still a part of the chemical injection process. When it starts, the unit is filled with chemical. In order to maintain proper kinetics, the displacement rinse must proceed at the same rate as the chemical injection step, otherwise the resin at the bottom of the unit will have had a shorter contact time with the chemical that the resin at the top.

Distillation: - Perhaps the oldest technique for water purification is the boiling of water. Boiling water killed any organisms present, helped precipitate some of the salts present, drove off carbon dioxide gas, and in short, made water fit to drink.

Lost in history is the individual who noticed that when water boiled, it gave off water vapor which could then be collected, condensed and turned into water again. Very pure water.

The distillation procedure for demineralizing water has been successfully used through the ages as a means to obtain pure water. Until the 20th century it was the only way to demineralize water.

Distillation has always had its drawbacks. It is costly in energy consumed. It is slow, and distillation equipment is expensive and difficult to maintain. Single distilled water isn't all that pure. Some of the electrolytes aerosol over into the distillate. Any substance present with a vapor pressure equal to or greater than that of water goes over as well. To get a truly reagent grade of water requires multiple distillations.

As distillation proceeds, electrolytes dissolved in water can precipitate out of solution and unless properly controlled by continual waste water flow, cause deposits and scale on expensive distillation equipment. With one notable exception (See Vacuum Distillation), about the best thing that can be said about distillation is that it is traditional.

Effluent: – The output or discharge from a water treatment process.

Electrolyte: – A chemical compound which, when dissolved or ionized in water, allows it to conduct electric current.

Endotoxin: – A poisonous substance present in bacteria that is released when the cell disintegrates. In water treatment, it most often refers to pyrogens.

Exhaustion: - Ion exchange resin that has a majority of available sites taken up with impurities. For example, Cation resin loaded with ions and ready to be treated with acid. (See regeneration)

The fact that ion exchange resins can be regenerated and be used over and over again make them a very practical and economical means of water purification.

Fast Rinse: - The rinse that follows the chemical injection and displacement rinse. It is a true rinse to blow out all remaining chemical in the ion exchange bed.

Feedwater: – Water entering a treatment process, usually used for the raw water introduced into a Reverse osmosis system.

Filtration: – Removal of suspended matter by passing it through a porous matrix that prevents particles from getting through, usually by entrapment on or in the filter matrix.

Fines: - Small pieces of water purification media, typically broken pieces of ion exchange resin, that escape from a water purification tank. Fines are typically backwashed out and down the drain during the regeneration of the water purifier.

Freeboard: - The empty space in an ion exchanger or filter above the media bed. Regenerable conditioners are 1/2 to 2/3 filled to provide an empty space for the media backwash. Service type equipment will usually have 6 ton 9 inches of freeboard.

GAC: - Granular Activated Carbon; A form of activated carbon used in water purification. (See Activated Carbon)

Grain: – The weight of 1/7000 of a pound. It has been historically used to describe the amount of dissolved solids in water.

GPD: – (Gallons Per Day) this is the standard at which R.O. systems are sized. Example: - a 1000 G.P.D. R.O. system will produce 1000 gallons per day of pure water in a 24 hour period. Systems are generally sized for the maximum amount of water used in the heaviest 24 hour period.

GPG: - (Grains Per Gallon) Usually expressed as equivalents as $CaCO_3$, 1 GPG = 17.1 ppm. A grain is 1/7000th of a pound.

GPM: – (Gallons Per Minute) Unit of water flow.

Hardness: – Dissolved minerals in water, specifically Magnesium (Mg^{++}), Calcium (Ca^{++}), Iron (Fe^{+++}) and Manganese (Mn^{+++}). Hardness originally referred to the soap-consuming power of water. Hardness minerals precipitate out of water very easily which can cause problems for certain processes. Hardness can cause boiler or pipe scale and failure of reverse osmosis membranes.

Hardness Fouling: - Typically the forming of a calcium or magnesium precipitate within a resin bead. Hardness fouling of Anion resin takes place when there is hardness present in the feed water. The result can be either a hydroxide or carbonate precipitate within the anion bead.

Hardness fouling occurs in cation resin when the calcium ion is present on the cation resin, which is then is regenerated with sulfuric acid at too high a concentration. The resulting hardness fouling is specifically a calcium a sulfate precipitate within the bead.

In both cases the hardness precipitation blinds off exchange sites and continually elutes into the product water. The treatment is an acidic chloride regeneration.

Hydrochloric Acid: – HCl, Dissolved Hydrogen Chloride Gas. At about 36% it is sometimes called Muriatic Acid. It is a strong oxidizing Acid. It is used alternately with sulfuric acid for the regeneration of cation resin.

Inert: – Does not dissolve in water, nor react chemically with other substances.

In-Line: – An integral part of the flow path. In a fluid stream, something is said to be in-line if the entire fluid stream flows directly through it.

Inorganic: – Commonly referred to as mineral, it includes all matter that is not animal or vegetable and contains no carbon atoms. (CO_2 is normally the only exception.) Inorganic substances normally dissociate in water to form ions.

Ions: - Electrically charged atoms or groups of atoms. The charge of a single ion may be positive or negative: - ions of metals such as calcium Ca++, magnesium Mg++, sodium Na+ and of hydrogen H+ are positively charged and are called CATIONS. Their charges are balanced by negatively charged ANIONS such as chloride Cl-, sulfate SO4=, etc. These ions are known as electrolytes because they conduct electricity.

Ion Exchange: - The chemical exchange of ions typically accomplished by a synthetic resin in bead form.

Ion Exchange Resin: - A synthetic substance made of specially treated plastic* which has the property of being able to exchange ions. Resin is in the form of small spherical plastic beads, about 1 mm in diameter, with ion exchange properties.

> *The most common plastic used for ion exchange resin is polystyrene cross linked with divynalbenzene. When it is sulphonated it takes on sulfite sights and acts as a cation exchanger. When it is ammoniated it takes on ammonia sights and acts as an anion exchanger.

It has been estimated that one average ion exchange resin particle, one half mm in diameter, may contain more than 280 billion exchange sites.

Kinetics: - (Exchange Kinetics) - A description of the time vs. flow rate required for an ion exchange resin to both regenerate and exhaust. Too high a flow rate for a given quantity and crosslinking of resin may not allow enough time for the resin to make the ion exchange desired.

Leach: – To dissolve by the action of a moving liquid. For example, high purity water leaches trace impurities from glass vessels.

Megohm: – A measure of ionic purity in water. Resistivity (the reciprocal of conductivity) is a measure of specific resistance to electrical flow. The fewer dissolved ions in water the higher its resistivity. One megohm-cm is equivalent to one million ohms of resistance measured between

two electrodes one centimeter apart. The theoretical maximum ionic purity for water is 18.3 megohm-cm at 25°C.

Membrane: - Membranes are thin polymer films that are permeable to water and other fluids. Microporous membrane filters have measurable pore structures which physically remove particles or microorganisms larger than pore size. Ultrafiltration membranes, (sometimes called molecular sieves), also remove molecules larger than a specified molecular weight. Reverse osmosis membranes are permeable to water molecules, and very little else, rejecting even dissolved ions in water. Also a common reference to a single R.O. membrane without the pressure vessel.

Membrane Fouling: – When gelatinous coatings, colloidal masses or dense bacterial growth form a compacted crust on membrane or filter surfaces which blocks further flow.

Mho: - Unit of measurement for conductance; the reciprocal of ohm (resistance).

Micro: – Prefix meaning one millionth, as in microgram, micrometer.

Micrometer: – One millionth of a meter. Still widely referred to as a micron in the U.S., although micrometer is now the internationally accepted standard. (Please see Micron)

Micromhos: - Measures water quality in conductance as opposed to resistance. 1 micromho = 1,000,000/ohms. (Please see Microsiemens, below)

Microsiemens (Micromhos): - A method of describing water purity using its conductivity. It is the inverse of the resistance of the water measured in ohms/cc times 1,000,000. NOTE: - A microsiemens number divided by 2 gives an approximation of the ppm (Parts Per Million) of dissolved solids in water.

Micron: -One millionth of a meter or 0.000001 Meters (Very small). Usually used to measure particle or microorganism sizes.

Milli: – Prefix meaning thousandths, as in milliliter, milligram.

Mixed Bed Deionization: - Deionizers that purify water using two ion exchange resins mixed in the same tank. One resin is a cation exchange resin which exchanges positively charged ions. The other resin is an anion exchange resin which exchanges negatively charged ions. When the resins are mixed, as the water passes through the resin bed it encounters a cation resin bead, then an anion resin bead, then cation, anion, cation, anion and so forth. The water is deionized then re-deionized continually resulting in an ultra high purity product. Mixed beds provide the very best quality water obtainable but are expensive to operate. Mixed beds are generally used as polishers following other less expensive water purification methods.

Module: - Reverse osmosis membrane(s) installed in a pressure vessel.

Muriatic Acid: - High strength Hydrochloric Acid, usually 30%+. (See Hydrochloric Acid.)

Nano: – A prefix meaning billionths, as in nanogram, nanosecond. One nanogram per liter is equal to one par-per-trillion. Light travels a little more that a foot in one nanosecond.

Nanometer: - One billionth of a meter. Usually used to measure the wavelength of electromagnetic radiation or molecular or atomic sizes. (See Angstrom)

Neutralization: - Combining a strong acid waste from the regeneration of a cation with the a corrosive waste caustic soda from the regeneration of an anion to form a neutral waste water. (Please see pH)

Nitric Acid: - HNO3, a strong oxidizing Acid. NEVER USE NITRIC ACID TO REGENERATE A DEIONIZER. AN EXPLOSION CAN OCCUR.

Nominal: - (as opposed to Absolute) Refers to a cartridge filter's ability to live up to it's rating. A nominal 0.45 micron filter will remove 95% of particles 0.45 microns and larger while an absolute 0.45 micron filter will remove at least 99.9% of all particles 0.45 microns in size or larger.

Ohms Resistance: - In water purification a water's quality can be measured by its ohms resistance per cubic centimeter. It describes the cell originally used to measure water purity. It is two platinum electrodes, each one square centimeter, positioned parallel, one centimeter apart. 20,000 ohms =~ 24 ppm, 200,000 ohms =~ 2 ppm, 18,300,000 ohms = 0.028 ppm

Organic contamination: - Anything living, previously living, and/or anything that contains carbon. Organics in water are anything from bacteria and microorganisms to three lettered carcinogens such as THM. They also include tannins, lignans and organo-metals such as organic iron.

Osmosis: – The diffusion of a solvent through a semipermeable membrane from a less concentrated solution to a more concentrated solution.

Ozone: - (O3) A gas used primarily to kill any micro-organisms present in water. Ozone is created at the point of use by, 1) Corona Discharge (passing air or oxygen through an electric arc) 2) Ultraviolet radiation, (subjecting air or oxygen to electromagnetic radiation of a wave length of 1849 angstroms) or, 3) Membrane electrolysis of the water being treated. The water is converted into hydrogen and oxygen gasses. The Hydrogen is vented and the oxygen is converted into ozone.

Ozone kills micro-organism through oxidation, similar to the way chlorine works. The variables associated with Ozone are oxygen content of the gas used to create it, and the final O_3 concentration in water. Since Ozone acts as an oxidizing agent, it can cause chemical changes with non-living organics and will react with reducing agents.

Packaged Deionization: - A deionizer system capable of automated regeneration. As opposed to Service Deionization.

Parts Per Million: - (ppm) A measure of water purity by weight. An example of 1 ppm is one gram of impurity in 1,000,000 grams of water. To obtain Grains Per Gallon from parts per million, divide by 17.1.

Pathogen: - A microorganism that causes disease.

Percent Recovery: - The amount of water that is recovered by the R.O. membranes as a percentage of the feed water as calculated by the following formula:

$$\% \text{ Recovery} = \frac{\text{Product water flow rate}}{\text{Feed water flow rate}} \times 100\%$$

Percent Rejection: - The quantity of dissolved solids rejected by the R.O. membrane as calculated by the following formula:

$$\% \text{ Rejection} = \frac{\text{Feed water ppm} - \text{Product water ppm}}{\text{Product water ppm}} \times 100\%$$

Permeate: - The pure water produced by a Reverse Osmosis system. The word "Permeate" comes from the fact that water is forced by pressure to permeate through the R.O. membrane. (See Product water)

pH: - The measure of acidity or basisity of a liquid. The pH range is 0 to 14, with 7 being neutral. Going lower from 7 is getting more and more acidic. Going higher from seven is getting more and more caustic. The actual chemist's definition of pH is: - "The negative log of the hydrogen ion concentration in moles per liter."

Pico: – A prefix meaning one trillionth, as in picogram.

Polished Water: – High purity water after it has undergone a second treatment step. Ultrapure water usually undergoes two or more treatment steps; more economical pretreatment processes (e.g., reverse osmosis) are used to remove all but a very small fraction of the impurities, and highly efficient polishing processes (e.g., mixed-bed deionization) are used to remove the impurities that remain.

Portable exchange deionization: - Deionizers regenerated by others off site. Portable exchange is usually selected because of the difficulty involved with proper regeneration of deionizers. Some users would rather pay a little more to avoid the problems involved in on site regeneration.

Potable Water: - Water that is fit for human consumption.

ppb: – Parts per billion, or micrograms per liter. Abbreviated ppb only in the U.S. One part per billion is like seeing a silver dollar on the earth's equator from a geosyncronous orbiting satellite.
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ppm: – Parts per million or milligrams per liter. One of the measures of the quality of water.

Pretreatment: – Initial water treatment steps performed prior to final processing to prolong the life of cartridges and filters and to protect downstream elements form premature failure.

Product Water: - Typically the pure water produced by a Reverse Osmosis system.

psig: – Pounds per square inch of gauge pressure, or pressure above atmospheric pressure.

Regeneration: - A typical basic deionizer system consist of a vessel containing cation resin and another vessel containing anion resin. A solution rich in hydrogen ions [H+] such as 10% hydrochloric acid [HCl] or 4% sulfuric acid [H2SO4] is passed through the cation resin. The concentration of hydrogen ions in the acid solution is high enough to force any other cations off the resin in preference for the hydrogen ions.

The anion resin is treated with 5% sodium hydroxide [NaOH] so that its exchange sites are loaded with hydroxyl ions [OH].

Recirculation: – Continuous recirculation may be necessary to maintain uniformly high purity in larger water systems. Water is continuously recirculated and reprocessed to prevent stagnation and to rinse out residual impurities in the system. Bacteria flourish in stagnant water.

Reject: – In reverse osmosis and ultrafiltration, those impurities not able to permeate the membrane are said to be rejected (removed). They are flushed away in the reject (waste) stream.

Resin: - (See Ion Exchange Resin)

Resistivity Monitor: - Measures the dissolved solids in water by passing an electrical current through water. The greater the resistance to the current, the better the water. An example of a resistivity monitor is the Beckman SM-1. It is an analog type meter which displays the OHMS or MEGOHM reading of water, as read from a resistivity cell immersed in water. The accuracy of readings is enhanced by permanently mounting the cell in the water line. (See Conductivity Monitor.)

Reverse Osmosis: - (RO) In nature, with two solutions of differing ionic content are separated by a semi-permeable membrane, water from the less concentrated side has a tendency to pass through the membrane to the more concentrated side. Reverse osmosis uses this phenomena to purify water by applying pressure to the concentrated side and force water back to the pure side, thus: - REVERSE osmosis.

In practice, water is pumped at pressures from 200 to 400 psi through a semi-permeable membrane leaving dissolved and particulate materials behind. The process works on a percent recovery basis. Typically for every three gallons of product water there will be one gallon of waste water. The waste water carries away all the solids that are separated from the product water by the membrane.

The effectiveness of the rejection of dissolved ionic material is a function of both molecular weight and ionic charge. The larger heavier ions are more completely rejected than smaller lighter ones.

The rejection of non-ionic or organic material is primarily by mechanical filtration. Most substances with a molecular weight of over 100 will be completely rejected by an R.O. membrane. Low molecular weight organics, such as formaldehyde or phenol, can pass freely through an R.O. membrane, as can most dissolved gases. Oil, suspended solids and particulate matter are mechanically filtered, as are viruses, bacteria, pyrogens, and larger organic molecules.

Service Deionization: - A portable exchange deionizer system that is transported from a central regeneration plant to a location where the deionization is to take place, and returned to the plant

for regeneration. A portable exchange deionizer is simply a pressure vessel with resin in it. It does not have a regeneration capability.

Service Run: - All of the exchangeable anions and cations that were in the water are now held on the cation and anion resins exchange sites. The hydrogen ions [H+] exchanged off of the cation resin combine with the hydroxyl ions [OH] exchanged off of the anion resin to form pure water (HOH=H2O). The end result is all the exchangeable cations and anions are removed from the water and are replaced by hydrogen and hydroxide ions which combine to form a little more pure water. The resins are said to be exhausted when a majority of available sites are taken up with impurities. The cation resin is then treated with acid, the anion with caustic, and the deionizer is ready to operate again.

Salinity: – The concentration of soluble mineral (mainly salts of the alkali metals or of magnesium) in water.

Salt: – Any of numerous compounds that result from replacement of part or all of the acid hydrogen of an acid by a metal or a radical acting like a metal; an ionic or electrovalent crystalline compound.

Salt Rejection: – In reverse osmosis, the ratio of salts removed (rejected) to the original salt concentration.

Scale: – The mineral deposits that can coat the insides of boiler or the surfaces of RO membranes. It usually consists of calcium carbonate, which precipitates out of solution.

Semipermeable: – Membranes that do not have measurable pores, but through which smaller molecules can pass.

Slow Rinse: - (See Displacement Rinse)

Sodium Hydroxide: - NaOH, Caustic Soda, purchased in liquid form at 50% It can also be obtained in flake form but then it must be dissolved in water and that is a pain. Sodium Hydroxide is used to regenerate Anion resin.

Softener: - (See Water Softener)

Solution: – A liquid that contains dissolved solute.

Specific Conductance: – The reciprocal of specific resistance, usually expressed in microsiemens/cm, identical to micromhos/cm.

Specific Resistance: – Resistance of a one-centimeter cube of water to the passage of electricity under standard conditions, expressed in ohms-cm. It is a measure of the Total Ionized Solids concentration.

Sterilization: – Destruction or removal of all viable organisms.

Sterilizer: - A substance or process that kills microorganisms.

Strong Base Anion Resin: - Ion exchange resin which removes all anions from water replacing them with [OH-]. (See Weak Base Anion Resin.)

Sulfuric Acid: - H_2SO_4: - A strong acid. The commercial strength of sulfuric acid is about 92%. It is used alternately with Hydrochloric Acid for the regeneration of Cation resin. Regeneration strengths should never exceed 4%. If the cation resin is treating hard water, the beginning strength should be 2% or less, with a 2nd step of 4% or less.

Suspended Solids: - Particulate impurities that can be removed using mechanical filters. Where high flow rates or heavy particulate loading is expected, sand or multimedia filtration is available which can filter out particles to 10-20 microns in size. Even finer particle filtration can be provided using cartridge filtration, down to 1.0 microns.

TFC Membrane: - (Thin Film Composite) A type of reverse osmosis membrane that is impervious to bacterial attack, can operate in a pH range of 2-12, provide excellent R.O. water, but must be fed with chlorine free water. Any type of oxidizer will ruin a TFC membrane.

TOC: - (Total Organic Carbon) The amount of carbon in a water sample that is not carbon dioxide, carbonate or bicarbonate ions. To make this mesurement all carbon compounds are oxidized to carbon dioxide which is then measured to determine TOC.

Total Ionized Solids: – Concentration of dissolved ions in solution, expressed in concentration units of calcium carbonate.

Total Organic Carbon: – (TOC) A measure of the level of organic impurities in water, which determines the operating life of activated carbon beds.

Total Solids: – Total solids in water include both dissolved and suspended solids. Determined by weighing sample before and after evaporation.

Two-Bed: – Separate beds or layers of cation and anion exchange resins. Results in lower purity than mixed-bed deionization, but provides higher capacity in terms of throughput.

Turbidity: - All observable and filterable material in water such as silt sand and clay. A suspension of fine particles that obscures light rays. Turbidity is typically measured in NTU, JTU, or light passage.

Two Bed Deionization: - Deionizers that purify water using two ion exchange resins in two different tanks. One tank contains cation exchange resin which exchanges positively charged ions. The other tank contains anion exchange resin which exchanges negatively charged ions. Two bed deionization as opposed to mixed bed deionization provides a lower quality water, but are much less expensive to operate. Two bed deionization is generally used prior to mixed bed because it is a less expensive water purification method.

Ultrafiltration: – Molecular sieves; membranes with pores small enough to remove large molecules. Rated in terms of nominal molecular weight cutoff. A 10,000 Dalton (molecular weight) UF membrane, for example, will remove bacterial pyrogens, which are typically in the range of 20,000 Daltons.

Ultrapure Water: – Water with a specific resistance higher than 1 megohm-cm. In the laboratory, it usually refers to ASTM D1193 Type 1 reagent grade water. Anything in laboratory water that is not H 2 O is an impurity. Although chemically pure water is not attainable, ultrapure water systems are now capable of reducing impurities down to the limits of detection.

Ultraviolet Sterilization: - Typically a stainless steel housing containing a mercury-vapor lamp that emits ultraviolet radiation. The radiation kills microbes, bacteria and viruses. It will also oxidize organic material.

Ultraviolet radiation: - Used primarily to kill any micro-organisms present in water. The subject water is exposed to electromagnetic radiation of a wave length of 2537 angstroms for a specified duration. The quantity of radiation necessary to kill a specific micro-organism ranges from 2,500 to 440,000 micro-watt seconds per square centimeter. Most common micro-organisms can be killed with about 9,000 micro-watt seconds of UV radiation.

The variables associated with UV are flow rate, water clarity, tube clarity and the quantity of the proper wavelength radiation available.

Since UV acts as an oxidizing agent, with sufficient exposure it will break up non-living organics there by reducing the Total Organic Carbon (TOC) in the water.

USP: - (United States Pharmacopea) Published standards for purified water. Purified water can fall into several classifications of purity, depending on the application. These standards are available from any scientific bookstore.

UV Oxidation: – Ultraviolet radiation is employed in water purification for the photochemical oxidation of organic impurities, resulting in HPLC grade water with organic impurity levels below 5 ppb.

Vacuum Distillation: - The distillation of water under a vacuum. By distilling under vacuum, the vapor pressure of water is effectively increased, allowing more purified water production with the same heat input. Vacuum distillation is used to best effect in the desalination of sea water.

Viscosity: - The speed at which a fluid will flow through a specific orifice size. Measures the "thickness" of a liquid.

WFI: - Water For Injection.

Water Analysis: - The following information should be included in a water analysis report to select and size water purification equipment: -

Influent Water Analysis, preferably in ppm expressed as calcium carbonate.
Typical Cations:
Calcium [Ca++], Magnesium [Mg++], Sodium (Na+], Potassium (K+], Iron (Fe+++)
Typical Anions:
Bicarbonate (HCO3=], Sulfate (SO4=], Chloride (Cl-], Nitrate (NO3=], Silica (SiO2-].
Other Data:
PH. Free Chlorine, Turbidity, Color. Odor, Temperature, COD

Most municipal water districts will furnish an analysis of the water they provide. Always try to learn if there are any unusual seasonal conditions or changes in the water supply. If a good analysis is not available, a sample of the water should be analyzed by a licensed laboratory.

Water Softener: - (Ion Exchange Softener) A water softener removes calcium and magnesium ions from water by ion exchange. As calcium and magnesium are picked up by the resin, sodium is released. Sodium is a much easier ion to live with than either calcium or magnesium, the "hardness ions." In the process of removing hardness, the resin beads introduce an equivalent amount of sodium into the water.

When a softener has exhausted its supply of sodium, a 10 to 12% brine solution made by dissolving sodium chloride (NaCl) in water, which is then slowly passed through the resin. The resin has a stronger attraction for hardness ions (calcium and magnesium) than sodium ions; however, since the 10 to 12% brine is so much more concentrated than the hardness ions held on the resin, the sodium ions overpower the hardness ions and kick them off. After the resin has been loaded up with new sodium ions, and the excess salt solution is rinsed out, the softener is said to be "regenerated" and will once again exchange sodium for hardness, thereby softening water.

Water treatment: - Also referred to as water conditioning, can consist of adding, as well as removing, chemicals to change the properties of water. In water softening, for example, sodium ions are substituted for ions which cause “hardness”, thus reducing the scale-forming tendencies of water. Water purification, on the other hand, always consists of removing undesirable impurities.

Weak Acid Cation Resin: - A very high capacity resin that removes only the cations associated with alkalinity. It can be used in both softening and deionization. It is good only for very specific applications, and cannot be used generally. When it is used, the vessel containing it must allow 100% to 400% freeboard because of its very high expansion characteristics.

Weak Base Anion Resin: - A very high capacity resin that removes only the strongly basic anions, allowing the Weakly Basic anions to remain in water. [SO4], [Cl], [NO3], are removed. Typically, [CO3] and [SiO2] remain in the water. The advantage of using weak base resin is that it has a high capacity and that of the anions left in the water, CO3 will go off as a gas (CO2) and there isn't much SiO2 in the water to start with.

Zeolite: - A white granular aluminum silicate that was used for water softening. Zeolite is now obsolete, but the name hangs around.