

Preparation of Reagent Water in the Laboratory

Glossary of Terms

(Edition 11)

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Comment

This glossary is intended to provide explanations and definitions for some of the common terms associated with the preparation of reagent-grade water for the laboratory. Though a concerted effort has been made to provide practical, understandable, correct definitions and explanations, it can undoubtedly be improved through usage. The contents will be reviewed and updated frequently – comments and suggestions are welcome.

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1,2 Diaminoethane, 2-Amino-2-methyl-1-propanol – See Corrosion Inhibitors

3-Hydroxyquinuclidine – See Corrosion Inhibitors

3-Methoxypropylamine – See Corrosion Inhibitors

Absolute Purity Water – Water that is contaminant-free. Such water has a resistivity of 18.2×10^6 ohms-cm at 25° C and its preparation and maintenance is complex. It is not necessarily true that water with a resistivity of 18.2×10^6 ohms-cm at 25° C will be pure (see Conductivity).

Absolute Retention Rating – 100% retention of an organism or particle that is at, or slightly larger than, the rated pore size of a filter. (Also see Grow Through, Nominal Pore Size, and Nominal Retention Rating)

Absorption – A process by which one substance is taken up by another, either chemically or physically, and held in pores or interstices in the interior as when a sponge “soaks up” a liquid.

Accuracy – In terms of instruments and scientific measuring systems, accuracy may be defined as the conformity of an indicated value to an accepted standard value, or true value. See Precision.

Acid Feed – Injecting acid (into water); usually, to prevent the precipitation of carbonates that occurs when CO₂ is removed from water by boiling or reverse osmosis.

Activated Carbon (also, Activated Charcoal or Granulated Activated Charcoal) – A material produced by the destructive distillation of coconut and pecan shells, wood, coal, or other materials at 450° C to create charcoal, which is subsequently ground and “activated” in a poorly understood process involving roasting at 1000° C. Alkaline oxide ash may be removed by washing the material with acid. Activated Carbon is used to chemically remove chlorine from water (1 pound of carbon can react with 2-6 pounds of chlorine) and to remove other water contaminants through a combination of chemical reaction and sorption.

Cautionary Note: Activated Carbon is very much overrated as a means of removing organic substances from water in small-scale systems. Beds of activated carbon provide an excellent environment for the proliferation of microorganisms.

ACS – Abbreviation for American Chemical Society

Adsorption – Adherence of molecules, atoms and ions of gas or liquid to the surface of another substance (solid or liquid) as the result of a variety of weak attractions that involve ionic, Van der Waals, and surface-active (drophobic/hydrophilic) forces.

Agglomerate – Combination or aggregation of colloidal particles into clusters by neutralizing the electrical charges that maintain the stability of the colloidal suspension (see flocculation).

Alkalinity – The concentration of hydroxides of alkali metals, cesium, lithium, potassium, rubidium, and sodium.

Alum – Aluminum ammonium (or potassium) sulfate, commonly added as a flocculent (see Agglomeration and Flocculation).

A.M.U. – Abbreviation for Atomic Mass Unit.

Angstrom (Å)– 10^{-10} meter. One ten-thousandth of a micron.

Anion – A negatively charged ion (attracted to a positively charged anode).

Anion Exchange Resin – An ion exchange resin with positively charged exchange sites, which can bind negatively charged anions. Strong anion resins are benzyltrimethyl quaternary ammonium hydroxide (Type 1) or benzyldimethylethyl quaternary ammonium hydroxide (Type 2) derivatives of polystyrene, which is cross-linked with divinylbenzene.

Aquifer – Underground layer of permeable rock, sand or gravel that contains water.

ASTM – The American Society of Testing and Materials.

ATCC – Abbreviation for American Type Culture Collection.

At-Line (measurement) – A probe is said to be at-line when the sample stream is not returned to main stream, perhaps because the measurement process contaminates the sample.

Atomic Absorption Spectrophotometry – Spectrophotometry based on the absorption of light energy by unexcited atoms (usually vaporized). The light sources are typically constructed to give very narrow spectral emission that corresponds to the primary absorption spectrum of the atoms to be measured. This technology is more sensitive than atomic emission spectrophoto-

tometry, because it is relatively more difficult to excite a significant percentage of atoms to emit light under controlled conditions.

Atomic Emission Spectrophotometry – Spectrophotometry based on the emission of light energy by excited atoms in a heated vapor.

Atomic Weight – The average mass of all the isotopes, weighted by frequency of occurrence, of an element, as compared with the atomic weight of C¹², which is taken to be 12.

Atomic Mass Unit (A.M.U. or Dalton) – 1 A.M.U. = 1/12 the mass of C¹², which is 1.656×10^{-24} gm.

Austenite – A nonmagnetic solid solution of carbon or iron carbide in iron (After Sir Wm. C. Roberts-Austen). Nonmagnetic stainless steels are referred to as, “austenitic”.

Autotroph (microorganism) – A microorganism which uses only inorganic materials as its source of nutrients.

Avagadro Constant – The number of particles (6.02×10^{23}), real or imaginary, of the type specified by the chemical formula of a substance in one mole of the substance.

Azeotrope – A liquid mixture (azeotrope) of two or more substances, which behaves like a single substance in that the vapor produced by partial evaporation has the same composition as the liquid (at constant pressure). This occurs when the relationship between vapor pressure and concentration deviates sufficiently to cause a maximum or minimum in the curve, the mixture of substances at that point is an azeotrope and it will distill as though it were a pure substance with a boiling point different from any of its components. Azeotropy is of practical significance for laboratory water distillation when specific contaminants are of concern. A case in point would be corrosion inhibitors. These substances are added to central boiler plant steam and they have been selected because they do not separate readily from water by distillation. Central “distilled” water should be considered suspect for substances that distill with water

Background – In the context of reagents, including water, it is the contamination that overlaps with an experimental measurement to reduce the signal to noise (background) ratio. Put another way, it is the “apparent” measurement of an experimental variable when the variable has intentionally been omitted from the experiment.

Backwash – Reversing the flow through a filter or bed to wash out materials that became trapped during forward flow operation.

Bar – Unit of pressure. 1 bar = $1 \text{ kg/cm}^2 = 100 \text{ kPa} = 14.5 \text{ psi}$ = pressure at the base of 33.45 foot column of water (stp).

Baseline – The curve representing the scanning analysis of a “blank”, which has been processed as though it were a test sample and which was expected to be identical to test samples except that the unknown to be measured was intentionally omitted (see Blank).

Bed – In the context of water, it is a packed volume of particulate material, typically, sand, carbon, ion exchange resin etc.

Bias – In terms of measurement, “bias” is an indication of the degree to which a result deviates in a systematic fashion (see Systematic Error) from the true value. See Precision and Accuracy.

Biocide – A chemical or physical agent that kills microorganisms.

Biological Oxygen Demand (BOD) – The amount of oxygen required to oxidize the dissolved organic matter in water sample by aerobic (bacterial) decay.

Biofilm – A layer of organisms embedded in an organic matrix, composed mostly of glycoproteins and heteropolysaccharides. Organisms in this layer can multiply even when the concentration of nutrients in the main volume of liquid is very low, and the layer protects the organisms from periodic treatment with many biocides that are effective in killing free-floating organisms.

Blank – An analysis of a sample, from which a variable component was intentionally omitted for the purpose of establishing to what extent all the known components affect the background of the analytical measurement (see Background).

BOD – Abbreviation for Biological Oxygen Demand.

Boiler – That stage of a still in which the liquid is heated to the point that it changes phase to a vapor. Ideally, this is accomplished with as little mist production as possible and without heating the vapor or liquid above the boiling temperature, in order to maximize the purity of the vapor.

Breakthrough – The point at which an active component of a water purification system begins to pass a contaminant that the process should be able to remove under ideal conditions. For example, a carbon bed or ion exchange resin would begin to “breakthrough” if the flow rates were so high as to prevent complete interaction between the beds and the contaminants.

British Thermal Unit (Btu) – The quantity of heat necessary to raise the temperature of one pound of water by 1°F. $1 \text{ Btu} = 1055.06 \text{ J} = 252.1 \text{ calories} = 0.293 \text{ watt-hour}$.

Btu – Abbreviation for British Thermal Unit.

Buffer – A solution that is capable of opposing small changes in chemical composition; particularly in pH.

Bubble Point – The pressure at which air can be forced through a wetted membrane (filter). This value is related to the largest pore in the membrane. Different wetting solutions will result in different bubble points.

CA Membrane – Cellulose diacetate/triacetate RO membrane (see Membranes RO).

Cal – Abbreviation for Kilocalorie. See Kilocalorie.

Calorie (cal) – The quantity of heat necessary to raise the temperature of 1 g of water by 1°C. Known as the small calorie. $1 \text{ cal} = 4.185 \text{ J} = 4.185 \text{ watt-second} = 1.159 \times 10^{-3} \text{ watt-hours} = 3.9 \times 10^{-3} \text{ BTU}$. See Kilocalorie.

CAP – College of American Pathologists

Carbonate Hardness – The concentration of bicarbonates and carbonates of calcium and magnesium in water (see Hardness).

Cation – A positively charged ion (attracted to a negatively charged cathode).

Cation Exchange Resin – An ion exchange resin with negatively charged exchange sites, which can bind positively charged cations. Strong cation resins are typically polysulfonic acid derivatives of polystyrene, which is cross-linked with divinylbenzene.

Centi (c) – Prefix meaning hundredths, as in centimeter (cm).

Centigrade (°C) – Unit of temperature. $^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$.

CFU – Abbreviation for Colony Forming Unit.

Channeling – Failure of a bed caused when water finds furrows or channels, through which it can flow; thereby short-circuiting the bulk of the bed and reducing the effective contact.

Chelating Agents – Organic compounds that form strong, spatially optimized, multi point ionic bonds with multivalent ions, often forming enclosing, ring-like structures (i.e., as in claws of a crab [derivaton]). Chelating agents are used to sequester ions to prevent their precipitation and/or to facilitate their removal. Examples of chelating agents are: Ethylenediametetraacetic acid (EDTA) and nitrilotriacetic acid (NTA).

Chemical Oxygen Demand (COD) – The amount of oxygen needed to completely oxidize all oxidizable organic and inorganic substances in water.

Chloramines – A chlorine compound formed by reaction with organic amines or ammonia.

Chlorination – Adding chlorine or hypochlorites (OCl) to water for disinfection.

Chlorine Demand – Amount of chlorine used up by reacting with oxidizable substances in water before chlorine residual can be measured.

Chlorine Residual – The amount of chlorine that remains active after specified contact period.

Coagulation – Adding insoluble compounds to water that neutralize the electrical charge on colloids, causing them to coalesce to form larger particles that can be removed by settling. also referred to as flocculation.

COD – Abbreviation for Chemical Oxygen Demand.

Coil Heat Exchange – An heat exchange designed around a coil, though which one of the substances moves, entering at one end and exiting at the other end. Such a design will result in a temperature gradient along the length of the coil. See Heat Exchange.

Coliform Bacteria – A group of enteric, fermentative, gram-negative rod bacteria found in mammalian intestines and soil. Their presence in water is an indicator of possible fecal pollution.

Colloidal Particles – Particles so fine they will not settle without prior coagulation. They range from 10 to 1,000 Å, have a net negative charge, and readily clog membranes and foul resin beds.

Colony Forming Unit (CFU) – One colony of bacteria grown in the determination of microbiological content (see Microbiological Content). A CFU does not necessarily equate to a single organism, because bacteria often occur as pairs, chains, and clusters.

Concentrate – In relation to membrane filtration, the liquid, containing dissolved and suspended matter that *concentrates* on one side of the membrane.

Concentration Polarization – The phenomenon in ultrafiltration (UF) and reverse osmosis (RO) in which solutes form a dense, polarized layer next to the membrane surface which eventually blocks further flow. UF and RO systems counteract this by maintaining turbulence and continuously flushing the solute away from the membrane surface.

Condensate – Liquid that has formed from a vapor as heat was withdrawn from the vapor. During ideal condensation the condensate and vapor will be in equilibrium and their temperatures will be the same.

Condenser – The stage of a still that removes sufficient heat from a vaporized liquid to cause the vapor to change to a liquid phase. Ideally, this is accomplished under conditions approaching equilibrium and without reducing the temperature of the liquid below the temperature of the vapor, in order to maximize the purity of the condensed substance.

Conductance – Not equivalent to conductivity (see conductivity for definition).

Conductivity (electrical conductivity of aqueous solutions) – Electrical conductance (G) is measured by applying a voltage to a pair of electrodes immersed in an aqueous solution at a known temperature.

$$G = I/E$$

In the above equation, *I* is amperage and *E* is voltage. Usually the voltage is applied as alternating current or short DC pulses to avoid polarization effects. The electrodes are fixed with respect to one another.

To remove the dependence upon the size and shape of the conductor requires use of conductivity (*k*) rather than conductance (G). Since conductance increases directly with the cross-sectional area of a conductor and decreases with the length of the conductor, conductivity is defined by:

$$k = G/A$$

In the above equation, *l* is the length of the conductor and *A* is its cross-sectional area. The SI unit for conductivity is the siemens per meter, S/m (c.g.s: S/cm). By calibrating a set of electrodes with a reference solution of known conductivity and temperature, measurements of conductance can be converted to conductivity.

The reciprocal of conductivity is resistivity. A solution with a conductivity of 0.1 μ S/cm will have a resistivity of 10 M Ω -cm.

The conductivity of high-purity water is very temperature sensitive; it will decrease by about 1.7 times as the temperature rises from 20° C to 30° C.

Cautionary Note: It is not true that water with a conductivity of 0.055 μ S/cm (resistivity of 18.2 M Ω -cm) at 25° C is absolutely pure. Thus, water treated by mixed-bed ion exchange can have a conductivity of approximately 0.055 μ S/cm at 25° C and yet contain large quantities of particulates and dissolved organic substances that either do not form ions or form ions with such low mobilities that they do not carry significant current. In fact, it is possible to add contaminants to water which will reduce the conductivity below that of pure water.

See also: Molar Conductivity

Contact – See Membrane Contactor

Corrosion Inhibitors –The pH of boiler steam is traditionally maintained at 7.5 - 9.2 in order to prevent corrosion of metal parts. This is often accomplished by adding amines such as:

- 1,2 Diaminoethane;
- 2-Amino-2-methyl-1-propanol (AMP);
- Morpholine (MO);
- 3-Hydroxyquinuclidine (3-OH-Q);
- 3-Methoxypropyl amine (MPA);
- Ammonia; or
- Ethanolamine (EOA).

These substances may appear in central distilled water as the result of perforated heat exchangers, when the still's source water is heated by steam.

Counter-Current – A process in which a liquid and vapor stream or two immiscible liquids or a liquid and a solid are caused to flow in opposite directions and past or through one another with more or less intimate contact for equilibrium. The purpose of counter-current flow is usually to use the opposite directions of flow to purify one of the materials.

Covalent Bonding – A chemical bond in which atoms share electrons.

Crossflow (a filtration term) – That portion of water that flows across the surface of a filter element, as opposed to flowing through the element. RO membranes and ultrafilter membranes must have substantial crossflow to rinse away concentrate. Crossflow may also be referred to as tangential flow.

Dalton – See Atomic Mass Unit.

Deadleg – A stagnant section of a piping system, which has been defined as being 6 times longer than the diameter of the pipe involved in hot water systems and 3-4 diameters in cold water systems (*6d rule*).

Deionization (DI) – Removing dissolved ions from a solution by passing it through a bed of ion exchange resins, consisting of polymer beads that exchange hydrogen ions for cations and hydroxyl ions for anions. The ionic impurities remain bound to the resins, and the hydrogen and hydroxyl ions combine with each other to form water (see Anion Resin and Cation Resin).

Demineralization – The removal of minerals; sometimes used interchangeably with deionization. Typically, this term refers to the removal of minerals by ion exchange; however, other methods could be employed.

Depth Filter – A filter media which traps particles on the surface and in the matrix of the material. Typically, these media are fibrous. This type of media does not normally give absolute retention ratings, but nominal retention ratings, and pore sizes distributed broadly within a range. (Also see Surface Filter)

Desalination – The removal of dissolved salts from brine to produce a potable water.

Detection limit – At a specified level of confidence, the lowest result that verifies the presence of what is being measured.

DI – An abbreviation for Deionization.

Diffusion – The spontaneous mixing of one substance with another when in contact or separated by a permeable or micro porous membrane.

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

Dissolved Ionized Gases – Gases which combine reversibly with water to produce substances that dissociate into ions (e.g., CO₂ and SO₂).

Dissolved Organics – Organic substances (see Organics), that is dispersed in water to give a single homogeneous liquid phase.

Dissolved Solids – Also referred to as Total Dissolved Solids (TDS), it is the amount of nonvolatile matter dissolved in a water sample.

Distillation – A purification process that takes advantage of changing the phase of a substance from liquid to vapor and back to liquid at the boiling temperature of the substance, in order to separate it from other substances with higher or lower boiling points.

DNA – Abbreviation for deoxyribonucleic acid.

EDTA – Abbreviation for ethylenediametetraacetic acid (see Chelating Agents).

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

Electrodeionization (EDI) – The process of removing the ionic impurities from water by the passage of electric current (DC). Modern EDI uses a pair of ion-permeable membranes to separate the ions from the water, under the influence of DC electric current. The EDI cell is filled with mixed-bed ion-exchange resin to enhance removal of ions and to lower electrical power consumption. The electric current also produces H⁺ and OH⁻ ions by splitting water molecules. These ions effect continuous regeneration of the ion exchange resins.

Electrolyte – A substance that will provide ionic conductivity when dissolved in water.

Empty Bed Contact Time (EBCT) – EBCT is the bed volume, typically of carbon, divided by the volume flow rate of the liquid.

Endotoxin – A thermostable, lipopolysaccharide component from the cell wall of viable or nonviable gram-negative microorganisms.

Endotoxin Unit (EU) – An unit of activity, measured by the LAL (Limulus Amebocyte Lysate) test, calibrated to the USP reference endotoxin (lot G). The current reference preparation, an endotoxin purified from the cells of E. coli O113, is used internationally and is also designated the 2nd International Standard for Endotoxin (World Health Organization). WHO defines activity in In-

ternational Units (IU); IU's are equivalent to EU's. The Biological Reference Preparation specified in the European Pharmacopeia is the same preparation.

Entrainment (distillation) – As a general definition relating to liquids and gases, entrainment is the transport of mass drawn from a less turbulent medium into a more turbulent medium. In distillation two types of entrainment are of importance, surface entrainment and steam entrainment. Surface entrainment involves moving contaminants from the boiler water toward the condenser in the film of water that covers all hydrophilic surfaces within a still, and which is propelled by the flow of steam. Steam entrainment involves the transport of particles of boiler water as mist (formed with the bubbling that inevitably results from boiling) through the still with the flow of steam.

Epifluorescence – Method of fluorescence microscopy in which the excitatory light is transmitted through the objective onto the specimen rather than through the specimen; only reflected excitatory light needs to be filtered out rather than transmitted light, which would be of much higher intensity.

Equivalent Conductance – See Molar Conductivity.

Equivalent Weight – The molecular weight divided by the valance. Thus, the molecular weight of CaCO_3 is 100 and the equivalent weight is 50.

Equivalent Ionic Conductivity (I) – See Molar Conductivity

Ethanolamine – See Corrosion Inhibitors.

Ethylenediametetraacetic acid (EDTA) – See Chelating Agents.

Evaporator – See Boiler.

Exhaustion – Activated carbon or ion exchange resins are termed “exhausted” when their capacity has been sufficiently depleted to prevent effective operation under normal conditions.

Extractables – Undesirable foreign substances that are leached or dissolved by water from the materials of construction used in filters, storage vessels, distribution piping and other wetted surfaces.

Fahrenheit (°F) – Unit of temperature. $^{\circ}\text{F} = 9/5^{\circ}\text{C} + 32$.

Faraday Constant (F) – The quantity of electricity contained in 1 mole of electrons (96485 coulombs/mole).

Feedwater – Source water entering a treatment process.

Filtration – A purification process in which a liquid or gas is passed through a porous material to separate particles, impurities etc.

Flocculation – Addition of one or more chemicals to agglomerate colloidal particles into clusters or flocs, which will settle or can be filtered.

Flow Decay – Measuring the decline in flow rate through a filter to establish a Silt Density Index for the water being filtered (see Silt Density Index).

Flow Restrictor – A flow-limiting orifice (jet) used to control flow rate or pressure drop in a liquid stream.

Fluorescence – **1.** The emission of electromagnetic radiation, especially of visible light, stimulated in a substance by the absorption of incident radiation and persisting only as long as the stimulating radiation is continued. **2.** The property of emitting such radiation. **3.** The radiation so emitted.

Fouling – When gelatinous coatings, colloidal masses or dense bacterial growth forms a compacted coating on membrane or filter surfaces, restricting further flow and potentially leading to irreversible damage.

Gallon (Gal) – U.S. gallons. 1 Gal = 3.785 l

Gallons Per Hour (gph) – U.S. gallons per hour. 1 gph = 3.785 lph

Gallons Per Minute (gpm) – U.S. gallons per minute. 1 gpm = 3.785 lpm

Gel – A colloid in which the disperse phase has combined with the continuous phase to produce a viscous, jelly-like product.

Glucan – A polyglucose (e.g., callose, cellulose, starch amylose, glycogen amylose).

GMP – Abbreviation for Good Manufacturing Practices.

Grain (gr) – Unit of weight. 1 grain = 0.002286 ounces = 0.0648 grams.

Grains per Gallon – Concentration of dissolved ions in water, generally as calcium carbonate. 7,000 grains is equal to a pound. One grain per gallon = 17.1 ppm.

Gram (g) – Unit of weight 1 gram = 0.035 ounces.

Granular Activated Carbon (GAC) – See Activated Carbon

Growththrough – A time-related phenomenon in which successive generations of bacteria grow through a membrane filter with pores small enough to prevent passage of the original parent organism.

Hardness – The concentration of calcium and magnesium salts in water. Hardness is a term originally referring to the soap-consuming power of water. As such, it is sometimes also taken to include barium, strontium, iron and manganese. Hardness is generally associated with boiler scaling and the fouling of RO membranes.

Heat Exchange – A system for transferring heat between two materials that do not mix or are separated to prevent mixing. Still condensers use coil, jacket, and hot-finger types of heat exchanges.

Heat of Fusion – See Latent Heat of Fusion

Heat of Vaporization – See Latent Heat of Vaporization

Hertz (Hz) – Unit of electrical frequency.
1 Hertz = 1 cycle per second.

Heterotroph (organisms) – An organism that obtains its carbon as well as its energy from organic substances (see autotroph).

High Density Polyethylene (HDPE) – HDPE pipe is essentially pure organic material. It is relatively prone to oxidation; however, it is not nearly as susceptible to oxidation as polypropylene.

High Performance (Pressure) Liquid Chromatography (HPLC): An analytical technique for performing chromatographic separation in which the mobile phase (eluent or carrier) is forced through a narrow column of very densely packed stationary phase under substantial pressure.

Hollow Fiber – Refers to reverse osmosis (RO) and ultrafiltration (UF) membranes designed around small diameter (about 0.05" I.D.) tubes, as opposed to sheets. The inner surface of a tube is a very thin (RO or UF) membrane skin supported by a thicker porous outer layer which gives the tube its strength. Water is forced through the center of each tube and purified permeate is collected from the outer wall.

Hot-Finger Heat Exchange – An heat exchange, which is designed to minimize any difference in temperature over the active interface region of the heat exchange.

Thus, in the case of a water still, cooling water would enter the center of the hot-finger central chamber to mix rapidly with water already present in the chamber and the overflow of cooling water would exit from a point that was not actively involved in exchanging heat. The surface temperature of the active heat exchanging surface would be relatively uniform. See Heat Exchange.

HPLC – See High Performance Liquid Chromatography

Hydration – The association of water with charged (ions) and uncharged atoms and molecules through hydrogen bonding and covalent bonding.

Hydrogen Bonding – A weak electrostatic bond that forms between covalently bonded (chemical bond) hydrogen and a strongly electronegative atom with a lone pair of electrons (e.g., oxygen, nitrogen, fluorine). Hydrogen bonds have about 1/10 the strength of covalent bonds.

Hydrophilic – Having a strong affinity for water; wettable (e.g., glass).

Hydrophobic – Non-wetting; water repelling (e.g., Teflon).

ID – Abbreviation for Inside Diameter or Dimension

In-Line (measurement) – An integral part of the flow path. A probe is said to be in-line if the fluid stream flows by, or through, the probe.

Inorganic – All substances that are not carbon compounds and such binary compounds as carbon oxides, the carbides, carbon disulfide; such ternary compounds as metallic cyanides, metallic carbonyls, phosphene, carbonyl sulfide, etc.; and the metallic carbonates.

Ion – An atom or radical with an electrical charge that is positive (cation) or negative (anion) as a result of having lost or gained electrons.

Ion Exchange – Also called deionization. A reversible chemical reaction between a solid (ion exchanger) and a fluid (often water) by means of which ions may be exchanged from one substance to another. In water purification, hydrogen ions are exchanged for cations and hydroxyl ions for anions. The hydrogen and hydroxyl ions combine to form pure water. See Anion Exchange Resins and Cation Exchange Resins.

J – Abbreviation for Joule.

Jacket Heat Exchange – An heat exchange designed around a jacketed chamber. Typically, a cooling liquid or gas flows through the jacket, entering at one end and exiting at the other end. Such a design will result in a temperature gradient along the length of the jacket. See Heat Exchange.

Jet – See Flow Restrictor.

Joule (J) – Unit of work or energy. $1 \text{ J} = 1 \text{ Newton-meter} = 1 \text{ watt-second} = 2.77 \times 10^{-4} \text{ watt-hour} = 0.239 \text{ calories} = 9.4 \times 10^{-4} \text{ BTU}$.

Kilo (k) – Prefix meaning one thousand, as in kilogram (kg) or kilometer (km).

Kilocalorie (Cal) – The quantity of heat necessary to raise the temperature of 1 kg of water by 1°C. Known as a large calorie. $1 \text{ Cal} = 1000 \text{ cal} = 4.185 \times 10^3 \text{ J} = 4.185 \times 10^3 \text{ watt-second} = 1.159 \text{ watt-hours} = 3.9 \text{ BTU}$.

Kilogram (kg) – Unit of weight. $1 \text{ kg} = 2.2046 \text{ lbs}$.

Kilogram/cm² – Unit of pressure (see Bar). $1 \text{ kg/cm}^2 = 1 \text{ bar} = 100 \text{ kPa} = 14.5 \text{ psi} = \text{pressure at the base of } 33.45 \text{ foot column of water (stp)}$.

Langelier Saturation Index (LSI) – A measure of the degree of saturation of calcium carbonate in water, which is based on pH, alkalinity and hardness. $\text{LSI} = (\text{pH of the water without } \text{CaCO}_3) - (\text{pH of the water saturated with } \text{CaCO}_3)$. If the Langelier Index is positive, calcium carbonate can precipitate out of solution to form scale.

Latent Heat of Fusion – Refers to the heat lost or gained when liquid water changes to ice or vice versa. $L_f = 333.6 \text{ J/g}; 6.010 \text{ kJ/mol}$

Latent Heat of Vaporization – Refers to the heat lost when liquid water changes into vapor. This is also commonly known as the latent heat of evaporation. $L_v = 2.2578 \text{ kJ/g}; 40.657 \text{ kJ/mol}$

Leach – To dissolve by the action of a percolating liquid (i.e., contaminants *leach* from carbon and ion exchange beds).

Limulus Amebocyte Lysate (LAL) – Bacterial endotoxin initiates activation of a proenzyme (a cascade of serine protease enzymes) in ruptured Limulus amebocytes (LAL), which can be coupled to a color producing reaction. This reaction is the basis of the LAL assay for endotoxins.

Lipopolysaccharide – A molecule or compound in which lipids and polysaccharides are linked, as in cell membranes (see Endotoxin).

Liter (l) – Unit of volume. $1 \text{ l} = 0.26 \text{ Gal}$.

Liter Per Hour (lph) – Unit of water flow. $1 \text{ lph} = 0.26 \text{ gph}$.

Liter Per Minute (lpm) – Unit of water flow. $1 \text{ lpm} = 0.26 \text{ gpm}$.

Macro reticular Resin – Typically, an ion exchange resin with a relatively large pore structure, permitting larger molecules to diffuse into the internal spaces of the resin beads.

ME– Abbreviation for Multiple Effect [still].

Megapure Water – Typically, advertising hyperbole for which there is no generally agreed upon definition.

Membrane Contactor – A device for bringing water under pressure into close proximity with a gas phase across a large surface area in order to achieve equilibrium rapidly. In one design, microporous polypropylene hollow fibers are knitted into an array that is wound around a distribution tube. Because the hollow fiber membrane is hydrophobic, the aqueous stream will not penetrate the pores. Membrane contactors are frequently used to remove CO₂ and other volatile substances from water.

Membranes (Reverse Osmosis) – RO membranes have such fine pores that they can (under ideal conditions) reject large percentages dissolved inorganic salts (approximately 95%) and prevent the passage of substances with molecular weights of greater than 200 daltons. There are two basic classes of RO membrane in common use, CA membranes that are made primarily of cellulose diacetate/triacetate films and TF membranes that are made of thin films of polyamide materials.

Method – A definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces a test result.

Mho – Obsolete unit of measurement for conductance; the reciprocal of ohm (resistance). See Siemens.

Mho/cm – Obsolete unit of conductivity. See Siemens/cm.

Micro (μ) – Prefix meaning one millionth, as in microgram (μg) or micrometer (μm).

Microbial content – The quantity of viable aerobic and facultative heterotrophic anaerobic bacteria, as determined by total colony count after incubation at $36 \pm 1^\circ\text{C}$ for 24 hours, followed by a 24 hours at ambient temperature ($23 \pm 3^\circ\text{C}$) and reported as colony-forming units per milliliter (CFU/ml). Samples must be suitably diluted or concentrated to permit meaningful counts. This test will not detect all microorganisms.

Micrometer (Micron) – One millionth of a meter.

Microorganism – A small, usually microscopic, living organism; types include bacteria, viruses, molds, yeasts, and protozoa.

Milli (m) – Prefix meaning thousandths, as in milliliter (ml) or milligram (mg).

Milliequivalent (Meq) – 1/1000 of one Equivalent Weight (see Equivalent Weight). For CaCO_3 , 1 ppm is equal to 0.02 Meq/L, since the Equivalent Weight for CaCO_3 is 50.

Mixed-Bed Ion Exchange – Mixing both anion and cation resins in the same chamber results in higher efficiency.

Mobility of Ions (μ) – The average drift velocity of an ion in solution, divided by the strength of the electric field that produces the net movement of the ion. Mobility is an indication of the effective size of an ion in solution.

Molar Conductivity – The conductivity of a solution of a strong electrolyte decreases as the solution concentration decreases. For dilute solutions, or solutions sufficiently dilute that the ionic environment does not change significantly upon further dilution, the conductivity, k , should decrease as it does with concentration only because the number of charge carriers per unit volume decreases. It is therefore convenient to factor out the dependence upon concentration by defining the molar conductivity, L , of an electrolyte:

$$L_{\text{SI}} = k/c$$

If the concentration of ions is expressed in mol/m^3 the appropriate SI unit for molar conductivity, L , is:

$$\text{S m}^2/\text{m mol}_{\text{ions}}$$

which reduces to:

$$\text{S m}^2/\text{mol}_{\text{ions}}$$

Under the c.g.s. metric version of L , called the *equivalent conductance*, the formula for conductivity would be:

$$L_{\text{cgs}} = k/c$$

Where the concentration of ions, c , is in moles/liter, or equivalents/liter. As a consequence *equivalent conductance* values are 1000 times greater than *molar conductivity* values. This unit corresponds to the physical system in which one equivalent of electrolyte is enclosed by two 1 cm^2 electrodes placed exactly one centimeter apart.

The German physicist Friedrich Kohlrausch (1840-1910) found that for dilute solutions of strong electrolytes, extrapolation of measured values of L to infinite dilution was approximately linear when done against the square root of concentration. This means that the data suggest an equation containing an empirical coefficient B characteristic of the electrolyte:

$$L^1 = L^0 - Bc^{1/2}$$

At infinite dilution, where ions must necessarily conduct independently of each other, *Kohlrausch's law of the independent migration of ions* takes the status of an axiom rather than that of an experimental fact. It is, nevertheless, empirically true that each species of ion present at infinite dilution contributes a fixed amount to the total ionic conductivity regardless of the nature of any other ions present. This means that the total conductivity of a sufficiently dilute solution is given by the sum of the individual ionic conductivities of the i different kinds of ions present in it:

$$k = (\text{the sum over all ions } i \text{ of}) k_i$$

It is convenient to define the molar ionic conductivities L of individual ions in the same manner as molar conductivities of electrolytes; in other words, for the i th ion $g_i = L_i c_i$. The equation which expresses, at sufficient dilution, Kohlrausch's axiom now becomes

$$k = (\text{the sum over all ions } i \text{ of}) L_i c_i$$

The molar conductivity of an electrolyte salt at sufficient dilution is then simply the sum of the molar ionic conductivities of the ions produced by dissociation of the salt:

$$L^0 = (\text{the sum over all ions } i \text{ of}) n_i L_i^0$$

In the above equation n_i is the number of moles of ions produced by the dissociation of one mole of the salt.

Molar Ionic Conductivity – See Molar Conductivity

Molar Volume – The molar volume for any ideal gas is a constant (22.4 liters at 0° C and 24.8 liters at 25° C at 1 bar pressure and (22.4 liters at 0° C and 24.5 liters at 25° C at 1 atm. pressure).

Mole (mol) – An amount of a chemical, the mass of which is equal to the molecular weight of the chemical.

Molecular Weight – The weight of a molecule that may be calculated as the sum of the atomic weights of its constituent atoms.

Morpholine – See Corrosion Inhibitors.

MTBF – Abbreviation for Mean Time Between Failure.

N – Abbreviation for Newton.

Nano (n) – A prefix meaning billionths, as in nanogram (ng) or nanosecond (ns).

Nanofiltration (NF) – Filtration through material with sufficiently fine pores to prevent the passage of even small molecules, having molecular weights on the order of 300-1000 daltons. Nanofilters are also referred to as low-rejection RO membranes

Newton (N) – Unit of force. The force required to accelerate 1 kg to 1 meter per second per second.
1 N = 0.102 kg (force) = 3.60 oz (force).

NF – Abbreviation for Nanofilter and National Formulary.

NIST – Abbreviation for National Institute of Standards and Technology.

NIST Traceable – Refers to the fact that a secondary or tertiary reference standard material or reference is related in a traceable fashion to a NIST primary standard material or reference.

Nitrilotriacetic acid (NTA) – See Chelating Agents.

Nominal Pore Size (Filtration) – A filter should retain 99.9% of all particles larger than its nominal rated pore size.

Cautionary Note: Pore sizes are estimated by a variety of indirect techniques, such as increasing the pressure of a gas against a filter and watching for the point at which

bubbles form on the downstream, liquid side. The indirect tests are validated; however, the non-ideal (polygonal) shapes of pores and the potential for manufacturing defects leaves room for error.

Nominal Retention Rating – Retention of less than 100% of an organism or particle that is at, or slightly larger than, the rated pore size of a filter. The value should be stated at a particle size and percentage retained. (Also see Absolute Retention Rating, Grow Through, and Nominal Pore Size)

Non-purgeable Organic Carbon (NPOC) – The mass of organic carbon remaining after sparging a sample to remove inorganic carbon.

NPDWR – Abbreviation for National Primary Drinking Water Regulations.

NPT – Abbreviation for National Pipe Thread.

Nephelometer – An instrument similar in design to a colorimeter, except that the scattering of light is measured (see Tyndall Effect).

NF – Abbreviation for National Formulary and Nanofiltration.

NTA – Abbreviation for nitrilotriacetic acid (see Chelating Agents).

OD – Abbreviation for Outside Diameter or Dimension.

Off-Line (measurement) – Measurements that are made by separating (i.e., collecting) samples for determination after a significant interval of time and usually at some distance from the collection point.

Ohm (Ω) – The practical unit of electrical resistance in a circuit, where a potential difference of one volt produces a current of one ampere.

Ohm-cm (Ω -cm) – Unit of resistivity.

Oligotroph (microorganism) – A microorganism that grows optimally under nutrient limited conditions.

On-Line (measurement) – A measurement is said to be an on-line measurement when it is made *in-line* or *at-line*.

Organic – In general, all carbon compounds, both natural and man-made, except such binary compounds as carbon oxides, the carbides, carbon disulfide; such ternary compounds as metallic cyanides, metallic carbon-

yls, phosgene, carbonyl sulfide, etc.; and the metallic carbonates.

Orthophosphates – See Scaling Agents.

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

Pa – Abbreviation for Pascal.

Pascal (Pa) – Unit of pressure. $1 \text{ Pa} = 1 \text{ Newton/m}^2 = 1 \times 10^{-5} \text{ bar} = 1.45 \times 10^{-4} \text{ psi}$

Particulate – Usually, material large enough to be removed by filtration.

Passivation – After fabrication, a stainless system must be “passivated”. Historically, passivation involved treated the stainless steel surface with mineral acids to dissolve exposed iron and produce a resistant, chromium oxide surface layer. Modern passivation also involves the use of chelating agents, mixed with accelerators and synergists, and has become a very complex science (see Stainless Steel).

PEEK – Abbreviation for poly-ether-ether-ketone.

Percent Recovery – As it applies to reverse osmosis or ultrafiltration, “percent recovery” is the ratio of permeate output to source water input, expressed as a percent.

Percent Rejection – Percent rejection of an RO system or ultrafilter is defined as the ratio of concentration difference across the membrane to the bulk concentration on the brine side: $\text{Rejection} = (C_i - C_p)/C_i$, where C_i is the solute concentration in inflow and C_p is the solute concentration in permeate.

Perfluoro-alkoxy vinyl ether (PFA) – PFA is a fully fluorinated polymer that can be used for the construction of piping systems. Compared with PVDF, PFA has increased chemical resistance and stability and a higher operating temperature.

Permeate – As it applies to reverse osmosis, “permeate” refers the water and other materials, passing through the membrane.

PET – Abbreviation for polyethylene terephthalate copolymer.

PFA – Abbreviation for perfluoro-alkoxy vinyl ether.

pH – The negative logarithm of the hydrogen ion activity measured electrometrically and determined by the electromotive force between a glass electrode and reference electrode when immersed in an aqueous solution (calibrated against known buffer solutions). A solution with a pH lower than 7 is acidic and if its pH is higher than 7, it is alkaline.

Pico (p) – A prefix meaning one trillionth, as in picogram (pg).

Planktonic – A term used to describe free-floating microorganisms.

Plasticizer – A chemical added to plastics to make them softer and more flexible.

POC – Abbreviation for Purgeable Organic Carbon.

Polish (water) – A vague and often misapplied term that implies post-treatment processing of water to remove additional contaminants. Thus, ion exchange may be used to “polish” a purified water by increasing the resistivity of the water; however, the use of the ion exchange may actually increase the total concentration of impurities in the water by adding substances that are not detected by resistivity measurements (e.g., organics, particles microorganisms etc.).

Polyacrylic acids – See Scaling Agents.

Polymaleic acids – See Scaling Agents.

Poly-ether-ether-ketone (PEEK) – Provided as piping material for high-purity water systems, it is an essentially pure fluoropolymer with excellent chemical stability and a higher operating temperature than PVDF.

Polyethylene terephthalate copolymer – A clear, tough plastic with very low permeability to volatile substances. The material is also considered to be non-toxic for most tissue culture cells.

Polytetrafluoroethylene (PTFE) – The most chemically resistant of the fluoropolymers. This material cannot be welded or easily formed into pipes.

Polyvinyl chloride (PVC) – Provided as piping material for water systems, PVC pipe is not pure polyvinyl chloride; it is a complex mixture that includes about 15% by weight of compounding materials. Due to the instability of the chlorine bonds to heat and UV, particularly at tertiary positions of polymer branching, stabilizers must be added. These stabilizers are often organometallic in nature. Activated carbon is added to reduce UV penetra-

tion and to improve strength. Additional materials are added to give opacity and color, and plasticizers are added to make the PVC more compatible with molding/extruding processes. Despite all these potential contaminants, high-purity water distribution systems created from PVC pipe, which has been specified to contain low levels of problem additives, have proven effective.

Polyvinylidene fluoride (PVDF) – Provided as piping material for high-purity water systems, it is essentially a pure fluoropolymer, with no stabilizers, pigments, lubricants, or antioxidants. It has half as many fluorine atoms as PTFE and combines excellent chemical resistance with good molding/extruding properties. PVDF has a tensile modulus comparable to that of PVC.

Potable – Suitable for drinking.

PPB – Parts per billion (equivalent to micrograms per liter).

PPM – Parts per million (equivalent to milligrams per liter).

Practice – A definitive procedure for performing one or more specific operations or functions that does not produce a test result. See Method.

Precipitate – When a solution reaches saturation with respect to any of the solute components of the solution, those components will, with promoting conditions, condense as a solid “precipitate”. In the absence of promoting conditions, it is possible to achieve supersaturation without precipitation (see Scaling Agents).

Precision – The degree of exactness with which a quantity is stated (i.e., the number of significant places). Also, an indication of the scatter or random error associated with a measurement, expressed quantitatively as the standard deviation. “Precision” and “accuracy” are not synonymous. See Accuracy.

Pretreatment – Initial water treatment steps performed to protect downstream elements, such as RO systems and beds, from premature failure.

Product Water – The purified water produced as a result of treatment.

psi – Pounds per square inch of pressure. Often used interchangeably with “psig”. 1 psi = 0.069 bar = 6.90 kPa = pressure at the base of 27.68 inch column of water (stp).

PSI – Abbreviation for Practical Scaling Index or Pounds per Square Inch

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

PSPS Membrane – Polysulfonated polysulfone RO membrane (see Membranes RO).

PTFE – Abbreviation for polytetrafluoroethylene.

Purgeable Organic Carbon (POC) – Also referred to as Volatile Organic Carbon (VOC). Organic carbon molecules that have significant vapor pressures, relative water (e.g., short chain aliphatics, alcohols, ketones, esters, halomethanes, aromatic compounds such as benzene, toluene, cyclohexane etc.) that are easily removed from a water sample by sparging or by means of a contactor membrane.

PVC – Abbreviation for polyvinyl chloride.

PVDF – Abbreviation for polyvinylidene fluoride.

Pyrogens – Substances that cause a fever when injected into an animal (typically a rabbit).

QA – Abbreviation for Quality Assurance.

QC – Abbreviation for Quality Control.

Reagent Grade Water – Water suitable for use in making up critical reagents or for use in sensitive analytical procedures. Various professional organizations, such as ACS, ASTM, NCCLS and USP have provided minimal standards or guidelines for reagent water.

Regenerate – Typically, this refers to the restoration of a bed of activated carbon or ion exchange resin through chemical and physical means

Resin (Ion Exchange) – See Anion Exchange Resins and Cation Exchange Resins.

Resistivity – The resistance between opposite faces of a one-centimeter cube of a given material at a specified temperature. The reciprocal of conductivity (see conductivity). The unit of resistivity is Ω -cm.

The resistivity of high-purity water is very temperature sensitive; it will increase by about 1.7 times (approximately 1 $M\Omega$ -cm/degree) as the temperature rises from 20° C to 30° C.

Reverse Osmosis – A process in which osmotic flow is reversed. Water and a limited number of impurities (based on their vapor pressure and charge) are forced under pressure to flow across a semipermeable membrane, producing purified water on the output side of the membrane and concentrating dissolved and suspended impurities on the high-pressure side of the membrane. The concentrate continually flows away from the membrane. See Membranes RO.

RNA – Abbreviation for ribonucleic acid.

Rouge – Primarily colloidal iron oxide, mixed with traces of heavy metals (e.g., nickel and chromium) and other metals (possibly aluminum), and produced on the surface of stainless steels. Spots of rouge may appear on stainless steel surfaces; however, rouge may also be filtered from water in contact with stainless steel surfaces.

Rpm – Abbreviation for Revolutions Per Minute.

S – Abbreviation for Siemens.

Salinity – The concentration of soluble minerals (often restricted to salts of the alkali metals or of magnesium) in water.

Salt – Any of numerous compounds that result from replacement of some or all of the acid hydrogen of an acid by a metal or a radical, acting like a metal.

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

Sanitization – Chemical and/or physical processes used to kill microorganisms or reduce contamination.

Saturation Index – See Langelier Saturation Index.

Scale – The deposits (largely calcium carbonate, but including a variety of organic and inorganic substances) that coat the insides of boilers or the surfaces of RO membranes as the solutions become saturated.

Scaling Agents – Compounds that can be added to source waters to reduce or prevent precipitation by chelating ions, stabilizing supersaturation, and destabilizing crystal formation. Examples are: polyacrylic acids, sodium hexametaphosphate, orthophosphate, and polymaleic acids.

Sedimentation – A primary step in larger scale water treatment. Water is allowed to stand long enough for solids to settle by gravity.

Semipermeable – A membrane through which one (or more) of the substances comprising a mixture or solution may pass, but not all.

Siemens (S) – The accepted unit for conductance, formerly the mho (reciprocal ohm).

Silt Density Index (SDI) – This index is a measure of the silt content of water. It is based on how rapidly a 0.45 μ (rated) filter plugs when water is passed through it at 30 psig (207 kPa). $SDI = 100(1 - t_i/t_f)/T$, where t_i is the time required to flow 500 ml of test water through the filter, T is an interval during which the test water continues to flow (usually 15 minutes), and t_f is the time required to flow 500 ml of test water through the filter at the end of the time interval.

Sodium hexametaphosphate – See Scaling Agents.

Softener – Water treatment equipment that uses a sodium-based cation exchange resin to replace water hardness ions with sodium ions.

Solarization (quartz) – A change in quartz due to illumination with ultraviolet (or solar) light. High intensities of UV illumination can cause photo-thermal damage in quartz, dramatically increasing the scattering and attenuation of UV light.

Solute – One or more substances that dissolve in another.

Solution – A homogeneous mixture of one or more substances (solutes) dispersed at the molecular level in a quantity of dissolving medium (solvent).

Solvent – The component of a solution that is present in the largest concentration.

SOP – Abbreviation for Standard Operating Procedure.

Sorb – To attract and retain substances by absorption or adsorption.

Sorption – The process or state of being sorbed.

Source water – Water that is introduced into a purification process.

Sparge (water) – Injection of gas below the water surface to remove other dissolved gasses and volatile molecules.

Specific Conductance – See Conductivity

Spore – A reproductive element of one of the lower organisms such as algae, fungi, protozoa, etc. Also, an environmentally resistant form of a bacterial cell.

Stainless steel – Stainless steels, used in water systems, are alloys of steel containing chromium and nickel and, in some types, molybdenum and titanium. There are many grades of stainless steel and the grades vary considerably with regard to ease of machining, ease of welding, smoothness of finish, corrosion resistance, and cost. Low-carbon, L grades, and grades containing titanium are preferred for welding. Low-carbon grades are less likely to produce carbides, which will result in corrosion. At present, the trend is to use austenitic (non-magnetic) grades 316, 316L, and 316Ti, because they have a good mix of advantages. After fabrication, a stainless system must be passivated to remove exposed iron (see Passivation).

Standard – A document that details a specific method for analysis, together with the expected precision and accuracy that should be attained by following the method. Also, a material or reference that has been extensively defined and accepted as a primary standard, or has been suitably quantified against secondary or tertiary standard(s) in such a manner that it is traceable to the primary standard(s). See NIST Traceable.

Steam Entrainment – See Entrainment.

Sterile – Free from *all* microorganisms.

Sterilization – Destruction or removal of *all* microorganisms.

Surface Entrainment – See Entrainment.

Surface Filter – A filter material that retains particles solely on its surface. Membranes are usually referred to as surface filters; however, they can be asymmetric, thus having some depth filter characteristics. Such filters are usually rated in terms of absolute retention, rather than nominal retention.

Suspended Solids – Undissolved solids that can be removed by filtration.

Systematic Error – A bias (see Bias) in a measurement or determination, which is not random and which would affect accuracy (see Accuracy).

TDS – Abbreviation for Total Dissolved Solids

TFM – Abbreviation for Thin Film Membrane (See RO Membranes).

THM – Abbreviation for Trihalomethanes.

Thin-film Composite – An RO membrane created by extruding a thin layer of an aromatic polyamide onto a less dense polysulfone substrate.

TIC – Abbreviation for Total Inorganic Carbon.

TIS – Abbreviation for Total Ionized Solids.

Tissue Culture – Growing tissue cells in a culture medium (*in vitro*).

TOC – Abbreviation for Total Organic Carbon.

Total Dissolved Solids (TDS) – The residual matter after filtration of water through a very fine filter and the gradual evaporation of all the water from a given sample of the filtered water.

Total Inorganic Carbon (TIC) – The total mass of carbonate carbon in a sample.

Total Ionized Solids (TIS) – Concentration of dissolved ions in solution, expressed as NaCl, and measured by conductance. This test assumes that the preponderance of the ionized material will be small (hydrated) mobile ions (see Conductivity).

Total Organic Carbon (TOC) – There are two types of TOC: 1) TOC_{true} , also referred to as $TOC_{by\ difference}$, and 2) TOC_{direct} , also referred to as total Non-purgeable Organic Carbon (NPOC). TOC_{true} is equal to TC (total carbon) – TIC (total inorganic carbon). TOC_{direct} is equal to TC – (TIC + POC). POC (purgeable organic carbon, also referred to as Volatile Organic Carbon (VOC), is equal to the mass of volatile carbon chemicals that purge from a sample if TIC is removed by acidification and the CO_2 is removed by sparging. Short chain aliphatics, alcohols, ketones, esters, halomethanes, aromatic compounds such as benzene, toluene, cyclohexane etc. would be POC.

Total Solids (TS) – The residual matter after gradual evaporation of all the water from a given sample of water.

Trend Meter – A meter that is designed to focus on the rate at which some measurement changes, as opposed to the absolute value of the measurement at a particular point in time.

Trihalomethanes (THM) – The collection of $CHCl_3$, $CHBr_3$, $CHBrCl_2$, and $CHBr_2Cl$, which form as the results of chlorination or bromination (or chlorination of water in

which bromide salts are present) of water containing organic material.

Turbidity – Cloudiness in a liquid caused by fine particles (see Nephelometer).

TS – Abbreviation for Total Solids.

Two-Bed Ion Exchange – Separate beds or layers of cation and anion exchange resins, connected in series.

Tyndall Effect – The scattering of light by particles.

UF – Abbreviation for Ultrafiltration.

Ultrafiltration (UF) – Filtration through material with sufficiently fine pores to prevent the passage of molecules with molecular weights on the order of tens of thousands of daltons. Ultrafilter materials are usually rated by the molecular weight cut-off point at which they are effective (e.g., 10,000 daltons).

Ultrapure Water – Typically, advertising hyperbole for which there is no generally agreed upon definition.

Ultraviolet Sterilization – A process by which UV, typically 254 nm, is used to kill microorganisms, but not necessarily all microorganisms (sterilization is often incomplete).

USP – Abbreviation for U.S. Pharmacopoeia.

USPC – Abbreviation for U.S. Pharmacopoeia Conventions.

Ultraviolet (UV) Oxidation – 185 nm UV produces hydroxyl radicals that will oxidize organic material to smaller ionizable components.

UV – Abbreviation for Ultraviolet.

VAC – Abbreviation for Volts, Alternating Current.

Van der Waals' Force – Weak attractive forces between atoms and/or molecules, resulting from the sympathetic movements of electrons.

Vapor Pressure – The pressure (mm Hg) characteristic at any given temperature for a vapor in equilibrium with its liquid or solid form.

Viable Organism – Any organism that is capable of living and reproducing.

VC – Abbreviation for Vapor Compression (still).

Virus – A group of minute infectious agents, which are not visible in a light microscope (with certain exceptions such as poxviruses), characterized by a lack of independent metabolism and by a lack of ability to replicate except within living host cells. Their genetic material is either RNA or DNA, but not both, and the genetic material is coated with a protein sheath (capsid).

Viscosity – The property of a fluid or semifluid that results in a shearing stress (friction), which is a function of the gradient of the velocity of flow perpendicular to the flow.

VOC – Abbreviation for Volatile Organic Carbon.

Volatile Organic Carbon (VOC) – Organic carbon molecules that have significant vapor pressures, relative water (e.g., methylbenzene, toluene, 1,2-dibromoethane).

Water Breakthrough Pressure – The pressure at which water can be forced through a hydrophobic membrane. This value is related to the largest pore size of the membrane. Organic solutions or water solutions containing organics may wet the hydrophobic membrane.

Watt (W) – Unit of energy. $1 W = 1 A \times 1 V = J/s = 0.239 \text{ cal/s}$.

Zeolite – Any of various natural or synthetic hydrated aluminum silicates, which can serve as ion-exchange materials.

Zero Static Valve (ZSV) – These branch valves are designed to minimize any *dead space* on the input side of the valve by flowing distribution loop water by the sealing surface with as little dead space as possible.