



## Standard Terminology Used for Crossflow Microfiltration, Ultrafiltration, Nanofiltration and Reverse Osmosis Membrane Processes<sup>1</sup>

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### 1. Scope

1.1 This terminology covers the use of crossflow microfiltration, ultrafiltration, nanofiltration and reverse osmosis for membrane separation processes.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

D 1129 Terminology Relating to Water<sup>2</sup>

D 2035 Practice for Coagulation-Flocculation Jar Test of Water<sup>3</sup>

### 3. Significance and Use

3.1 The need to understand the relationships found in membrane unit processes for water treatment increases with the continuing demand for these separation systems. Defining the terms common to crossflow microfiltration, ultrafiltration, nanofiltration and reverse osmosis processes assist the manufacturer, consultant and end-user in eliminating inter-process terminology confusion.

### 4. Terminology

#### 4.1 Definitions:

**absorption**—the holding of a substance within a solid by cohesive or capillary forces.

**accumulator**—a pulsation dampener installed on the suction and/or discharge lines of pumps, generally plunger type, to minimize pressure surges and provide uniformity of flow.

**accuracy**—the closeness of agreement between an observed value and an accepted reference value. Where an accepted reference value is not available, a measure of the degree of conformity of a value generated by a specific procedure to

the assumed or accepted true value, and includes both precision and bias.

**acetylation**—substitution of an acetyl radical for an active hydrogen. Specifically, formation of cellulose acetate from cellulose.

**acidity**—the quantitative capacity of aqueous media to react with hydroxyl ions.

**activated carbon**—granulated or powdered activated carbon used to remove tastes, odor, chlorine, chloramines, and some organics from water. A family of carbonaceous substances manufactured by processes that develop adsorptive properties.

**adsorption**—the holding of a substance onto the surface of a solid by chemical surface forces, without forming new chemical bonds.

**aerobic bacteria**—bacteria that require oxygen for growth. See **bacteria, aerobes**.

**aggregate**—granular material such as sand, gravel, crushed stone.

**air scour**—distributing air over the entire filter area at the bottom of a filter media flowing upward to improve the effectiveness of backwashing or to permit the use of lower backwash water flow rate, or both.

**algae**—any of a group of chiefly aquatic mono cellular plants with chlorophyll often masked by a brown or red pigment.

**alkalinity**—the quantitative capacity of aqueous media to react with hydrogen ions. “M” alkalinity is that which will react with acid as the pH of the sample is reduced to the methylorange endpoint of about 4.5. “P” alkalinity is that which reacts with acid as the pH of the sample is reduced to the phenolphthalein end point of 8.3. “M” is the total alkalinity which is the sum of hydroxide plus carbonate plus bicarbonate contents, “P” includes all the hydroxyl and half the carbonate content.

**alum**—aluminum sulfate,  $Al_2(SO_4)_3 \cdot XH_2O$  ( $X = 14-18$ ), a coagulant.

**ambient temperature**—the temperature of the surroundings, typically 20°–25°C.

**amorphous**—non crystalline, devoid of regular cohesive structure.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 11.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 11.02.

**anaerobic bacteria**—bacteria that do not use oxygen. Oxygen is toxic to them. See **bacteria**, **anaerobes**.

**amphoteric**—capable of acting as an acid or a base.

**angstrom (Å)**—a unit of length equaling  $10^{-10}$  metres,  $10^{-4}$  µmetres,  $10^{-8}$  centimetres and  $3.937 \times 10^{-9}$  in. The symbol is Å, A or A.U. .

**anion**—negatively charged ion.

**anion exchange material**—a material capable of the reversible exchange of negatively charged ions.

**anisotropic membrane**—a nonuniform structure in cross-section; typically the support substructure has pores much larger than the barrier layer. See **asymmetric membranes**.

**anode**—positive electrode.

**anionic polyelectrolyte**—usually acrylamide and acrylic acid copolymers, negatively charged, used for coagulation/flocculation, see Polyelectrolytes.

**anthracite**—a granular hard coal used as a filtration media, commonly used as the coarser layer in dual and multimedia filters.

**antifoulant**—see **antiscalant**.

**antiscalant**—a compound added to a water which inhibits the precipitation of sparingly soluble inorganic salts.

**anti-telescoping device**—a plastic or metal device attached to the ends of a spiral wound cartridge to prevent movement of the cartridge leaves in the feed flow direction, due to high feed flows.

**AOOC**—assimilable organic carbon.

**aquifer**—a water-bearing geological formation that provides a ground water reservoir.

**aramid**—a fully aromatic polyamide.

**array**—an arrangement of devices connected to common feed, product and reject headers; that is, a 2:1 array.

**asymmetric membrane**—membrane which has a change in pore structure with depth. See **anisotropic membranes**.

**ATD**—see **anti-telescoping device**.

**atomic weight**—the relative mass of an atom based on a scale in which a specific carbon atom (carbon 12) is assigned a mass value of 12.

**ATP**—adenosine triphosphate.

**autopsy**—the dissection of a membrane module or element to investigate causes of unsatisfactory performance.

**availability**—the on-stream time or rated operating capacity of a water treatment system.

**a-value**—membrane water permeability coefficient. The coefficient is defined as the amount of water produced per unit area of membrane when net driving pressure (NDP) is unity, a unit of measurement is  $m^3/hr/m^2/kPa$ .

**AWWA**—American Water Works Association.

**AWWARF**—American Water Works Association Research Foundation.

**backwash**—reverse the flow of water with/without air either across or through a medium or membrane designed to remove the collected foreign material from the bed or membranes.

**bacteria**—any of a class of microscopic single-celled organisms reproducing by fission or by spores. Characterized by round, rod-like spiral or filamentous bodies, often aggregated into colonies or mobile by means of flagella. Widely

dispersed in soil, water, organic matter, and the bodies of plants and animals. Either autotrophic (self-sustaining, self-generative), saprophytic (derives nutrition from non-living organic material already present in the environment), or parasitic (deriving nutrition from another living organism). Often symbiotic (advantageous) in man, but sometimes pathogenic.

**bactericide**—agent capable of killing bacteria.

**bacteriostat**—substance that prevents bacterial growth and metabolism but does not necessarily kill them.

**bank**—a grouping of devices. See **array**, **block**, **train**.

**bar**—unit of pressure; 14.50 lbs/in.<sup>2</sup>, 1.020 kg/cm<sup>2</sup>, 0.987 atm, 0.1 MPa.

**BAT**—best available technology.

**baume scale, °Be**—a measure of the density of a solution relative to water.

$$^{\circ}BE = 145 - \frac{145}{\text{specific gravity}^*}$$

United States for densities greater than unity.

$$^{\circ}BE = \frac{140}{\text{specific gravity}^*} - 130$$

For densities less than unity.

\*60°F/60°F

**bed depth**—the depth of the filter medium or ion exchange resin in a vessel.

**bed expansion**—the depth increase of filter medium or ion exchange resin that occurs during backwashing.

**binders**—in reference to cartridge filters, chemicals used to hold, or 'bind', short fibers together in a filter.

**biocide**—a substance that kills all living organisms.

**biological deposits**—the debris left by organisms as a result of their life processes.

**biomass**—any material which is or was a living organism or excreted from a micro-organism.

**biostat**—a substance that inhibits biological growth.

**binding**—in surface filtration, a build-up of particulates on the filter, restricting fluid flow through the filter at normal pressures.

**block**—a grouping of devices in a single unit having common control. See **array**, **bank**, **train**.

**BOD (biochemical oxygen demand)**—the amount of dissolved oxygen utilized by natural agencies in water in stabilizing organic matter at specified test conditions.

**body feed**—the continuous addition of filter medium (for example, diatomaceous earth) to sustain the efficacy of the filter.

**BOO**—build, own, operate.

**BOOT**—build, own, operate and transfer.

**boundary layer**—a thin layer at the membrane surface where water velocities deviate significantly less than those in the bulk flow.

**brackish water**—water with an approximate concentration of total dissolved solids ranging from 1000 to 10 000 mg/L. See **high brackish water**, **sea water**.

**breakpoint chlorination**—the point at which the water chlorine demand is satisfied and any further chlorine is the chlorine residual, the "free" chlorine species.

**break tank**—a storage device used for hydraulic isolation and surge protection.

**brine**—the concentrate (reject) stream from a crossflow membrane device performing desalination. Portion of the feed stream which does not pass through the membrane.

**brine (concentrate) seal**—a rubber lip seal on the outside of a spiral wound cartridge which prevents feed by-pass between the cartridge and the inside pressure vessel wall.

**brine seal carrier**—see **ATD**.

**brine system staging**—a process in which the concentrate, under pressure, of a group of membrane devices is fed directly to another set of membrane devices to improve the efficiency of the water separation.

**bubble point pressure**—the pressure necessary to displace a liquid held by surface tension forces from the largest equivalent capillaries in a membrane filter.

**bubble point test**—a nondestructive membrane filter test used to assess filter integrity and proper installation.

**bundle**—a general term for a collection of parallel filaments or fibres.

**B-value—salt diffusion coefficient**—The coefficient is defined as the amount of salt transferred per unit area of membrane when the difference in salt concentration across the membrane is unity. A unit of measurement is m/h.

**BWRO**—brackish water reverse osmosis.

**CAC**—combined available chlorine.

**calcium carbonate equivalents (mg/L as CaCO<sub>3</sub>)**—a method for expressing mg/L as ion in terms of calcium carbonate. Concentration in calcium carbonate equivalents is calculated by multiplying concentration in mg/L of the ion by the equivalent weight of calcium carbonate (50) and dividing by the equivalent weight of the ion. (See Table 1).

**carbonate hardness**—the hardness in a water caused by carbonates and bicarbonates of calcium and magnesium. The amount of hardness equivalent to the alkalinity formed and deposited when water is boiled. In boilers, carbonate hardness is readily removed by blowdown.

**calcium hypochlorite**—Ca (HClO)<sub>2</sub>, a disinfection agent.

**cartridge**—see **spiral-wound cartridge**.

**catalyst**—a substance whose presence initiates or changes the rate of a chemical reaction, but does not itself enter into the reaction.

**cathode**—negative electrode.

**cation**—positively charged ion.

**cation exchange material**—a material capable of the reversible exchange of positively charged ions.

**cationic polyelectrolyte**—a polymer containing positively charged groups used for coagulation/flocculation, usually dimethyl - aminoethyl methacrylate or dimethyl-aminoethyl acrylate. See **polyelectrolyte**.

**cellulose**—an amorphous carbohydrate (C<sub>6</sub>H<sub>10</sub>O<sub>5</sub>) that is the principal constituent of wood and plants.

**cellulose acetate (CA)**—in the broad sense, any of several esters of cellulose and acetic acid.

**celsius (°C)**—the designation of the degree on the International Practical Temperature Scale. Formerly called centigrade, °C = K minus 273.15. K = Kelvin.

**centigrade**—since 1948, now called Celsius, a temperature scale.

**ceramic membrane**—generally a glass, silica, alumina, or carbon based membrane. Generally used in micro and ultrafiltration. They tend to withstand high temperatures and wide pH ranges and be more chemically inert than polymeric membranes.

**CFU**—colony forming unit; unit used in the measure of total bacteria count (TBC).

**channeling**—unequal flow distribution in the desalination bundle or filter bed.

**chelating agents**—a sequestering or complexing agent that, in aqueous solution, renders a metallic ion inactive through the formation of an inner ring structure with the ion.

**chemical feed pump**—a pump used to meter chemicals, such as chlorine or polyphosphate, into a feed water supply.

**chloramine**—a combination of chlorine and ammonia in water which has bactericidal qualities for a longer time than does free chlorine.

**chlorine**—chemical used for its qualities as a bleaching or oxidizing agent and disinfectant in water purification.

**chlorine demand**—the amount of chlorine used up by reacting with oxidizable substances in water before chlorine residual can be measured.

**chlorine, residual**—the amount of available chlorine present in water at any specified time.

**chlorine, free available**—the chlorine (Cl<sub>2</sub>), hypochlorite ions

**TABLE 1 Conversion Factors<sup>A,B</sup>**

mg/l as ion	mg/l as CaCO <sub>3</sub>	Clark or English Degree	Grain per US Gallon	French Degree	German Degree	EPM MEQ/L	Atomic Weight
Ca <sup>++</sup>	2.495	0.175	0.0583	0.250	0.140	0.0499	40.08
Mg <sup>++</sup>	4.112	0.288	0.0583	0.411	0.231	0.0823	24.32
Na <sup>+</sup>	2.175	0.152	0.0583	0.218	0.122	0.0435	22.99
K <sup>+</sup>	1.279	0.089	0.0583	0.128	0.072	0.0256	39.10
Sr <sup>++</sup>	1.141	0.080	0.0583	0.114	0.064	0.0288	87.63
Ba <sup>++</sup>	0.728	0.051	0.0583	0.073	0.041	0.0146	137.36
Fe <sup>++</sup>	1.791	0.125	0.0583	0.179	0.101	0.0358	55.85
HCO <sub>3</sub> <sup>-</sup>	0.819	0.057	0.0583	0.082	0.046	0.0164	61.02
SO <sub>4</sub> <sup>-</sup>	1.041	0.073	0.0583	0.104	0.058	0.0208	96.07
Cl <sup>-</sup>	1.410	0.098	0.0583	0.141	0.079	0.0282	35.46
F <sup>-</sup>	2.632	0.184	0.0583	0.263	0.148	0.0526	19.00
NO <sub>3</sub> <sup>-</sup>	0.806	0.056	0.0583	0.081	0.045	0.0161	62.00
CO <sub>3</sub> <sup>--</sup>	1.666	0.117	0.0583	0.167	0.094	0.0323	60.01
PO <sub>4</sub> <sup>---</sup>	1.579	0.110	0.0583	0.158	0.089	0.0316	94.98

<sup>A</sup>To convert from mg/l as ion to any other unit multiply by factor.

<sup>B</sup>To convert to mg/l as ion from any other unit divide by factor.