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GLOSSARY

Absorption: Assimilation of molecules or other substances into the physical structure of a liquid or solid without chemical reaction.

Acidity: Theoretically, in water, an excess of H^+ ions over OH^- ions that occurs at a pH below 7. In water analysis, an excess of H^+ ions that is measurable by titration where the pH is less than 4.2 to 4.4, where M alkalinity disappears (at the methyl orange endpoint).

Activated sludge: An aerobic biological process for conversion of soluble organic matter to solid biomass, removable by gravity or filtration.

Adsorption: Physical adhesion of molecules or colloids to the surfaces of solids without chemical reaction.

Aerobic organism: An organism that requires oxygen for its respiration.

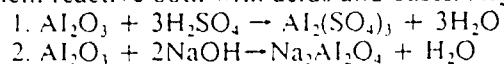
Aerosol: A colloidal system involving liquid or solid particulates dispersed in air.

Agglomerate: To gather fine particulates together into a larger mass.

Algae: Simple plants containing chlorophyll. Many are microscopic, but under conditions favorable for their growth they grow in colonies and produce mats and similar nuisance masses.

Alkalinity: By definition, total alkalinity (also called M alkalinity) is that which will react with acid as the pH of the sample is reduced to the methyl orange endpoint—about pH 4.2. Another significant expression is P alkalinity, which exists above pH 8.2 and is that which reacts with acid as the pH of the sample is reduced to 8.2.

Amphoteric: Capable of reacting in water either as a weak acid or as a weak base. For example, aluminum salts hydrolyze in water to produce a compound that may be considered a weak base, $Al(OH)_3$, or a weak acid, H_3AlO_3 . A property of certain oxides makes them reactive both with acids and bases. Al_2O_3 is an example:



- Anaerobic organism:** An organism that can thrive in the absence of oxygen.
- Anion:** A negatively charged ion resulting from dissociation of salts, acids, or alkalies in aqueous solution.
- Anionic:** The condition of a polymer, colloid, or large particle having exchangeable cations on its surface and an opposite, negative charge on the substrate.
- Anode:** In electrolysis or electrochemical corrosion, a site where metal goes into solution as a cation leaving behind an equivalent of electrons to be transferred to an opposite electrode, called a cathode.
- Anodizing:** The treatment of a metal surface whereby the metal is made anodic.
- API gravity:** An index of specific gravity defined by the American Petroleum Institute.
- API separator:** A simple gravity separator meeting the design standards of the American Petroleum Institute for separation of oil and solids from wastewater.
- Aquifer:** A porous, subsurface geological structure carrying or holding water, such as a well.
- Avogadro's number:** The number of molecules in a gram-molecular weight of any substance, 6.02×10^{23} .
- Bacteria:** Microscopic single-cell plants which reproduce by fission or by spores, identified by their shapes: coccus, spherical; bacillus, rod-shaped; and spirillum, curved.
- Base:** An alkaline substance.
- Biocide:** A chemical used to control the population of troublesome microbes.
- Biota:** All living organisms of a region or system.
- Black liquor:** Kraft cooking liquor recovered from brown stock washers in the pulp mill.
- Blast furnace:** A furnace producing iron from ore by reduction with coke.
- Blowdown:** The withdrawal of water from an evaporating water system to maintain a solids balance within specified limits of concentration of those solids.
- Blowpit:** The vessel receiving cooked wood pulp from the digester.
- BOD:** Biochemical oxygen demand of a water, being the oxygen required by bacteria for oxidation of the soluble organic matter under controlled test conditions.
- Broke:** Trim or excess sheet from paper manufacture returned to a pulping device for recovery.
- BS&W (bottom sediment and water):** A measure of oil quality based on the volume percent of sediment and water that can be centrifuged from a sample.
- Buffer:** A substance in solution which accepts hydrogen ions or hydroxyl ions added to the solution as acids or alkalies, minimizing a change in pH.
- Bulk density:** The measured density/volume ratio for a solid including or not corrected for the voids contained in the bulk of material, in lb/ft^3 or kg/m^3 .
- Bulking:** Production of a light, fluffy biomass, usually due to the presence of filamentous organisms.
- Cake:** A term applied to a dewatered residue from a filter, centrifuge, or other dewatering device.
- Carbonate hardness:** That hardness in a water caused by bicarbonates and carbonates of calcium and magnesium. If alkalinity exceeds total hardness, all hardness is carbonate hardness; if hardness exceeds alkalinity, the carbonate hardness equals the alkalinity.
- Carryover:** The presence of boiler water in steam caused by foaming or entrainment.

Catalysis: Addition of a material (catalyst) that does not take a direct part in a chemical reaction but increases the rate of the reaction.

Cathode: In electrolysis or electrochemical corrosion, a site on a surface where cations in solution are neutralized by electrons to become elements that either plate out on the surface or react with water to produce a secondary reaction.

Cation: A positively charged ion resulting from dissociation of molecules in solution.

Cationic: The condition of a polymer, colloid, or large particle having exchangeable anions on its surface and an opposite, positive charge on the substrate.

Caustic soda: A common water treatment chemical, sodium hydroxide (lye).

Centrate: The liquid remaining after removal of solids as a cake in a centrifuge.

Chelating agents: Organic compounds having the ability to withdraw ions from their water solutions into soluble complexes.

Coagulation: The neutralization of the charges on colloidal matter (sometimes also considered to be flocculation).

Coalescence: The gathering together of coagulated colloidal liquid particles into a single continuous phase.

COD: Chemical oxygen demand, a measure of organic matter and other reducing substances in water.

Coliform bacteria: Bacteria found in the intestinal tract of warm-blooded animals and used as indicators of pollution if found in water.

Colloids: Matter of very fine particle size, usually in the range of 10^{-5} to 10^{-7} cm in diameter.

Concentration: The process of increasing the dissolved solids per unit volume of solution, usually by evaporation of the liquid; also, the amount of material dissolved in a unit volume of solution.

Concentration cell: The connection of two solutions of the same composition but different concentrations by a metal conductor to produce current flow through the circuit.

Concentration ratio: In an evaporating water system, the ratio of the concentration of a specific substance in the makeup to its concentration in the evaporated water, usually measured in the blowdown.

Condensate: Water obtained by evaporation and subsequent condensation.

Conduction: The transfer of heat through a body by molecular motion.

Conductivity: The ability of a substance to conduct heat or electricity. Electrical conductivity is usually expressed in microsiemens per centimeter.

Connate water: Fossil water produced with oil.

Consistency: In the pulp/paper industry, a term for the density in percent by weight dry matter, of a slurry of pulp.

Contaminant: Any foreign component present in another substance; e.g., anything in water that is not H_2O is a contaminant.

Convection: The transfer of heat through a fluid by circulating currents.

Coordinated phosphate: A boiler treatment scheme using phosphate buffers to avoid the presence of hydroxyl alkalinity.

Cracking: An oil-refining process that breaks large molecules into smaller ones.

Critical pressure: The pressure at the critical temperature above which the fluid no longer has the properties of a liquid, regardless of further increase in pressure.

- Cupola:** A furnace for melting scrap or pig iron with coke.
- Cycles of concentration:** Concentration ratio.
- Dealkalization:** Any process for reducing the alkalinity of water.
- Decantation:** An elutriation process, where the supernatant liquor contains recoverable leaching chemical.
- Deinking:** The process of removing ink from secondary fibers.
- Deionization:** Any process removing ions from water, but most commonly an ion exchange process where cations and anions are removed independently of each other.
- Demineralization:** Any process used to remove minerals from water; however, commonly the term is restricted to ion exchange processes.
- Desalination:** The removal of inorganic dissolved solids from water.
- Desalting:** The removal of salt from crude oil.
- Detackify:** Treatment of solids from a paint spray booth to eliminate their sticky properties.
- Dewater:** To separate water from sludge to produce a cake that can be handled as a solid.
- Dialysis:** A separation process that depends on differences in diffusion rates of solutes across a permeable membrane.
- Diatoms:** Organisms related to algae, having a brown pigmentation and a siliceous skeleton.
- Disinfection:** Application of energy or chemical to kill pathogenic organisms.
- Dispersant:** A chemical which causes particulates in a water system to remain in suspension.
- Donnan effect:** The rejection of diffusion of external ions by a semipermeable membrane because of a high internal concentration of ions of the same charge.
- Drift:** Entrained water in the stack discharge of a cooling tower.
- Economizer:** A heat exchanger in a furnace stack that transfers heat from the stack gas to the boiler feedwater.
- EDTA:** Ethylenediaminetetraacetic acid. The sodium salt is the usual form of this chelating material.
- Electrolyte:** A substance that dissociates into two or more ions when it dissolves in water.
- Elution:** The process of extracting one solid from another. Often used incorrectly to describe the regeneration of an ion exchanger.
- Elutriation:** The washing of a sludge with water to free it of its mother liquor.
- Emulsion:** A colloidal dispersion of one liquid in another.
- Endothermic:** Absorbing heat.
- Enthalpy:** The total heat content of a body.
- Entrainment:** The transport of water into a gas stream. In a boiler, this is carryover; in a cooling tower, drift.
- Entropy:** A mathematical expression applying to the limits to the availability of energy; a measure of the random motion of matter.
- Enzyme:** As applied to water, a chemical produced by living cells having the ability to reduce large organic molecules to units small enough to diffuse through the cell membrane.
- EPA:** Environmental Protection Agency.

Equalization: Minimization of variations in flow and composition by means of a storage reservoir.

Equivalent weight: The weight in grams of a substance which combines with or displaces one gram of hydrogen; it is usually obtained by dividing the formula weight by the valence.

Eutrophication: Enrichment of water, causing excessive growth of aquatic plants and an eventual choking and deoxygenation of the water body.

Exothermic: Evolving heat.

Facultative organisms: Microbes capable of adapting to either aerobic or anaerobic environments.

FDA: Food and Drug Administration.

Fermentation: The conversion of organic matter to CO_2 , CH_4 , and similar low-molecular weight compounds by anaerobic bacteria.

Filler: Clay, calcium carbonate, or other minerals added to cellulose fiber in the production of certain grades of paper or board.

Filtrate: The liquid remaining after removal of solids as a cake in a filter.

Filtration: The process of separating solids from a liquid by means of a porous substance through which only the liquid passes.

Fission: In biology, the process of reproduction by cell splitting.

Flash: The portion of a superheated fluid converted to vapor when its pressure is reduced.

Flocculation: The process of agglomerating coagulated particles into settleable flocs, usually of a gelatinous nature.

Flotation: A process for separating solids from water by developing a froth in a vessel in such fashion that the solids attach to air particles and float to the surface for collection.

Flume: A raceway or channel constructed to carry water or to permit flow measurements.

F/M ratio: Food-to-mass or food-to-microorganism ratio used to predict the phase of growth being experienced by the major microbial populations in a biological digestion process.

Fourdrinier: A design of paper machine using a continuous wire for forming the sheet.

Freundlich isotherm: The plot of test data related to the removal of colloidal matter from water showing the process to be adsorption.

Fumes: An aerosol with solids as the dispersed colloids.

Fungi: As applied to water, simple, one-celled organisms without chlorophyll, often filamentous. Molds and yeasts are included in this category.

Galvanic couple: The connection of two dissimilar metals in an electrolyte that results in current flow through the circuit.

Gangue: The earthy material remaining from ore beneficiation.

Grains per gallon: A unit of concentration. $1 \text{ gr/gal} = 17.1 \text{ mg/L}$.

Green liquor: The liquor resulting from dissolving molten smelt from the kraft recovery furnace in water.

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 iron and manganese. "Permanent hardness" is the excess of hardness over alkalinity. "Temporary hardness" is hardness equal to or less than the alkalinity. These are also referred to as "noncarbonate" or "carbonate" hardness, respectively.

Heat rate: An expression of heat-conversion to power, given in Btu/kWh. Theoretical conversion is 3413 Btu/kWh.

Henry's law: An expression for calculating the solubility of a gas in a fluid based on temperature and partial pressure.

Hindered settling: A stage of settling where the accumulated settled solids have compacted to an extent that egress of water from the mass is hindered and, therefore, settling is slowed.

Humidification: The addition of water vapor to air.

Hydrophilic: Having an affinity for water. Its opposite, non-water-wettable, is hydrophobic.

Infiltration: Inleakage of groundwater into sewage piping.

Inhibitor: A chemical that interferes with a chemical reaction, such as corrosion or precipitation.

Ion: An atom or radical in solution carrying an integral electric charge, either positive (cation) or negative (anion).

Ion exchange: A process by which certain undesired ions of given charge are absorbed from solution within an ion-permeable absorbent, being replaced in the solution by desirable ions of similar charge from the absorbent.

Ionic strength: A measure of the strength of a solution based on both the concentrations and valences of the ions present.

Kraft: An alkaline chemical pulping process, using salt cake as makeup.

Langelier index: A means of expressing the degree of saturation of a water as related to calcium carbonate solubility.

Leakage: The presence in the effluent of a species of ions in the feed to an ion exchanger.

Lignin: The major noncellulose constituent of wood.

Lime: A common water treatment chemical. Limestone, CaCO_3 , is burned to produce quicklime, CaO , which is mixed with water to produce slaked, or hydrated, lime, Ca(OH)_2 .

Lipophilic: Having an affinity for oil. The opposite of hydrophilic (i.e., hydrophobic).

Membrane: A barrier, usually thin, that permits the passage only of particles up to a certain size or of special nature.

Metabolize: To convert food, such as soluble organic matter, to cellular matter and gaseous by-products by a biological process.

Microorganism: Organisms (microbes) observable only through a microscope; larger, visible types are called *macroorganisms*.

Mineral: Any inorganic or fossilized organic material having a definite chemical composition and structure found in a natural state.

Miscibility: The ability of two liquids, not mutually soluble, to mix.

Mist: An aerosol with liquids as the dispersed colloids.

Mole: A unit weight or volume of a chemical corresponding to its molecular weight. A mole of water weighs 18 g, and its vapor occupies 22.4 L at standard temperature and pressure.

Monomer: A molecule, usually an organic compound, having the ability to join with a number of identical molecules to form a polymer.

Neutralization: Most commonly, a chemical reaction that produces a resulting environment that is neither acidic nor alkaline. Also, the addition of a scavenger chemical to an aqueous system in excess concentration to eliminate a corrosive factor, such as dissolved oxygen.

Noncarbonate hardness: Hardness in water caused by chlorides, sulfates, and nitrates of calcium and magnesium.

Noncondensibles: Gaseous material not liquefied when associated water vapor is condensed in the same environment.

NPDES permit: The National Pollution Discharge Elimination System permit required by and issued by EPA.

NSSC: The neutral sulfite, semichemical pulping process.

NTA: Nitrilotriacetic acid, a chelant with the sodium salt being the usual form.

Occlusion: An absorption process by which one solid material adheres strongly to another, sometimes occurring by coprecipitation.

Opacity: The percentage of light transmission through a plume.

Ore: A mineral containing useful substances which can be extracted.

Orifice: An opening through which a fluid can pass; a restriction placed in a pipe to provide a means of measuring flow.

ORP: Oxidation Reduction Potential. See "Redox potential."

Osmosis: The passage of water through a permeable membrane separating two solutions of different concentrations; the water passes into the more concentrated solution.

Oxidation: A chemical reaction in which an element or ion is increased in positive valence, losing electrons to an oxidizing agent.

Packing: The fill in a confined space in a stripping vessel, ranging from simply shaped units such as rocks or slats to complex shapes that provide large surface area per unit volume.

Pasteurization: A process for killing pathogenic organisms by heat applied for a critical period of time.

Pathogens: Disease-producing microbes.

Periodic chart: An arrangement of the elements in order of increasing atomic number that illustrates the repetition (or periodicity) of key characteristics.

Permeability: The ability of a body to pass a fluid under pressure.

pH: A means of expressing hydrogen ion concentration in terms of the powers of 10; the negative logarithm of the hydrogen ion concentration.

Photosynthesis: The process of converting carbon dioxide and water to carbohydrates, activated by sunlight in the presence of chlorophyll, liberating oxygen.

Pickle liquor: Acid used in treating steel for removal of oxide scale.

Plankton: Small organisms with limited powers of locomotion, carried by water currents from place to place.

Polarize: In corrosion, to develop a barrier on the anodic or cathodic surface, disrupting the corrosion process.

Pollutant: A contaminant at a concentration high enough to endanger the aquatic environment or the public health.

Polyelectrolyte: A polymeric material having ion exchange sites on its skeleton.

Polymer: A chain of organic molecules produced by the joining of primary units called *monomers*.

Polyphosphate: Molecularly dehydrated orthophosphate.

Precipitate: An insoluble reaction product; in an aqueous chemical reaction, usually a crystalline compound that grows in size to become settleable.

Protozoa: Large, microscopic single-cell organisms higher on the food chain than bacteria, which consume bacteria.

Pulp: Fibrous matter.

Radiation: In a furnace, the transfer of heat by energy waves, much like other forms of electromagnetic waves (e.g., light and radio waves).

Rag: Debris that accumulates at an oil-water interface.

Rankine cycle: The successive changes in heat content and temperature as water is converted to steam, expands through a prime mover, condenses, and returns to the boiler.

Recovery furnace: A furnace which burns black liquor from the kraft pulping process, to recover the cooking chemicals as smelt.

Red mud: The gangue from bauxite processing.

Redox potential: Reduction-oxidation potential measured against a standard electrode.

Reduction: A chemical reaction in which an element or compound gains electrons, being reduced in positive valence.

Regenerative heating: In utility stations, a scheme for reducing heat losses to the main condenser in the cycle by using steam extracted from the turbine to heat feedwater. In engineering designs, the use of a heat exchanger to preheat the feed to a process by extracting heat from the product.

Reheater: A heat exchanger located in a furnace to increase the temperature of steam extracted from a turbine for reinjection.

Resolution: The breaking of an emulsion into its individual components.

Reverse osmosis: A process that reverses (by the application of pressure) the flow of water in the natural process of osmosis so that it passes from the more concentrated to the more dilute solution.

Reversion: The return of molecularly dehydrated phosphate (polyphosphate) to its hydrated origin (orthophosphate).

Ringlemann test: A method of comparing the opacity of a stack plume to an arbitrary set of standard disks of increasing degrees of discoloration.

Salinity: The presence of soluble minerals in water.

Salt-splitting: The ability of an anion exchanger to convert a salt solution to caustic; the ability of a cation exchanger to convert a salt solution to acid.

Saturation index: The relation of calcium carbonate to the pH, alkalinity, and hardness of a water to determine its scale-forming tendency.

Saveall: A general term for several designs of devices used to recover fiber from white water and clarify the water for reuse.

Scale: The precipitate that forms on surfaces in contact with water as the result of a physical or chemical change.

Scale pit: A collection chamber alongside a rolling mill that receives roll cooling water containing metallic scale.

Scouring: The removal of surface debris from raw textile fibers.

Secondary fibers: In the paper industry, fibers reclaimed from waste paper.

Sedimentation: Gravitational settling of solid particles in a liquid system.

Seed: A particle or particles, usually crystalline, added to a supersaturated solution to induce precipitation.

Selectivity: The order of preference of an ion exchange material for each of the ions in the surrounding aqueous environment.

- Sensible heat:** Heat measurable by temperature alone.
- Sequester:** To form a stable, water-soluble complex.
- Sewage:** Waste fluid in a sewer.
- Silt density index:** A measure of the tendency of a water to foul a reverse osmosis membrane, based on timed flow through a membrane filter at constant pressure.
- Sinter:** A clinker-like material produced in a special furnace from a mixture of coal and recovered iron-bearing materials, such as scale pit solids, used as charge for a blast furnace.
- Sizing:** A surface finish, such as starch, applied to paper and textile fibers.
- Slag:** In metallurgical processing, the impurities separated from molten metal during refining; in boiler furnaces, the noncombustible ash which has reached fusion temperatures.
- Slop oil:** A general term in oil refining applying to tramp oil discharge to the oily sewer during shutdown and startup or through abnormal operation.
- Sludge volume index:** An inverse measure of sludge density.
- Slurry:** A water containing a high concentration of suspended solids, usually over 5000 mg/L.
- Smelt:** Molten slag; in the pulp industry, the cooking chemicals tapped from the recovery boiler as molten material and dissolved in the smelt tank as green liquor.
- Soda ash:** A common water-treatment chemical, sodium carbonate.
- Sodium absorption ration (SAR):** In irrigation water, a relationship between sodium and hardness used to predict acceptability for both the plant and soil being irrigated.
- Softening:** The removal of hardness (calcium and magnesium) from water.
- Sour water:** Waste waters containing malodorous materials, usually sulfur compounds.
- Spore:** A reproductive cell, or seed, of algae, fungi, or protozoa.
- Stability index:** An empirical modification of the saturation index used to predict scaling or corrosive tendencies in water systems.
- Stickwater:** The distillate produced in the cooking of meat or in the rendering of fat and scraps.
- Stiff-Davis index:** An index used to predict the stability of brackish waters, such as those used in waterflooding.
- Stoichiometric:** The ratio of chemical substances reacting in water that corresponds to their combining weights in the theoretical chemical reaction.
- Stokes' law:** An expression for calculating the rate of fall of particles through a fluid based on densities, viscosity, and particle size.
- Superheater:** A heat exchanger located in a furnace to increase the temperature of steam leaving the boiler drum.
- Supernate:** The liquid overlying the sludge layer in a sedimentation vessel.
- Surfactant:** A surface active agent: usually an organic compound whose molecules contain a hydrophilic group at one end and a lipophilic group at the other.
- Synergism:** The combined action of several chemicals which produces an effect greater than the additive effects of each.
- Synfuels:** Liquid or gaseous fuels produced from coal, lignite, or other solid carbon sources.
- Tailings:** The residue from separation of useful values from an ore.
- Thermocline:** The layer in a lake dividing the upper, current-mixed zone, from the cool lower stagnant zone.

Threshold treatment: The control of scale or deposits by application of sub-stoichiometric dosage of treatment chemical.

Transpiration: Respiration of plants.

Tuberculation: A corrosion process that produces hard mounds of corrosion products on the metal surface, increasing friction and reducing flow in a water distribution system.

Turbidity: A suspension of fine particles that obscures light rays but requires many days for sedimentation because of the small particle size.

Turnover: The mixing of lower and upper layers in a lake in spring and fall caused by temperature and density equalization.

USDA: United States Department of Agriculture.

USGS: United States Geological Survey, Department of the Interior.

Venturi: A device for measuring fluid flow, including a short converging cone succeeded on the same axis by a long diverging cone. This device is also used in gas scrubbing.

Waterflooding: A process of displacing oil from underground formations with water and returning it to the surface for recovery.

Weir: A spillover device used to measure or control water flow.

White liquor: Cooking liquor from the kraft pulping process produced by recausticizing green liquor with lime.

White water: The filtrate from a paper- or board-forming machine, usually recycled for density control.

Yield: The rate of production of cake from a dewatering device.

Zeta potential: The difference in voltage between the surface of the diffuse layer surrounding a colloidal particle and the bulk liquid beyond.

POTENTIALLY USEFUL WEBSITES

http://www.awwa.org	American Water Works Association
http://www.cleant2o.com	Wastewater Treatment Virtual Library
http://www.eic.or.jp/eanet/	Japan Environment Agency
http://www.enviro-engrs.org	American Academy of Environmental Engineers
http://www.epa.gov	U.S. Environment Protection Agency
http://www.iawq.org.uk	International Water Association
http://www.nalco.com	Nalco Chemical Company
http://www.pollutionsolutions.com	Environmental Solutions Inc.
http://www.wef.org	Water Environment Federation
http://www.webdirectory.com	Environmental Organization Web Directory
http://www.wsscc.org/interwater	interWATER Gateway to Water and Sanitation Information
http://www.wwinternational.com	Water and Wastewater International

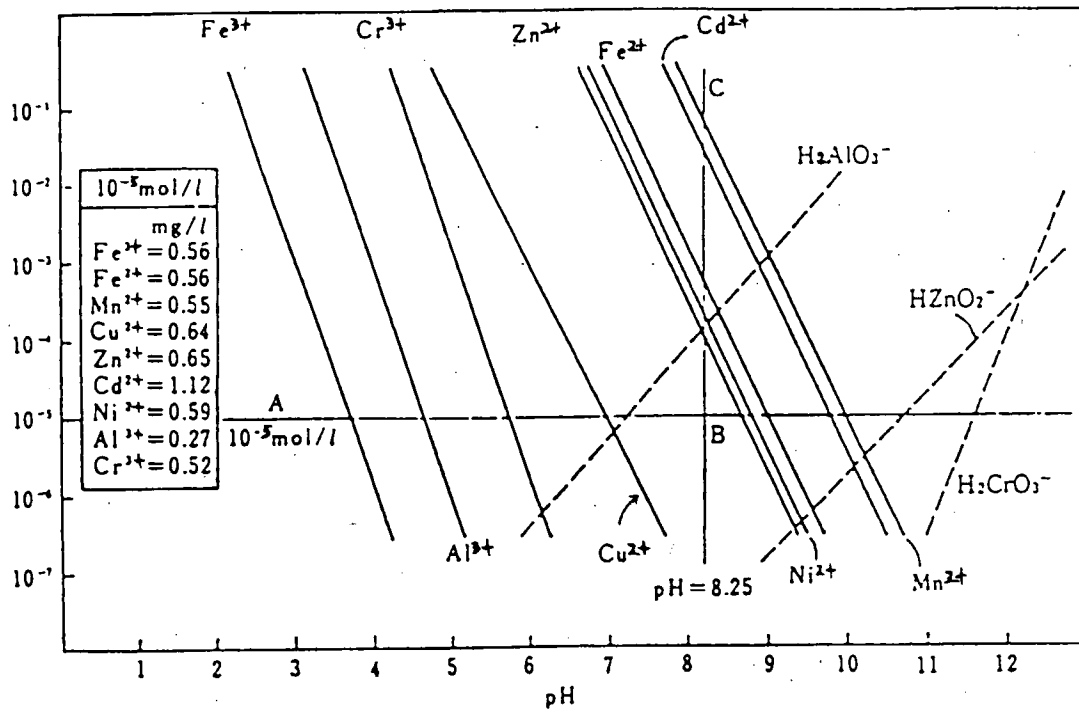
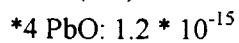
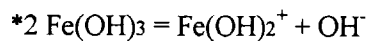
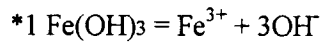


Figure Relationship between metals solubility and pH

Table Solubility Product of Metal Hydroxide

Hydroxide	Ksp	Hydroxide	Ksp
Al(OH) ₃	1.1 * 10 ⁻³³	Fe(OH) ₃	7.1 * 10 ⁻⁴⁰ *1
Ca(OH) ₂	5.5 * 10 ⁻⁶		4.8 * 10 ⁻²⁸ *2
Cd(OH) ₂	3.9 * 10 ⁻¹⁴	Mg(OH) ₂	1.8 * 10 ⁻¹¹
Co(OH) ₂	2.0 * 10 ⁻¹⁶	MN(OH) ₂	1.9 * 10 ⁻¹³
Cr(OH) ₃	6.0 * 10 ⁻³¹	Ni(OH) ₂	6.5 * 10 ⁻¹⁸ *3
Cu(OH) ₂	6.0 * 10 ⁻²⁰	Pb(OH) ₂	1.6 * 10 ⁻⁷ *4
Fe(OH) ₂	8.0 * 10 ⁻¹⁶	Sn(OH) ₂	8.0 * 10 ⁻²⁹
		Zn(OH) ₂	1.2 * 10 ⁻¹⁷



Source: Kougaiboushi-no-Gijutsu-to-Houki

TABLE SUMMARY OF CARBON ADSORPTION CAPACITIES

Compound	Adsorption(a) Capacity, mg/g	Compound	Adsorption(a) Capacity, mg/g
bis(2-Ethylhexyl) phthalate	11,300	Phenanthrene	215
Butylbenzyl phthalate	1,520	Dimethylphenylcarbinol*	210
Heptachlor	1,220	4-Aminobiphenyl	200
Heptachlor epoxide	1,038	beta-Naphthol*	200
Endosulfan sulfate	686	alpha-Endosulfan	194
Endrin	666	Acenaphthene	190
Fluoranthene	664	4,4' Methylene-bis- (2-chloroaniline)	190
Aldrin	651	Benzo(k)fluoranthene	181
PCB-1232	630	Acridine orange*	180
beta-Endosulfan	615	alpha-Naphthol	180
Dieldrin	606	4,6-Dinitro-o-cresol	169
Hexachlorobenzene	450	alpha-Naphthylamine	160
Anthracene	376	2,4-Dichlorophenol	157
4-Nitrobiphenyl	370	1,2,4-Trichlorobenzene	157
Fluorene	330	2,4,6-Trichlorophenol	155
DDT	322	beta-Naphthylamine	150
2-Acetylaminofluorene	318	Pentachlorophenol	150
alpha-BHC	303	2,4-Dinitrotoluene	146
Anethole*	300	2,6-Dinitrotoluene	145
3,3-Dichlorobenzidine	300	4-Bromophenyl phenyl ether	144
2-Chloronaphthalene	280	p-Nitroaniline*	140
Phenylmercuric Acetate	270	1,1-Diphenylhydrazine	135
Hexachlorobutadiene	258	Naphthalene	132
gamma-BHC (lindane)	256	1-Chloro-2-nitrobenzene	130
p-Nonylphenol	250	1,2-Dichlorobenzene	129
4-Dimethylaminoazobenzene	249	p-Chlorometacresol	124
Chlordane	245	1,4-Dichlorobenzene	121
PCB-1221	242	Benzothiazole*	120
DDE	232	Diphenylamine	120
Acridine yellow*	230	Guanine*	120
Benzidine dihydrochloride	220	Styrene	120
beta-BHC	220	1,3-Dichlorobenzene	118
N-Butylphthalate	220	Acenaphthylene	115
N-Nitrosodiphenylamine	220	4-Chlorophenyl phenyl ether	111
		Diethyl phthalate	110

TABLE SUMMARY OF CARBON ADSORPTION CAPACITIES (cont.)

<u>Compound</u>	<u>Adsorption(a) Capacity, mg/g</u>	<u>Compound</u>	<u>Adsorption(a) Capacity, mg/g</u>
2-Nitrophenol	99	Bromoform	20
Dimethyl phthalate	97	Carbon tetrachloride	11
Hexachloroethane	97	bis(2-Chloroethoxy) methane	11
Chlorobenzene	91	Uracil*	11
p-Xylene	85	Benzo(ghi)perylene	11
2,4-Dimethylphenol	78	1,1,2,2-Tetrachloroethane	11
4-Nitrophenol	76	1,2-Dichloropropene	8.2
Acetophenone	74	Dichlorobromomethane	7.9
1,2,3,4-Tetrahydro- naphthalene	74	Cyclohexanone*	6.2
Adenine*	71	1,2-Dichloropropane	5.9
Dibenzo(a,h)anthracene	69	1,1,2-Trichloroethane	5.8
Nitrobenzene	68	Trichlorofluoromethane	5.6
3,4-Benzofluoranthene	57	5-Fluorouracil*	5.5
1,2-Dibromo-3-chloro- propane	53	1,1-Dichloroethylene	4.9
Ethylbenzene	53	Dibromochloromethane	4.8
2-Chlorophenol	51	2-Chloroethyl vinyl ether	3.9
Tetrachloroethene	51	1,2-Dichloroethane	3.6
o-Anisidine*	50	1,2-trans-Dichloroethene	3.1
5 Bromouracil	44	Chloroform	2.6
Benzo(a)pyrene	34	1,1,1-Trichloroethane	2.5
2,4-Dinitrophenol	33	1,1-Dichloroethane	1.8
Isophorone	32	Acrylonitrile	1.4
Trichloroethene	28	Methylene chloride	1.3
Thymine*	27	Acrolein	1.2
Toluene	26	Cytosine*	1.1
5-Chlorouracil*	25	Benzene	1.0
N-Nitrosodi-n-propylamine bis(2-Chloroisopropyl) ether	24	Ethylenediaminetetra- acetic acid	0.86
Phenol	21	Benzoic acid	0.76
		Chloroethane	0.59
		N-Dimethylnitros- amine	6.8 x 10 ⁻⁵

TABLE SUMMARY OF CARBON ADSORPTION CAPACITIES (cont.)

<u>NOT ADSORBED</u>	
Acetone cyanohydrin	Adipic acid
Butylamine	Choline chloride
Cyclohexylamine	Diethylene glycol
Ethanol	Hexamethylenediamine
Hydroquinone	Morpholine
Triethanolamine	

*Compounds prepared in "mineralized" distilled water containing the following composition:

<u>Ion</u>	<u>Conc., mg/l</u>	<u>Ion</u>	<u>Conc., mg/l</u>
Na ⁺	92	PO ₄ ⁼	10
K ⁺	12.6	SO ₄ ⁼	100
Ca ⁺⁺	100	Cl ⁻	177
Mg ⁺⁺	25.3	Alkalinity	200

(a) Adsorption capacities are calculated for an equilibrium concentration of 1.0 mg/l at neutral pH.

R.A. Dobbs and J.M. Cohen
 EPA-600/8-80-023
 CARBON ADSORPTION ISOTHERMS FOR TOXIC ORGANICS
 1980

Chemicals for Wastewater Treatment

Hydrochloric Acid (20°C)

Bé	Specific Gravity	HCl (%)	HCl (g/l)	Bé	Specific Gravity	HCl (%)	HCl (g/l)
0.5	1.0032	1	10.03	14.2	1.1083	22	243.8
1.2	1.0082	2	20.16	15.4	1.1187	24	268.5
2.6	1.0181	4	40.72	16.6	1.1290	26	293.5
3.9	1.0279	6	61.67	17.7	1.1392	28	319.0
5.3	1.0376	8	83.01	18.8	1.1493	30	344.8
6.6	1.0474	10	104.7	19.9	1.1593	32	371.0
7.9	1.0574	12	126.9	21.0	1.1691	34	397.5
9.2	1.0675	14	149.5	22.0	1.1789	36	424.4
10.4	1.0776	16	172.4	23.0	1.1885	38	451.6
11.7	1.0878	18	195.8	24.0	1.1980	40	479.2
12.9	1.0980	20	219.6				

Sulfuric Acid (20°C)

Bé	Specific Gravity	H ₂ SO ₄ (%)	H ₂ SO ₄ (g/l)	Bé	Specific Gravity	H ₂ SO ₄ (%)	H ₂ SO ₄ (g/l)
0.7	1.0051	1	10.05	41.8	1.4049	51	716.5
1.7	1.0118	2	20.24	42.5	1.4148	52	735.7
2.6	1.0181	3	30.55	43.2	1.4248	53	755.1
3.5	1.0250	4	41.00	44.0	1.4350	54	774.9
4.5	1.0317	5	51.59	44.7	1.4453	55	794.9
5.4	1.0385	6	62.31	45.4	1.4557	56	815.2
6.3	1.0453	7	73.17	46.1	1.4662	57	835.7
7.2	1.0522	8	84.18	46.8	1.4768	58	856.5
8.1	1.0591	9	95.32	47.5	1.4875	59	877.6
9.0	1.0661	10	106.6	48.2	1.4983	60	899.9
9.9	1.0731	11	118.0	48.9	1.5091	61	920.6
10.8	1.0802	12	129.6	49.6	1.5200	62	942.4
11.7	1.0874	13	141.4	50.3	1.5310	63	964.5
12.5	1.0947	14	153.3	51.0	1.5421	64	986.9
13.4	1.1020	15	165.3	51.7	1.5533	65	1010
14.3	1.1094	16	177.5	52.3	1.5646	66	1033
15.2	1.1168	17	189.9	53.0	1.5760	67	1056
16.0	1.1243	18	202.4	53.7	1.5874	68	1079
16.9	1.1318	19	215.0	54.3	1.5989	69	1103
17.7	1.1394	20	227.9	55.0	1.6105	70	1127
18.6	1.1471	21	240.9	55.6	1.6221	71	1152
19.4	1.1548	22	254.4	56.3	1.6338	72	1176
20.3	1.1626	23	267.4	56.9	1.6456	73	1201
21.1	1.1704	24	280.9	57.5	1.6574	74	1226
21.9	1.1783	25	294.6	58.1	1.6692	75	1252
22.8	1.1862	26	308.4	58.7	1.6810	76	1278
23.6	1.1942	27	322.4	59.3	1.6927	77	1303
24.4	1.2023	28	336.6	59.9	1.7043	78	1329
25.2	1.2102	29	351.0	60.5	1.7158	79	1355
26.0	1.2185	30	365.6	61.1	1.7272	80	1382
26.8	1.2267	31	380.3	61.6	1.7383	81	1408
27.6	1.2349	32	395.2	62.1	1.7491	82	1434
28.4	1.2432	33	410.3	62.6	1.7594	83	1460
29.1	1.2515	34	425.5	63.0	1.7693	84	1486
29.9	1.2599	35	441.0	63.5	1.7786	85	1512
30.7	1.2684	36	456.6	63.9	1.7872	86	1537
31.4	1.2769	37	472.5	64.2	1.7951	87	1562
32.2	1.2855	38	488.5	64.5	1.8022	88	1586
33.0	1.2941	39	504.7	64.8	1.8087	89	1610
33.7	1.3028	40	521.1	65.1	1.8144	90	1633
34.5	1.3116	41	537.8	65.3	1.8195	91	1656
35.2	1.3205	42	554.6	65.5	1.8340	92	1678
35.9	1.3294	43	571.6	65.7	1.8279	93	1700
36.7	1.3384	44	588.9	65.8	1.8312	94	1721
37.4	1.3476	45	606.4	65.9	1.8337	95	1742
38.1	1.3569	46	624.2	66.0	1.8355	96	1762
38.9	1.3663	47	642.2	66.0	1.8364	97	1781
39.6	1.3758	48	660.4	66.0	1.8361	98	1799
40.3	1.3854	49	678.8	65.9	1.8342	99	1816
41.1	1.3951	50	697.6	65.8	1.8305	100	1831

Nitric Acid (20°C)

Bé	Specific Gravity	HNO ₃ (%)	HNO ₃ (g/l)	Bé	Specific Gravity	HNO ₃ (%)	HNO ₃ (g/l)
0.5	1.0036	1	10.01	34.8	1.3160	51	671.2
1.3	1.0091	2	20.18	35.3	1.3219	52	687.4
2.1	1.0146	3	30.44	35.8	1.3278	53	703.7
2.9	1.0201	4	40.80	36.3	1.3336	54	720.1
3.6	1.0256	5	51.28	36.7	1.3393	55	736.6
4.4	1.0312	6	61.87	37.2	1.3449	56	753.1
5.2	1.0369	7	72.58	37.6	1.3505	57	769.8
5.9	1.0427	8	83.42	38.1	1.3560	58	786.5
6.7	1.0485	9	94.37	38.5	1.3614	59	803.2
7.5	1.0543	10	105.4	38.9	1.3667	60	820.0
8.2	1.0602	11	116.6	39.3	1.3719	61	836.9
9.0	1.0661	12	127.9	39.7	1.3769	62	853.7
9.8	1.0721	13	139.4	40.1	1.3818	63	870.5
10.5	1.0781	14	150.9	40.4	1.3866	64	887.4
11.3	1.0842	15	162.6	40.8	1.3913	65	904.3
12.0	1.0903	16	174.4	41.1	1.3959	66	921.3
12.8	1.0964	17	186.4	41.5	1.4001	67	938.3
13.5	1.1026	18	198.5	41.8	1.4018	68	955.3
14.2	1.1088	19	210.7	42.1	1.4091	69	972.3
15.0	1.1150	20	223.0	42.4	1.4134	70	989.4
15.7	1.1213	21	235.5	42.7	1.4176	71	1006
16.4	1.1276	22	248.1	43.0	1.4218	72	1024
17.1	1.1340	23	260.8	43.3	1.4258	73	1041
17.9	1.1404	24	273.7	43.6	1.4298	74	1058
18.6	1.1469	25	286.7	43.9	1.4337	75	1075
19.4	1.1531	26	299.9	44.1	1.4375	76	1093
20.0	1.1600	27	313.2	44.4	1.4413	77	1110
20.7	1.1666	28	326.6	44.7	1.4450	78	1127
21.4	1.1733	29	340.3	44.9	1.4486	79	1144
22.1	1.1800	30	354.0	45.1	1.4521	80	1162
22.8	1.1867	31	367.9	45.4	1.4555	81	1179
23.5	1.1931	32	381.9	45.6	1.4589	82	1196
24.2	1.2002	33	396.1	45.8	1.4622	83	1214
24.9	1.2071	34	410.4	46.1	1.4655	84	1231
25.6	1.2140	35	424.9	46.3	1.4686	85	1248
26.2	1.2205	36	439.4	46.5	1.4716	86	1266
26.8	1.2270	37	454.0	46.7	1.4745	87	1283
27.5	1.2335	38	468.7	46.8	1.4773	88	1300
28.1	1.2399	39	483.6	47.0	1.4800	89	1317
28.7	1.2463	40	498.5	47.2	1.4826	90	1334
29.3	1.2527	41	513.6	47.4	1.4850	91	1351
29.8	1.2591	42	528.8	47.5	1.4873	92	1368
30.4	1.2655	43	544.2	47.6	1.4892	93	1395
31.0	1.2719	44	559.6	47.8	1.4912	94	1402
31.6	1.2783	45	575.2	47.9	1.4932	95	1419
32.1	1.2847	46	591.0	48.0	1.4952	96	1435
32.7	1.2911	47	606.8	48.2	1.4974	97	1452
33.2	1.2975	48	622.8	48.4	1.5008	98	1471
33.8	1.3040	49	639.0	48.7	1.5056	99	1491
34.3	1.3100	50	655.0	49.2	1.5129	100	1513

Phosphoric Acid (20°C)

Bé	Specific Gravity	H ₂ PO ₄ (%)	H ₃ PO ₄ (g/l)	P ₂ O ₅ (%)	P ₂ O ₅ (g/l)
0.6	1.0038	1	10.04	0.72	7.271
1.3	1.0092	2	20.18	1.4	14.62
2.8	1.0200	4	40.80	2.9	29.56
4.3	1.0309	6	61.85	4.3	44.81
5.8	1.0420	8	83.36	5.8	60.39
7.3	1.0532	10	105.3	7.2	76.29
8.8	1.0647	12	127.8	8.7	92.55
10.3	1.0764	14	150.7	10.1	109.2
11.8	1.0884	16	174.1	11.6	126.1
13.3	1.1008	18	198.1	13.0	143.5
14.8	1.1131	20	222.7	14.5	161.3
16.3	1.1263	22	247.8	15.9	179.5
17.8	1.1395	24	273.5	17.4	198.1
19.2	1.1529	26	299.8	18.8	217.1
20.7	1.1665	28	326.6	20.3	236.6
22.2	1.1805	30	351.2	21.7	256.5
25.8	1.216	35	425.6	25.4	308.3
29.4	1.254	40	501.6	29.0	363.4
32.9	1.293	45	581.9	32.6	421.5
36.4	1.335	50	667.5	36.2	483.5
39.9	1.379	55	758.5	39.8	549.4
43.3	1.426	60	855.6	43.5	619.5
46.7	1.475	65	958.8	47.1	691.5
50.0	1.526	70	1068	50.7	773.8
53.2	1.579	75	1181	51.3	857.9
56.2	1.633	80	1306	58.0	946.4
59.2	1.689	85	1436	61.6	1040
76.2	1.746	90	1571	65.2	1138
63.1	1.770	92	1628	66.6	1180
64.2	1.794	94	1686	68.1	1222
65.3	1.819	96	1746	69.5	1265
66.4	1.814	98	1807	71.0	1309
67.5	1.870	100	1870	72.4	1355

Sodium Chloride (20°C)

Bé	Specific Gravity	NaCl (%)	NaCl (g/l)
0.8	1.0053	1	10.05
1.8	1.0425	2	20.25
3.8	1.0268	4	41.07
5.8	1.0413	6	62.48
7.7	1.0559	8	84.47
9.6	1.0707	10	107.1
11.5	1.0857	12	130.3
13.3	1.1009	14	154.1
15.1	1.1162	16	178.6
16.9	1.1319	18	203.7
18.7	1.1478	20	229.6
20.4	1.1640	22	256.1
22.2	1.1804	24	283.3
23.9	1.1972	26	311.3

Sodium Sulfite (19°C)

Bé	Specific Gravity	Na ₂ SO ₃ (%)	Na ₂ SO ₃ (g/l)
1.1	1.0078	1	10.08
2.5	1.0172	2	20.31
5.1	1.0363	4	41.45
7.6	1.0556	6	63.34
10.1	1.0751	8	86.01
12.6	1.0918	10	109.5
14.9	1.1146	12	133.8
17.2	1.1516	14	158.8
19.4	1.1549	16	184.8
21.7	1.1755	18	211.6

Sodium Carbonate (20°C)

Bé	Specific Gravity	Na ₂ CO ₃ (%)	Na ₂ CO ₃ (g/l)	Na ₂ CO ₃ ·10H ₂ O (%)	Na ₂ CO ₃ ·10H ₂ O (g/l)
1.2	1.0086	1	10.09	2.70	27.23
2.7	1.0190	2	20.38	5.40	55.02
5.6	1.0398	4	41.59	10.80	112.3
8.3	1.0606	6	63.64	16.20	171.8
10.9	1.0816	8	86.53	21.60	233.6
13.5	1.1029	10	110.3	27.00	297.7
16.0	1.1244	12	134.9	32.40	361.3
18.5	1.1463	14	160.5	37.80	433.3

Sodium Phosphate Monobasic (25°C)

Density	NaH ₂ PO ₄ (%)
1.0045	1
1.0120	2
1.0270	4
1.0422	6
1.0575	8
1.0730	10

Sodium Phosphate Dibasic (18°C)

Specific Gravity	Na ₂ PO ₄ (%)
1.009	1
1.020	2
1.043	4
1.067	6

Sodium Phosphate Tribasic (15°C)

Specific Gravity	Na ₃ PO ₄ (%)
1.0092	1
1.0194	2
1.0405	4
1.0624	6
1.0850	8
1.1083	10

Sodium Bicarbonate (18°C)

Specific Gravity	NaHCO ₃ (%)
1.0059	1
1.0132	2
1.0206	3
1.0280	4
1.0354	5
1.0429	6
1.0505	7
1.0581	8

Sodium Silicate (20°C)

Bé	Specific Gravity	Na ₂ O + 3.9 SiO ₂ (%)	Na ₂ O + 3.9 SiO ₂ (g/l)	Bé	Specific Gravity	Na ₂ O + 3.9 SiO ₂ (%)	Na ₂ O + 3.9 SiO ₂ (g/l)
0.9	1.006	1	10.06	0.9	1.006	1	10.06
2.0	1.014	2	20.28	2.0	1.014	2	20.28
4.2	1.030	4	41.2	4.2	1.030	4	41.20
6.4	1.046	6	62.76	6.5	1.047	6	62.82
8.6	1.063	8	85.04	8.9	1.065	8	85.20
10.7	1.080	10	108.0	11.1	1.083	10	108.3
12.9	1.098	12	131.8	13.3	1.101	12	132.1
14.6	1.116	14	156.2	15.5	1.12	14	156.8
17.1	1.131	16	181.4	17.7	1.239	16	182.2
19.2	1.153	18	207.5	19.9	1.159	18	208.6
21.3	1.172	20	231.4	22.0	1.179	20	235.8
23.3	1.191	22	262.0	24.2	1.200	22	264.0
25.3	1.211	24	290.6	26.3	1.222	24	293.3
27.3	1.232	26	320.3	28.4	1.244	26	323.4
29.3	1.253	28	350.8	30.6	1.267	28	354.8
31.3	1.275	30	382.5	32.6	1.290	30	387.0
33.3	1.298	32	415.4	31.7	1.314	32	420.5
				36.7	1.339	34	455.3
				38.8	1.365	36	491.4
				40.9	1.393	38	529.3

Potassium Hydroxide (15°C)

Bé	Specific Gravity	KOH (%)	KOH (g/l)
1.2	1.0083	1	10.08
2.5	1.0175	2	20.35
3.8	1.0267	3	30.80
3.0	1.0359	4	41.44
6.3	1.0452	5	52.26
7.5	1.0544	6	63.26
8.7	1.0637	7	74.46
9.9	1.0730	8	85.84
11.0	1.0824	9	97.42
12.2	1.0918	10	109.2
13.3	1.1013	11	121.1
14.5	1.1108	12	133.3
15.6	1.1203	13	145.6
16.7	1.1299	14	158.2
17.8	1.1396	15	170.9
18.8	1.1493	16	183.9
19.9	1.1590	17	197.0
20.9	1.1688	18	210.4
22.0	1.1786	19	223.9
23.0	1.1884	20	237.7
24.0	1.1984	21	251.7
25.0	1.2083	22	265.8
27.0	1.2184	23	280.2
27.0	1.2285	24	294.8
27.9	1.2387	25	309.7
28.9	1.2489	26	324.7
29.8	1.2592	27	340.0
30.8	1.2695	28	355.5
31.7	1.2800	29	371.2
32.6	1.2905	30	387.2
33.6	1.3010	31	403.3
34.5	1.3117	32	419.7
35.4	1.3224	33	436.4
36.2	1.3331	34	453.3
37.1	1.3440	35	470.4
38.0	1.3549	36	487.8
38.8	1.3659	37	505.4
39.7	1.3769	38	523.2
40.5	1.3879	39	544.3
41.4	1.3991	40	559.6
42.2	1.4103	41	578.2
43.0	1.4215	42	597.0
43.8	1.4329	43	616.1
44.6	1.4443	44	635.5
45.4	1.4558	45	655.1
46.2	1.4673	46	675.0
47.0	1.4790	47	695.1
47.7	1.4907	48	715.5
48.5	1.5025	49	736.2
49.2	1.5143	50	757.2
50.0	1.5262	51	778.4
50.7	1.5382	52	799.9

Sodium Hydroxide (20°C)

Bé	Specific Gravity	NaOH (%)	NaOH (g/l)
1.4	1.0095	1	10.10
2.9	1.0207	2	20.41
4.5	1.0318	3	30.95
6.0	1.0428	4	41.71
7.4	1.0538	5	52.69
8.8	1.0648	6	63.89
10.2	1.0758	7	75.31
11.6	1.0869	8	86.95
12.9	1.0979	9	98.81
14.2	1.1089	10	110.9
16.8	1.1309	12	135.7
19.2	1.1530	14	161.4
21.6	1.2751	16	188.0
23.9	1.1972	18	215.5
26.1	1.2191	20	243.8
28.2	1.2411	22	273.0
30.2	1.2629	24	303.1
32.1	1.2848	26	334.0
34.0	1.3064	28	365.8
35.8	1.3279	30	398.4
37.5	1.3490	32	431.7
39.1	1.3696	34	465.7
40.7	1.2900	36	500.4
42.2	1.4101	38	535.8
43.6	1.4300	40	572.0
45.0	1.4491	42	608.7
46.3	1.2685	44	646.1
47.5	1.4873	46	684.2
48.8	1.5065	48	723.1
49.9	1.5253	50	762.7

Ammonia (20°C)

Bé	Specific Gravity	NH ₃ (%)	NH ₃ (g/l)
10.9	0.9939	1	9.939
11.5	0.9895	2	19.79
11.7	0.9811	4	39.24
13.9	0.9730	6	58.38
15.1	0.9651	8	77.21
16.2	0.9575	10	95.75
17.3	0.9501	12	114.0
18.5	0.9430	14	132.0
19.5	0.9362	16	149.8
20.6	0.9295	18	167.3
21.7	0.9229	20	184.6
22.8	0.9164	22	201.6
23.8	0.9101	24	218.4
24.9	0.9040	26	235.0
25.9	0.8982	28	251.4
27.0	0.8920	30	267.6

Ammonia (15°C, measured in closed tube)

Bé	Specific Gravity	NH ₃ (%)	NH ₃ (g/l)
34.9	0.849	45	382.1
38.3	0.832	50	416.0
41.8	0.815	55	448.3
45.9	0.796	60	477.6
50.4	0.776	65	504.4
55.4	0.755	70	528.5
61.0	0.733	75	549.8
66.9	0.711	80	568.8
73.5	0.688	85	584.8
80.5	0.665	90	598.5
88.1	0.642	95	609.9
96.5	0.618	100	618.0

Lime

CaO (g/l)	CaO (%)	Ca(OH) ₂ (%)	Density (20°C/20°C)
10	0.99	1.31	1.0085
20	1.96	2.59	1.017
30	2.93	3.87	1.0245
40	3.88	4.81	1.0315
50	4.18	5.13	1.039
60	5.74	6.36	1.046
70	6.65	7.58	1.0535
80	7.54	8.79	1.0605
90	8.43	9.96	1.0675
100	9.30	11.14	1.075
110	10.16	12.29	1.0825
120	11.01	13.43	1.0895
130	11.86	14.55	1.0965
140	12.68	15.67	1.104
150	13.50	16.76	1.111
160	14.30	17.84	1.1185
170	15.10	18.90	1.1255
180	15.89	19.95	1.1325
190	16.67	21.00	1.140
200	17.43	22.03	1.1475
210	18.19	24.04	1.1515
220	18.91	25.03	1.1615
230	19.68	26.01	1.1685
240	20.41	26.96	1.176
250	21.12	27.91	1.1835
260	21.84	28.86	1.1905
270	22.55	29.80	1.1975
280	23.24	31.71	1.205
290	23.92	31.61	1.2125
300	24.60	32.51	1.2195

Ferrous Sulfate (18°C)

Bé	Specific Gravity	FeSO ₄ (%)	FeSO (g/l)	FeSO ₄ ·7H ₂ O (%)	FeSO ₄ ·7H ₂ (g/l)
0.1	1.0007	0.2	2.001	0.366	3.663
0.4	1.0028	0.4	4.011	0.732	7.341
0.7	1.0046	0.6	6.028	1.10	11.03
0.9	1.0065	0.8	8.052	1.46	14.74
1.2	1.0085	1.0	10.09	1.83	18.46
2.6	1.0180	2	20.36	3.66	37.26
5.2	1.0375	4	41.50	7.32	75.95
7.9	1.0575	6	63.45	11.0	115.1
10.6	1.0785	8	86.28	14.6	157.9
13.2	1.1000	10	110.0	18.3	201.3
15.8	1.1220	12	131.6	22.0	246.4
18.3	1.1445	14	160.2	25.6	293.3
20.8	1.1675	16	186.8	29.3	341.9
23.2	1.1905	18	214.3	32.9	392.2
25.5	1.2135	20	242.7	36.6	444.2

Ferric Sulfate (17.5°C)

Bé	Specific Gravity	Fe ₂ (SO ₄) ₃ (%)	Fe ₂ (SO ₄) ₃ (g/l)
1.0	1.007	1	10.07
2.3	1.016	2	20.32
4.7	1.033	4	41.32
6.9	1.050	6	63.00
9.1	1.067	8	85.36
11.2	1.084	10	108.4
13.5	1.103	12	132.4
15.8	1.122	14	157.1
17.9	1.141	16	182.6
20.1	1.161	18	209.0
22.2	1.181	20	236.2
28.2	1.241	25	310.3
31.1	1.307	30	392.1
39.6	1.376	35	481.6
44.9	1.449	40	579.6
50.1	1.582	45	687.6
55.1	1.613	50	806.5
59.9	1.703	55	936.7
64.4	1.798	60	1079

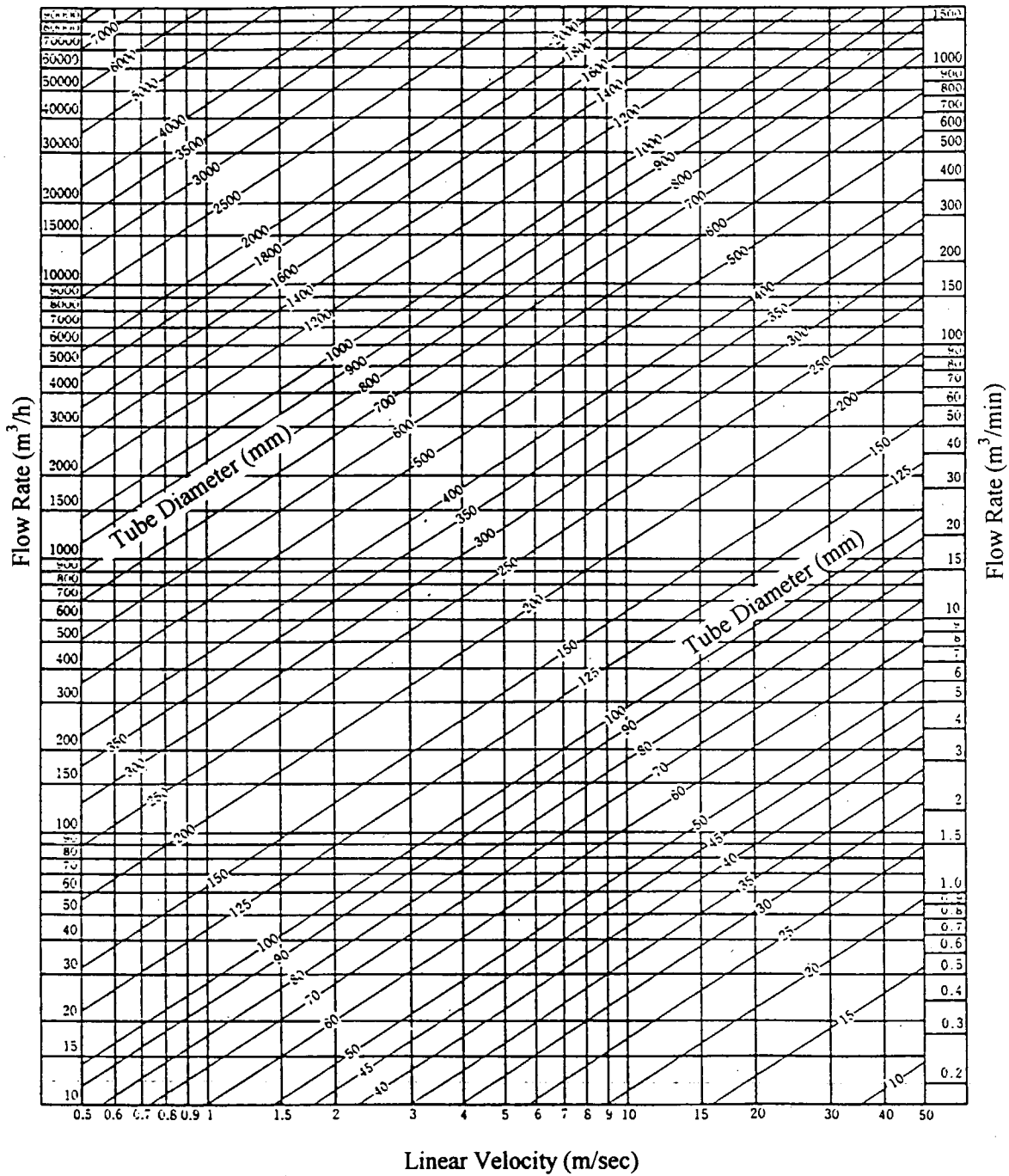
Aluminium Sulfate (15°C)

Bé	Specific Gravity	Al ₂ (SO ₄) ₃ (%)	Al ₂ (SO ₄) ₃ (g/l)	Al ₂ (SO ₄) ₃ ·18H ₂ O (%)	Al ₂ (SO ₄) ₃ ·18H ₂ O (g/l)
1.3	1.0093	1	10.09	1.948	19.66
2.8	1.0195	2	20.39	3.896	39.72
5.6	1.0104	4	41.62	7.791	81.06
8.4	1.0618	6	63.71	11.69	124.1
11.2	1.0837	8	86.75	15.58	168.9
13.9	1.1062	10	110.6	19.48	215.5
16.6	1.1293	12	135.5	23.37	264.0
19.2	1.1529	14	161.4	27.27	314.4
21.8	1.1770	16	188.3	31.16	366.8
24.3	1.2017	18	216.3	35.06	421.3
26.8	1.2270	20	245.4	38.96	478.1
29.3	1.2531	22	275.7	42.85	537.1
31.7	1.2803	24	307.3	46.75	598.5
34.1	1.3079	26	340.1	50.64	662.4

LINE SIZING CHART

$$Q = \frac{\pi}{4} d^2 \times V \times 3600 \times 10^{-6} \quad \text{m}^3/\text{h}$$

$$= \frac{\pi}{4} d^2 \times V \times 60 \times 10^{-3} \quad \text{t/min} \quad d \text{ in mm} \quad V \text{ in m/s}$$



Pressure Drop by Piping Components

Type of valva/fitting			Equivalent length (m)
Vaves (full-open)	Ball valve	Reduced bore 40 mm and smaller	65 D
		Reduced bore 50 mm and larger	45 D
	Gate valve	Standard bore	13 D
			65 D
	Globe valve	Straight pattern	340 D
		Y pattern	160 D
		Angle pattern	145 D
	Check valve	Swing type	135 D
		Ball or piston type, 40 mm and smaller	340 D
	Plug valve	regular pattern	45 D
Butterfly valve	150 mm and larger	20 D	
Control valves		ask instrument group	
Fittings	Tee	Flow straight through	20 D
		Flow through side outlet	65 D
	Elbow	90° ,R= 1 1/2 D	20 D
		45° ,R= 1 1/2 D	16 D
	Bend	90° ,R= 4D	14 D
		90° ,R= 5D	16 D
		180° ,R= 4D	25 D
		180° ,R= 5D	28 D
Miscellaneous	Strainer	Pump suction Y-type and bucket type	250 D
	Equipment		ask equipment manufacturer

Note: D = nominal size in meters.

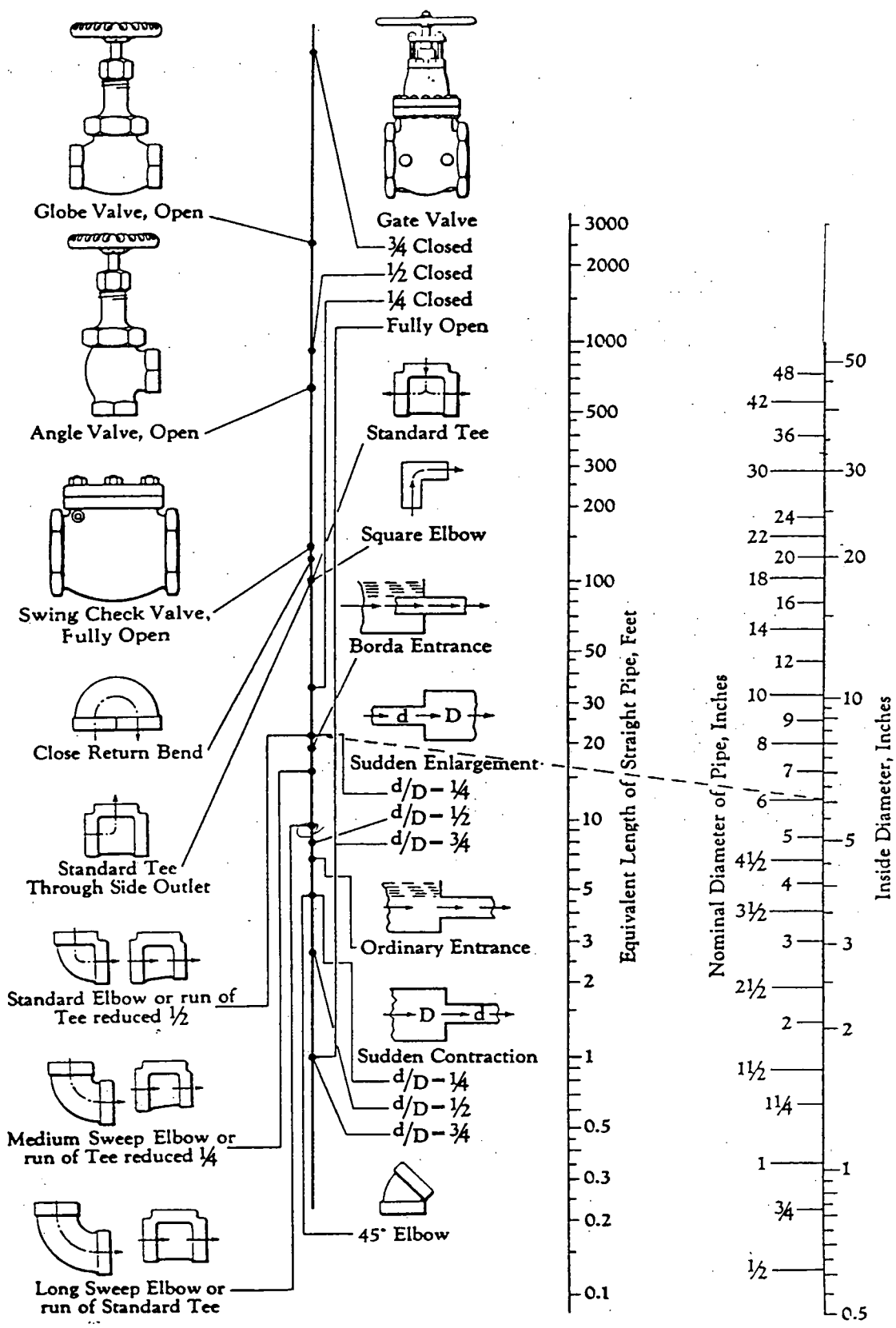


Figure 2-7. Resistance of valves and fittings to flow of fluids. (Reprinted by permission "Technical Paper #409," Crane Co., Engineering Div., 1942, Chicago.)

1 Feet = 0.305 m

Reference for Material Selection

Chemicals	Solution Strength	Pumps	Valves	Piping	Tanks	Agitators
Coagulant						
Aluminium Sulfate $Al_2(SO_4)_3 \cdot 14H_2O$	15 to 17 % as Al ₂ O ₃	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel or Rubber/PP lined CS	316L Stainless Steel	316L Stainless Steel
Calcium Hydroxide $Ca(OH)_2$	5 % Slurry	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel
Ferric Chloride FeCl ₃	32% FeCl ₃	FRP, PVC, or PVDF	FRP, PVC, or PVDF	FRP, PVC, or PVDF	FRP, or Rubber lined CS	FRP, PVC, or PVDF
Ferrous Sulfate $FeSO_4 \cdot 7H_2O$	20 % as Fe	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel
Polyelectrolytes						
pH adjustment	0.5 to 5.0 %	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel
Calcium Carbonate CaCO ₃	5 % Slurry	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel
Hydrochloric Acid HCl	30 to 40 % HCl	Hastelloy	Hastelloy or Rubber Lined CS	Rubber or PPL lined CS	Rubber or PPL lined CS	Hastelloy or Rubber Lined CS
Sodium Hydroxide NaOH	25 to 50% NaOH	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel
Sulfuric Acid H ₂ SO ₄	93 to 98%	Alloy 20 or PTFE lined CS	Alloy 20 or PTFE lined CS	PP lined CS	Carbon Steel	Alloy 20
Nutrient Sources						
Ammonium Hydroxide NH ₄ OH	20 % NH ₄ OH	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel
Ammonium Phosphate	98% NH ₄ H ₂ PO ₄	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel or rubber/PP line CS	304L Stainless Steel, or FRP	304L Stainless Steel
Phosphoric Acid H ₃ PO ₄	75% as H ₃ PO ₄	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel
Urea NH ₂ CONH ₂	40% Urea	316L Stainless Steel	316L Stainless Steel	316L Stainless Steel	316L Stainless Steel or PVE lined CS	316L Stainless Steel
Oxidant						
Hydrogen Peroxide H ₂ O ₂	35 to 70% H ₂ O ₂	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel	304L Stainless Steel
Sodium Hypochlorite NaOCl	13 to 17 % NaOCl	PPL or PTFE lined CS, Hastelloy C	PVDC, PV2F line Ductile Iron, or Hastelloy C	Butyl Rubber line CS	Glass Reinforced Epoxy, or Butyl Rubber lined CS	Butyl Rubber line CS

Blower Calculation Example using spreadsheet

1 Oxygen Requirement

$$\text{Oxygen Requirement for BOD Removal} = [a \cdot (S_o - S_e) \cdot Q + b \cdot X \cdot V] \cdot 10^{-3}$$

Q	2000 m ³ /D
Reactor volume	2000 m ³
MLSS	3000 mg/l
RW_BOD	1000 mg/l
TW_BOD	30 mg/l
Constant_a	0.535 kg/kg
Constant_b	0.163 kg/kg/D
Oxygen Requirement	2015.9 kgO ₂ /d

2 Air requirement

$$\text{Air requirement} = \text{Oxygen requirement} \cdot 22.4/32 \cdot 1/\text{oxygen efficiency} \cdot 1/0.21 \cdot ((\text{temp}+273)/273)$$

Oxygen requirement	2015.9 kgO ₂ /D
Temp	0 °C
Oxygen efficiency	10 %
Air requirement	55905.24 m ³ N/D
	2329.385 m ³ N/h
	38.82308 m ³ N/min

3 The power requirement for blower (2+1S Basis)

$$P_w = (w \cdot R \cdot T_1) / (29.7 \cdot n \cdot e) \cdot (((p_2/p_1)^{0.283}) - 1)$$

Air in N	27952.62 m ³ N/D
	1164.692 m ³ N/h
	19.41154 m ³ N/min
	21.9002 m ³ /min
w: weight of flow air	0.415962 kg/s
R: engineering gas constant for air	8.314 kJ/k mol °K
T1: absolute inlet temp.	308 °K
p1: absolute inlet press.	1 atm
p2: absolute outlet press.	1.7 atm
n: (k-1)/k=	0.283 for air
k=	1.395 for air
29.7: constant for SI unit conversion	
e: efficiency	0.4

The required power for blower=	51.33392 kW
	55 kW

OIL Separator

Oil separation by gravity is applicable only to remove free state oils and hydrocarbons from wastewater.

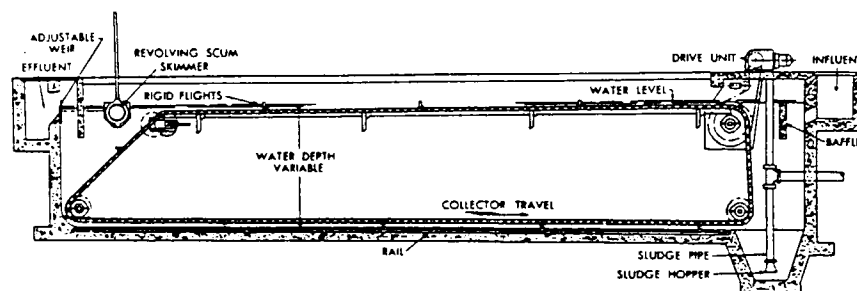
There are several types of gravity separators.

Oil concentration in the treated water is 10 to 50 mg/L in general. This value does not meet to the discharge limitation in many cases.

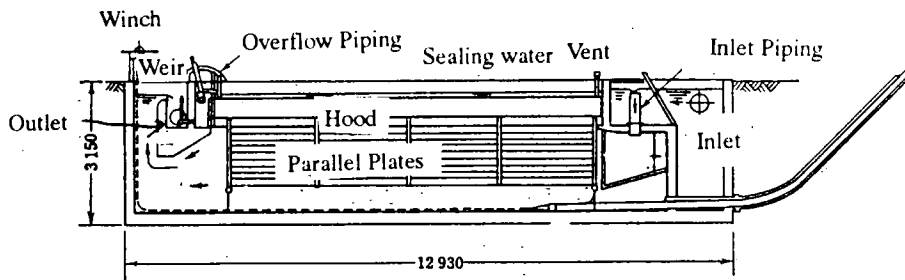
So that oil separator is generally used as preliminary treatment prior to dissolved air flotation process.

Type of Oil Separator

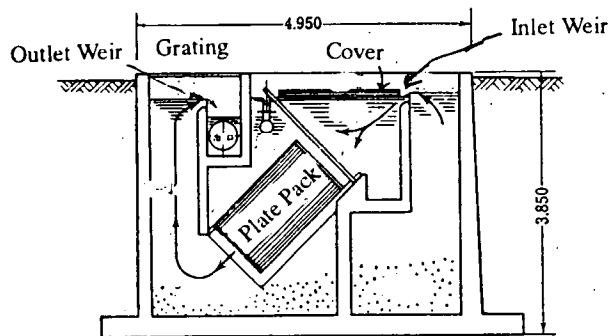
Item	API (American Petroleum Institute)	PPI (Parallel Plate Interceptor)	CPI (Corrugated Plate Interceptor)
Area required	1	0.50	0.35
Applicable oil droplet size	150 μ	60 μ	60 μ
Oil droplet floating velocity	0.9 mm/sec	0.2 mm/sec	0.2 mm/sec
Structure	Simple	Complicated	Complicated
Maintenance	Easy	Hard	Hard
Installation Cost	Inexpensive	Expensive	Inexpensive
License fee	None	Required	Required



Schematics of API separator



Schematics of PPI separator



Schematics of CPI separator

Design and engineering of API separator should be conformed to “Management of Water Discharges: Design and Operation of Oil-Water Separators, API, 1990”.

For installation and operation, following item should be paid attention.

- It is recommended not to use pump for influent feeding in order to avoid emulsifying of oil and grease.
- Furnish the retention tank with smooth surface in order to avoid turbulences.
- Floated oil layer should be skimmed adequately.
- The overflow weir and skimming pipe should be leveled horizontally.
- In order to maintain good floating performance, solid substances, chemicals, and sand should not be fed into the wastewater.