DRAFT TANZANIA STANDARD

TBS/MMDC 9 (331) P3 Mineral Processing Terminology - Part 3:
Metal Recovery Processes

TANZANIA BUREAU OF STANDARDS

First Edition

0 Foreword

This draft Tanzania Standard is being prepared by the Mineral Processing and Equipment Technical Committee (MMDC 9), under the supervision of the Mining and Minerals Standards Divisional Committee (MMDC).

This document has been prepared in order to standardize and co-ordinate technical terms in current use in the mining industry and ensure expertise of other type of mining activities.

The need for this document arose from the widely varying interpretation of terms used within the industry and the prevalent use of more than one synonym.

In preparation of this draft Tanzania Standard assistance was derived from https://www.911metallurgist.com/blog/crushing-industry-vocabulary ,Glossary of Terms for Ion Exchange Resins (Jacobi RESINEX) and Dictionary of Mining, Mineral, and Related Terms in Mineral Processing (Hacettepe University Department of Mining Engineering).

This draft Tanzania Standard is the part of the general title of Mineral Processing Terminology which consists of the following parts, -

Part 1: Comminution

Part 2: Concentration

Part 3: Metal recovery processes

Part 4: Metallurgical accounting

Part 5: Mine effluent detoxifications

1 Scope

This document specifies the commonly used terms in mineral processing, only terms which have a specific meaning in this field have been included in Metal recovery processes (elution/adsorption, solvent extraction, ion exchange, electrowining and smelting).

2 Normative references

This document does not contain normative references.

3 Terms and definitions

3.1 Elution/Adsorption

3.1.1 AARL (Anglo American Research Laboratory)

type of elution where the pregnant eluate from elution column after being electrowon is not recycled back and is discarded.

3.1.2 Activity

the measure of the ability of the carbon to adsorb gold from solution as compared to that of fresh carbon. It is expressed in percentage (%).

3.1.3 Acid Wash

the process used to remove calcium carbonate and other acid soluble impurities from loaded carbon using hydrochloric acid.

3.1.4 Acid wash column

vessel in which loaded carbon is washed with acid.

3.1.5 Barren

used to describe carbon or solution that no longer contains gold. It can be barren carbon means carbon has had gold removed or barren solution meaning solution which has had gold removed.

3.1.6 Bed volume

the volume of the bed of carbon in the elution or acid wash columns for a particular tonnes of carbon.

3.1.7 Carbon regeneration

the process of removing organic materials from carbon by volatilizing at high temperatures (650° to 700°C) hence restoring active sites.

3.1.8 Cold cyanide Wash

the process used to remove copper prior to elution and electrowinning.

3.1.9 Elution Column

pressure vessel constructed from stainless steel in which elution processes occur.

3.1.10 Desorption

the opposite process during which the molecules are released from the surface where they were adsorbed.

3.1.11 Eduction

process of transferring carbon using pressurized water.

3.1.12 Eluant

a solution used to remove gold from loaded carbon into solution.

3.1.13 Eluate

solution resulting from elution process.

3.1.14 Eluate strainers

closed vessels that collect trashes from eluate discharged from elution column before being recycled to heat exchangers.

3.1.15 Eluate tank

a tank used to temporarily store eluate solution prior to electro winning.

3.1.16 Elution/Desorption/Stripping

a) the process by which gold is removed from the loaded carbon back into a solution.

b) the process of extracting a valuable metal from an aqueous system by washing with a solvent; as in washing of loaded ion-exchange resins to remove metal captured ions (move to solvent extraction).

3.1.17 Foulants

materials other than valuable metal adsorbed or absorbed onto the carbon hence decreasing the number of active sites available for adsorption of the valuable metal.

3.1.18 Fouling

the build-up of organic and inorganic substances on carbon which affects carbon adsorption by reducing carbon activity.

3.1.19 Gasket

seals fitted between heat exchanger plates to ensure that no solution leaks out.

3.1.20 Glycol

a heat transfer fluid used in heat exchangers to heat strip solution.

3.1.21 Heat exchangers

a) device for inducing or removing heat to or from a pregnant/barren solution.

b) device for transferring heat from one medium to another.

3.1.22 Hydrochloric acid

used in acid washing as a cleaning agent for activated carbon.

3.1.23 Interlocks

an alarm or condition which is required to allow an event to occur.

3.1.24 Loaded carbon

carbon loaded with gold.

3.1.25 Notches

paths through which thickener overflow flows out of the thickener.

3.1.26 Permissives

made up of one or more interlocks, which will need to be healthy before a piece of equipment can operate.

3.1.27 Portable water

suitable water for human consumption.

3.1.28 Pre-dryer

hopper whereby carbon is kept in order to remove moisture before being fed into the kiln. Hot gases are forced by means of exhaust fan to remove moisture from the carbon.

3.1.29 PLC (Programmable Logic Controller)

device that controls and monitors the logic of electrical controls of plant equipment including both interlocks and Permissives.

3.1.30 Pregnant solution

used to describe solution that contains high levels of gold.

3.1.31 Pyrolysis

stage in carbon regeneration where Foulants are burned without oxygen at about 500-700°C.

3.1.32 Quench

rapid cooling of regenerated carbon from the kiln to improve physical properties.

3.1.33 Quench tank

tank used for rapid cooling of regenerated carbon from the kiln.

3.1.34 Reagents

chemicals used in process plant.

3.1.35 Regeneration kiln

a) device used to remove volatile organic materials from carbon.

b) device used to thermally destroy the unwanted components adsorbed on activated carbon surface.

3.1.36 Sulphamic acid (H_2NSO_3H)

chemical used in elution circuit as a cleaning agent to descale heat exchanger plates.

3.1.37 Vaporisation

the stage in carbon regeneration where foulants are vaporized at about 200-500°C.

3.1.38 Zadra elution

type of elution where loaded eluate or pregnant solution discharged from elution column goes to electrowinning cell and the eluate discharging from electrowinning cell is reheated and passed through the column again.

3.2 Electrowinning and Smelting

3.2.1 Anode

the positive pole of an electrolytic cell.

3.2.2 Barren eluate

the solutions with less amount of gold left after passing Electrowining cells.

3.2.3 Base metal

Any non-precious metal (e.g. copper, lead, zinc, nickel, etc.).

3.2.4 Basic/ Steel Making Grade Pig Iron

pig iron (including hot metal) used for production of steel.

3.2.5 Blast furnace

reaction vessel in which mixed charges of oxide ores, fluxes and fuels are blown with a continuous blast of hot air and oxygen-enriched air for the chemical reduction of metals to their metallic state.

3.2.6 Blister copper

crude form of copper (assaying about 99%) produced in a smelter, which requires further refining before being used for industrial purposes.

3.2.7 Bullion

raw gold that is reduced to nearly pure form ready to be shipped to the mint to be cast into bars or ingots for easy storage and shipping.

3.2.8 Calcine

name given to concentrate that is ready for smelting (i.e. the sulphur has been driven off by oxidation).

3.2.9 Calcining

prolonged heating of the cathodes at 750°C, the purpose being to oxidise the impurities (iron, copper etc) that are present with the gold so that they can be 'slagged off' in the subsequent smelt.

3.2.10 Cathode

the negative pole of an electrolytic cell.

3.2.11 Cathode Surface Area

electrowinning efficiency optimized by maximizing the cathode surface area exposed to the solution.

3.2.12 Cyanide Concentration

amount of cyanide in the eluate required for optimizing cell performance.

3.2.13 Cathode Reaction - Gold Deposition

electrolytically displacement of gold from the alkaline cyanide solution (pregnant eluate) and deposited on the cathode surface.

3.2.14 Cell Current / amps

a measure of the amount of current, or electrons, flowing through the cell.

3.2.15 Cell anodes

positive electrodes made of stainless steel mesh**.**

3.2.16 Cell voltage

the electrical potential difference between the two electrodes of an electrochemical cell.

3.2.17 Chloridizing roasting

Transformation of certain metal compounds to chlorides, through oxidation or reduction. Some metals such as uranium, titanium, beryllium and some rare earths are processed in their chloride form. Certain forms of chloridizing roasting may be represented by the overall reactions:

$2NaCl + MS + 2O_2 = Na_2SO_4 + MCl$,

$4NaCl + 2MO + S_2 + 3O_2 = 2Na_2SO_4 + 2MCl_2$

3.2.18 Converter

furnace used to separate copper metal from matte.

3.2.19 Crucible

container made of refractory ceramic clays to be able to withstand the intense heat of the furnace, molten metal and slag.

3.2.20 Current

the amount of electric charge flowing past a specified circuit point per unit time.

3.2.21 Custom smelter

smelter which processes concentrates from independent mines. Concentrates may be purchased or the smelter may be contracted to do the processing for the independent company.

3.2.22 Direct current

an electric current flowing in one direction only.

3.2.23 Direct Reduced Iron (DRI) / Sponge Iron (SI)

solid metallic iron product obtained upon Direct Reduction of high grade iron ore in solid state itself without being converted into liquid form like that in Blast Furnace.

3.2.24 Gold concentration

the content of gold in a pregnant solution or eluate.

3.2.25 Electrochemical cell

a device that produces an electric current from energy released by a spontaneous redox reaction.

3.2.26 Electrowinning cells

cells which converts the gold ions (charged gold particles) in the solution into solid gold.

3.2.27 Electrometallurgy

the process of using electricity to extract the valuable metal from the concentrate.

3.2.28 Electrons

sub atomic particles revolve around the nucleus of an atom and have a negative charge.

3.2.29 Electrodes

positive or negative pole of an electric cell.

3.2.30 Electrolyte

non-metallic electric conductor (as a solution, liquid, or fused solid) in which current is carried by the movement of ions instead of electrons with the liberation of matter at the electrodes; a liquid ionic conductor.

3.2.31 Electrostatic precipitator

device for cleaning fine dust from contaminated air. It uses an electric field to polarize suspended particulates.

3.2.32 Electrowinning

an electrochemical process in which a metal dissolved within an electrolyte is plated onto an electrode (cathode), used to recover metals such as cobalt, copper, gold, and nickel from solution in the leaching of ores, concentrates, precipitates, matte, etc.

3.2.33 Eluate mixing and Short Circuiting

Process enhancing the degree of mixing within the cell to improve the rate of deposition.

3.2.34 Extraction

the removal of the valuable metal from the leach solution or concentrate – the main extraction methods use heat, chemicals, or electricity.

3.2.35 Foundry Grade Pig Iron

pig iron used in the Foundries for production of Cast Iron (CI) Castings using Cupola Furnace. This is the major use of pig iron.

3.2.36 Flash smelting

smelting process for sulphur-containing ores in which the dried and powdered ore, mixed with oxygen, is ignited on discharge from a nozzle, melts, and drops to the bottom of a settling chamber.

3.2.37 Gold Smelting

the removal of the metallic and other impurities into the slag phase and produce a gold-silver bullion containing typically >95% precious metals.

3.2.38 Gold Ingot

gold bar usually cast from a mould for convenience in handling and measuring.

3.2.39 Gold bar

quantity of refined metallic gold of any shape that is made by a bar producer meeting standard conditions of manufacture, labelling, and record keeping.

3.2.40 Hot metal (liquid iron)

the hot, liquid, metallic iron product obtained upon reduction of iron ore (normally in Blast Furnace or in Corex Furnace). It contains about 93-94% Iron (Fe) and other elements/impurities like Carbon (4%), Silicon (~1%), Manganese (+1%) Sulphur, Phosphorus etc.

3.2.41 Liquid steel

the immediate hot molten steel product from Steel Melting Shop (LD Converter/Electric Arc Furnace/Electric Induction Furnace/Energy Optimising Furnace).

3.2.42 Iron making

the process of Reduction of iron ore using the relevant reducing agent (Reductant).

3.2.43 Ingot steel (Ingots)

the primary solid product obtained upon solidification of liquid steel in conventional, vertical, Cast Iron Molds which are intended for rolling into intermediate/semi-finished products after re-heating.

3.2.44 Matte

product of a smelter, containing metal and some sulphur, which must be refined further to obtain pure metal.

3.2.45 Magnetic roasting

this involves controlled roasting of the ore to convert it into a magnetic form, thus enabling easy separation and processing in subsequent steps. For example, controlled reduction of haematite (non- magnetic Fe_2O_3) to magnetite (magnetic Fe_3O_4).

3.2.46 Mould

the form/shape where charge is poured into cast iron moulds, and the gold sets into bars.

3.2.47 Net smelter return

share of the net revenues generated from the sale of metal produced by a mine.

3.2.48 Oxidizing roasting

heating the ore in excess of air or oxygen, to burn out or replace the impurity element, generally sulfur, partly or completely by oxygen. For sulfide roasting, the general reaction can be given by:

$$\mathbf{2MS\ (s) + 3O_2\ (g) = 2MO\ (s) + 2SO_2\ (g)}$$

M =Metal, S= sulphur

3.2.49 Pig iron

crude iron from a blast furnace.

3.2.50 Quenching bath

the bath which is used to cool the bars.

3.2.51 Reduction roasting

partial reduction of an oxide ore before the actual smelting process.

3.2.52 Reduction

the final, high-temperature step in smelting, in which the oxide becomes the elemental metal. A reducing environment (often provided by carbon monoxide, made by incomplete combustion in an air-starved furnace) pulls the final oxygen atoms from the raw metal.

3.2.53 Refining

the process of removing impurities from the metal after it has been extracted from the concentrate.

3.2.54 Rectifier

equipment used in mines to convert alternating current to direct current.

3.2.55 Roasting

process of heating the sulfide ore to a high temperature in presence of air.

3.2.56 Slag

the top layer of the multilayer melt formed during some metal smelting and refining operations, in smelting, it contains the gangue minerals and the flux.

3.2.57 Smelting

process of applying heat to ore or concentrate in order to extract a base metal (e.g. copper, lead, zinc, nickel, etc.). It is a form of extractive metallurgy which uses heat and a chemical reducing agent to decompose the ore, driving off other elements as gases or slag and leaving the metal base behind.

3.2.58 Smelting Furnace

cylindrical firebrick lined furnace installed in the gold room, furnace is Liquefied Petroleum Gas (LPG) fixed at the base and has a hydraulic rating mechanism for pouring.

3.2.59 Solution Conductivity

the conductivity of the eluate (i.e., how well the solution conducts electricity/how well electrons flow through the solution) also affects cell performance.

3.2.60 Sulfating roasting

oxidizes certain sulfide ores to sulfates in a controlled supply of air to enable leaching of the sulfate for further processing.

3.2.61 Sinter roasting

this involves heating the fine ores at high temperatures, where simultaneous oxidation and agglomeration of the ores take place. For example, lead sulfide ores are subjected to sinter roasting in a continuous process after froth flotation to convert the fine ores to workable agglomerates for further smelting operations.

3.2.62 Steel

an iron based alloy containing Carbon, Silicon, Manganese etc.

3.2.63 Steel making

the process of selective oxidation of impurities present in the charge material (Hot metal/Scrap/DRI) in the presence of suitable fluxes in the Steel Melting Shops (SMS).

3.2.64 Volatilizing roasting

involves careful oxidation at elevated temperatures of the ores, to eliminate impurity elements in the form of their volatile oxides. Examples of such volatile oxides include As_2O_3, Sb_2O_3, ZnO and sulfur oxides.

3.3 Solvent extraction

3.3.1 Contactor

device for dispersing and disengaging immiscible solutions; extractor, may be single stage, as in a mixer-settler, or multiple stage, as in columns and certain centrifuges.

3.3.2 Countercurrent extraction

multistage extraction in which the aqueous and organic solutions flow in opposite directions.

3.3.3 Concentration or distribution coefficient

extraction coefficient, E-A/O, stripping coefficient, S-O/A, representing the ratio of metal solute concentrations after contacting (equilibrating) an aqueous and organic solution under defined conditions.

3.3.4 Extraction or distribution isotherm

graphical representation of isothermal equilibrium concentrations of a metal solute, in aqueous and organic solutions, over an ordered range of conditions in extraction (extraction isotherm) or stripping (stripping isotherm).

3.3.5 Extract

organic phase after extraction (loaded solvent), or aqueous phase after stripping (loaded strip liquor); the solution into which transfer of a metal solute is effected; used as a verb to describe transfer of a metal solute between two immiscible liquids.

3.3.6 Extractant

organic solution or the active organic solute used in extracting the metal into a separate phase.

3.3.7 Loaded organic

organic solvent containing metal solute after contacting the aqueous feed liquor; the extract.

3.3.8 Loading capacity

saturation limit of metal solute in organic or strip liquor.

3.3.9 Mixer-settler

device for liquid-liquid extraction, comprising separate mixing and settling compartments.

3.3.10 Pulse column

multistage contactor comprised of a column usually containing parallel, horizontal, perforated plates (disks) through which the aqueous and organic feed streams are advanced counter currently a pulsing motion.

3.3.11 Raffinate

the liquid phase from which solute has been removed by single or multiple-stage contacting with an immiscible solvent.

3.3.12 Settling

separation of dispersed immiscible liquids by coalescence and sedimentation.

3.3.13 Stage

single contact (dispersion and disengagement); sometimes refers to a theoretical stage which is a contact that attains equilibrium conditions.

3.3.14 Stripping

removal of extracted metal solute from loaded organic extract; re-extraction; back extraction. Selective stripping refers to separate removal of specific metal solutes from an extract containing more than one metal solute.

3.3.15 Solvent

the liquid phase that preferentially dissolves the extractable solute from the feed in liquid – liquid extraction.

3.3.16 Solvent extraction

separation of one or more metallic solutes, from a mixture, by mass transfer between immiscible phases in which at least one phase is an organic liquid.

3.4 Ion exchange terminologies

3.4.1 Acidity

an expression of the concentration of hydrogen ions present in a solution.

3.4.2 Adsorption

the attachment of charged particles to the chemically active groups on the surface and in the pores of an ion exchanger.

3.4.3 Alkalinity

an expression of the total basic anions (hydroxyl groups) present in a solution.

3.4.4 Anion

a negatively charged ion.

3.4.5 Ash

the residual mineral content of resin after incineration at 800° C.

3.4.6 Attrition

the rubbing of one particle against another in a resin bed; frictional wear that will affect the size of resin particles.

3.4.7 Backwash

the upward flow of water through a resin bed (i.e., at the bottom of the exchange unit, out at the top) to clean and reclassify the bed after exhaustion.

3.4.8 Base

the hydroxyl form of a cation or a compound that can neutralize an acid.

3.4.9 Batch operation

the utilization of ion exchange resins to treat a solution in a container where in the removal of ions is accomplished by agitation of the solution and subsequent decanting of the treated liquid.

3.4.10 Bed

the ion exchange resin contained in a column.

3.4.11 Bed depth

the height of the resinous material in the column after the exchanger has been properly conditioned for effective operation.

3.4.12 Bed expansion

the effect produced during backwashing: The resin particles become separated and rise in the column. The expansion of the bed due to the increase in the space between resin particles may be controlled by regulating backwash flow.

3.4.13 Bicarbonate alkalinity

the presence in a solution of hydroxyl (OH^-) ions resulting from the hydrolysis of carbonates or bicarbonates. When these salts react with water a strong base and a weak acid are produced, and the solution is alkaline.

3.4.14 Breakthrough

the first appearance in the solution flowing from an ion exchange unit of unabsorbed ions similar to those which are depleting the activity of the resin bed. Breakthrough is an indication that regeneration of the resin is necessary.

3.4.15 Brine

a salt solution, generally sodium chloride in a saturated solution.

3.4.16 BS&D

procedure for resin volume measurement where in an ion exchange resin bed is first backwashed, then allowed to settle and then drained of water. The resultant bed- height is measured for volume calculations.

3.4.17 Buffer

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

3.4.18 Capacity

the ability of an ion exchange material to absorb ions. Usually expressed in kilograins per cubic foot or milliequivalents per millilitre.

3.4.19 Capacity, operating

the portion of the total capacity utilized in practical ion exchange operation.

3.4.20 Capacity, salt-splitting

the portion of total capacity to split neutral salt.

3.4.21 Capacity, total

the ultimate exchange capacity of the resin.

3.4.22 Carbonaceous exchangers

Ion exchange materials of limited capacity prepared by the sulfonation of coal, lignite, peat, etc.

3.4.23 Cation

a positively charged ion.

3.4.24 Channelling

cleavage and furrowing of the bed due to faulty operational procedures, in which the solution being treated follows the path of least resistance, runs through these furrows, and fails to contact active groups in other parts of the bed.

3.4.25 Chemical stability

resistance to chemical change which ion exchange resins must possess despite contact with aggressive solutions.

3.4.26 Column operation

Conventional utilization of ion exchange resins in columns through which pass, either upflow or downflow, the solution to be treated.

3.4.27 Condensate polishers

Ion exchange resins being used to remove or exchange ions as well as to filter condensate for reuse in the steam cycle.

3.4.28 Conductivity

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

3.4.29 Cross linkage

the degree of binding of a monomer or set of monomers to form an insoluble tri-dimensional resin matrix.

3.4.30 Cycle

a complete course of ion exchange operation. For instance, a complete cycle of cation exchange would involve: exhaustion of regenerated bed, backwash, regeneration and rinse to remove excess regenerant.

3.4.31 Deashing

the removal from solution of inorganic salts by means of adsorption by ion exchange resins of both the cations and the anions that comprise the salts.

3.4.32 Deionization

a more general term than deashing, embraces the removal of all charged constituents or ionizable salts (both inorganic and organic) from solution.

3.4.33 Demineralization

Sometimes used interchangeably with deionization, it refers to the removal of minerals and mineral salts using ion exchange.

3.4.34 Density

the weight of a given volume of exchange material, backwashed and in place in the column.

3.4.35 Diffusion

usually referred to ion exchange resins as the diffusion of ions through the ion exchange resin beads.

3.4.36 Dissolved solids

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

3.4.37 Downflow

Conventional direction of solutions to be processed in ion exchange column operation, i.e., at the top, out at the bottom of the column.

3.4.38 Dry solids

the matter, usually expressed in weight percent, remaining after liquid removal.

3.4.39 Efficiency

the effectiveness of the operational performance of an ion exchanger. Efficiency in the adsorption of ions is expressed as the quantity of regenerant required to effect the removal of a specified unit weight of adsorbed material, e.g., pounds of acid per kilograins of salt removed.

3.4.40 Effluent

the solution which emerges from an ion exchange column.

3.4.41 Equilibrium reactions

the interaction of ionisable compounds in which the products obtained tend to revert to the substances from which they were formed until a balance is reached in which both reactants and products are present in definite ratios.

3.4.42 Equivalent weight

the molecular weight of any element or radical expressed as grams, pounds, etc., divided by the valence.

3.4.43 Exchange sites

the reactive groups on an ion exchange resin.

3.4.44 Exchange velocity

the rate with which one ion is displaced from an exchanger in favor of another.

3.4.45 Exhaustion

the state in which the resin is no longer capable of useful ion exchange; the depletion of the exchanger's supply of available ions. The exhaustion point is determined arbitrarily in terms of: (a) a value in parts per million of ions in the effluent solution; (b) the reduction in quality of the effluent water determined by a conductivity bridge which measures the electrical resistance of the water.

3.4.46 Fines

extremely small particles of ion exchange materials.

3.4.47 Flow rate

the volume of solution passing through a given quantity of resin within a given time. Usually expressed in terms of gallons per minute per cubic foot of resin, as milliliters per minute per milliliter of resin, or as gallons per square foot of resin per minute.

3.4.48 Freeboard

the space provided above the resin bed in an ion exchange column to allow for expansion of the bed during backwashing.

3.4.49 Grain

A unit of weight; 0.0648 grams.

3.4.50 Grains per gallon

a) An expression of concentration of material in solution, generally in terms of calcium carbonate. One grain (as calcium carbonate) per gallon is equivalent to 17.1 parts per million.

b) a unit of water hardness defined as 1 grain (64.8 milligrams) of calcium carbonate dissolved in 1 US gallon of water (3.785412 L). It translates into 1 part in about 58,000 parts of water or 17.1 parts per million (ppm). Also called Clark degree (in terms of an imperial gallon).

3.4.51 Gram-milliequivalents

the equivalent weight in grams, divided by 1000.

3.4.52 GEL

Ion exchange resins that are made up of firm gel structure in a solid bead form allowing for the diffusion of ions through the gel.

3.4.53 Hardness

the scale-forming and lather- inhibiting qualities which water, high in calcium and magnesium ions, possesses. Temporary hardness, caused by the presence of magnesium or calcium bicarbonate, is so called because it may be removed by boiling the water to convert the bicarbonates to the insoluble carbonates. Calcium sulfate, magnesium sulfate, and the chlorides of these two metals cause permanent hardness.

3.4.54 Hardness as Calcium Carbonate

the expression ascribed to the value obtained when the hardness forming salts are calculated in terms of equivalent quantities of calcium carbonate; a convenient method of reducing all salts to a common basis for comparison.

3.4.55 Head loss

the reduction in liquid pressure associated with the passage of a solution through a bed of exchange material; a measure of the resistance of a resin bed to the flow of the liquid passing through it.

3.4.56 Hydraulic classification

the rearrangement of resin particles in an ion exchange unit. As the backwash water flows up through the resin bed, the particles are placed in a mobile condition wherein the larger particles settle and the smaller particles rise to the top of the bed.

3.4.57 Hydrogen cycle

complete course of cation exchange operation in which the adsorbent is employed in the hydrogen or free acid form.

3.4.58 Hydroxyl

the term used to describe the anionic radical (OH-) which is responsible for the alkalinity of a solution.

3.4.59 Hydroxymethyl furfural, HMF

5 (Hydroxymethyl) -2-furaldehyde, a precursor of the coloring matter from the decomposition of glucose and also thereby assisting in the color development in sugars. HMF is produced during contact with strong acid cation resins in H^+ form at elevated temperatures.

3.4.60 Influent

the solution which enters an ion exchange unit.

3.4.61 Ion

any particle of less than colloidal size possessing either a positive or a negative electric charge.

3.4.62 Ion exchange

an exchange of ions in a crystal with irons in a solution. Used as a method for recovering valuable metals, such as uranium, from solution.

3.4.63 Ionisation

the dissociation of molecules into charged particles.

3.4.64 Ionisation constant

an expression in absolute units of the extent of dissociation into ions of a chemical compound in solution.

3.4.65 Kilograin

unit of weight; one thousand grains.

3.4.66 Leakage

the phenomenon in which some of the influent ions are not adsorbed or exchanged and appear in the effluent when a solution is passed through an under- regenerated exchange resin bed.

3.4.67 Microporous

resins that have a rigid polymer porous network in which there exists a true pore structure even after drying. The pores are larger than atomic distances and are not part of the gel structure.

3.4.68 Monomer

A single reactive molecule capable of combining with another different monomer to form a polymer. where two monomers combine the resulting product is called a polymer.

3.4.69 Negative charge

the electrical potential which an atom acquires when it gains one or more electrons; a characteristic of an anion.

3.4.70 Physical stability

the quality which an ion exchange resin must possess to resist changes that might be caused by attrition, high temperatures, and other physical conditions.

3.4.71 Porosity

an expression of the degree of permeability in ion exchange resins to liquids and large organic molecules. Gel resins, even when referred to as highly porous, have a negligible porosity in comparison to the macropores inherent in the microporous resins.

3.4.72 Positive charge

the electrical potential acquired by an atom which has lost one or more electrons; a characteristic of a cation.

3.4.73 Quaternary ammonium

a specific basic group $[-N(CH_3)^{3+}]$ on which depends the exchange activity of certain anion exchange resins.

3.4.74 Raw water

untreated water from wells or from surface sources.

3.4.75 Regenerant

the solution used to restore the activity of an ion exchanger. Acids are employed to restore a cation exchanger to its hydrogen form; brine solutions may be used to convert the cation exchanger to the sodium form. The anion exchanger may be rejuvenated by treatment with an alkaline solution.

3.4.76 Regeneration

restoration of the activity of an ion exchanger by replacing the ions adsorbed from the treated solution by ions that were adsorbed initially on the resin.

3.4.77 Resistivity

a measure of specific resistance to the flow of electricity. In water, it is an accurate measure of ionic purity.

3.4.78 Rinse

the operation which follows regeneration; a flushing out of excess regenerant solution.

3.4.79 Salt splitting

the conversion of salts to their corresponding acids or bases by passage through ion exchange resins containing strongly acidic or strongly basic functional groups.

3.4.80 Selectivity

the difference in attraction of one ion over another by an ion exchange resin.

3.4.81 Siliceous Gel Zeolite

a synthetic, inorganic exchanger produced by the aqueous reaction of alkali with aluminum salts.

3.4.82 Sphericity

relating to the spherical nature and whole bead content of a resin.

3.4.83 Sulfonic

specific acidic group (SO_3H) on which depends the exchange activity of certain cation exchange resins.

3.4.84 Swelling

the expansion of an ion exchange bed which occurs when the reactive groups on the resin are converted into certain forms.

3.4.85 Throughput

the amount of solution treated prior to the exhaustion of the ion exchange resin.

3.4.86 Throughput volume

the amount of solution passed through an exchange bed before exhaustion of the resin.

3.4.87 Total ionized solids

concentration of dissolved ions in solution, expressed in concentration units of NaCI (sodium chloride). It determines the operating life of ion exchange resins, and is calculated from measurements of Specific Resistance.

3.4.88 Total organic carbon

A measure of the level of organic impurities in water, which determines the operating life of activated carbon beds.

3.4.89 Upflow

the operation of an ion exchange unit in which solutions are passed in at the bottom and out at the top of the container.

3.4.90 Valence

a measurement of the number of atoms or ions of hydrogen it takes to com- bine with or be replaced by an element or radical. In short, the number of positive or negative charges of an ion.

3.4.91 Void volume

the space between particles of ion exchange resins in a settled bed, also called interstitial volume.