

APPENDIX-I

FRACTIONS AND MULTIPLICATIONS OF UNITS

(A) Greek Alphabets

A	α	Alpha	N	ν	Nu
B	β	Beta	Ξ	ξ	Xi
Γ	γ	Gamma	O	o	Omicron
Δ	δ	Delta	Π	π	Pi
E	ϵ	Epsilon	P	ρ	Rho
Z	ζ	Zeta	Σ	σ	Sigma
Θ	θ	Theta	Y	υ	Upsilon
I	ι	Iota	Φ	ϕ	Phi
K	κ	Kappa	X	χ	Chi
Λ	λ	Lambda	Ψ	ψ	Psi
M	μ	Mu	Ω	ω	Omega

(B) SI Units

Fraction	Prefix	Abbreviation	Power	Prefix	Abbreviation
10^{-1}	deci	d	10^1	deca	da
10^{-2}	centi	c	10^2	hecta	h
10^{-3}	milli	m	10^3	kilo	k
10^{-6}	micro	μ	10^6	mega	M
10^{-9}	nano	n	10^9	giga	G
10^{-12}	pico	p	10^{12}	terra	T
10^{-15}	femto	f			
10^{-18}	atto	a			

APPENDIX II

(A) Some Notations of Units and their Abbreviations in SI Units

Property	Units in full names	Abbreviations for the units
Acceleration due to gravity	metre per second square	m/s ²
Amount of heat	joule	J
Capacity of a pump	metre cube per hour	m ³ /h
Centrifugal force	newton	N
Concentration	Moles	Mol
	Molarity	M
	Normality	N
	Molality	m
Density	kilogram per metre cube	kg/m ³
Displacement in pump	metre cube per minute	m ³ /min
Drop in head	metre	m
Energy	joule	J
Enthalpy per unit mass	joules per kilogram	J/kg
Film coefficient or Surface coefficient	watt per metre square-Kelvin	W/m ² ·K
Force	newton	N
Frequency	hertz	Hz
Gravitational force	newton	N
Heat transfer	joule	J
Heat transfer coefficient	watt per metre square-Kelvin	W/m ² ·K
Heat transfer rate	joule per second	J/s
Height or length	metre	m
Length	metre	m
Mass	kilogram	kg
Power	watt	W
Pressure	pascal	Pa
Pressure drop	pascal	Pa
Pressure head	metre	m

Property	Units in full names	Abbreviations for the units
Rate of discharge of liquid	meter cube per minute	m ³ /min
Rate of drying	kilogram per hour	kg/h
Rate of entry of feed	kilogram per hour	kg/h
Specific energy	millijoule per kilogram	mJ/kg
Specific surface	metre square per meter cube	m ² /m ³
Speed of rotation	Revolutions per second	r/s
Steam pressure	pascal	Pa
Stefan Boltzmann constant	watt per metre square Kelvin ⁴	W/m ² ·K ⁴
Surface area	metre square	m ²
Surface energy	millijoules per metre square	mJ/m ²
Temperature	Degree Kelvin	K
	Degree Celsius	°C
Tensile strength	megapascal	Mpa
Thermal conductivity	watt per metre square-Kelvin	W/m ² ·K
Time	second (or minute or hour)	s (or min or h)
Velocity	metre per second	m/s
Viscosity	pascal.second	Pa·s
Volume	metre cube (or litre)	m ³ (or l)
Work done	watt hour	W·h
Young's modulus	megapascal	Mpa

(B) Some Important conversions in SI Units

Pascal (Pa)	= N/m ²	= kg/m·s ²
Newton (N)	= kg/m	
Joule (J)	= N·m	= kg·m ² /s ²
N·m	= J	
N·m/s	= J/s	= W
J/s	= W	
W	= N·m/s	

APPENDIX-III
INTER-CONVERSION OF UNITS

TABLE-1
FPS to SI Units

Measurement	Unit	Conversion factor	Reciprocal
Area	1 ft ²	$9.290 \times 10^{-2} \text{ m}^2$	10.764
	1 in ²	$6.452 \times 10^{-4} \text{ m}^2$	1550
Density	1 lb/ft ³	16.0185 kg/m ³	6.243×10^{-2}
	1 lb/in ³	27.680 kg/m ³	3.613×10^{-5}
Energy, work and power	1 Btu	$1.055 \times 10^3 \text{ joules}$	9.4781×10^{-4}
Force	1 lbf	4.448 N	0.225
Heat transfer coefficient	Btu/s·ft ² °F	20.44 kW/m ² ·K	4.89×10^{-2}
Length	1 foot	0.3048 meter	3.2808
	1 inch	$2.54 \times 10^{-2} \text{ meter}$	39.370
Mass	1 pound (lb)	0.4536 kg	2.2046
	1 US ton	$9.072 \times 10^{-4} \text{ kg}$	11.02×10^2
Mass flow rate	1 lb/s	0.454 kg/s	2.205
Power	1 ft.lbf/s	1.356 W	0.738
	1 lbf·ft	$1.355 \times 10^{-3} \text{ kJ}$	7.38×10^2
Pressure	1 lbf/in ²	6895 Pa	1.45×10^{-4}
	1 atm.	$1.013 \times 10^2 \text{ kPa}$	9.87×10^{-3}
	1 bar	100 kPa	0.01
	1 inHg	3386 Pa	2.95×10^{-4}
Stress	1 lbf/in ²	$6.8948 \times 10^3 \text{ kPa}$	1.4504×10^{-4}
Thermal conductivity	1 Btu·ft/h·ft ² ·°F	1.730 W/m·K	0.578
	1 Btu·in/h·ft ² ·°F	0.1442 W/m·K	6.935
Thermal resistance	1 °F·ft ² ·h/Btu	$1.761 \times 10^2 \text{ K} \cdot \text{m}^2/\text{kW}$	5.679×10^{-3}
	1 lbf/ft ²	$4.788 \times 10^{-2} \text{ kPa}$	20.886
Vacuum	1 inHg (60°F)	3.377 kPa	0.2961
	1 inH ₂ O (39.2°F)	0.2491 kPa	4.0145
Velocity	1 ft/s	0.305 m/s	3.281
	1 in/s	0.0254 m/s	39.37

Measurement	Unit	Conversion factor	Reciprocal
Viscosity	1 lbf·s/in ²	$6.894 \times 10^3 \text{ Pa} \cdot \text{s}$	1.451×10^{-4}
	1 lbf·s/ft ²	47.88 Pa·s	2.0886×10^{-2}
Volume	1 ft ³	$2.832 \times 10^{-2} \text{ m}^3$	35.315
	1 in ³	$1.693 \times 10^{-5} \text{ m}^3$	61.024
	1 US gallon	$4.54 \times 10^{-3} \text{ m}^3$	220.264

TABLE-2
Interconversion of Units (Fundamental and Derived) with Conversion Factors

Unit	Conversion factor × unit	Reciprocal
1 foot	= 30.48 cm (or ml)	0.03281
1 pound (lb)	= 453.6 gram	2.2046×10^{-3}
1 cm ²	= $1.639 \times 10^{-5} \text{ m}^2$	6.1024×10^4
1 dyne	= 0.01 mN	100
1 dyne/cm ²	= 0.1 Pa	10
1 cm H ₂ O (4°C)	= $9.80 \times 10^{-2} \text{ kPa}$	10.205
1 cal	= $4.184 \times 10^{-3} \text{ kJ}$	239.00
1 erg	= $1.0 \times 10^{-7} \text{ J}$	10 ⁷
1 °C·m ² ·h/kcal	= $8.604 \times 10^2 \text{ K} \cdot \text{m}^2/\text{kW}$	1.162×10^{-3}
1 cal·m/s·cm ² ·°C	= $4.184 \times 10^2 \text{ W/m} \cdot \text{K}$	2.39×10^{-3}
1 mmHg	= 6.895 kPa	0.145
1 cal/s·cm ² ·°C	= $41.84 \text{ kW/m}^2 \cdot \text{K}$	2.39×10^{-2}

TEMPERATURES

TABLE-3
Interconversion of Temperature and Relevant Equations

1 R (Rankine)	= (1/18) K (Kelvin)
1 K (Kelvin)	= 1.8 R (Rankine)
T R (Rankine)	= T °F + 459.67
T °F (Fahrenheit)	= T R - 459.67
T °C (Celcius)	= (°F - 32)/1.8 °C
T °F (Fahrenheit)	= 32 + 1.8 °C
ΔT °C	= 1.8 ΔT °F = ΔT K

DEFINITIONS AND MEANINGS

- Actual screen :** A screen which does not give perfect separation about the cut diameter of the powder.
- Agitation :** Refers to the induced motion of a material in a specified way, usually in a circulatory pattern inside a container.
- Air binding:** In centrifugal pumps, the entry of air into the pump at the initial stage practically stops delivering the liquid. This phenomenon is known as air binding.
- Amorphous solids :** These are the solids which do not have specific shape.
- Attrition :** It involves breaking down of the material by rubbing action between two surfaces.
- Axial angle :** It is an angle between the two perpendiculars to the intersecting faces in a crystal.
- Axial flow of liquids :** The flow of liquid that acts in a direction parallel to the impeller shaft.
- Axial length :** It is the distance between centres of two atoms in a crystal.
- Azeotropic distillation :** It is a distillation method in which azeotropic mixture is broken by the addition of a third substance, which forms a new azeotrope with one of the components.
- Azeotropic solution :** It is a solution which distils unchanged at a constant temperature.
- Belt idlers :** These are supporting rollers, which are arranged on a shaft below the belt.
- Bernoulli's theorem:** States that in a steady state, ideal flow of an incompressible fluid, the total energy per unit mass, which consists of pressure energy, kinetic energy and datum energy, at any point of the fluid is constant.
- Binary liquids :** Are those liquids which are miscible with one another in all proportions.
- Biological corrosion :** The metabolic action of microorganisms can either directly or indirectly cause deterioration of a metal (corrosion).

- Black body :** It is a body that radiates maximum possible amount of energy at a given temperature.
- Blending :** It is mixing of powders smoothly and inseparably together.
- Bound water :** Is the minimum water held by the material that exerts an equilibrium vapour pressure less than the pure water at the same temperature.
- Bulk transport :** Is the movement of a large portion of a material from one location to another location in a given system.
- Calandria :** It is a steam compartment, which consists of a number of tubes fitted in a vessel and is included in the evaporator.
- Caking :** Is the process of formation of clumps or cakes when crystals are improperly stored.
- Cavitation :** It is a phenomenon of formation of vapour bubbles and their sudden collapse in a pump.
- Centrifugal effect :** It is expressed as a ratio of centrifugal force to gravitational force.
- Centrifugal force :** It is due to inertia of a rotating body and it acts on the rotating body in a direction away from the point or axis of rotation or revolution.
- Centrifugal pump :** An hydraulic machine which converts the mechanical energy into pressure energy by means of centrifugal force.
- Centrifugation :** It is a unit operation employed for separating the constituents present in a dispersion with the aid of centrifugal force.
- Clarification :** It is a process of separation of liquids containing solids not exceeding 1.0%.
- Coefficient of thermal conductivity :** Is defined as the quantity of heat flowing per second across one square metre area of cross section of a slab of the material of one metre thickness, whose faces are maintained at a steady temperature difference of one degree Kelvin.
- Compression :** It is a means by which the material is crushed between rollers by the application of pressure.
- Conduction :** It is a process in which heat flow in a body is achieved by the transfer of the momentum of individual atoms or molecules without mixing.
- Convection :** It is a process in which heat flow is achieved by actual mixing of warmer portions with cooler portions of the same material.
- Corrosion :** Is a reaction of a metallic material with its environment, which causes a measurable change to the material and can result in a functional failure of the metallic component or of a complete system.

Critical humidity : Is the humidity above which crystals absorb moisture and below which they do not absorb moisture.

Crystal : It is a solid particle, which is formed by the solidification (crystallisation) process (under suitable environment) of a substance in which structural units are arranged by a fixed geometric pattern or lattice.

Crystal growth : It is a diffusion of solute molecules or ions from solution to reach the faces of a crystal, which helps in their growth.

Crystal hydrate : It is a solid substance which associates with water.

Crystal lattice : It is the orderly internal arrangement of particles in three dimensional space.

Crystallization : Is a spontaneous arrangement of the particles into a repetitive orderly array, i.e., regular geometric patterns.

Cutting : It is a means of tearing the material by a sharp blade.

Dalton's law : It states that the total pressure exerted by an ideal gaseous mixture is equal to the sum of the individual partial pressures of the component gases, if alone were present and occupied the total volume.

Depth filtration : It is a filtration process, in which the slurry penetrates to a point where the diameter of solid particles is greater than that of the tortuous void or channel.

Destructive distillation : It is a distillation method in which the distillate is a decomposition product of the constituents of the organic matter burnt in the absence of air.

Diaphragm : It is a flexible physical barrier.

Distilland : The feed liquid mixture to be distilled.

Distillate (condensate) : The liquid condensed during distillation.

Distillation : It is a separation of the components of a liquid mixture by processes involving vaporisation and subsequent condensation at another place.

Double acting pump : It is a pump that displaces water on both halves of the cycle of the movement of the pumping element (piston or plunger), i.e., during up-stroke and down-stroke.

Drop-wise condensation : It is a process in which the condensed liquid collects as drops that may range from microscopic size up to drops that are seen with the naked eye.

Drying : It is a process of removal of small amounts of water or other liquid from a material by the application of heat.

Energy : The energy of a body is measure of the capacity or ability of the body to do work.

Energy balance : The law of conservation of energy states that the energy output must be same as the energy input in any process.

Equilibrium moisture content (EMC) : Is the amount of water present in the solid, which exerts a vapour pressure equal to the vapour pressure of the atmosphere surrounding it.

Erosion : It is the destruction of a metal by abrasion and attrition caused by the flow of liquids or gases.

Eutectic point : The temperature and pressure at which the frozen solid vaporises without conversion to a liquid.

Evaporation : It is a process of vaporising large quantities of volatile liquid to get a concentrated product.

Extractive distillation : It is a distillation method in which azeotropic mixture is broken by the addition of a third substance which is relatively nonvolatile liquid compared to the components to be separated.

Film type condensation : A process in which the condensed liquid wets the surface on which it is condensing and forms a continuous film of condensate.

Filter aid : It forms a surface deposit which screens out the solids and also prevents plugging of the supporting filter medium.

Filter cake : The accumulated solids that are retained on the filter medium.

Filter medium : Is a porous medium used to retain the solids.

Filtrate : The clear liquid that has passed through the filter medium.

Filtration : Is a process of separation of solids from a fluid by passing the same through a porous medium that retains the solid but allows the fluid to pass through.

Filtration centrifuge : A centrifuge in which solids pass through the porous medium based on the difference in the densities of the solid and liquid phases on application of centrifugal force.

Flash distillation (equilibrium distillation) : It is a distillation process in which the entire liquid mixture is suddenly vaporised (flash) by passing the feed from a high pressure zone to a low pressure zone.

Flaw in a particle : It is a structural weakness that may develop into a crack under strain.

Flight in conveyor : The conveying mechanism such as screw element used in the screw conveyor.

Fluid dynamics : It deals with the study of fluids in motion.

Fluid flow : It is the study of flow of substances that do not permanently resist distortion.

Fluid statics : It deals with the fluids at rest in equilibrium.

Fluidised state : It is a state in which solids are suspended in a stream of air.

Forced convection : It is a heat transfer process in which mixing of fluid is obtained by a stirrer or agitator or pumping the fluid for recirculation.

Fourier's law : This law states that the rate of heat flow through a uniform metal is proportional to the area, the temperature drop and inversely proportional to the length of the path of flow

Fractional distillation : It is a distillation process in which vaporisation of liquid mixture gives rise to a mixture of constituents from which the desired one is separated in pure form.

Fractionating column : It is a special type of still-head in which condensation and revaporisation take place simultaneously.

Free moisture content (FMC) : Is the amount of water that is free (easy) to evaporate from the surface.

Galvanic corrosion : Corrosion associated with the flow of current to a less-active metal (cathode) from a more-active metal (anode) in the same environment.

Grey body : It is a body whose absorptivity is constant at all wavelengths of radiation, at a given temperature.

Heat exchanger : It is a heating device used for transferring heat from one fluid (hot gas or steam) to another fluid through a metal wall.

Heat interchanger : It is a heating device used for transferring heat from one liquid to another liquid or from one gas to another gas through a metal wall.

Ideal screen : A screen which sharply separates the feed mixture in such a way that the smallest particle in the oversize will be just larger than the largest particle in the undersize.

Ideal solution (perfect solution) : It is a solution in which the attractions between unlike molecules are of the same order as between like molecules.

Impact : It involves the operation of splitting the material apart, when a lump of material strikes against the rotating hammers.

Inertia : It is the intrinsic property of a body by virtue of which it cannot change by itself its state of rest or uniform motion along a straight line.

Isomorphism : It is a phenomenon in which two or more substances possess the same crystalline form and crystals of one such substance can be grown in the saturated solution of the other.

Kinetic energy : Of a body is the energy possessed by the body by virtue of its motion.

Laminar flow (viscous flow) : It is a flow in which the fluid particles move in layers or laminar with one layer sliding over the other.

Laminar mixing : Is the mixing of two dissimilar liquids through laminar flow, i.e., the applied shear stretches the interface between them.

Latent heat of vaporisation : Is defined as the quantity of heat required to convert a unit mass of the liquid at its boiling point from the liquid to the vapour state without a change in temperature.

Manometers : These are the devices used for the measurement of pressure difference at a point of fluid.

Material balance : The law of conservation of matter states that material cannot be destroyed or created, it can be changed from one form to another.

Mier's supersaturation theory : Postulates a definite relationship between concentration and temperature at which crystals will spontaneously form in an initially unseeded solution.

Miscible liquids : These liquids are miscible in all proportions.

Mixing : Putting together in one mass or assemblage with more or less thorough diffusion of the constituent elements among one another.

Mixing : Is a process that tends to result in a randomization of dissimilar particles within a system.

Molecular diffusion : Is the mixing at molecular level in which molecules diffuse due to thermal motion.

Molecular distillation (short path distillation or evaporative distillation) : It is a distillation method in which each molecule in the vapour phase travels mean free path and gets condensed individually without intermolecular collisions on application of vacuum.

Natural convection : It is a heat transfer process in which mixing of fluids is accomplished by the natural currents set up, when body of fluid is heated.

Nucleation : It refers to the birth of very small bodies of a new phase within a homogenous supersaturated liquid phase, which is responsible for crystallisation.

Over-size powder : The material that remains on the given screening surface.

Partially miscible liquids : These are the liquids, which are miscible in one another at one particular proportion.

Permeability : It is the flow rate of a liquid of unit viscosity across a unit area of cake thickness under a pressure gradient of unity.

Pitch : It is the distance the propeller would move through the fluid per revolution, if slippage does not occur.

Polymorph : It is a chemical substance, which can exist in more than one crystalline form.

Potential energy : It is the energy possessed by the body by virtue of its position or configuration.

Power pump : It is a pump in which the moving element (piston or plunger) is actuated by some form of energy other than steam.

Pressure head : It is defined as the height of a column of liquid of known density, which is numerically equal to a pressure term.

Pseudomorph : It is a solid form, which arise because of inclusion of small amounts of solvent of crystallisation.

Radial flow of liquid : It is the flow of liquid that acts in a direction vertical to the impeller shaft.

Radiation : It is a process in which heat flows through space by means of electromagnetic waves.

Raoult's law : It states that the partial vapour pressure of each volatile constituent is equal to the vapour pressure of the pure constituent multiplied by its mole fraction in the solution at a given temperature.

Real solution (perfect solution) : The solution which does not obey ideal solution behaviour or which do not obey Raoult's law.

Reciprocating pump : It is a pump in which the pumping element moves in a forward and backward directions in a cylinder.

Reducing valves : These are the valves used in order to maintain uniform pressure in one part of the system at a level lower than the pressure in another part of the system.

Reynolds number : It is a ratio of inertial force to viscous force of a flowing fluid.

Rotary positive displacement pump : It is a pump in which liquid is mechanically displaced by the rotation of one or more elements within a stationary housing.

Sedimentation centrifuge : A centrifuge that produces sedimentation of solids based on the difference in the densities of two or more phases of the mixture.

Self-priming pump : It is a pump, which can remove air from casing by suitable mechanism.

Sieve number : It indicates the number of meshes per linear length of 0.0254 m (one inch).

Simple distillation : Is a process of converting a single constituent from a liquid (or mixture) into its vapour, transferring the vapour to another place and recovering the liquid by condensing the vapour, usually by allowing it to come in contact with the cold surface.

Single acting pump : It is a pump, which displaces water on one half of the cycle of the movement of the pumping element (piston or plunger), i.e., during the down stroke.

Size reduction : Is a process of reducing large solid unit masses (vegetable or chemical substances) into small unit masses, coarse particles or fine particles.

Size separation : It is a unit operation, that involves the separation of a mixture of various sizes of particles into two or more portions by means of screening surfaces.

Steady state system : The system is said to be in steady state, if the operating conditions do not vary with time.

Steam distillation : It is a method of distillation carried with the aid of steam and is used for the separation of high boiling substances from nonvolatile impurities.

Stoichiometry : It means carrying out of calculations based on quantitative relationships.

Sublimation : It is a process in which direct change of water from solid into vapour takes place without conversion into a liquid phase.

Supersaturated solution : Is one that contains more of the dissolved solute than it would normally contain in a saturated solution at a definite temperature.

Surface coefficient : It is the conductive capacity of the stagnant film for the transfer of heat.

Surface filtration : It is a screening action (filtration process) by which pores or holes of the medium prevent the passage of solids.

Tangential flow of liquid : It is the flow of liquid that acts in a direction tangent to the circle of rotation around the impeller shaft.

Thermal conductivity : It is the reciprocal of thermal resistance.

Turbulent flow : A flow is said to be turbulent, if the Reynolds number is more than 4000 in a pipe.

Turbulent flow : It is the flow in which the fluid particles continuously transfer momentum to adjacent layers.

Turbulent mixing : is mixing due to turbulent flow, which results in random fluctuation of the fluid velocity at any given point within the system.

Unbound water : Is the amount of water (moisture) held by the material that exerts an equilibrium vapour pressure equal to that of pure water at the same temperature.

Under-size powder : The material that can pass through the screening surface

Unit cell : It is the smallest geometric portion of the crystal, which repeats to build up the whole crystal.

Unit operation : A process frequently consists of a fewer number of distinct individual steps. Each step is called unit operation.

Unit process : It is one in which several unit operations are combined in a sequence to achieve the objectives of a chemical or physical process.

Unsteady state : If the operating conditions are varying with time, then the system is said to be in unsteady state.

Validation : It is a procedure that demonstrates the ability of consistently producing a product with the established specifications under ideal conditions.

Valve : It is a device used to control the rate of flow of fluid in a pipeline.

Variable area meter : It is a device that measures the area of flow, so as to produce a constant head differential.

Variable head meter : It is a device that measures the variation in the pressure across a fixed constriction placed in the path of flow consisting of a constant area.

Viscous flow : A flow is said to be viscous if the Reynolds number is less than 2000 in a pipe or the fluid flows in layers.

Volatility : Of any substance in solution may be defined as the equilibrium partial pressure of the substance in the vapour state divided by the mole fraction of the substance in the solution.

Vortex : It is a strong circulatory flow pattern manifests near the impeller shaft.

Young's modulus : The ratio of the longitudinal stress to the longitudinal strain within elastic limits.

Zeotropic mixture : It is a mixture whose total vapour pressure is always intermediate between those of pure components.

APPENDIX-V

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