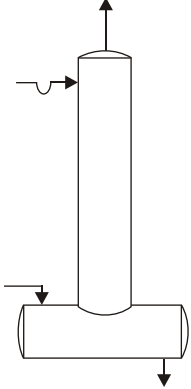
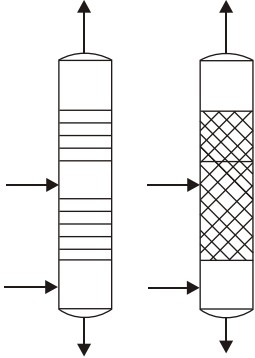
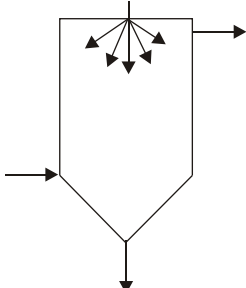
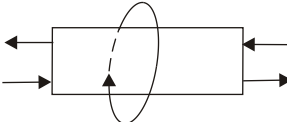
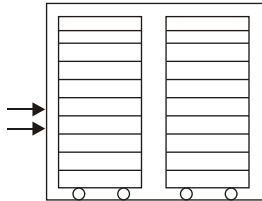
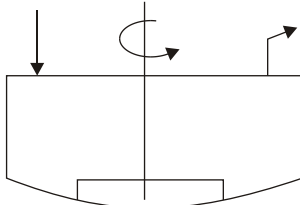


Appendix - A

Process Equipment Symbols

<i>Unit Operation</i>	<i>Schematic Representation</i>	<i>Comments</i>
<p>1. Distillation</p> <p>(a) Batch</p>		<p>Utilized for intermittent operation and handling small volumes of feed and product</p>
<p>(b) Continuous Fractionator</p>		<p>Suitable for high volume continuous separation of complex mixtures eg. petroleum fraction</p>
<p>2. Drying of Solids</p> <p>(a) Spray Drier</p>		<p>Employed for large capacity operation on liquid feed to give powdered, spherical, free flowing product ;used in production of pigments, detergents, synthetic resins and misc inorganic salts</p>

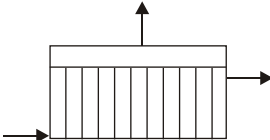
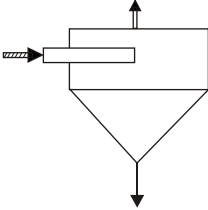
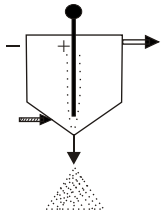
Unit Operation	Schematic Representation	Comments
(b) Rotary Drier		<p>Suitable for drying free flowing granular solids which do not dust or stick ; high temp models are kilns for calcining cement, lime, etc.</p>
(c) Tunnel Drier		<p>Best suited to drying pastes or powders in trays ; also used to dry pottery, lumber, leather, etc., In sheet shaped forms</p>
3.Evaporation		<p>Used for small batches ; often of viscous mat's ; such designs are easy to clean</p>
(a) Open Pan		

Unit Operation	Schematic Representation	Comments
<p>4. Extraction</p> <p>(a) Liquid - liquid</p>		<p>Used to contact solvent and feed to give raffinate and extract ; widely adapted to removal of naphthenes from lube oil fractions Using solvents such as furfural</p>
<p>(b) Solid-Liquid (Leaching)</p>		<p>Involves removal of a solute from a Solid by means of a liquid solvent Often used in ore treatment to Recover metal values</p>
<p>5.Fluid Handling</p> <p>(a)Centrifugal pump</p>		<p>Most widely used for liquids of all types ; simple in construction and maintenance</p>

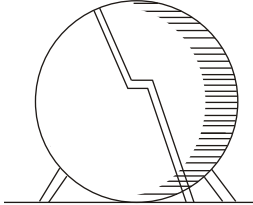
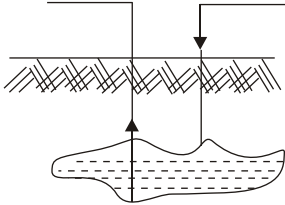
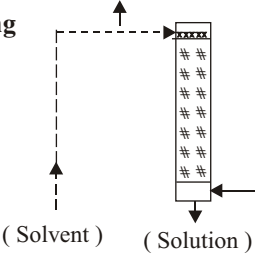
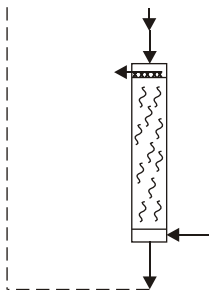
Unit Operation	Schematic Representation	Comments
(b) Reciprocating Pump Or Compressor		Generally used for higher pressure delivery ; may be used for metering or proportioning
(c) Jet Ejector		Used for lower pressure operation or production of vacuum ; steam often used as motive fluid
6. Fluid - Solid Contacting		
(a) Fixed Bed		Most widely used type of catalytic reactor ; used with precious metal catalysts to minimize attrition losses ; catalyst usually in form of pellets

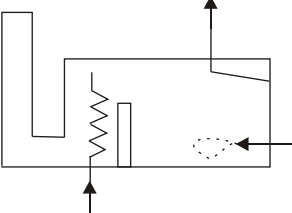
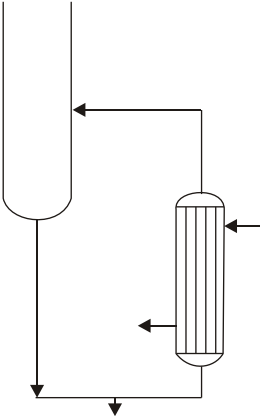
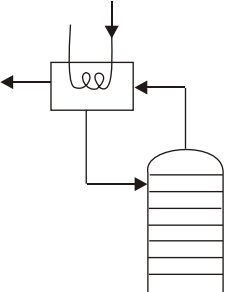
Unit Operation	Schematic Representation	Comments
6 . Fluid Bed		<p>Used to contact finely divided solids with reactant gases <i>e.g.</i>, Cracking catalyst with oil vapor and then with air ; also used in roasting of sulfide ores to give oxides and SO₂</p>
7. Fluid - Solid Separation	<p>(a) Centrifugation</p>	<p>Used to separate very finely divided solids from liquid or liquids from liquid emulsions</p>
(b) Setting Tank		<p>Simple device used to remove large particles from gas stream by simple setting in low velocity zone</p>

Unit Operation	Schematic Representation	Comments
(c) Wet Scrubber		<p>Effective means of removing suspended particles from gas stream by contact with liquid shower</p>
(d) Crystallizer		<p>Hot, nearly-saturated solutions are stirred and cooled to effect nucleation and crystal growth ; widely used with inorganic salts.</p>
(e) Filter (Rotary)		<p>Vacuum applied to interior of drum pulls filtrate out of cake; used to separate minerals from slurries, pulp fibers from water, etc.</p>

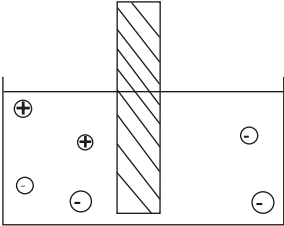
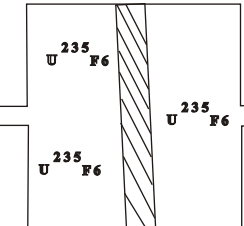
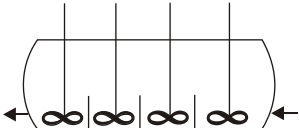
Unit Operation	Schematic Representation	Comments
(f) Filter Press		<p>Simplest type of pressure filter; widely used ; plates and fabric filter media may be made of a variety of corrosion resistant materials</p>
(g) Cyclone Separator		<p>Used to separate solid particles or liquid droplets from gases to permit product recovery or to cut down product loss and air pollution</p>
(h) Electrostatic Precipitator		<p>Used to remove fine dusts or mists suspended in gases ; features high collection efficiency at wide variety of operating conditions.</p>

Unit Operation	Schematic Representation	Comments
(j) Thickener - Classifier		<p>Used to separate slurry into sludges and clear liquids ; used widely in mineral industries and in sewage effluent clarification</p>
8 . Fluid Storage		
(a) Gas Holders		<p>Used for low pressure storage of gases at constant pressure using liquid seal (usually water)</p>
(b) Tanks		<p>Widely used for storage of liquids of all types , usually at atmospheric pressure ; may have floating roof</p>

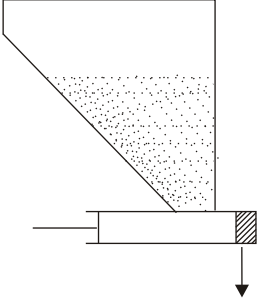
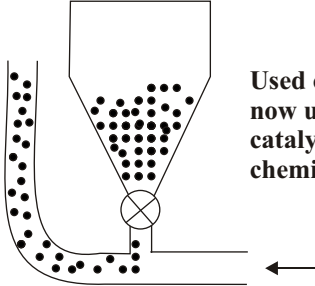
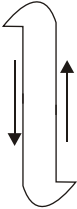
Unit Operation	Schematic Representation	Comments
(c) Pressurized Spheres		Used for pressurized storage of liquified gases or high vapor pressure liquids to permit safe storage with no vapor losses
(d) Underground Caverns		Used for large volume storage of liquids or of liquified gases
9. Gas-Liquid Contacting		
(a) Absorption		Used for taking up a soluble gas in a solvent liquid and producing a solution plus a lean exit gas ; e.g., Used in H ₂ S removal from hydrocarbons
(b) Stripping		Used for removing a soluble gas from solution by counter-current contact with an inert gas ; used to recover solute gas and regenerate solvent for subsequent absorption step

Unit Operation	Schematic Representation	Comments
<p>10. Heat Exchange (a) Fired Heater</p>		<p>Used to heat petroleum fraction to distillation or cracking temperatures in direct fired tubes.</p>
<p>(b) Reboiler</p>		<p>Uses natural circulation to circulate fractionating tower bottom in heat exchange with steam , e.g., to provide necessary heat for fractionation</p>
<p>(c) Condenser</p>		<p>Usually water-cooled tubular construction to provide reflux and overhead product from fractionating column</p>

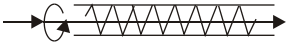
Unit Operation	Schematic Representation	Comments
(d) Shell And Tube Exchanger		Common type of device for process heat exchange
(e) Jacketed Kettle		Common construction for reaction kettles ; water or brine may be used for cooling ; hot water, oil or Dowtherm for heating
(f) Direct Mixing (Quenching)		Features intimate contact of coolant fluid (e.g., water) with process gases to give quick quench, e.g., in hydrocarbon pyrolysis to acetylene


Unit Operation	Schematic Representation	Comments
<p>11. Membrane Separation</p>		<p>Used to separate salts in sol's having widely different mole. E.g., Caustic from sugar or cellulose</p>
<p>(a) Dialysis</p>		<p>Uses micro porous (e.g., Ni) barriers in multistage operation to separate light (e.g., $U_{235}F_6$) from heavy (e.g., $U_{238}F_6$) components</p>
<p>(b) Gaseous Diffusion</p>		<p>May be used for liquid - liquid or solid - solid mixing in single or multiple compartments ; widely used in process industries</p>
<p>12. Mixing</p>	<p>(a) Agitation</p>	<p>May be used for liquid - liquid or solid - solid mixing in single or multiple compartments ; widely used in process industries</p>

Unit Operation	Schematic Representation	Comments
(b) Solids Blending		<p>The device shown divides and recombines a granular mass over and over again to effect uniformity</p>
13. Size Reduction and Enlargement		
(a) Crushing		<p>Used typically in 4:1 size reduction of hard materials from -5 to -20 mesh or -1 to -4 mesh</p>
(b) Grinding		<p>Wet or dry grinding may be carried out in presence of balls, pebbles or rods; feed may be -4 to -100 mesh and reduction ratio 10 - 15 to 1</p>

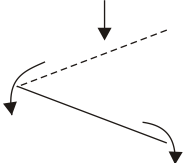
Unit Operation	Schematic Representation	Comments
(c) Pelletizing		<p>Used to make tablets from powders of Medicinals, catalysts, etc</p>
14. Solids Handling		
(a) Pneumatic Conveying		<p>Used originally for grain; now used widely for cement, catalysts, coke and powdered chemicals</p>
(b) Bucket Elevators		<p>Used for elevating materials; can be used for moving powdered or granular mat'ls to and from storage or between reaction vessels as in moving bed catalytic processes</p>

<i>Unit Operation</i>	<i>Schematic Representation</i>	<i>Comments</i>
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(c) Screw conveyor  Versatile ; can be used to mix and heat or cool ; can be operated underpressure ; useful for powders or sticky material.

(d) Belt Conveyor  Can be used to handle large volumes over long distances economically ; used near horizontal ; belting may be fabric or rubber

15. Solid / Solid Separation

(a) Screening  Wire , plastic or fabric screens are used to separate solids of varying sizes

Unit Operation	Schematic Representation	Comments
(b) Elutriation		<p>May be used to remove fines from a solid by passage of a gas to fluidize and transport the fines</p>
(c) Froth Floatation		<p>Finely ground (- 50 mesh) ores are suspend in water in presence of floating reagents (e.g., RCOONa) and blow with air ; desired product collects in froth.</p>
(d) Jigging		<p>One of the oldest processes used for separation of minerals from lighter gangues as a well as for separating coal from heavier contaminants</p>

Unit Operation	Schematic Representation	Comments
(e) Magnetic Separation		<p>Used to remove tramp iron from feed to subsequent grinding and pulverizing steps ; also used to concentrate magnetic iron ores</p>