Pump Types

- **Centrifugal** - Consists of an impeller rotating in a casing. Only wearing parts are the shaft seal and bearings. Used where large flow of liquid is desired. Self-priming centrifugals have same features as straight centrifugals but will prime without a foot valve after an initial filling of the pump casing. Non self-priming centrifugals work best with the liquid source higher then the pump (flooded suction-gravity feed). *As the discharge pressure (head) increases, flow and drive power requirements decrease. Maximum flow and motor load occurs at minimum head.*
- **Positive Displacement** - Pumping is created by moving chambers or pistons. The flow rate of this pump is the same at any pressure level. Generally self-priming. Should never be operated dry because of internal wearing of rubber parts. *As discharge flow is restricted, brake horsepower requirement increases.* A relief device should be provided on the discharge line to prevent overpressure and damage to pump or motor if discharge line is closed off or severely restricted. The most common types of positive displacement are piston, flexible impeller, rotary screw, gear, diaphragm and roller or vane.
    - **Piston** - Fluid is drawn in and forced out by pistons moving within cylinders. Used where pressures up to 500-600 PSI are required.
    - **Flexible Impeller** - A flexible, vaned member, usually rubber, rotating in an eccentric housing. The volume of the spaces between the vanes changes as the pump rotates, creating pumping action. For pressures up to 30 PSI.
    - **Rotary Screw** - A screw-shaped rotor, turning within a flexible stator, usually of rubber. Progressing cavities between screw and stator carry the fluid. For pressures up to 60 PSI. Can handle abrasive mixtures or slurries at slower speeds.
    - **Gear** - Consisting of two meshed gears in a housing. As gear rotate, fluid is carried in the space between teeth and the housing. Will not handle abrasives because of close running tolerances. For pressures up to 180 PSI.
    - **Diaphragm** - Consists of a flexible diaphragm which moves in a chamber, creating suction and pressure. As the diaphragm is moved up, it creates a vacuum which opens the suction valve and draws fluid into the chamber. When the diaphragm is forced down, fluid is forced out through the discharge valve.
    - **Roller or Vane** - Rollers or vanes in a rotor, rotating in an eccentric housing like a flexible impeller pump. For pressures up to 150 PSI.

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Pump Terminology

- **Pressure** - Measured in pounds per square inch (PSI). The force exerted by the liquid.
- **Flow** - The measure of the liquid volume capacity of the pump. Gallons per hour (GPH) or gallons per minute (GPM).
- **Static Discharge Head** - Vertical distance (in feet) from pump to point of discharge.
- **Flooded Suction** - Liquid flows to the pump by gravity when liquid source is higher than pump. Preferable for centrifugal pump installation.
- **Prime** - When liquid source is lower than the pump, a charge of liquid is required to begin pumping action of centrifugal pumps. The liquid may be held in the pump by a foot valve on the intake line or a valve or chamber within the pump.
- **Seal, Mechanical** - A device mounted in the pump housing and/or on the pump shaft to prevent leakage of liquid from the pump. Has a rotating part and a stationary part with highly polished touching surfaces. Has excellent sealing capability and life, but can be damaged by dirt or grit in the liquid.
- **Viscosity** - The "thickness" of a liquid, or its ability to flow. Temperature must be stated when specifying viscosity, since most liquids flows more easily as they get warmer. The more viscous the fluid, the slower the pump speed required. Viscosity is the internal friction of a liquid tending to reduce flow. It is ascertained by an instrument termed viscosimeter, of which there are several makes, viz, Saybolt, Universal; Tangliabue; Engler (used chiefly in continental countries); Redwood (used in British Isles and colonies). In the United States, the Saybolt and Tangliabue instruments are in general use with few exceptions. Viscosity is expressed as the number of seconds required for a definite volume of fluid under an arbitrary head to flow through
- **Dynamic Suction Lift** - Vertical distance from source of supply when pumping at required capacity, to centerline of pump, plus velocity head, entrance and friction loss, but not including internal pump losses, where static suction head exists but where the losses exceed the static suction head. The dynamic suction lift is the sum of the velocity head, entrance, friction, minus the static suction head, but not including internal pump losses. Dynamic suction lift, as determined on a test, is the reading of the mercury column connected to suction nozzle of pump, plus vertical distance between point of attachment of mercury column to centerline of pump, plus head of water resting on mercury column, if any.
- **Head** - Indicates the height of a column of water being pushed by the pump. Expressed in feet or meters. For water, divide head in feet by 2.31 to get pressure in pounds per square inch.
- **Suction Head** - Sometimes called head of suction, exists when the pressure measured at the suction nozzle and corrected to the centerline of the pump is above atmospheric pressure.
- **Static Suction Head** - Vertical distance from the free level of the source of supply to centerline of pump.
- **Dynamic Suction Head** - The reading of a gauge connected to suction nozzle of pump, minus vertical distance from center of gauge to centerline of pump, as determined on test. Suction head, after deducting the various losses, may be negative quantity, in which case a condition equivalent to suction lift will prevail.
- **Velocity Head** - Sometimes called head due to velocity, the velocity head of water moving with a given velocity is the equivalent head through which it would have to fall to acquire the same velocity; or the head necessary merely to accelerate the water. Knowing the velocity, we can readily figure the velocity head from

a standardized aperture at constant temperature.

- **Specific Gravity** - Ratio of the weight of a given volume of a liquid to the same volume of pure water. Pumping heavier liquids (specific gravity greater than 1.0) will require more drive horsepower. The ratio of the weight of any volume to the weight of an equal volume of some other substance taken as a standard at stated temperatures. For solids or liquids the standard is usually water, and for gases, the standard is air or hydrogen.
- **Total Head** - The sum of friction loss, discharge head and suction lift.
- **Static Head** - The vertical distance between the free level of the source of supply and the point of free discharge, or the level of the free surface of the discharged liquid.
- **Total Dynamic Head** - The vertical distance between source of supply and point of discharge when pumping at required capacity, plus velocity head, friction, entrance and exit losses. Total dynamic head, as determined on test where suction lift exists, is the reading of the memory column connected to the suction nozzle of the pump, plus the reading of a pressure gauge connected to discharge nozzle of pump, plus vertical distance between point of attachment of mercury column and center of gauge, plus excess, if any, velocity head of discharge over velocity head of suction, as measured at points where the instruments are attached, plus head of water resting of mercury column, if any. Total dynamic head, as determined on test where suction lift exists, is the reading of the gauge attached to the discharge nozzle of pump, minus the reading of a gauge connected to the suction nozzle of pump, plus or minus vertical distance between centers of gauges (depending upon whether suction gauge is below or above discharge gauge), plus excess, if any, of the velocity head of discharge over velocity head of

the simple formula:

$h = v^2 \div 2g$

in which "g" is acceleration due to gravity, or 32.16 feet per second; or knowing the head, we can transpose the formula to:

$v = \sqrt{2gh}$

and thus obtain velocity.

The velocity head is a factor in figuring the total dynamic head, but the value is usually small, and in most cases, negligible; however, it should be considered when the total head is low and also when the suction lift is high. Where the suction and discharge pipes are the same size, it is only necessary to include in the total head the velocity head generated in the suction piping. If the discharge piping is of different size than the suction piping, which is often the case, then it will be necessary to use velocity in the discharge pipe for computing the velocity head rather than the velocity in the suction pipe. Velocity head should be considered in accurate testing also, as it is a part of total head dynamic head and consequently affects the duty accomplished. In testing a pump, a vacuum gauge or mercury column is generally used for obtained dynamic suction lift. The mercury column or vacuum gauge will show the velocity head combined with entrance head, friction head and static suction lift. On the discharge side, a pressure gauge is usually used, but a pressure gauge will not indicate velocity head, and this must, therefore, be obtained by calculating the velocity or taking readings with a pitometer. Inasmuch as the velocity varies considerably at different points in the cross section of a stream, it is important, in using the pitometer, to take a number of readings at different points in the cross section. A table giving the relation between velocity and velocity head is shown below:

suction as measured at points where instruments are attached. Total dynamic discharge head is the total dynamic head minus dynamic suction lift, or plus dynamic suction head.

- **Lift (Suction Lift)** - Liquid is lower than the pump. Pumping action creates a vacuum and atmosphere pressure forces liquid up to pump. Theoretical limit of suction is 34 feet; practical limit is 25 feet or less, depending on pump types and elevation above sea level. Exists when the suction measured at the pump nozzle and corrected to the centerline of the pump is below atmospheric pressure.
- **Static Suction Lift** - Vertical distance from the free level of the source of supply to centerline of pump.

Velocity in Feet per Second	Velocity Head in Feet	Velocity in Feet per Second	Velocity Head in Feet
1	.02	9.5	1.4
2	.06	10	1.55
3	.14	10.5	1.7
4	.25	11	1.87
5	.39	11.5	2.05
6	.56	12	2.24
7	.76	13	2.62
8	1.0	14	3.05
8.5	1.12	15	3.50
9	1.25		

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Electric Motor Terms

- **Alternating Current (AC)** - A flow of electric current which constantly changes direction.
- **Ambient Temperature** - The air temperature surrounding the motor. Most motors are designed to operate in an ambient not over 40º C (104º F). Note: A rating of 40º C is not the same as a rating of 40º C rise. (See Temperature Rise)
- **Amperes** - The unit of intensity of electric current being produced in a conductor by the applied voltage.
- **Bearings, Ball** - Generally used where axial thrust exceeds 20 pounds. Ball bearing motors are factory lubricated and can be mounted in any position. Two methods are used to keep dirt out of bearings: Shields are metal rings with close running clearance on one side (single-shielded) or both sides (double-shielded) or
- **KVA Code** - This code letter is defined by NEMA standards to designate the locked rotor KVA per horsepower of a motor. It relates to starting current and selection of fuse or circuit breaker size.
- **Lead** - The conductor wire brought out from a coil or winding within the motor.
- **MFD** - Capacitor rating (microfarad)
- **NEMA** - The National Electrical Manufacturer's Association
- **Overload Protector** - A temperature detecting advice built into the motor from the power source if the temperature rise becomes excessive.
- **PSC** - Permanent Split Capacitor
- **Rotation** - Direction in which the shaft rotates. CW - clockwise; CCW - counter-clockwise; REV - reversible,

bearing; seals are similar to shields except have rubber lips that press against the inner face, more effectively excluding dirt, etc.

- **Direct Current (DC)** - Type of power supply available from batteries. generators (not alternators) or a rectified source used for special-purpose applications.
- **Enclosure** - The motor's housing. Common types are:
  Open Dripproof (ODP) - Ventilation openings in end shields and shell positioned as the prevent motor failure when liquid or solid particles enter and/or strike the enclosure within an angle of 15º from vertical. Usually used in reasonably clean indoor locations.
  Open Guarded - Has all openings giving direct access to live metal or hazardous rotating parts so sized or shielded as the prevent accidental contact as defined by probes illustrated NEMA standard.
  Totally Enclosed - No openings in the motor housing (but not airtight). Used in locations which are dirty, oily, etc.
  Totally Enclosed, Fan Cooled (TEFC) - With an external cooling fan. Depends on convection air for cooling, or on air flow from driven device (air-over).
  Explosion Proof (EP) - Totally enclosed designs built to withstand an explosion of gas or vapor within it and to prevent ignition of the gas or vapor surrounding the motor by sparks or expositions which may occur within the motor casing.
- **End Bell** - Shield at the end of the motor which supports the bearings. Also called the end plate.
- **Frame** - NEMA standardized motor mounting dimensions. Specifies the shaft height and motor mounting dimensions and provides recommendations for standard shift diameters and usable shaft extension lengths.
- **Frequency** - The number of complete cycles of current per second taken by alternating current. Unit of rotation can be changed. Rotation is specified as viewed facing opposite the shaft end of motor.
- **RPM** - Revolutions Per Minute. Measure of speed. The RPM reading on motors is approximately the full load speed. A two pole motor runs at approximately 3450, a four pole at 1725 and a six pole at 1140.
- **Service Factor** - The multiplier which, when applied to the rated horsepower, indicates permissible loading which may be carried continuously when the voltage and frequency are maintained at the value specified on the nameplate, although the motor will operate at an increased temperature rise. The service factor is a built-in safety margin.
- **Slot Insulation** - Also called the slot liner, the insulation in the slot containing the motor winding.
- **Stack** - Thickness of the stator.
- **Stator** - The portion of the motor on which the coils are wound.
- **Solid State Switch** - A solid state switching device with two basic components, a reed switch and a triac. The triac serves as the basic switching device, taking the start winding in and out of the circuit. It is controlled through interaction with the reed, the switch actuated by a coil in series with the power line. This SSS replaces the centrifugal switch and mechanism in single phase motors.
- **Submersible Motor** - A motor designed to run completely submerged under water.
- **Temperature Rise** - The amount by which a motor, operating under rated conditions, is hotter than its surroundings.
- **Thermal Protector** - A temperature sensing device built into the motor, that disconnects the motor from its power source if the temperature becomes excessive for any reason. Basic types include: Automatic resets - After the motor cools, the protector automatically

measure is Hertz.

- **Full Load Amps** - Line current (amperage) drawn by a motor when operating at rated load and voltage. Shown on motor nameplate. Important for proper wire size selection and motor starter heater selection.
- **Hertz** - Frequency in cycles per second of AC power; usually 60 Hz in United States, 50 or 60 Hz overseas.
- **Horsepower** - Defines the rated output capacity of the motor. It is based on breakdown torque, which is the maximum torque a motor will develop without an abrupt drop in speed.
- **Insulation** - Material which resists current flow. In motors, insulation is usually classed by maximum allowable operating temperature:
  Class A - 105º C (221º F)
  Class B - 130º C (266º F)
  Class F - 155º C (311º F)
  Class H - 180º C (356º F)

restores power. This type should not be used where unexpected starting may be hazardous. Manual reset - An external button must be pushed to restore power to the motor. Preferred when unexpected restarting would be hazardous.

- **Torque** - Twist or turning ability applied to a shaft. Measured in foot-pounds or inch-pounds. In a motor, important torque value are: Breakdown torque - The maximum torque a motor will produce while running, without an abrupt drop in speed and power. Full-loaded running torque - The amount of torque produced by a motor when running at rated horsepower. Starting torque - The torque produced at initial start. Pull-up torque - The minimum torque developed by the motor during the period of acceleration from reset to the speed at which breakdown occurs.
- **UL** - Underwriter's Laboratories. Establishes safety standards.