Pump Data

I. STANDARDS FOR MEASURING HEADS AND CAPACITY.

Head is measured in feet, pounds per square inch (PSI), or in inches of mercury. However, so that a common means of head measurement is understood, it is recommended that all heads be expressed in feet of water. Measurement of liquid should be expressed in U.S. gallons.

II. ATMOSPHERIC PRESSURE.

At sea level it is 14.7 PSI. This will maintain a column of mercury 29.9 inches or a column of water 33.9 ft. high. This is the theoretical height of which water may be lifted by suction. The practical limit for cold water (60 F) is 25 feet.

III. SUCTION AND DISCHARGE HEAD.

Static Suction Lift – Is the vertical distance from the center line of the pump's suction inlet to the constant level of the water. This is added to discharge head to obtain total dynamic head.

Positive Suction Head – Is the vertical distance above the center line of the pump's suction to the constant level of the water. This is subtracted from the discharge head to obtain total dynamic head.

Dynamic Suction Head – Is the suction lift (or head) plus suction line friction loss. May be positive or negative.

Static Discharge Elevation – Is the vertical distance from the pump's discharge to the highest point in the discharge line.

TDH (Total Dynamic Head) – Is the total head and is the total of static suction lift (head), friction loss in suction line, static discharge elevation, friction loss in discharge line and fittings, plus discharge pressure, if any. To be hydraulically correct, we should not include "Static Head" in total dynamic head. Dynamic means "moving" and "Dynamic Head" only includes velocity head and friction loss. However, most pump people use TDH interchangeably with TH (Total Head).

Friction Head – Is the heat loss experienced by the movement of the liquid through the suction and discharge lines. Charts are available showing loss in feet of head at various flows through various pipe or hose sizes. Charts also show velocity in feet/sec, which is particularly important when pumping liquids with solids in suspension. Fittings, valves, etc. must be considered.

IV. NPSH.

Net Positive Suction Head is defined as head that causes liquid to flow through the suction line and enter the impeller eye. This head comes from either atmospheric pressure or from a static suction head plus atmospheric pressure. Two types of NPSH will be considered.

Required NPSH – Is a function of pump design. It varies between different makes, between different models, and with capacity of any one pump. This value is supplied by the manufacturer, if available. Refer to pump curves or contact the factory.

Available NPSH – Is a function of the system in which pumps operate. Can be calculated for any installation. For a pump to operate properly, available NPSH should be greater than the required NPSH, plus 2 feet for safety factor, at a desired head and capacity. In simple terms, available NPSH is calculated by deducting from barometric pressure, in feet, the static suction head (+ or -), friction loss, and the vapor pressure (ft.) of liquid being pumped. Velocity heads should also be deducted.

NPSH does not indicate the priming capabilities of self-priming centrifugal pumps. This capability is shown, generally on engine driven pumps, by respective "break-off" lines representing 10, 15, 20, 25' static suction lifts.

V. USEFUL FACTORS OR FORMULAS.

a) Feet head x .433 = PSI (pounds per square inch).

b) PSI (water) x 2.31 = Ft. Head

c) Specific gravity of water (sp.gr.) = 1.0.

d) PSI (water) x 2.31/sp.gr. = Ft. Head

e) Weight of one U.S. gallon of water = 8.33 pounds

f) One cubit foot (cu.ft.) of water contains 7.48 gallons.

g) GPM = Gallons Per Minute.

h) Imperial gallon x 1.2 = U.S. gallon; U.S. GPM x .833 = Imp. GPM.

i) TDH = Total Head or total dynamic head.

j) WHP = Water Horsepower.

k) BHP = Brake Horsepower.

I) EFF = Pump Efficiency.

m) WHP = Ft .Head x GPM/3960

n) BHP = WHP/EFF or BHP = Ft. Head x GPM/3960 x EFF (Pump)

o) EFF = WHP/BHP x 100

p) For liquids having different specific gravity other than 1.0.

WHP = Ft. Head x GPM x sp.gr./3960

BPH = Ft. Head x GPM x sp.gr./3960 x EFF

BHP (for liquids other than water)

= BHP (for water) x sp.gr.

VI. EFFECT ON CENTRIFUGAL PUMPS ON CHANGE OF SPEED OR CHANGE OF IMPELLER DIAMETER.

Three rules govern the operation of centrifugal pumps:

a) Capacity varies directly with changes of speed or of the impeller diameter.

GPM1/GPM2 = RPM1/RPM2

or GPM1/GPM2 = Dia.1/Dia.2

GPM2 = GPM1/RPM1xRPM2

and GPM2 = GPM1/Dia.1xDia.2

b) Head varies as the square of the speed or the impeller diameter.

Head1/Head2= RPM12/RPM22

or Head1/Head2 = Dia.12/Dia.22

Hd2 = Hd1/RPM12/RPM22

and Hd2 = Hd1/Dia.12 /Dia.2

c) Power (BHP) varies as the cube of the speed or impeller diameter

BHP1/BHP2 = RPM13/RPM13
or BHP1 = Dia13/Dia23
BHP2 = BHP13/RPM13xRPM23
and BPH2= BHP13/Dia.13xDia23

VII. EFFECT OF ALTITUDE ON PUMPS

At elevations above sea level, suction lift should be reduced accordingly to insure that the same amount of water can get into the pump as would occur at an equivalent sea level lift. Lower atmospheric pressure reduces horsepower output of gas engines, thus

causing a drop in speed which reduces pump performance. Enginepower will decrease 3.5% for each 1000 ft. above sea level and 1% for each 10°F above standard temperature at 60°F.

ATMOSPHERIC PRESSURE CONDITIONS ELEVATIONS ABOVE SEA LEVEL

ALTITUDE ABOVE SEA LEVEL	ATMOSPHERIC PRESSURE POUNDS/SQ.IN.	BAROMETER READING INS. OF MERCURY	EQUIVALENT HEAD OR WATER, FT.	REDUCTION TO MAX. PRACTICAL DYN.SUCTION LIFT
0	14.7	29.929	33.95	0 ft.
1000	14.2	28.8	32.7	1.2″
2000	13.6	27.7	31.6	2.3″
3000	13.1	26.7	30.2	3.7″
4000	12.6	25.7	29.1	4.8″
5000	12.1	24.7	27.9	6″
6000	11.7	23.8	27.0	6.9″
7000	11.2	22.9	25.9	8″
8000	10.8	22.1	24.9	9″

VIII. GUIDELINES FOR PUMPING WARM WATER

MAXIMUM PRACTICAL DYNAMIC SUCTION LIFTAND VAPOR PRESSURE

WATER CHARACTERISTICS

ALTITUDE ABOVE SEA LEVEL	ATMOSPHERIC PRESSURE POUNDS/SQ.IN.	BAROMETER READING INS. OF MERCURY	EQUIVALENT HEAD OR WATER, FT.	REDUCTION TO MAX. PRACTICAL DYN.SUCTION LIFT
0	14.7	29.929	33.95	0 ft.
1000	14.2	28.8	32.7	1.2″
2000	13.6	27.7	31.6	2.3″
3000	13.1	26.7	30.2	3.7″
4000	12.6	25.7	29.1	4.8″
5000	12.1	24.7	27.9	6″
6000	11.7	23.8	27.0	6.9″
7000	11.2	22.9	25.9	8″
8000	10.8	22.1	24.9	9″

IX. EFFECT OF SPECIFIC GRAVITY

The specific gravity of a substance is the ratio of the weight of a given volume to the weight of an equal volume of water at standard conditions.

1. A centrifugal pump will always develop the same head in feet no matter what the specific gravity of the liquid pumped; however, the pressure (in pounds per square inch) will be increased or decreased in direct proportion to the specific gravity.
2. The brake horsepower (BHP) of a pump varies directly with specific gravity. If the liquid has a specific gravity other than water (1.0), multiply the BHP for water by the sp.gr. of liquid handled.

X. VISCOSITY

The viscosity of a fluid is the internal friction or resistance to motion of its particles. The coefficient of viscosity of a fluid is the measure of its resistance to flow. Fluids having a high viscosity are sluggish in flow, for example: heavy oil or molasses. Liquids such as water or gasoline have relatively low viscosity and flow readily. Viscosity is a fluid property independent of specific gravity. Viscosities vary with temperature; as temperature increases, viscosity decreases. Pressure changes have negligible influence on viscosity. There are many types of viscometers and expressed in many terms. Commonly used is SSU (Seconds Saybolt Universal). This is actually the time in seconds required for a given quantity of fluid to pass through a standard orifice under standard conditions. Viscous liquids tend to reduce the capacity, head, and efficiency, and increase the BHP.

Kinematic Viscosity (in Centistokes)
= Absolute Viscosity (in centipoise)/Specific Gravity
Centistrokes = SSU/4.64

This is an approximation for Viscosities greater than 250 S.S.U.The approximated performance for pumping fluids more viscous than water is determined from the following formula:

BHPvis = Qvis X Hvis X S.G./3960/Evis

HOW CENTRIFUGAL PUMPS WORK

Liquid is supplied to the inlet at the center of the pump head. Since centrifugal pumps are not self-priming, liquid must be supplied by gravity feed or the pump must be primed. The spinning impeller propels the liquid outward by centrifugal force, providing the motive force required to move the liquid. The specially shaped volute receives the liquid and converts the radial motion to a smooth pulseless flow. Easily adjust the flow rate by restricting the flow at the outlet.

CENTRIFUGAL PUMP TERMS

IMPELLER – A rotating vaned disck that provides the pumping force.

VOLUTE – The body of the pump that is shaped to receive liquid from the inlet and direct it through the outlet.

Liquid Pump Terminology

HEAD – The ability of a pump to push a column of water vertically in a pipe. As the column lengthens, the flow rate decreases until the column's weight just balances the pump's force and there is no flow. This height is the total head (usually expressed as feet of head).

FLOW RATE – Usually expressed in gallons per minute (GPM) for large-volume pumps; in gallons per hour (GPH) for small-volume pumps.

DYNAMIC SEAL – Seal located at the shaft end of the pump drive.

HECK VALVE – Allows liquid to flow in one direction only. Generally used in discharge line to prevent reverse flow.

DEAD HEAD – Ability of a pump to continue running without damage when discharge is closed off. Only recommended with centrifugal pumps.

DENSITY (specific weight of a fluid) – Weight per unit volume, often expressed as pounds per cubic foot or grams per cubic centimeter.

FLOODED SUCTION – Liquid flows to pump inlet from an elevated source by means of gravity. Recommended for centrifugal pump installations.

FLOW – A measure of the liquid volume capacity of a pump. Given in gallons per hour (GPH), gallons per minute (GPM), liters per minute (I/min), or milliliters per minute (ml/min).

FLUIDS – Include liquids, gases, and mixtures of liquids, solids, and gases. For the purposes of this catalog, the terms fluid and liquid are both used to mean a pure liquid or a liquid mixed with gases or solids that acts essentially like a liquid in pumping applications.

FOOT VALVE – A type of check valve with a built-in strainer. Used at point of liquid intake to retain liquid in system, preventing loss of prime when liquid source is lower than pump.

HEAD – A measure of pressure, expressed in feet of head for centrifugal pumps. Indicates the height of a column of water being moved by the pump, assuming negligible friction losses.

PRESSURE – The force exerted on the walls of a container (tank,,pipe etc.) by a liquid. Normally measured in pounds per square inch (psi) for positive displacement and metering pumps.

PRIME – A charge of liquid required to begin pumping action when liquid source is lower than pump. May be held in pump by a foot valve on the intake line, or by a valve or chamber within the pump.

SEAL – A device mounted in the pump housing and/or on the pump

shaft, to prevent leakage of liquid from the pump. There are three types:

1. LIP – A flexible ring (usually rubber or similar material) with the inner edge held closely against the rotating shaft by a spring.
2. MECHANICAL – Has a rotating part and a stationary part with highly polished touching surfaces. Has excellent sealing capability and long life, but can be damaged by dirt or grit in the liquid.
3. PACKED – Multiple flexible rings mounted around the pump shaft and packed together by tightening gland nuts; some leaking is essential for lubrication.

RELIEF VALVE – Usually used at the discharge of a positive displacement pump. An adjustable, spring-loaded valve opens when a preset pressure is reached. Used to prevent excessive pressure buildup that could damage the pump or motor.

SEALLESS (MAGNETIC DRIVE) – No seal is used; power is transmitted from motor to pump impeller by magnetic force.

SELF-PRIMING – Refers to pumps that draw liquid up from below pump inlet (suction lift), as opposed to pumps requiring flooded suction.

SPECIFIC GRAVITY – The ratio of the weight of a given volume of liquid to the same volume of pure water. Pumping heavier liquids (specific gravity greater than 1.0) will require more drive horsepower.

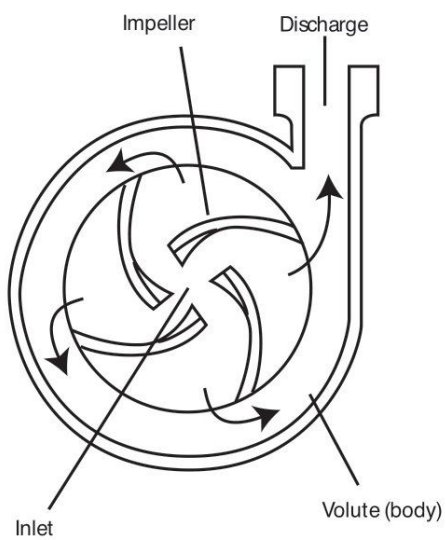
STATIC DISCHARGE HEAD – Maximum vertical distance (in feet) from pump to point of discharge with no flow.

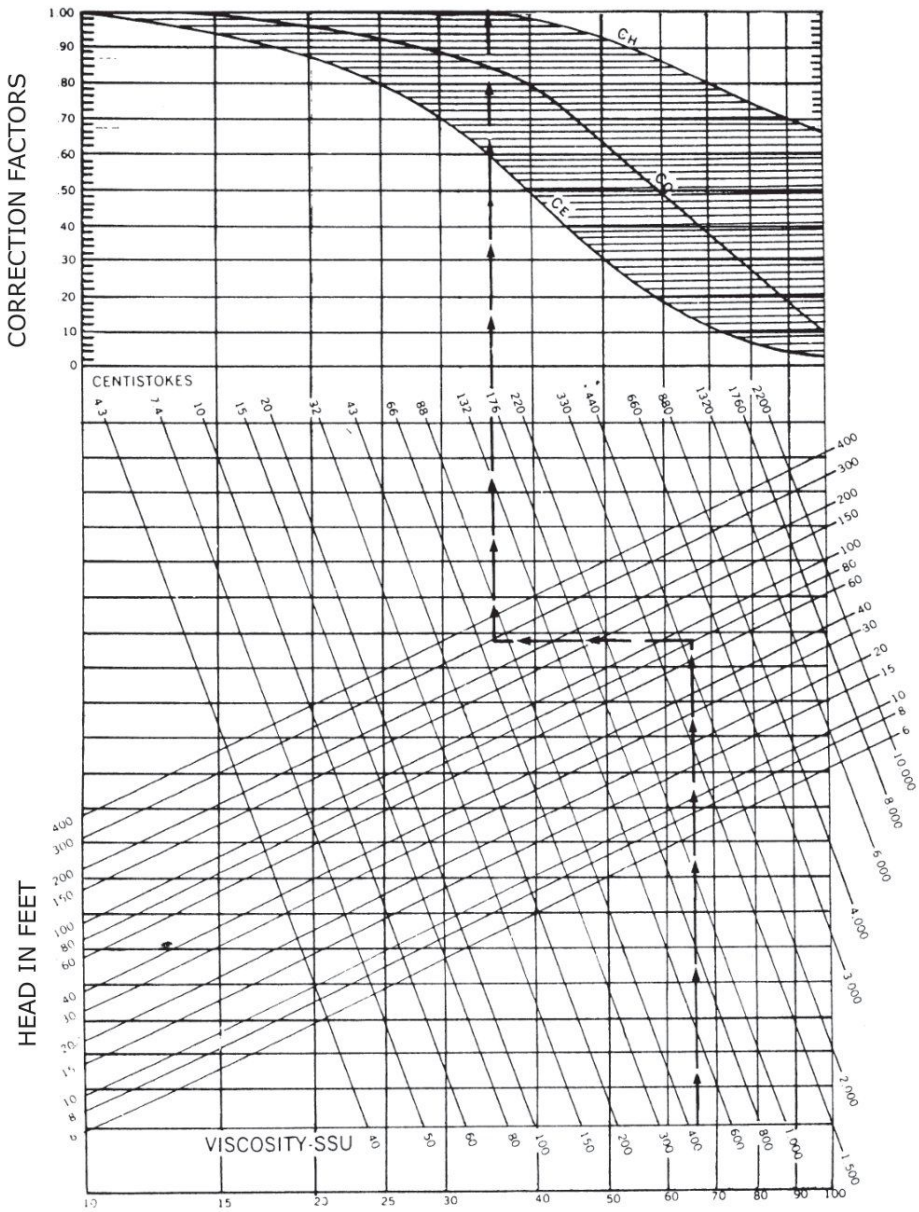
STRAINER – A device installed in the inlet of a pump to prevent foreign particles from damaging the internal parts.

SUMP – A well or pit in which liquids collect below floor level sometimes refers to an oil or water reservoir.

TOTAL HEAD – Sum of discharge head, suction lift, and friction loss.

VISCOSITY – The "thickness" of a liquid, or its ability to flow. Most liquids decrease in viscosity and flow more easily as they get warmer.





VISCOSITY CORRECTION CHART

Example - Viscosity

Determine BHPvis when pumping 66 usgpm at 80 ft. of 50% NaOH with a pump at 48% Eff. with water.

*S.G. = 1.53 *Given from other tables

*Visc = 78cSt = 120 CP/1.53

Qw = 66 usgpm

H.W. = 80 ft.

E.W. = 48% = .48

Cq = .84)

Ch = 1.00) From above chart

Ce = .58

Qw x Cq = 66 x .84 = 55.44

Hw x Ch = 80 x 1.00 = 80.0

Ew x Ce = .48 x .58 = .2784

BHPvis = 55.44 x 80.0 x 1.53/3960/0.2784 = 6.16 H.P.

WHERE

BHPvis = Viscous brake horsepower

S.G. = Specific Gravity

3960 = Constant

Qw = Capacity pumping water (USGPM)

Cq = Capacity correction factor (Fig 1)

Qvis = Viscous Capacity (USGPM) = Cq X Qw

Hw = Head pumping water (ft.)

CH = Head correction factor (Fig 1)

Hvis = Viscous head (ft) = Ch X Hw

Ew = Efficiency pumping Water

Ce = Efficiency correction factor (Fig 1)

Evis = Viscous Efficiency = Ce X Ew

BHPvis = (cq X Qs) X (Hw X Ch) X S.G./3960/Ce/Evis

PERFORMANCE CORRECTION CHART