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# VALUABLE PUMP FORMULAS

## Pressure

| | |
|---|---|
| Feet of Water X 0.4333 | = PSI |
| (PSI X 2.31)/Sp. Gr. | = Feet of Water |
| (Ft. Head x Sp. Gr.)/2.31 | =PSI |
| PSI x 6.9 | =kPa |
| ATM x 14.7 | =PSI |
| ATM x 33.9 | =Feet of Water |
| ATM x 760 | =mm Hg |
| kg/cm2 x 1.42 | =PSI |
| Meters of Water x 1.42 | =PSI |
| Bar x 14.5 | =PSI |
| Inches of Hg x 0.491 | =PSI |

## Pipe Velocity

| | |
|---|---|
| Velocity in Feet per Second: | $\frac{\text{GPM x 0.321}}{\text{Pipe Area in Square Inches}}$ |
| Rule of Thumb: | Typically, keep pipe velocities around 10 ft/second for good results. |
| Suction Piping: | Generally, have piping in one plane from source tank and have a straight run at least 10 times the pipes diameter leading into the pump suction. |
| Pipe Size: | Doubling the diameter of a pipe increases its capacity 4 times. |

## Centrifugal Pumps

| | |
|---|---|
| Liquid HP: | $\frac{\text{GPM x ft. of Head x Sp. Gr.}}{3960}$ |
| Brake HP: | $\frac{\text{GPM x TDH x Sp. Gr.}}{\text{3960 x Pump Efficiency}}$ |
| Efficiency Overall HP: | $\frac{\text{BHP}}{\text{Motor Efficiency}}$ |

Estimated effects of viscosity on Centrifugal Pumps

| SSU | FLOW | HEAD | EFFICIENCY |
|---|---|---|---|
| 35 | 100% | 100% | 80% |
| 500 | 95% | 98% | 80% |
| 1000 | 92% | 97% | 70% |

## Rotary Positive Displacement Pumps

| | |
|---|---|
| Liquid HP: | $\frac{\text{GPM x PSI}}{1714}$ |
| Volumetric Efficiency: | $\frac{\text{Actual GPM}}{\text{Theoretical GPM}}$ |
| Overall Pump Efficiency: | $\frac{\text{LHP}}{\text{BHP}}$ |
| Mechanical | $\frac{\text{Overall Pump Efficiency:}}{\text{Volumetric Efficiency}}$ |

## Approximate RPM @ Full Load - for medium sized motors

| Poles | RPM (60 Hz) | Sync Speed | RPM (50 Hz) | Sync Speed |
|---|---|---|---|---|
| 2 | 3500 | 3600 | 2850 | 3000 |
| 4 | 1750 | 1800 | 1450 | 1500 |
| 6 | 1150 | 1200 | 950 | 1000 |
| 8 | 850 | 900 | 700 | 750 |

Synchronous Speed (no load) Formula RPM= $\frac{\text{Frequency(Hz) x 120}}{\text{Number of Poles}}$

## Insulation Class NEMA 1.15 Service Factor

| | | |
|---|---|---|
| A | $150^{0}$ C | $221^{0}$ F |
| B | $130^{0}$C | $266^{0}$ F |
| F | $155^{0}$ C | $311^{0}$ F |
| H | $180^{0}$ C | $356^{0}$ F |

Maximum motor temperature including temperature rise plus $40^{0}$ C ambient temperature

## Rules of Thumb for Motors

| | |
|---|---|
| A motor develops 1.5 ft-lbs per HP @ 3600 RPM | A 3-phase motor draws 1.00 Amp per HP @ 557 Volts |
| A motor develops 3.0 ft-lbs per HP @ 1800 RPM | A 3-phase motor draws 1.25 Amp per HP @ 460 Volts |
| A motor develops 4.5 ft-lbs per HP@ 1200 RPM | A 3-phase motor draws 2.50 Amp per HP @ 230 Volts |

HP= $\frac{\text{Torque (ft-lbs) x RPM}}{5252}$ Torque (in lbs) $\frac{\text{HP x 63,000}}{\text{RPM}}$

## Particle Size Comparison

| Mesh | Inch | Micron |
|---|---|---|
| 3250 | .0002 | 6 |
| 1600 | .0005 | 14 |
| 750 | .0010 | 25 |
| 325 | .0016 | 40 |
| 250 | .0024 | 62 |
| 200 | .0029 | 74 |
| 180 | .0033 | 85 |
| 150 | .0041 | 100 |
| 120 | .0046 | 118 |
| 100 | .0055 | 149 |
| 80 | .0070 | 179 |
| 50 | .0117 | 300 |
| 40 | .0150 | 385 |
| 30 | .0200 | 513 |
| 24 | .0280 | 718 |
| 20 | .0340 | 872 |
| 18 | .0390 | 1000 |
| 16 | .0450 | 1154 |
| 14 | .0510 | 1308 |
| 12 | .0600 | 1538 |
| 10 | .0750 | 1923 |
| 8 | .0970 | 2488 |
| 6 | .1320 | 3385 |
| 4 | .1590 | 4077 |
| 2 | .2030 | 5205 |

1 Micron = $10^{-6}$ Meters
1 Micron = 3.9 x $10^{-5}$ inch

## Atmospheric Pressure

| Altitude in Feet | Pressure in PSIA |
|---|---|
| 0 | 14.70 |
| 100 | 14.64 |
| 300 | 14.54 |
| 500 | 14.43 |
| 700 | 14.33 |
| 1,000 | 14.17 |
| 1,500 | 13.92 |
| 2,000 | 13.66 |
| 3,000 | 13.17 |
| 4,000 | 12.69 |
| 5,000 | 12.23 |
| 7,000 | 11.34 |
| 10,000 | 10.11 |
| 15,000 | 8.29 |
| 20,000 | 6.76 |
| 25,000 | 5.45 |
| 30,000 | 4.36 |
| 40,000 | 2.72 |
| 50,000 | 1.68 |
| 60,000 | 1.04 |

## Viscosity

CONVERSIONS:

| | |
|---|---|
| SSU* | = Centistokes x 4.55 |
| Degrees Engler* | = Centistokes x 0.132 |
| Sec. Redwood 1* | = Centistokes x 4.05 |
| 1 Stoke | = 100 Centistokes |
| 1 Poise | = 100 Centipoises |
| Centistokes | = Centipoise/Sp. Gr. |

*Where Centistokes are greater than 50

Definitions:

Newtonian fluids are unaffected by shear, e.g. water mineral oil.

Non-Netownian fluids are affected by shear (5 types).

Bingham-Plastic fluids have an exact shear point which once exceeded, viscosity decreases.

Pseudo-Plastic fluids have no exact yield point, but instead, viscosity decreases as the magnitude of shear rate increases.

Dilatant fluids viscosity increases as the magnitude of the shear rate increases, e.g. printing ink, candy compounds.

Thixotropic fluids decrease in viscosity both in relation to the shear magnitude and the period of time subjected to shear. Viscosity might also depend on a previous shear condition, e.g. drilling mud, starches, paint.

Rheopectic fluids increase viscosity both in relation to the shear magnitude and the period of time subjected to shear, e.g. some greases.

## Affinity Laws for Centrifugal Pumps

These formulas can be used to estimate capacity, head and BHP for a pump speed or impeller diameter when a curve is not readily available.

1. Flow is directly proportional to the ratio of impeller speed:

$$GPM_2 = \frac{GPM_1 \times RPM_2}{RPM}$$

2. Head is directly Proportional to the square of the ratio of impeller speed:

$$Head_2 = Head1 \times \left(\frac{RPM_2}{RPM_1}\right)^2$$

3. The HP is directly proportional to the ratio of impeller speed:

$$BHP_2 = BHP_1 \times \left(\frac{RPM^2}{RPM_1}\right)$$

4. Flow is directly proportional to the ratio of impeller diameter:

$$Flow_2 = Flow_1 \times \left(\frac{\text{Impeller Diameter}_2}{\text{Impeller Diameter}_1}\right)^2$$

5. Head is directly proportional to the square of the ratio of Impeller diameter:

$$Head_2 = Head_1 \times \left(\frac{\text{Impeller Diameter}_2}{\text{Impeller Diameter}_1}\right)^2$$

6. The HP is directly proportional to the cube of the ratio of impeller diameter:

$$BHP_2 = BHP_1 \times \left(\frac{\text{Impeller Diameter}_2}{\text{Impeller Diameter}_1}\right)^2$$