Formula Reference Sheet

Convert pressure to head

$$\mathbf{h} = \frac{\boldsymbol{p}}{\boldsymbol{\rho} \cdot \boldsymbol{g}}$$

Where:

h = head, feet or meters

p = pressure, psi (Pa)

ρ = liquid density, lbm/ft^3 (kg/m^3)

g = Acceleration due to gravity, ft/s^2 (m/s^2)

Convert pressure (psi) to head in feet

$$h(\mathrm{ft}) = \frac{p(\mathrm{psi}) * 2.31}{Specific\,Gravity}$$

1 meter (m) = 3.281 feet (ft)

Calculation of velocity head

$$h_v = \frac{v^2}{2g}$$

Where:

h_v = velocity head, ft (m)

v = flow velocity, ft/s (m/s)

g = acceleration constant due to gravity

Gravitational acceleration constants

$$g = 32.2\frac{\mathrm{ft}}{\mathrm{s}^2} = 9.81\frac{\mathrm{m}}{\mathrm{s}^2}$$

Pump affinity rules with respect to impeller diameter

$$Q_2 = Q_1\frac{D_2}{D_1} \quad H_2 = H_1\frac{D_2^2}{D_1^2} \quad P_2 = P_1\frac{D_2^3}{D_1^3}$$

Where:

Q = flow rate

H = total head

P = pump input power

D = impeller diameter

Pump affinity rules with respect to pump speed

$$Q_2 = Q_1 \frac{n_2}{n_1} \quad H_2 = H_1 \frac{n_2^2}{n_1^2} \quad P_2 = P_1 \frac{n_2^3}{n_1^3}$$

Where

Q = flow rate

H = total head

P = pump input power

n = pump rotational speed

Calculation of Net Positive Suction Head Available (NPSHA)

NPSHA = $h_{atm} + h_{gs} + h_{vs} + z_s - h_{vp}$

Where

h_{atm} = atmospheric pressure head, ft (m)

h_{gs} = suction gauge head, ft (m)

h_{vs} = suction velocity head, ft (m)

z_s = *elevation from the suction gauge centerline to datum, ft (m)*

h_{vp} = liquid vapor pressure head, ft (m)

Calculation of Net Positive Inlet Pressure Available (NPIPA)

$$NPIPA = p_{s,absolute} - p_{vp,abs}$$

Where

$p_{s,absolute}$ = Total suction pressure absolute

$p_{vp,abs}$= Liquid vapour pressure absolute

Calculation of electrical input power

$$Input\ power\left(kW\right) = \frac{I \times V \times PF \times C}{1000}$$

Where

I = current in amperes (A) (meter reading)

V = volts (meter reading)

PF = power factor (motor curve or measured)

C = 1 for single-phase current

= 2 for two-phase four-wire control

= 1.73 for three-phase current

Calculation of power

Hydraulic Power as a function of Head

hydraulic power $\left(P_u\right) = \frac{Q \times H \times s}{3960}\left(hp\right)$, *also known as Water Horsepower (WHP, Pw) when water is the pumped fluid*

Hydraulic power $\left(p_u\right)$	*hp (horsepower)*
Head (H)	*feet*
Flow (Q)	*gpm*
Specific gravity (s)	*dimensionless*

3960 is a constant that incorporates two conversions: (1) convert flow (gpm) to pounds/minute, and (2) convert the product of mass flow × head (pound-foot/minute) to horsepower

$$P_u = \frac{Q \times H \times \rho \times g}{1000}(kW)$$

Where:

P_u = Hydraulic power (kW)

Q = Flow rate (m^3/s)

H = Head (m)

ρ = Density of fluid (kg/m^3)

g = Acceleration due to gravity (9.81 m/s2)

$$\text{Hydraulic Power}\left(P_u\right) = \frac{Q \times H \times s}{0.1022}\left(kW\right)$$

Where:

P_u = Hydraulic power (kW)

Head (H) meters (m)

Flow (Q) m^3/s

Specific gravity (s) dimensionless

0.1022 is metric units conversion to provide power in kilowatt (kW)

Hydraulic power as a function of total differential pressure

$$P_u(kW) = \frac{Q\left(\frac{m^3}{h}\right) \times \Delta p(\text{kPa})}{3600\ (\frac{s}{h})} = Q\left(\frac{m^3}{s}\right) \times \Delta p(\text{kPa})$$

$$P_u(\text{hp}) = \frac{Q(gpm) \times \Delta p(\text{psi})}{1714}$$

Pump Power Input $(P) = \frac{P_u}{\eta}$ *, also known as shaft power or Brake Horsepower (BHP)*

Where:

P_u = Hydraulic power (kW)

Pump Efficiency (η)

Power (kW) = 0.746 × Horsepower

Area of pipe

$\boldsymbol{A = \pi \times r^2}$

Where:

A= crossection area of the pipe inside diameter, ft^2 (m^2)

r = radius of the pipe inside diameter, ft (m)

Velocity (v) in pipe

$$v = \frac{Volume\ rate\ of\ \ flow}{Pipe\ inside\ diameter\ area}$$

$$v\left(\frac{ft}{s}\right) = \frac{0.4085 \times gpm}{pipe\ ID^2\ (inches)}$$

Resistance to flow in pipes and fittings

$$h_f = f \times \frac{I}{d} \times \frac{v^2}{2g}$$

Where

- h_f = frictional resistance in head
- *f* = piping friction factor
- *l* = length of pipe, ft (m)
- *d* = average ID of piping, ft (m)
- *v* = average velocity, ft/s (m/s)
- *g* = acceleration due to gravity

$$h_f = k \times \frac{v^2}{2g}$$

Where

- h_f = frictional resistance in head
- *k* = resistance coefficient for valve or fitting
- *v* = average velocity, ft/s (m/s)
- *g* = acceleration due to gravity