AFFINITY LAWS

The affinity laws express the mathematical relationship between the several variables involved in pump performance. They apply to all types of centrifugal and axial flow pumps. They are as follows:

1. With impeller diameter, D, held constant:

A. $\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$

B. $\frac{H_1}{H_2} = \left(\frac{N_1}{N_2}\right)^2$

C. $\frac{BHP_1}{BHP_2} = \left(\frac{N_1}{N_2}\right)^3$

Where:

Q = Capacity, GPM
H = Total Head, Feet
BHP = Brake Horsepower
N = Pump Speed, RPM

2. With speed, N, held constant:

A. $\frac{Q_1}{Q_2} = \frac{D_1}{D_2}$

B. $\frac{H_1}{H_2} = \left(\frac{D_1}{D_2}\right)^2$

C. $\frac{BHP_1}{BHP_2} = \left(\frac{D_1}{D_2}\right)^3$

BASIC SYMBOLS & FORMULAS

SYMBOLS

GPM = gallons per minute
CFS = cubic feet per second
Lb. = pounds
Hr. = hour
BBL = barrel (42 gallons)
Sp. Gr. = specific gravity
H = head in feet
psi = pounds per square inch
in. Hg. = inches of mercury
h_v = velocity head in feet
V = velocity in feet per second
g = 32.16 ft/sec^2 (acceleration of gravity)

A = area in square inches
I.D. = inside diameter in inches
BHP = brake horsepower
Eff. = pump efficiency expressed as a decimal
N_s = specific speed
N = speed in revolutions per minute
v = peripheral velocity of an impeller in feet per second
D = impeller in inches
Nc = critical speed
f = shaft deflection in inches
P = total force in lbs.
L = bearing span in inches
m = constant usually between 48 and 75 for pump shafts
E = modules of elasticity, psi — 27 to 30 million for steel

FORMULAS

$$GPM = \frac{0.002 \times Lb./Hr.}{Sp.\ Gr.}$$

$$GPM = \frac{Lbs./Hr.}{500 \times Sp.\ Gr.}$$

$$GPM = 449 \times CFS$$

$$GPM = 0.7 \times BBL./Hr.$$

$$H = \frac{2.31 \times psi}{Sp.\ Gr.}$$

$$H = \frac{1.134 \times in.\ Hg}{Sp.\ Gr.}$$

$$h_v \frac{V^2}{2g} = .0155\ V^2$$

$$V = \frac{GPM \times 0.321}{A} = \frac{GPM \times 0.409}{(I.D.)^2}$$

$$BHP = \frac{GPM \times H \times Sp.\ Gr.}{3960 \times Eff.} = \frac{GPM \times psi}{1715 \times Eff.}$$

$$Eff. = \frac{GPM \times H \times Sp.\ Gr.}{3960 \times BHP}$$

$$Sp.\ Gr. = \frac{141.5}{131.5 \times degrees\ A.P.I.}$$

$$N_c = \frac{187.7}{\sqrt{f}}$$

$$f = \frac{PL^3}{mEI}$$

$$N_s = \frac{N\sqrt{GPM}}{H^{3/4}}$$

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

$$v = \frac{N \times D}{229}$$

$$DEG.\ C = (DEG.\ F - 32) \times 5/9$$

$$DEG.\ F = (DEG.\ C \times 9/5) + 32$$