General Equations

$$A_{Rectangular} = \frac{W * H}{144}$$

$$A_{Round} = \frac{\pi d^2}{576}$$

$$A_{Flat\_Oval} = \frac{\pi d^2}{576} + \frac{(W - d) * d}{144}$$

$$V_{Rectangular} = \frac{H * W * L}{1728}$$

$$V_{Cylinder} = \frac{\pi d^2 * L}{6912}$$

$$\mathrm{C} = \pi * d$$

$$\mathrm{C}_{60^\circ} = \frac{\pi * d}{6}$$

$$\mathrm{C}_{90^\circ} = \frac{\pi * d}{4}$$

$$T_{mix} = \frac{(Flow_1 *\times T_1 + Flow_2 \times T_2)}{(Flow_1 + Flow_2)}$$

$$PickupGain_{New} = \left(\frac{Flow_{BAS}}{Flow_{Measured}}\right)^2 \times PickupGain_{Old}$$

$$Flow\ Coeff._{New} = \left(\frac{Flow_{BAS}}{Flow_{Measured}}\right) \times Flow\ Coeff._{Old}$$

$$d_{Equivalent} = \sqrt{\frac{4*\mathrm{H}*\mathrm{W}}{\pi}}$$ (Based on equal area)

Air Equations

$$V = 1096.7 * \sqrt{\frac{V_P}{\rho}}$$

$$\rho_{STP} = 4005 * \sqrt{\mathrm{V_p}}$$

$$\rho_{Local} = 1.325 * \left(\frac{P_b}{T+460}\right)$$

$$V_{Corrected} = V_{Measured} * \sqrt{\frac{0.0748}{\rho}}$$

$$Q_{Sensible} = 60 * C_P * \rho * cfm * \Delta T$$

$$Q_{STP} = 1.08 * cfm * \Delta T$$

$$Q_{Total} = 4.5 * cfm * \Delta h$$

$$Q_{Latent} = 4{,}840 * cfm * \Delta W(lb)$$

$$Q_{Latent} = 0.69 * cfm * \Delta W(gr.)$$

$$Q_{Transmission} = U * A * \Delta T$$

$$U = \frac{1}{R}$$

TP=VP+SP

$$T_{mix} = \frac{(\%_{RA} \times T_{RA} + \%_{OA} \times T_{OA})}{100}$$

$$\%\ OA = \frac{CFM_{Supply} - CFM_{Return}}{CFM_{Supply}}$$

$$\%OA = \frac{T_{RA} - T_{MA}}{T_{MA} - T_{OA}}$$

$$CFM_{OA} = CFM_{Supply} - CFM_{Return}$$

$$CFM_{OA} = \%OA * CFM_{Supply}$$

Fan Equations

$$cfm = A * V$$

$$Q = \frac{Vol * ACH}{60}$$

$$TS = \frac{(\pi * D * rpm)}{12}$$

$$bhp_{fan} = \left(\frac{cfm * \mathrm{SP}}{6356 * \varepsilon_{\mathrm{fan}}}\right)$$

$$\frac{cfm_2}{cfm_1} = \frac{rpm_2}{rpm_1}$$

$$\frac{SP_2}{SP_1} = \left(\frac{cfm_2}{cfm_1}\right)^2 = \left(\frac{rpm_2}{rpm_1}\right)^2$$

$$\frac{bhp_2}{bhp_1} = \left(\frac{cfm_2}{cfm_1}\right)^3 = \left(\frac{rpm_2}{rpm_1}\right)^3$$

$$\frac{\rho_2}{\rho_1} = \frac{SP_2}{SP_1} = \frac{bhp_2}{bhp_1}$$

$$\frac{rpm_{fan}}{rpm_{motor}} = \frac{pitch\ diameter_{motor}}{pitch\ diameter_{fan}}$$

$$d_{2(Max.Motor)} = d_{1(Current,Motor)} * \sqrt[3]{\frac{bhp_{2(Max)}}{bhp_{1(Current)}}}$$

$$D_{2(Min.\mathrm{Fan})} = D_{1(Current,\mathrm{Fan})} * \sqrt[3]{\frac{bhp_{1(\mathrm{Current})}}{bhp_{2(\mathrm{Max})}}}$$

$$L = 2 * C + 1.57(D + d) + \frac{(D - d)^2}{4 * C}$$

Pump Equations

$$\frac{gpm_2}{gpm_1} = \frac{rpm_2}{rpm_1} = \frac{D_2}{D_1}$$

$$\frac{H_2}{H_1} = \left(\frac{gpm_2}{gpm_1}\right)^2 = \left(\frac{rpm_2}{rpm_1}\right)^2 = \left(\frac{D_2}{D_1}\right)^2$$

$$\frac{bhp_2}{bhp_1} = \left(\frac{gpm_2}{gpm_1}\right)^3 = \left(\frac{rpm_2}{rpm_1}\right)^3 = \left(\frac{D_2}{D_1}\right)^3$$

$$whp = \left(\frac{gpm * H * SG}{3960}\right)$$

$$whp = \left(\frac{gpm * H * SG}{3960}\right)$$

$$bhp = \left(\frac{gpm * H * SG}{3960 * E_P}\right)$$

$$E_P = \left(\frac{whp * 100}{bhp}\right)$$

$$whp = bhp * E_P$$

$$NPSHA = P_a \pm P_s + \frac{V^2}{2 * g} - P_{vp}$$

$$H = f * \left(\frac{L}{D}\right) * \left(\frac{V^2}{2 * g}\right)$$

$$H_{Feet} = \frac{H_{PSI} * 2.31}{SG}$$

Hydronic Equations

$$Q_{Sensible} = 60 * C_p * \rho * gpm * \Delta T$$

$$Q_{STP} = 500 * gpm * \Delta T$$

$$\frac{\Delta P_2}{\Delta P_1} = \left(\frac{gpm_2}{gpm_1}\right)^2 = \left(\frac{rpm_2}{rpm_1}\right)^2 = \left(\frac{D_2}{D_1}\right)^2$$

$$\Delta P = \left(\frac{gpm}{C_V}\right)^2$$

$$P = \frac{F}{A}$$

Electrical Equations

$$E = I * R$$

$$P = E * I = I^2 * R$$

$$R_{Series} = R_1 + R_2 + \cdots + R_N$$

$$R_{Parallel} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}}$$

$$Bhp_{Single\ Phase} = \left(\frac{I * E * PF * \varepsilon}{746}\right)$$

$$Bhp_{Three\ Phase} = \left(\frac{I * E * PF * \varepsilon * 1.732}{746}\right)$$

$$FLA_{Actual} = \frac{FLA_{NP} * V_{NP}}{V_{Measured}}$$

$$Bhp = HP_{NP} * \frac{I_{Measured} - (I_{NoLoad} * 0.5)}{FLA_{Actual} - (I_{NoLoad} * 0.5)}$$

$$\%\ Voltage\ Imbalance = \left(\frac{Max.\ Deviation\ from\ Average}{V_{Average}}\right) * 100$$

Abbreviations

General Equations

A = Area (FT^2)

C = Circumference (Units of Length)

$C_{60°}$ = 60° along Circumference (Units of Length)

$C_{90°}$ = 90° along Circumference (Units of Length)

d = Duct/Pipe Diameter (Units of Length)

$d_{equivalent}$ = Equivalent duct diameter

L = Length (Inches)

W = Width (Inches)

V = Volume (FT^3)

STP = Standard Temperature and Pressure

T = Temperature (Units of Temp.)

Air and Fan Equations

A = Area (FT^2)

L = Belt length (Inches)

ACH = Air Changes per Hour

bhp = Brake horsepower

C = Center distance (Inches)

cfm = Cubic Feet per Minute

C_P = Specific heat (BTU/lb*°F)

D = Fan sheave pitch diameter (Inches)

d = Motor sheave pitch diameter (Inches)

ρ = density (lb/ft^3)

Δh = Enthalpy difference (Btu/lb dry air)

Δt = Temperature difference (°F)

ΔW = Humidity Ratio (lb. or grains of water per lb of dry air)

P_a = Absolute pressure (lb per in^2 absolute, or psi)

P = Static or Total pressure

Pb = Absolute static pressure (Inches Hg.)

Q = Heat flow (Btu/hr)

R = Thermal resistances (ft^2*hr*°F/Btu)

RPM = Revolutions per minute

TS = Tip Speed (Ft per minute)

T = Temperature (°F)

SP = Static Pressure (Inches W.G.)

TP = Total Pressure (Inches W.G.)

VP = Velocity Pressure (Inches W.G.)

U = Heat transfer coefficient (Btu/ft2*hr*F)

Vol = Total Volume (ft^3)

V = Velocity (ft/min)

V_M = Measured velocity (ft/min)

Hydronic and Pump Equations

bhp = Brake horsepower

C_v = Valve constant

cfm = Cubic Feet per Minute

C_P = Specific heat (BTU/lb*°F)

D = Impeller diameter (Units of Length)

ΔP = Pressure difference (PSI)

Δt = Temperature difference (°F)

E_P = Pump efficiency

F= Force (lbs)

f = Friction factor

g = Acceleration of gravity (32 ft/s^2)

gpm = Gallons Per Minute

H = Head (feet W.G.)

h = Head loss (feet W.G.)

L = Length of pipe (ft)

NPSHA = Net Positive Suction Head Available (ft)

P = Pressure (lbs per in^2)

P_a = Atmospheric pressure (34 ft. W.G.)

P_s = Pump Centerline pressure (ft. W.G.)

P_{VP} = Absolute vapor pressure (ft. W.G.)

ρ = density (lb/ft^3)

Q = Heat flow (Btu/hr)

rpm = Revolutions Per Minute

SG = Specific Gravity (for water, use 1.00)

V = Velocity (ft/min)

$V^2/2g$ = Velocity head at point P_s (ft W.G.)

whp = Water horsepower

W.G. = Water Gauge

Electrical Equations

bhp = Brake Horsepower

E = Volts

FLA = Full Load Amps

Hp = Horsepower (Hp)

I = Amps (A)

MO = Actual motor operating amps

NL = Motor No-Load Amps

NP = Name plate

PF = Power Factor

P = Power (Watts)

R = Resistance (Ohms)

ε = Efficiency

Constants

Specific Heat of water C_P = 1.00(BTU/lb*F)

Specific Heat of water vapor C_P = 0.45(BTU/lb*F)

Specific Heat of dry air C_P = 0.24(BTU/lb*F)

Density of water (standard) d = 62.4(lb/ft^3)

Density of air (standard) d = 0.075(lb/ft^3)

Specific Volume of air (standard) = 13.33(ft^3/lb)

Latent Heat of Vaporization of air = 970(BTU/lb)

Latent Heat of Fusion of air = 144(BTU/lb)

Atmospheric pressure =14.69 psi

Specific gravity of water = 1

Conversion Factors

1ft. W.G. = 12 in. W.G.

1 Gallon Water = 8.33 lbs.

2.31 psi = 1 ft. W.G.

1 ft. W.G. = 0.433 psi.

1 psi = 2.04 In. W.G.

1 ft^3 of water = 7.49 Gallons

1 Watt = 3.413 Btu/h

1 Kilowatt = 1000 watts

1 HP = 745.7 watts

1 HP = 0.7457 kW

1 Ton of refrigeration = 12,000 Btu/h

1 lbs water in dry air = 7000 grains of moisture in dry air