Helpful HVAC Hints

o or 1 = Old   n or 2 = New

$$\frac{CFM_2}{CFM_1} = \frac{RPM_2}{RPM_1} \qquad CFM_2 = CFM_1 \times \frac{RPM_2}{RPM_1} \qquad RPM_2 = RPM_1 \times \frac{CFM_2}{CFM_1}$$

Static pressure varies as the ***square*** of the rpm: $\frac{SP_2}{SP_1} = \left(\frac{RPM_2}{RPM_1}\right)^2$

Horsepower varies as the ***cube*** of the rpm: $\frac{BHP_2}{BHP_1} = \left(\frac{RPM_2}{RPM_1}\right)^3$

* CFM and RPM are Interchangeable.

$$\frac{CFM_2}{CFM_1} = \sqrt{\frac{SP_2}{SP_1}} \qquad \left(\frac{CFM_2}{CFM_1}\right)^2 = \frac{SP_2}{SP_1} \qquad CFM_2 = CFM_1 \times \sqrt{\frac{SP_2}{SP_1}} \qquad SP_2 = SP_1 \times \left(\frac{CFM_2}{CFM_1}\right)^2$$

Static pressure varies directly with density: $\frac{SP_2}{SP_1} = \frac{D_2}{D_1}$

Horsepower varies directly with the density: $\frac{BHP_2}{BHP_1} = \frac{D_2}{D_1}$

$$\frac{CFM_2}{CFM_1} = \sqrt[3]{\frac{BHP_2}{BHP_1}} \qquad \left(\frac{CFM_2}{CFM_1}\right)^3 = \frac{BHP_2}{BHP_1} \qquad CFM_2 = CFM_1 \times \sqrt[3]{\frac{BHP_2}{BHP_1}} \qquad BHP_2 = BHP_1 \times \left(\frac{CFM_2}{CFM_1}\right)^3$$

$$FanBHP = \frac{CFM \times SP}{6356 \times SE} \qquad PumpBHP = \frac{GPM \times TDH}{3960 \times Eff}$$

For Standard Air (70F @ 29.92"):

$$V = 4005 \times \sqrt{VP} \qquad VP = \left(\frac{V}{4005}\right)^2$$

For Other Than Standard Air:

$$V = 1096.7 \times \sqrt{\frac{VP}{Den}} \qquad Den = 0.075 \times \frac{530}{460 + T} \times \frac{BAR}{29.92}$$

V = Velocity   VP = Velocity Pressure   Den = Density

$BTUH = M \times sp.ht. \times \Delta T$ M=Mass Flow Rate in Lbs. per Hour.   sp.ht.=Specific Heat in BTU/Lb. per Degree F.

Water: sp.ht.=1.0   0.12 gal.=1lb.   8.33 lbs.=1 gal.   8.33 lbs. x 60 min. = 500 lbs per hour   500 x 1.0 = 500

Air: sp.ht=0.24   13.3 cu.ft.=1 lb.   0.075 lbs.=1 cu.ft.   .075 lbs. x 60 min. = 4.5 lbs per hour   4.5 x 0.24 = 1.08

MECHANICAL TEST & BALANCE, INC.

TOTAL SYSTEM ANALYSIS

Helpful HVAC Hints

O = Old	A = Air	R = Return	M = Mixed	T = Temperature

$$\%OA = \frac{(RAT - MAT)}{(RAT - OAT)} \times 100$$

$$MAT = \frac{(\%OA \times OAT) + (\%RA \times RAT)}{100}$$

$$OAT = \frac{(MAT \times 100) - (\%RA \times RAT)}{\%OA}$$

$$RAT = \frac{(MAT \times 100) - (\%OA \times OAT)}{\%RA}$$

$$FanTipSpeedFPM = RPM \times \frac{Circ.(in.)}{12}$$

$$Circ.(in.) = \frac{Ts(FPM) \times 12}{RPM}$$

$$RPM = \frac{Ts(FPM) \times 12}{Circ.(in.)}$$

BL=Belt Length (in.) C=Distance between shaft centers (in.) D= Fan sheave dia. (in.) d=Motor Sheave dia. (in.)

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

$$FanRPM = MotorRPM \times \frac{d}{D}$$

$$MotorRPM = FanRPM \times \frac{D}{d}$$

VAV boxes or airflow controllers: 1 ton of cooling = 12,000 BTUH

$$CFM = C_v \times \sqrt{\Delta P}$$

$$C_v = \frac{CFM}{\sqrt{\Delta P}}$$

$$\Delta P = \left(\frac{CFM}{C_v}\right)^2$$

$$\text{Static Fan Efficiency} = \frac{CFM \text{ x SP}}{6356 \text{ x BHP}}$$

New **Motor** Sheave size:

$$\textbf{Dia.}_n = \text{Dia.}_o \text{ x } \frac{RPM_n}{RPM_o}$$

New **Fan** Sheave size:

$$\textbf{Dia.}_n = \text{Dia.}_o \text{ x } \frac{RPM_o}{RPM_n}$$

$$\textbf{Max. Motor Sheave} = \text{Existing Motor Sheave Dia. x } \sqrt[3]{\frac{\text{Max. BHP}}{\text{Existing Est. BHP}}}$$

$$\textbf{Max. Fan Sheave Dia.} = \frac{\text{Existing Fan Sheave Dia.}}{\sqrt[3]{\frac{\text{Max. BHP}}{\text{Existing Est. BHP}}}}$$

** indicates read amps or voltage*

$$\textbf{Estimated BHP} = \frac{A^* \text{ x } V^*}{745.7}$$

$$\textbf{Single Phase BHP} = \frac{A^* \text{ x } V^* \text{ x Eff. x PF}}{745.7}$$

$$\textbf{Three Phase BHP} = \frac{1.732 \text{ x } A^* \text{ x } V^* \text{ x Eff. x PF x L}}{745.7}$$

$$\frac{RPM_{fan}}{RPM_{motor}} = \frac{\text{Pitch dia. motor sheave}}{\text{Pitch dia. fan sheave}}$$

Helpful HVAC Hints

V=Volts A=Amperes R=Ohms P=Watts PF=Powerfactor (Motor) Eff=Efficiency (Motor) HP=Horsepower
BHP=Break Horsepower (Motor) r=running np=nameplate

Ohm's Law: $V = A \times R$ $R = \frac{V}{A}$ $A = \frac{V}{R}$

Single Phase: $P = V \times A \times PF$ $V = \frac{P}{A \times PF}$ $A = \frac{P}{V \times PF}$ $BHP = \frac{V \times A \times Eff \times PF}{746}$

Three Phase: $P = V \times A \times PF \times 1.732$ $V = \frac{P}{A \times PF \times 1.732}$ $A = \frac{P}{V \times PF \times 1.732}$ $BHP = \frac{V \times A \times Eff \times PF \times 1.732}{746}$

Estimated BHP from Amps and Volts: $BHP = npHP \times \frac{rV \times rA}{\text{np}V \times \text{np}A}$

Hydronics: = CFM = GPM, RPM = GPM

Valve flow: $GPM = C_v \times \sqrt{\Delta P(psi)}$ $GPM = C_v \times \sqrt{\frac{\Delta P(feet)}{2.31}}$ $Cv = \frac{GPM}{\sqrt{\Delta P(psi)}}$ $\Delta P(psi) = \left(\frac{GPM}{Cv}\right)^2$

Coefficient of performance: $COP = \frac{BTUH}{Watts \times 3.41}$ Tower approach: $LWT - EATwb$

Equivalents:
1 psi = 2.31ft. H2O = 27.72 in. H2O = 2.04 in. HG
1 in. HG = 0.49 psi = 1.13 ft. H2O = 13.58 in. H2O
0 psig at sea level = 14.7 psia = 29.92 in. HG = 33.96 ft. H2O = 407.5 in. H2O
1 gal H2O = 8.3 lbs. 1 lb. H2O = 0.12 Gal. 1 cu.ft. H2O = 7.5 gal. = 62.25 lbs.
1 ton = 12,000 BTUH 1 Watt = 3.41 BTUH 1 HP = 746 Watts = 2544 BTUH
1 gal Heating Oil = 140,000 BTU (Typ.)

Round Duct = R2 x 3.14 = Area ÷ 144 = Sq. Ft.

Square Duct = W x H = Area ÷ 144 = Sq. Ft.

Oval Duct = W-H = ? x H = Area
H/2 = (?)2 x 3.14 = + ?
? ÷ 144 = Sq.Ft.

Example: **33 x 16**
Oval Duct = 33-16 = 17 x 16 = 272
16/2 = (8)2 x 3.14 = + 200.96
472.96 ÷ 144 = 3.28 Sq.Ft.

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$$CFM = \frac{BTUH(Sensible)}{1.08 \times \Delta T(DryBulb)}$$

$$BTUH = CFM \times 1.08 \times \Delta T \times \frac{Den}{0.075}$$

$$\Delta T = \frac{BTUH}{1.08 \times CFM}$$

$$BTUH(Total) = CFM \times \Delta h \times 4.5 \times \frac{Den}{0.075}$$

h = Enthalpy in BTU per Lb.

$$\frac{BTUH}{1000} = MBH$$

$$GPM = \frac{BTUH}{500 \times \Delta T(Water)}$$

$$BTUH = GPM \times 500 \times \Delta T$$

$$\Delta T = \frac{BTUH}{500 \times GPM}$$

$$AirChanges / Hr. = \frac{CFM \times 60}{RoomVolume}$$

$$CFM = RoomVolume \times \frac{AirChanges / Hr}{60}$$

Quick Reference = Ratio To Be Used As A Estimation:

Step One:

Find the ratio of CFM NEEDED to CFM MEASURED. To do this;

CFM needed ÷ CFM measured = ratio

STORE THIS NUMBER IN MEMORY!

Whenever you see RATIO below, it refers to the one stored in memory.

Step Two:

TO FIND NEW FAN RPM..................**OLD RPM *x* RATIO = NEW RPM**

TO FIND NEW STATIC PRESSURE..................**OLD STATIC *x* RATIO^2 = NEW RPM**

TO FIND NEW BHP..................**OLD BHP *x* RATIO^3 = NEW BHP**

TO FIND NEW AMPS..................**OLD AMPS *x* RATIO^3 = NEW AMPS**

TO FIND NEW DRIVE SHEAVE SIZE.................**OLD DRIVE *x* RATIO**

TO FIND NEW FAN SHEAVE SIZE..................**OLD FAN SHEAVE ÷ RATIO**