FAN LAWS

INCOMPRESSIBLE FLOW & CONSTANT EFFICIENCY

1) $CFMa = CFM_b \times (RPM_a / RPM_b)$

2) $FTPa = FTP_b \times (RPM_a / RPM_b)^2 \times (\delta_a / \delta_b)$

3) $HPa = HP_b \times (RPM_a / RPM_b)^3 \times (\delta_a / \delta_b)$

4) $PWLa = PWL_b + 50 \log (RPM_a / RPM_b) + 20 \log (\delta_a / \delta_b)$

WHERE:

RPM = rotative speed
CFM= capacity
FTP= fan total pressure
HP= power
PWL= sound power level, dB
δ= gas density

Example:

The fan operates at 11,500 rpm and delivers 800 cfm @ 6 in wg at 0.0765 lb/ft^3. The fan requires 1300 watts. The noise level is 85 dB.

What is the fan performance at 0.063 lb/ft^3 and 7600 rpm?

1) $CFMa = CFM_b \times (RPM_a / RPM_b)$
$CFMa = 800 \times (7600 / 11500)$
$CFMa = 529$ cfm

2) $FTPa = FTP_b \times (RPM_a / RPM_b)^2 \times (\delta_a / \delta_b)$
$FTPa = 6.0 \times (7600 / 11500)^2 \times (.063 / .0765)$
$FTPa = 2.16$ in wg

3) $HPa = HP_b \times (RPM_a / RPM_b)^3 \times (\delta_a / \delta_b)$
$HPa = 1300 \times (7600 / 11500)^3 \times (.063 / .0765)$
$HPa = 309$ watts

4) $PWLa = PWL_b + 50 \log (RPM_a / RPM_b) + 20 \log (\delta_a / \delta_b)$
$PWLa = 85 + 50 \log (7600 / 11500) + 20 \log (.063 / .0765)$
$PWLa = 85 - 8.99 - 1.69$
$PWLa = 74$ dB

BASIC FORMULAS

PRESSURE CONVERSIONS:

psi= 0.0361 *(in wg) in Hg = 2.036*(psi) millibars= 0.4018*(in wg)

in wg = 13.60*(in Hg) psi= 0.4912 * (in Hg) bars = 0.0690 * (psi)

CAPACITY CONVERSIONS:

liters/sec = 0.4719*(cfm) cfm = 2.1192*(l/s)

POWER CONVERSIONS:

WATTS = 745.7*(hp) BTU/HR = 3.413*(watts)

DENSITY CALCULATION:

$\rho\ (lb/ft^3) = 1.326*Pb\ (in\ Hg) / (459.7 + T_F)$ $\rho\ (lb/ft^3) = .07647 * (P/P_0) * (T_O/T)$ T(°R)

$\rho\ (kg/m^3) = 16.0169 * \rho\ (lb/ft^3)$

VELOCITY:

$V\ (ft/sec) = cfm / (60 * A(ft^2))$

MASS FLOW:

$m\ (lb/min) = \rho\ (lb/ft^3) * cfm$

VELOCITY PRESSURE:

$Pv\ (in\ wg) = V^2/4460$ @ 0.075 lb/ft^3 $Pv\ (in\ wg) = V^2/4372$ @ 0.0765 lb/ft^3

FAN AIR HORSEPOWER:

$AHP = CFM * P_{TOTAL} / 6356$

FAN TOTAL EFFICIENCY:

$\eta_{TOTAL} = 745.6 * AHP / WATTS$

AIR TEMPERATURE RISE:

$\Delta T_{AIR} = 0.2370 * Watts / m\ (lb/min)$ where c_p=.240 Btu / lb-°F

SYSTEM RESISTANCE CURVE:

$\Delta P_{SYSTEM} \alpha\ (cfm)^n$ n = 2 for turbulent flow

DC Power:

Watts (DC) = Volts * Amps

3 Phase AC Power:

Watts (AC) = 1.732 * Volts * Amps * Power Factor

Power Factor = Watts / (1.732 * Volts * Amps)