Application Engineering Basics

Throughout our catalog, you will find terminology used for air moving selection and product sizing. Below are a few of the key terms:

Flow

- Volume Rate/Time
- Charts are in SCFM, m^3/min, or L/S
- SCFM = Standard Cubic Feet Per Minute (American) where temperature = 68°F, air density = 0.075 lb/cubic foot, and altitude = 0 feet above sea level
- M^3/min = Cubic Meters Per Minute (Metric)
- L/sec = Liters Per Second (Metric)
- 1 m^3/min = 35.3 SCFM
- 1 L/sec = 2.119 SCFM
- See Standard Engineering Conversions for other flows on pg. I-2

Pressure

- Force/Area
- Rotron charts are in IWG, PSIG, MM of Water, IHG, or mbar
- IWG = Inches of Water Gauge (American)
- PSIG = Pounds Per Square Inch Gauge (American)
- MM of Water = Millimeter of Water Gauge (Metric)
- IHG = Inches of Mercury Gauge (American)
- mbar = Millibar Gauge (Metric)
- PSIA = Pounds Per Square Inch Absolute (American)
- 27.7 IWG = 1 PSIG
- 703.58 MM of Water = 1 PSIG
- 2.036 IHG = 1 PSIG
- 0.069 Bars = 69 mbar = 1 PSIG
- Standard Atmosphere = 0 PSIG = 14.7 PSIA
- See Basic Fan Laws Chart for correcting pressure due to speed or density changes on pgs. I-5 and I-6

Density

- Weight/Volume
- Standard Air = 0.075 lb/cubic foot
- See Density Chart for other gases on pg. I-4
- See Density Correction Chart due to altitude and temperature changes on pg. I-3

Specific Gravity

- Density Ratio Relative to Air
- Standard Air SG = 1.0
- Methane SG = 0.55
- See Specific Gravity Chart for other gases on pg. I-4

Velocity

- Distance/Time or Flow/Area
- FPM = Feet Per Minute (American)
- MPH = Miles Per Hour (American)
- M/min = Meters Per Minute (Metric)
- Km/h = Kilometers Per Hour (Metric)
- 88 FPM = 1 MPH
- 26.82 M/min = 1 MPH
- 1.609 Km/h = 1 MPH
- See Standard Engineering Conversion Chart for other velocities on pg. I-2
- See Orifice Flow Calculation Chart for air flow equations on pg. I-7

Pressure Drop/Back Pressure/Impedance

- Friction causes air to slow down and lost energy is measured in pressure drop terms
- Typical pressure drop areas include piping, elbows, accessories and system
- Each fixed system has a fixed system impedance caused by a single or multiple pressure drop points
- Changing the system impedance will cause blowers work point to change
- Changing the blower with fixed system impedance will change the working back pressure
- See Friction Loss Per Foot of Tubing and Fitting Charts on pg. I-8

Application Engineering Basics

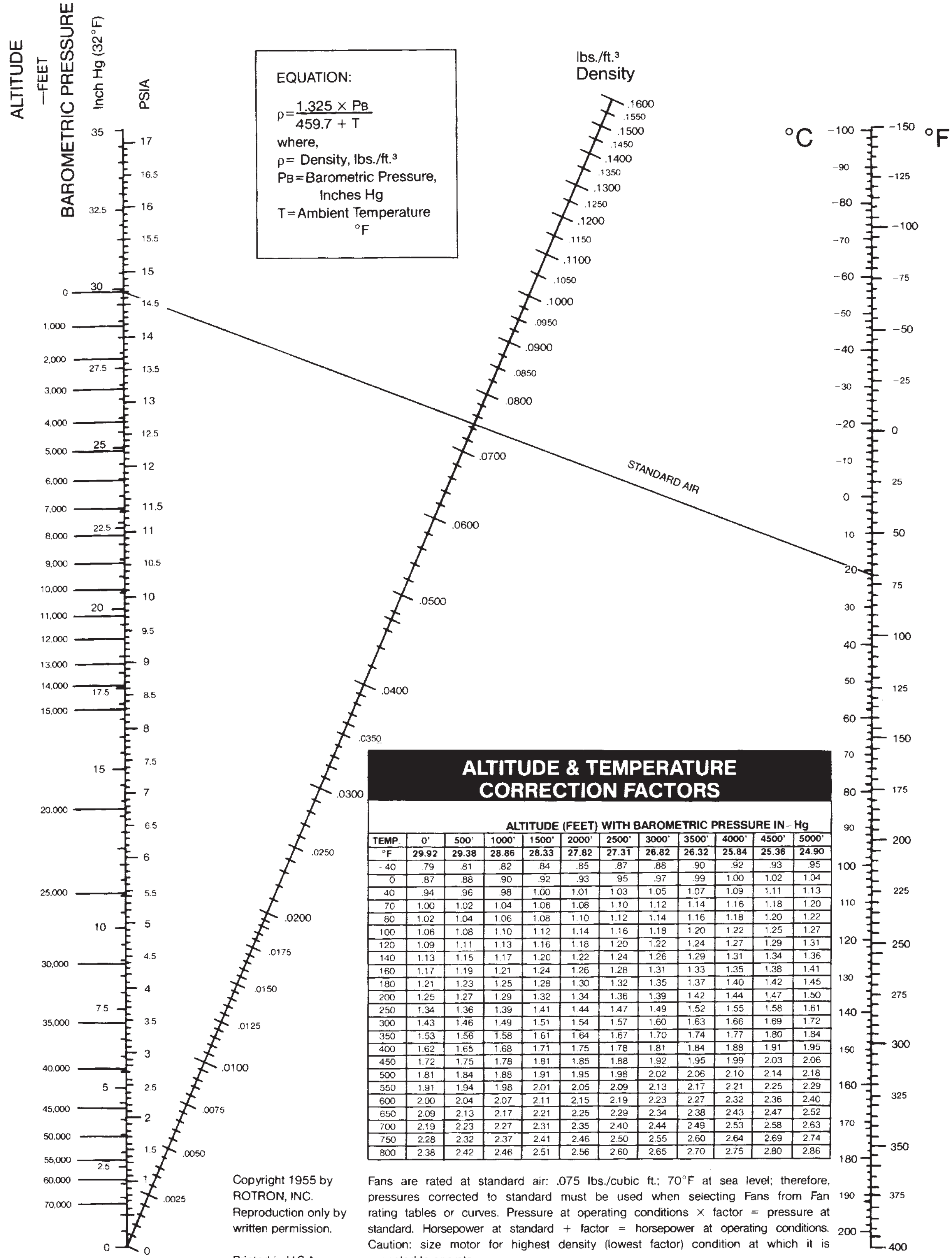
Standard Engineering Conversions

MULTIPLY	BY	TO OBTAIN
Atmospheres	76.0	Cms. of Mercury
Atmospheres	29.92	Inches of Mercury
Atmospheres	33.90	Feet of Water
Atmospheres	10,333	Kgs./Sq. Inch
Atmospheres	1.013×10^{5}	Pascals
Atmospheres	14.70	Pounds/Sq. Inch
Atmospheres	760	Torrs
Bars	0.9869	Atmospheres
Bars	$1. \times 10^{6}$	Dynes/Sq. Cm.
Bars	1.020×10^{4}	Kgs./Square Meter
Bars	14.50	Pounds/Sq. Inch
British Thermal Units	0.2520	Kilogram-Calories
British Thermal Units	777.5	Foot-Pounds
British Thermal Units	3.927×10^{-4}	Horsepower-Hours
British Thermal Units	1054	Joules
British Thermal Units	107.5	Kilogram-Meters
British Thermal Units	2.928×10^{-4}	Kilowatt-Hours
Centimeters of Mercury	0.01316	Atmospheres
Centimeters of Mercury	0.4461	Feet of Water
Centimeters of Mercury	136.0	Kgs./Square Meter
Centimeters of Mercury	0.1934	Pounds/Sq. Inch
Centimeters/Second	1.969	Feet/Minute
Centimeters/Second	0.6	Meters/Minute
Cubic Centimeters	3.531×10^{-5}	Cubic Feet
Cubic Centimeters	6.102×10^{-2}	Cubic Inches
Cubic Centimeters	10^{-6}	Cubic Meters
Cubic Centimeters	10^{-3}	Liters
Cubic Feet	2.832×10^{4}	Cubic Cms.
Cubic Feet	1728	Cubic Inches
Cubic Feet	0.02832	Cubic Meters
Cubic Feet	0.03704	Cubic Yards
Cibic Feet	7.481	Gallons
Cubic Feet	28.32	Liters
Cu. Ft. of Water (60°F)	62.37	Pounds
Cubic Feet/Minute	472.0	Cubic Cms./Sec.
Cubic Feet/Minute	0.4720	Liters/Second
Cubic Feet/Minute	62.4	Lbs. of Water/Min.
Cubic Inches	16.39	Cubic Centimeters
Cubic Inches	5.787×10^{-4}	Cubic Feet
Cubic Inches	1.639×10^{-5}	Cubic Meters
Cubic Inches	2.143×10^{-5}	Cubic Yards
Cubic Meters	10^{6}	Cubic Centimeters
Cubic Meters	35.31	Cubic Feet
Cubic Meters	61,023	Cubic Inches
Cubic Meters	1.308	Cubic Yards
Cubic Yards	7.646×10^{5}	Cubic Centimeters
Cubic Yards	27	Cubic Feet
Cubic Yards	46,656	Cubic Inches
Cubic Yards	0.7646	Cubic Meters
Feet	30.48	Centimeters
Feet	12	Inches
Feet	0.3048	Meters
Feet	1/3	Yards
Feet of Air (1 atmosphere 60°F)	5.30×10^{-4}	Pounds/Square Inch
Feet/Minute	0.5080	Centimeters/Sec.
Feet/Minute	0.01667	Feet/Second
Feet/Minute	0.01829	Kilometers/Hour
Feet/Minute	0.3048	Meters/Minute
Feet/Minute	0.01136	Miles/Hour
Grams/Cu. Cm.	62.43	Pounds/Cubic Foot
Horsepower	42.44	British Thermal Units/Min.
Horsepower	33,000	Foot-Pounds/Min.
Horsepower	10.70	Kg.-Calories/Min.
Horsepower	745.7	Watts
Horsepower-Hours	2547	British Thermal Units
Inches	2.540	Centimeters
Inches	10^{3}	Mils
Inches of Mercury	0.03342	Atmospheres
Inches of Mercury	13.60	Inches of Water
Inches of Mercury	345.3	Kgs./Square Meter
Inches of Mercury	25.40	Mms. of Mercury
Inches of Mercury	0.4912	Pounds/Square In.
Inches of Water	0.002458	Atmospheres
Inches of Water	0.07355	Inches of Mercury
Inches of Water	25.40	Kgs./Square Meter
Inches of Water	5.204	Pounds/Square Ft.
Inches of Water	0.03613	Pounds/Square In.

MULTIPLY	BY	TO OBTAIN
KGS./Cubic Meter	0.06243	Pounds/Cubic Foot
Kilometers	3281	Feet
Kilowatts	56.92	British Thermal Units/Min.
Kilowatts	737.6	Foot-Pounds/Sec.
Kilowatts	1.341	Horsepower
Kilowatts	14.34	Kg.-Calories/Min.
Kilowatt-Hours	3415	British Thermal Units
Liters	10^{3}	Cubic Centimeters
Liters	61.02	Cubic Inches
Liters	10^{-3}	Cubic Meters
$Log_{10}N$	2.303	$Log_{E}N$ or Ln N
Log N or Ln N	0.4343	$Log_{10}N$
Meters	100	Centimeters
Meters	3.2808	Feet
Meters	39.37	Inches
Meters	10^{-3}	Kilometers
Meters/Minute	1.667	Centimeters/Sec.
Meters/Minute	3.281	Feet/Minute
Meters/Minute	0.06	Kilometers/Hour
Meters/Minute	0.03728	Miles/Hour
Miles	5280	Feet
Miles	1.6093	Kilometers
Miles	1760	Yards
Miles/Hour	44.70	Centimeters/Sec.
Miles/Hour	88	Feet/Minute
Miles/Hour	1,467	Feet/Second
Miles/Hour	1.6093	Kilometers/Hour
Miles/Hour	26.82	Meters/Minute
Mms. of Mercury	0.0394	Inches of Mercury
Mms. of Mercury	1.3595^{-3}	Kgs./Square Cm.
Mms. of Mercury	0.01934	Pounds/Square Inch
Pints (Liq.)	28.87	Cubic Inches
Pints (U.S. liquid)	473,179	Cubic Centimeters
Pints (U.S. liquid)	16	Ounces (U.S. fluid)
Pounds	444,823	Dynes
Pounds	453.6	Grams
Pounds	16	Ounces
Pounds of Carbon to CO^{2}	14,544	British Thermal Units (mean)
Pounds of Water	27.68	Cubic Inches
Pounds of Water	0.1198	Gallons
Pounds of Water Evaporated at 212°F	970.3	British Thermal Units
Pounds/Cubic Foot	16.02	Kgs./Cubic Meter
Pounds/Square Foot	4,882	Kgs./Square Meter
Pounds/Square Inch	0.06804	Atmospheres
Pounds/Square Inch	27.7	Inches of Water
Pounds/Square Inch	2.036	Inches of Mercury
Pounds/Square Inch	703.1	Kgs./Square Meter
Pounds/Square Inch	6.895×10^{3}	Pascals
Pounds/Square Inch	51.715	Millimeters of Mercury at 0°C
Square Centimeters	1.973×10^{5}	Circular Mils
Square Centimeters	1.076×10^{-3}	Square Feet
Square Centimeters	0.1550	Square Inches
Square Feet	929.0	Square Centimeters
Square Feet	0.09290	Square Meters
Square Inches	1.273×10^{6}	Circular Mils
Square Inches	6.452	Square Centimeters
Square Inches	6.944×10^{-3}	Square Feet
Square Inches	10^{6}	Square Mils
Square Inches	645.2	Square Millimeters
Square Kilometers	10.76×10^{6}	Square Feet
Square Kilometers	10^{6}	Square Meters
Square Kilometers	1.196×10^{6}	Square Yards
Square Meters	10.764	Square Feet
Square Meters	1.196	Square Yards
Temp. (Degs. C.) + 273	1	Abs. Temp. (Degs. C.)
Temp. (Degs. C.) + 17.8	1.8	Temp. (Degs. Fahr.)
Temp. (Degs. F.) + 460	1	Abs. Temp. (Degs. F.)
Temp. (Degs. F.) -32	5/9	Temp. (Degs. Cent.)
Watts	0.05692	British Thermal Units/Min.
Watts	10^{7}	Ergs/Second
Watts	44.26	Foot-Pounds/Min.
Watts	1.341×10^{-3}	Horsepower
Watts	0.01434	Kg.-Calories/Min.
Watts	10^{-3}	Kilowatts
Watts-Hour	3.415	British Thermal Units
Watts-Hour	1.341 x 10-	Horsepower/Hours
Watts-Hour	10^{-3}	Kilowatt-Hours

Application Engineering Basics

Density Correction Chart



EQUATION:

$$\rho = \frac{1.325 \times P_B}{459.7 + T}$$

where,
ρ = Density, lbs./ft.³
P_B = Barometric Pressure, Inches Hg
T = Ambient Temperature °F

ALTITUDE & TEMPERATURE CORRECTION FACTORS

TEMP.	ALTITUDE (FEET) WITH BAROMETRIC PRESSURE IN - Hg										
	0'	500'	1000'	1500'	2000'	2500'	3000'	3500'	4000'	4500'	5000'
°F	29.92	29.38	28.86	28.33	27.82	27.31	26.82	26.32	25.84	25.36	24.90
-40	.79	.81	.82	.84	.85	.87	.88	.90	.92	.93	.95
0	.87	.88	.90	.92	.93	.95	.97	.99	1.00	1.02	1.04
40	.94	.96	.98	1.00	1.01	1.03	1.05	1.07	1.09	1.11	1.13
70	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20
80	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22
100	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.25	1.27
120	1.09	1.11	1.13	1.16	1.18	1.20	1.22	1.24	1.27	1.29	1.31
140	1.13	1.15	1.17	1.20	1.22	1.24	1.26	1.29	1.31	1.34	1.36
160	1.17	1.19	1.21	1.24	1.26	1.28	1.31	1.33	1.35	1.38	1.41
180	1.21	1.23	1.25	1.28	1.30	1.32	1.35	1.37	1.40	1.42	1.45
200	1.25	1.27	1.29	1.32	1.34	1.36	1.39	1.42	1.44	1.47	1.50
250	1.34	1.36	1.39	1.41	1.44	1.47	1.49	1.52	1.55	1.58	1.61
300	1.43	1.46	1.49	1.51	1.54	1.57	1.60	1.63	1.66	1.69	1.72
350	1.53	1.56	1.58	1.61	1.64	1.67	1.70	1.74	1.77	1.80	1.84
400	1.62	1.65	1.68	1.71	1.75	1.78	1.81	1.84	1.88	1.91	1.95
450	1.72	1.75	1.78	1.81	1.85	1.88	1.92	1.95	1.99	2.03	2.06
500	1.81	1.84	1.88	1.91	1.95	1.98	2.02	2.06	2.10	2.14	2.18
550	1.91	1.94	1.98	2.01	2.05	2.09	2.13	2.17	2.21	2.25	2.29
600	2.00	2.04	2.07	2.11	2.15	2.19	2.23	2.27	2.32	2.36	2.40
650	2.09	2.13	2.17	2.21	2.25	2.29	2.34	2.38	2.43	2.47	2.52
700	2.19	2.23	2.27	2.31	2.35	2.40	2.44	2.49	2.53	2.58	2.63
750	2.28	2.32	2.37	2.41	2.46	2.50	2.55	2.60	2.64	2.69	2.74
800	2.38	2.42	2.46	2.51	2.56	2.60	2.65	2.70	2.75	2.80	2.86

Fans are rated at standard air: .075 lbs./cubic ft.; 70°F at sea level; therefore, pressures corrected to standard must be used when selecting Fans from Fan rating tables or curves. Pressure at operating conditions × factor = pressure at standard. Horsepower at standard + factor = horsepower at operating conditions. Caution: size motor for highest density (lowest factor) condition at which it is expected to operate.

Application Engineering Basics

Specific Gravity and Density of Various Gases at 60°F (1 ATM)

Gas or Vapor	Chemical Formula	Specific Gravity	Density (lbs./cu/ ft.)
Acetylene	C_2H_2	0.899	.0686
Air	–	1.00	.0763
Ammonia	NH_3	0.587	.0454
Argon	A	1.377	.1053
Benzene	C_6H_6	2.70	.205
Carbon Dioxide	CO_2	1.539	.1166
Chlorine	Cl_2	2.448	.0738
Ethane	C_2H_6	1.038	.0799
Ethylene	C_2H_4	0.969	.0739
Helium	He	0.138	.01054
Hydrogen	H_2	0.0695	.00531
Hydrogen Sulfide	H_2S	1.19	.0897
Methane	CH_4	0.555	.0424
Methyl Chloride	CH_3Cl	1.785	.1356
Nitrogen	N_2	0.967	.0738
Oxygen	O_2	1.105	.0843
Propane	C_3H_8	1.55	.1180
Sulfer Oxide	SO_2	2.26	.1720
Water Vapor	H_2O	0.622	.0373

Explosive Atmosphere Classification

North American	European	
Class I	**Zone 1**	
Group A	**Group II C**	Acetylene
Group B	**Group II C**	Hydrogen or equivalent hazard
Group C	**Group II B**	Ethyle ether vapors, ethylene or cyclopropane
Group D	**Group II A**	Gasoline, hexane, naptha, benzene, butane, alcohol, acetone, benzol, lacquer vapors or natural gas
Class II		
Group E	—	Metal dust
Group F	—	Carbon black, coal or coke dust
Group G	—	Flour, starch or grain

Temperature Conversion Chart

*In the center column, find the temperature to be converted. The equivalent temperature is in the left column, if converting to Celsius, and in the right column, if converting to Fahrenheit.

°C	Temp	°F	°C	Temp	°F	°C	Temp	°F	°C	Temp	°F
-78.9	-110	-166	1.7	35	95.0	27.2	81	177.8	182	360	680
-73.3	-100	-148	2.2	36	96.8	27.8	82	179.6	188	370	698
-67.8	-90	-130	2.8	37	98.6	28.3	83	181.4	193	380	716
-62.2	-80	-112	3.3	38	100.4	28.9	84	183.2	199	390	734
-56.7	-70	-94	3.9	39	102.2	29.4	85	185.0	204	400	752
-51.1	-60	-76	4.4	40	104.0	30.0	86	186.8	210	410	770
-45.6	-50	-58	5.0	41	105.8	30.6	87	188.6	216	420	788
-40.0	-40	-40	5.6	42	107.6	31.1	88	190.4	221	430	806
-34.4	-30	-22	6.1	43	109.4	31.7	89	192.2	227	440	824
-28.9	-20	-4	6.7	44	111.2	32.2	90	194.0	232	450	842
-23.3	-10	14	7.2	45	113.0	32.8	91	195.8	238	460	860
-17.8	0	32	7.8	46	114.8	33.3	92	197.6	243	470	878
-17.2	1	33.8	8.3	47	116.6	33.9	93	199.4	249	480	896
-16.7	2	35.6	8.9	48	118.4	34.4	94	201.2	254	490	914
-16.1	3	37.4	9.4	49	120.2	35.0	95	203.0	260	500	932
-15.6	4	39.2	10.0	50	122.0	35.6	96	204.8	266	510	950
-15.0	5	41.0	10.6	51	123.8	36.1	97	206.6	271	520	968
-14.4	6	42.8	11.1	52	125.6	36.7	98	208.4	277	530	986
-13.9	7	44.6	11.7	53	127.4	37.2	99	210.2	282	540	1004
-13.3	8	46.4	12.2	54	129.2	37.8	100	212.0	288	550	1022
-12.8	9	48.2	12.8	55	131.0	43	110	230	293	560	1040
-12.2	10	50.0	13.3	56	132.8	49	120	248	299	570	1058
-11.7	11	51.8	13.9	57	134.6	54	130	266	304	580	1076
-11.1	12	53.6	14.4	58	136.4	60	140	284	310	590	1094
-10.6	13	55.4	15.0	59	138.2	66	150	302	316	600	1112
-10.0	14	57.2	15.6	60	140.0	71	160	320	321	610	1130
-9.4	15	59.0	16.1	61	141.8	77	170	338	327	620	1148
-8.9	16	60.8	16.7	62	143.6	82	180	356	332	630	1166
-8.3	17	62.6	17.2	63	145.4	88	190	374	338	640	1184
-7.8	18	64.4	17.8	64	147.2	93	200	392	343	650	1202
-7.2	19	66.2	18.3	65	149.0	99	210	410	349	660	1220
-6.7	20	68.0	18.9	66	150.8	100	212	413	354	670	1238
-6.1	21	69.8	19.4	67	152.6	104	220	428	360	680	1256
-5.6	22	71.6	20.0	68	154.4	110	230	446	366	690	1274
-5.0	23	73.4	20.6	69	156.2	116	240	464	371	700	1292
-4.4	24	75.2	21.1	70	158.0	121	250	482	377	710	1310
-3.9	25	77.0	21.7	71	159.8	127	260	500	382	720	1328
-3.3	26	78.8	22.2	72	161.6	132	270	518	388	730	1346
-2.8	27	80.6	22.8	73	163.4	138	280	536	393	740	1364
-2.2	28	82.4	23.3	74	165.2	143	290	554	399	750	1382
-1.7	29	84.2	23.9	75	167.0	149	300	572	404	760	1400
-1.1	30	86.0	24.4	76	168.8	154	310	590	410	770	1418
-0.6	31	87.8	25.0	77	170.6	160	320	608	416	780	1436
0	32	89.6	25.6	78	172.4	166	330	626	421	790	1454
0.6	33	91.4	26.1	79	174.2	171	340	644	427	800	1472
1.1	34	93.2	26.7	80	176.0	177	350	662	432	810	1490

°F = 9/5C + 32   ABSOLUTE RANKIN (R) R = °F + 460
°C = 5/9 (F - 32)   ABSOLUTE KELVIN (K) K = °C + 273

NEMA Classifications

NEMA

- **Type 1** – General Purpose – Indoor
- **Type 2** – Dripproof – Indoor
- **Type 3** – Dusttight, Raintight and Sleet (Ice) Resistant – Outdoor
- **3R** – Rainproof and Sleet (Ice) Resistant – Outdoor
- **3S** – Dusttight, Raintight and Sleet (Ice) Proof – Outdoor
- **Type 4** – Watertight and Dusttight – Indoor
- **4X** – Watertight, Dusttight and Corrosion Resistant – Outdoor
- **Type 5** – Superseded by Type 12 for Control Apparatus
- **Type 6** – Submersible, Watertight, Dusttight and Sleet Resistant – Indoor and Outdoor
- **Type 7** – Class I, Group A, B, C or D Hazardous Locations; Air Break Equipment – Indoor
- **Type 8** – Class I, Group A, B, C or D Hazardous Locations; Oil-immersed Equipment – Indoor
- **Type 9** – Class II, Group E, F or G Hazardous Locations; Air-break Equipment – Indoor
- **Type 10** – Bureau of Mines
- **Type 11** – Corrosion Resistant and Dripproof; Oil-immersed – Indoor
- **Type 12** – Industrial Use, Dusttight and Driptight – Indoor
- **Type 13** – Oiltight and Dusttight – Indoor

Ref: NEMA Standards Publication, Pub. No. 1CS–1970

Application Engineering Basics

Physical Laws for Blower Applications

In the following formulae these symbols are used:

P – Pressure in pounds per square inch (PSI) or inches of mercury column (inches Hg)
CFM – Volume in cubic feet per minute
RPM – Speed in revolutions per minute
D – Density in pounds per cubic foot (lbs./cu. ft.)
H – Height of air or gas column (ft.)
SG – Specific Gravity (ratio of density of gas to the density of air)

"Standard Air" – Air at 68°F (absolute temperature 528°) and 29.92" Hg. (barometric pressure at sea level). The density of such air is 0.075 lbs./cu. ft. and the specific volume is 13.29 cu. ft./lb. The specific gravity is 1.0.

The outlet pressure of a blower depends on the condition of the air or gas at the inlet. The inlet condition is influenced by:

a – Specific gravity (The ratio of density of the gas to density of standard air)
b – Altitude (location of blower)
c – Temperature of inlet air

Basic Fan Laws Chart

VARIABLE	VOLUME	PRESSURE	HORSEPOWER
WHEN SPEED CHANGES	Varies DIRECT with Speed Ratio $CFM_2 = CFM_1 \left(\frac{RPM_2}{RPM_1}\right)$	Varies with SQUARE of Speed Ratio $P_2 = P_1 \left(\frac{RPM_2}{RPM_1}\right)^2$	Varies with CUBE of Speed Ratio $HP_2 = HP_1 \left(\frac{RPM_2}{RPM_1}\right)^3$
WHEN DENSITY CHANGES	Does Not Change	Varies DIRECT with Density Ratio $P_2 = P_1 \left(\frac{D_2}{D_1}\right)$	Varies DIRECT with Density Ratio $HP_2 = HP_1 \left(\frac{D_2}{D_1}\right)$

Volume

The Volume changes in *direct* ratio to the speed.
Example – A blower is operating at 3500 RPM and delivering 1000 CFM. If the speed is reduced to 3000 RPM, what is the new volume?

V_1 = Original Volume (1000 CFM)
V_2 = New Volume
RPM_1 = Original Speed (3500 RPM)
RPM_2 = New Speed (3000 RPM)

$$V_2 = V_1 \left(\frac{RPM_2}{RPM_1}\right)^1 = 1000 \times \left(\frac{3000}{3500}\right)^1 = 1000 \times .857 = 857 \text{ CFM}$$

Pressure

Pressure (barometric) varies in direct proportion to altitude.
Example – A blower is to operate at an elevation of 6000 feet and is to deliver 3 PSI pressure. What pressure (standard air) blower is required?

$$\text{Pressure} = 3 \times \frac{29.92}{23.98} = 3.75 \text{ or } 3\ 3/4 \text{ lb.}$$

If it is desired to determine what pressure a 3 lb. (standard air) blower will deliver at 6000 feet –

$$\text{Pressure} = 3 \times \frac{23.98}{29.92} = 2.4 \text{ or about } 2\ 1/2 \text{ lb.}$$

When a blower is to operate at a high altitude it is frequently specified that the blower be capable of handling a given volume of "standard air". It is then necessary to determine the equivalent volume of air at the higher altitude.
Example – A blower is to operate 6000 feet altitude and is to handle 1000 CFM of standard air. What is the CFM of air the blower must handle at 6000 feet altitude?

Let: V_1 = Volume of standard air (1000 CFM)
V_2 = Volume of thinner air
Hg_1 = Barometric pressure sea level (29.92)
Hg_2 = Barometric pressure 6000' (23.98)

$$V_2 = V_1 \times \frac{Hg_1}{Hg_2} = 1000 \times \frac{29.92}{23.98} = 1248 \text{ CFM}$$

The pressure changes as the *square* of the speed ratio.
Example – A blower is operating at a speed of 3500 RPM and delivering air at 5.0 pounds pressure. If the speed is reduced to 3000 RPM, what is the new pressure?

P_1 = Original Pressure (5 lbs.)
P_2 = New Pressure
RPM_1 = Original Speed (3500 RPM)
RPM_2 = New Speed (3000 RPM)

$$P_2 = P_1 \left(\frac{RPM_2}{RPM_1}\right)^2 = 5 \times \left(\frac{3000}{3500}\right)^2 = 5 \times .735 = 3.68 \text{ pounds}$$

Application Engineering Basics

The Air Density varies in inverse proportion to the absolute temperature.
Example – A blower is to handle 200°F air at 3 PSI pressure. What pressure (standard air) blower is required?

Let: P_1 = Pressure hot air (3 PSI)
P_2 = Pressure standard air
AT_1 = Absolute temperature hot air (200+460=660°F)
AT_2 = Absolute temperature standard air (68+460=528°F)

$$P_2 = P_1 \times \frac{AT_1}{AT_2} = 3 \times \frac{660}{528} = 3.75 \text{ or } 3\ 3/4 \text{ lb.}$$

A blower is capable of delivering 3 PSI pressure with standard air. What pressure will it develop handling 200°F inlet air?

$$P_1 = P_2 \times \frac{AT_2}{AT_1} = 3 \times \frac{528}{660} = 2.4 \text{ or about } 2\ 1/2 \text{ lb.}$$

Pressure varies in direct proportion to the density.
Example – A 3 lb. (standard air) blower is to be used to handle gas having a specific gravity of 0.5. What pressure does the blower create when handling the gas?

Let: Pa = Air pressure (3 lb.)
Pg = Gas pressure
SG = Specific gravity of gas (0.5)

Pg = Pa x SG = 3 x .5 = 1.5 lb.

If we are required to handle a gas having a specific gravity of 0.5 at 1.5 lb. pressure, we can determine the standard air pressure blower as follows:

$$\text{Let: Pa} = \frac{Pg}{SG} = \frac{1.5}{.5} = 3 \text{ lb.}$$

The following table gives the barometric pressure of various altitudes:
Absolute Pressure At Altitudes Above Sea Level (Based on U.S. Standard Atmosphere)

Altitude	Pressure		Altitude	Pressure		Altitude	Pressure	
Feet	In. Hg.	PSIA	Feet	In. Hg.	PSIA	Feet	In. Hg.	PSIA
0	29.92	14.70	2,500	27.31	13.41	7,000	23.09	11.34
500	29.38	14.43	3,000	26.81	13.19	7,500	22.65	11.12
600	29.28	14.38	3,500	26.32	12.92	8,000	22.22	10.90
700	29.18	14.33	4,000	25.84	12.70	8,500	21.80	10.70
800	29.07	14.28	4,500	25.36	12.45	9,000	21.38	10.50
900	28.97	14.23	5,000	24.89	12.23	9,500	20.98	10.90
1,000	28.86	14.18	5,500	24.43	12.00	10,000	20.58	10.10
1,500	28.33	13.90	6,000	23.98	11.77			
2,000	27.82	13.67	6,500	23.53	11.56			

Horsepower

The horsepower changes as the *cube* of the speed ratio.
Example – A blower is operating at a speed of 3500 RPM and requiring 50 horsepower. If the speed is reduced to 3000 RPM, what is the new required horsepower?

HP_1 = Original Horsepower (50)
HP_2 = New Horsepower
RPM_1 = Original Speed (3500 RPM)
RPM_2 = New Speed (3000 RPM)

$$HP_2 = HP_1 \times \left(\frac{RPM_2}{RPM_1}\right)^3 = 50 \times \left(\frac{3000}{3500}\right)^3 = 50 \times .630 = 31.5 \text{ horsepower}$$

The above is known as the 1-2-3 rule of blowers.

Horsepower vs. Specific Gravity & Ratio of density.
The horsepower varies in direct proportion to the specific gravity (ratio of density of gas to density of air).
Example – A standard air blower requires a 10 HP motor. What horsepower is required when this blower is to handle a gas whose specific gravity is 0.5?

HP = 10 x 0.5 = 5 horsepower

It is possible that several of the above modifications may be required on one installation. Therefore, it may be necessary to use various combinations of these formulae.

Application Engineering Basics

Orifice Flow Calculation

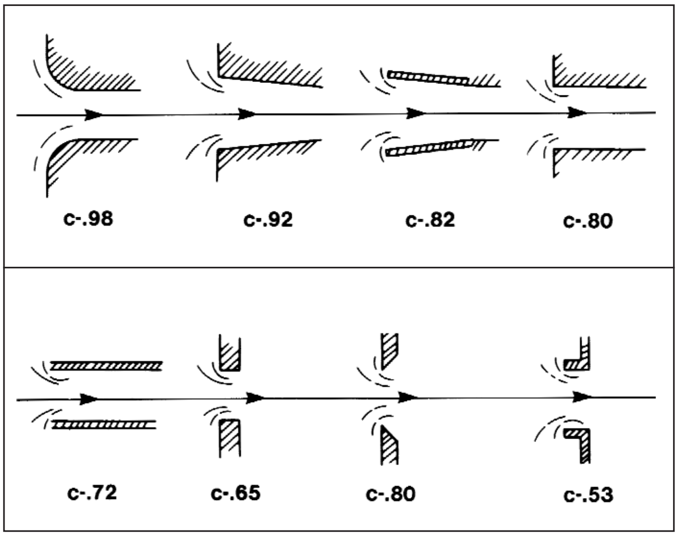
To determine air flow through an orifice:

$V = CK\sqrt{P}$ $Q = AV$ $VP = \left(\frac{V}{K}\right)^2$

Where:

- V = Velocity in feet per minute (fpm)
- C = Orifice Coefficient
- K = Constant = 14,786 when P is expressed in In. Hg
  21,094 when P is expressed in PSIG
  4,005 when P is expressed in In. of Water
  (Above constants are based on an air density of 0.075 lbs/ft³)
- P = Pressure differential across the orifice
- Q = Flow rate in cubic feet per minute (CFM)
- A = Total orifice area expressed in square feet
- VP = Velocity pressure (units are those of pressure)

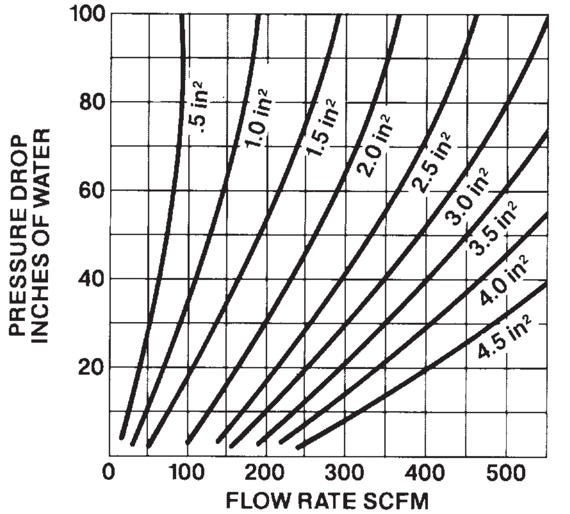
Coefficient C for Orifices Under Vacuum or Pressure Flow

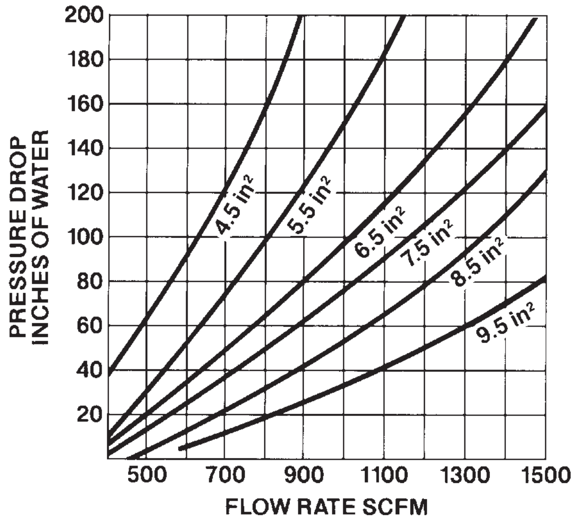


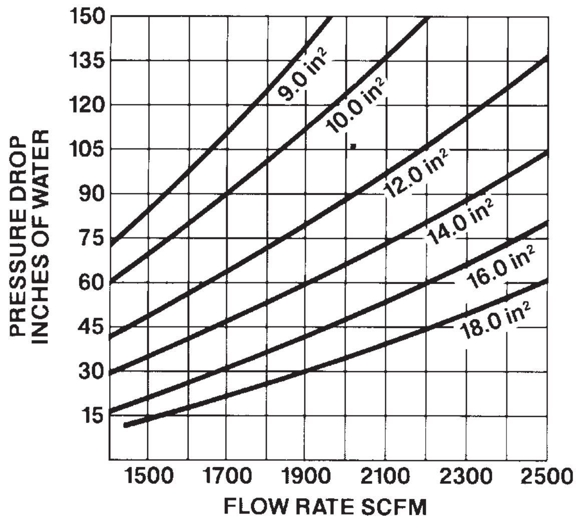
Area of Orifices Orifice Diameter in Inches		
Diameter in Inches	Square Inches	Square Feet
1/8	.01227	.000085
3/16	.02761	.00019
1/4	.04908	.00034
3/8	.11044	.00076
1/2	.19634	.00136
5/8	.30679	.00213
7/8	.60132	.00417
1.0	.78539	.00545

Orifice area (in sq. inches) = .25 X π X (orifice diameter in inches)²
Orifice area (in sq. feet) = Area in sq. inches ÷ 144

ORIFICE PRESSURE DROP AS A FUNCTION OF FLOW AND ORIFICE AREA (C=.65)

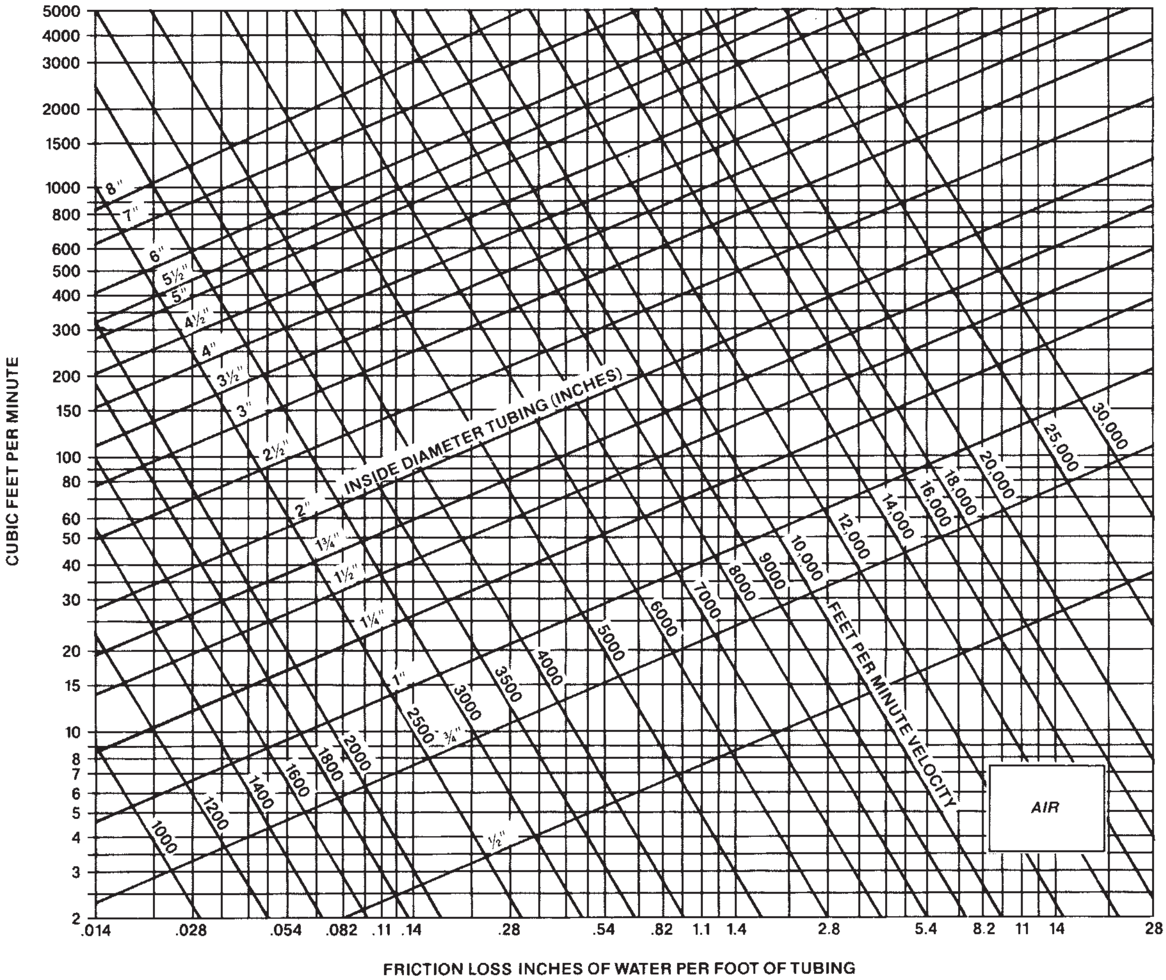






Application Engineering Basics

Friction Loss Per Foot of Tubing



Friction Loss in Fittings

To calculate friction loss in fittings use chart below. This chart will yield equivalent lengths (in feet) of tubing. Use this length with graph above to find friction loss in inches of water column.

NOMINAL PIPE SIZE (INCHES)	EQUIVALENT TUBING LENGTH (FEET)	
	90° EL	45° EL
1 1/4	3	1.5
1 1/2	4	2
2	5	2.5
2 1/2	6	3
3	7	4
4	10	5
5	12	6
6	15	7.5
8	20	10

Application Engineering Basics

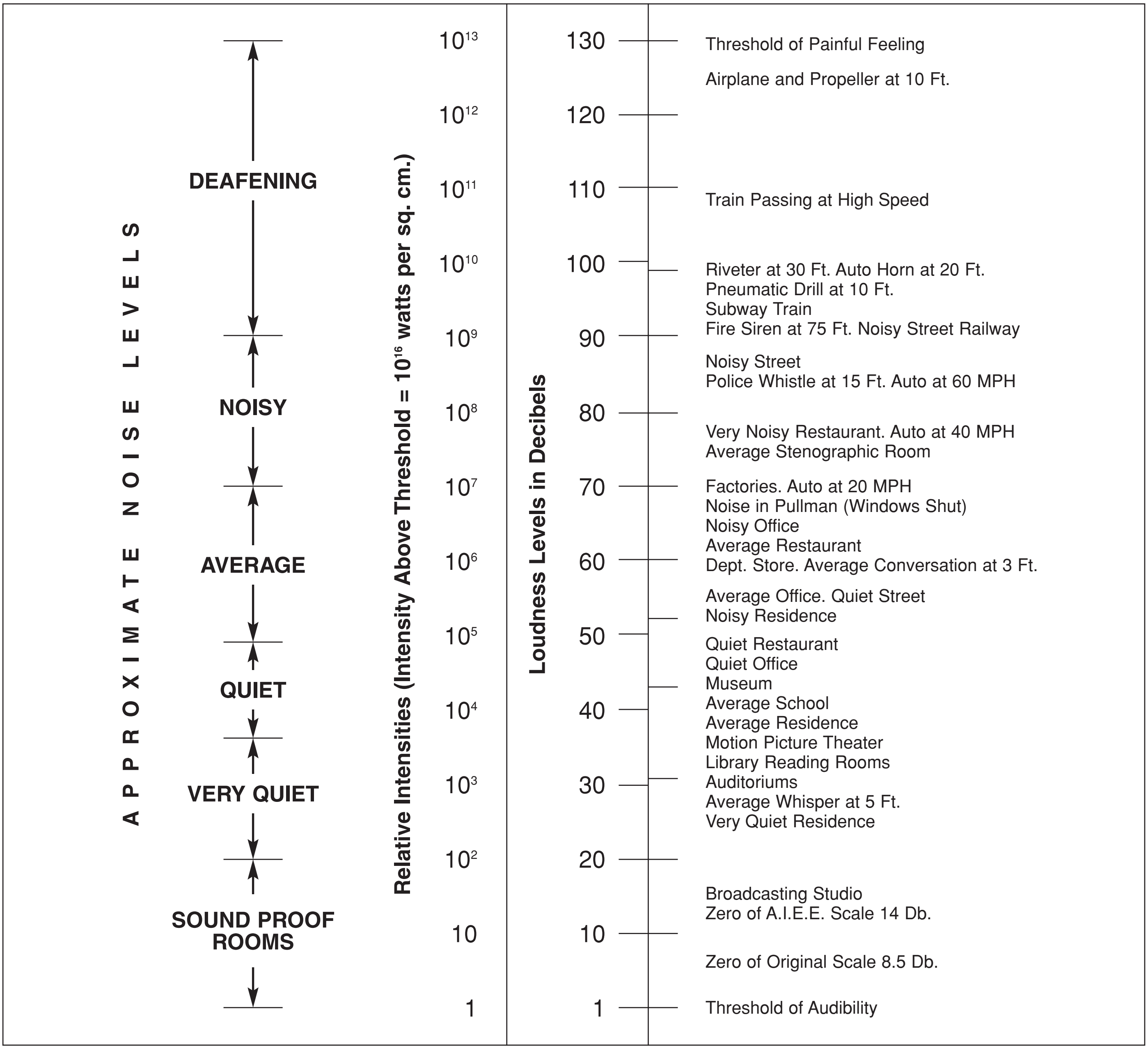
Noise Facts

- OSHA (Occupational Safety & Health Administration) regulates and monitors in-plant noise.
- Allowable noise is a function of dBA level at certain distance over an exposure time.
- OSHA regulations state 90 dBA for an 8 hour work period using slow responic setting on meter.
- Adding a second noise producer of equal dBA will add 3 dBA to the first dBA reading.
- Sound pressure level (SPL) decreases with distance (d)

  $(SPL)_2 = (SPL)_1 - 20LOG\left(\frac{d2}{d1}\right)$

  Therefore, each doubling of distance results in 6 dBA reduction.

Loudness Levels of Familiar Noises (Approximate Average Including Ear Network)



Application Engineering Basics

Industrial Blower Noise Chart* in dBA

* Average at 1 meter, 4 places around the blower

Model	Mode		Model	Mode		Model	Mode		Model	Mode		Model	Mode	
	Suction	Pressure		Suction	Pressure		Suction	Pressure		Suction	Pressure		Suction	Pressure
SE	60-62	60-62	101	65-67	66-68	513	80-81	80-81	707	83-85	84-86	S/P 9	90-91	90-91
MF	64-65	64-65	202M	67-69	68-70	505M	77-78	76-77	808	84-85	84-85	909	81-82	84-86
RDC	76-78	76-78	303M	65-67	67-69	523	82-83	82-83	623	81-82	81-82	1223	84-85	84-85
SL2	69-72	69-72	353M	72-73	73-74	555	80-81	80-81	S7	88-89	88-89	S/P 13	87-88	90-91
SL4	72-78	72-78	404M	73-74	74-75	656	82-83	82-83	858	84-85	84-85	14	86-87	86-87
SL5	76-79	76-79	454M	76-77	75-76	6	85-86	85-86	823	82-84	82-84	S/P 15	91-92	91-92

dBA at Distance Conversion Chart

To read, use straight edge to connect blower distance and dBA rating. A pivot point A will be developed. Use straight edge again with new distance and pivot point A to read dBA at new distance.