# ROTRON®

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
- ROTRON charts are in SCFM, m3/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
- M3/min = Cubic Meters Per Minute (Metric)
- L/sec = Liters Per Second (Metric)
- 1 m3/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

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## Standard Engineering Conversion

| 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 | $1.013 \times 10^{5}$ | Pascals |
| Atmospheres | 14.70 | Pounds/Sq. Inch |
| Atmospheres | 760 | Torrs |
| Bars | 0.9869 | Atmospheres |
| Bars | $1. \times 10^{6}$ | Dynes/Sq. Cm. |
| Bars | $1.020 \times 10^{4}$ | 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 | $3.927 \times 10^{-4}$ | Horsepower-Hours |
| British Thermal Units | 1054 | Joules |
| British Thermal Units | 107.5 | Kilogram-Meters |
| British Thermal Units | $2.928 \times 10^{-4}$ | 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 | $3.531 \times 10^{-5}$ | Cubic Feet |
| Cubic Centimeters | $6.102 \times 10^{-2}$ | Cubic Inches |
| Cubic Centimeters | $10^{-6}$ | Cubic Meters |
| Cubic Centimeters | $10^{-3}$ | Liters |
| Cubic Feet | $2.832 \times 10^{4}$ | 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 | $5.787 \times 10^{-4}$ | Cubic Feet |
| Cubic Inches | $1.639 \times 10^{-5}$ | Cubic Meters |
| Cubic Inches | $2.143 \times 10^{-5}$ | 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 | $7.646 \times 10^{5}$ | 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) | $5.30 \times 10^{-4}$ | 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 | $6.895 \times 10^{3}$ | Pascals |
| Pounds/Square Inch | 51.715 | Millimeters of Mercury at 0°C |
| Square Centimeters | $1.973 \times 10^{5}$ | Circular Mils |
| Square Centimeters | $1.076 \times 10^{-3}$ | Square Feet |
| Square Centimeters | 0.1550 | Square Inches |
| Square Feet | 929.0 | Square Centimeters |
| Square Feet | 0.09290 | Square Meters |
| Square Inches | $1.273 \times 10^{6}$ | Circular Mils |
| Square Inches | 6.452 | Square Centimeters |
| Square Inches | $6.944 \times 10^{-3}$ | Square Feet |
| Square Inches | $10^{6}$ | Square Mils |
| Square Inches | 645.2 | Square Millimeters |
| Square Kilometers | $10.76 \times 10^{6}$ | Square Feet |
| Square Kilometers | $10^{6}$ | Square Meters |
| Square Kilometers | $1.196 \times 10^{6}$ | 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 | $1.341 \times 10^{-3}$ | 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 |

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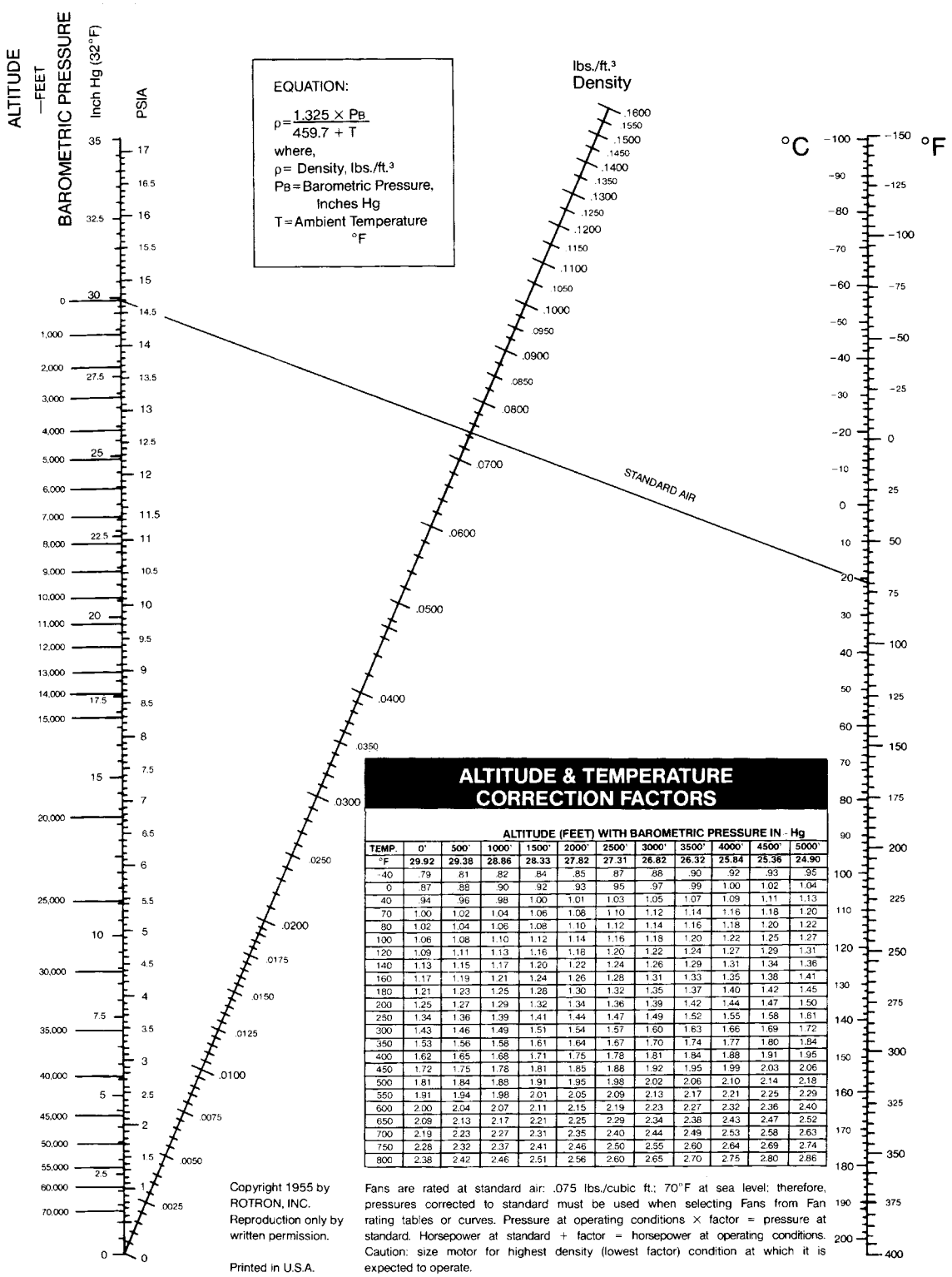
## Density Correction Chart




### ALTITUDE & TEMPERATURE CORRECTION FACTORS

| | ALTITUDE (FEET) WITH BAROMETRIC PRESSURE IN - Hg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TEMP. °F | 0' 29.92 | 500' 29.38 | 1000' 28.86 | 1500' 28.33 | 2000' 27.82 | 2500' 27.31 | 3000' 26.82 | 3500' 26.32 | 4000' 25.84 | 4500' 25.36 | 5000' 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 |

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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.

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## 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

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## 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)

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

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## Pressure (Cont'd)

**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 Feet | Pressure | | Altitude Feet | Pressure | | Altitude Feet | Pressure | |
|---|---|---|---|---|---|---|---|---|
| | In. Hg. | PSIA | | In. Hg. | PSIA | | 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.

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## Orifice Flow

### Orifice Flow Calculation

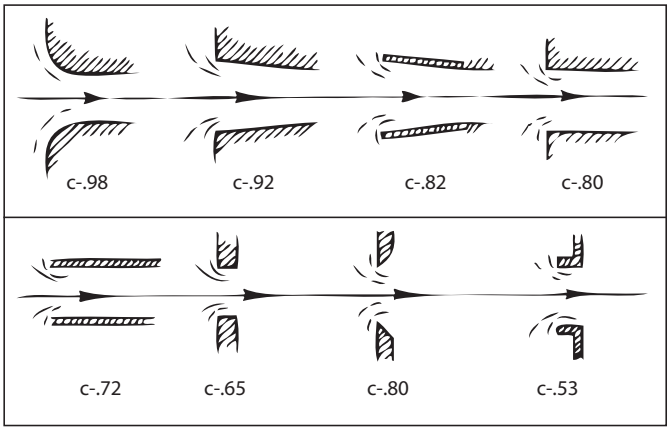
To determine air flow through an orifice:

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

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/ft $^3$)
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)

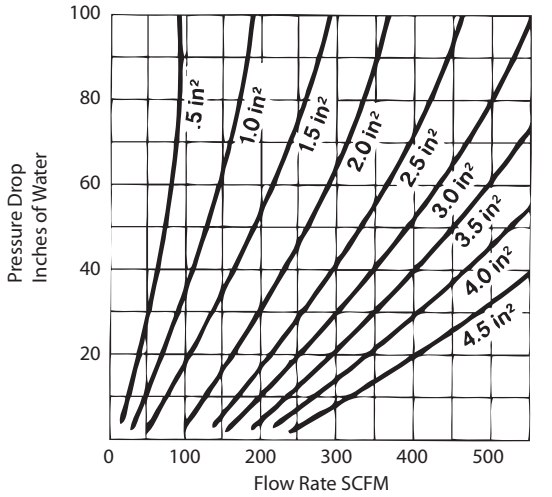
### Coefficient C for Orifices Under Vacuum or Pressure Flow

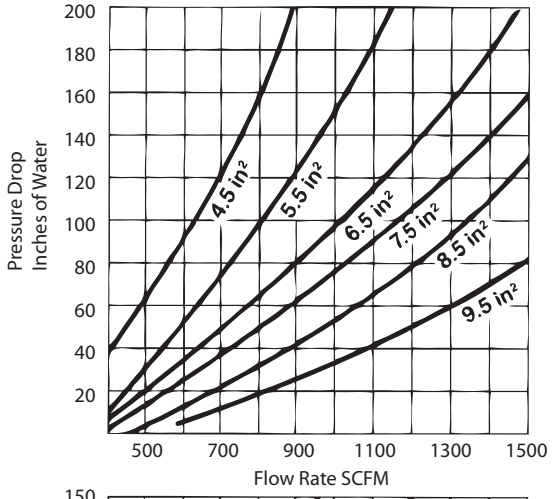


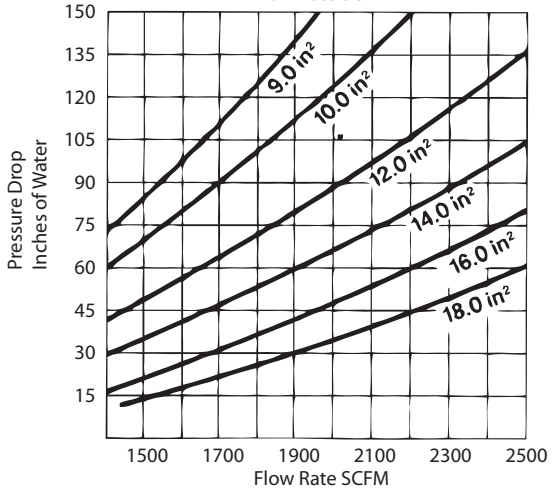

| Area of Orifices<br>Orifice Diameter in Inches | | |
|---|---|---|
| Diameter in Inches | Square Inches | Square Feet |
| 1/8 | .01227 | .000085 |
| 3/16 | .02761 | .00019 |
| 1/4 | .04908 | .00034 |
| 3/8 | .11044 | .00076 |
| 1/2 | .19634 | .00136 |
| 5/8 | .30679 | .00213 |
| 7/8 | .60132 | .00417 |
| 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)

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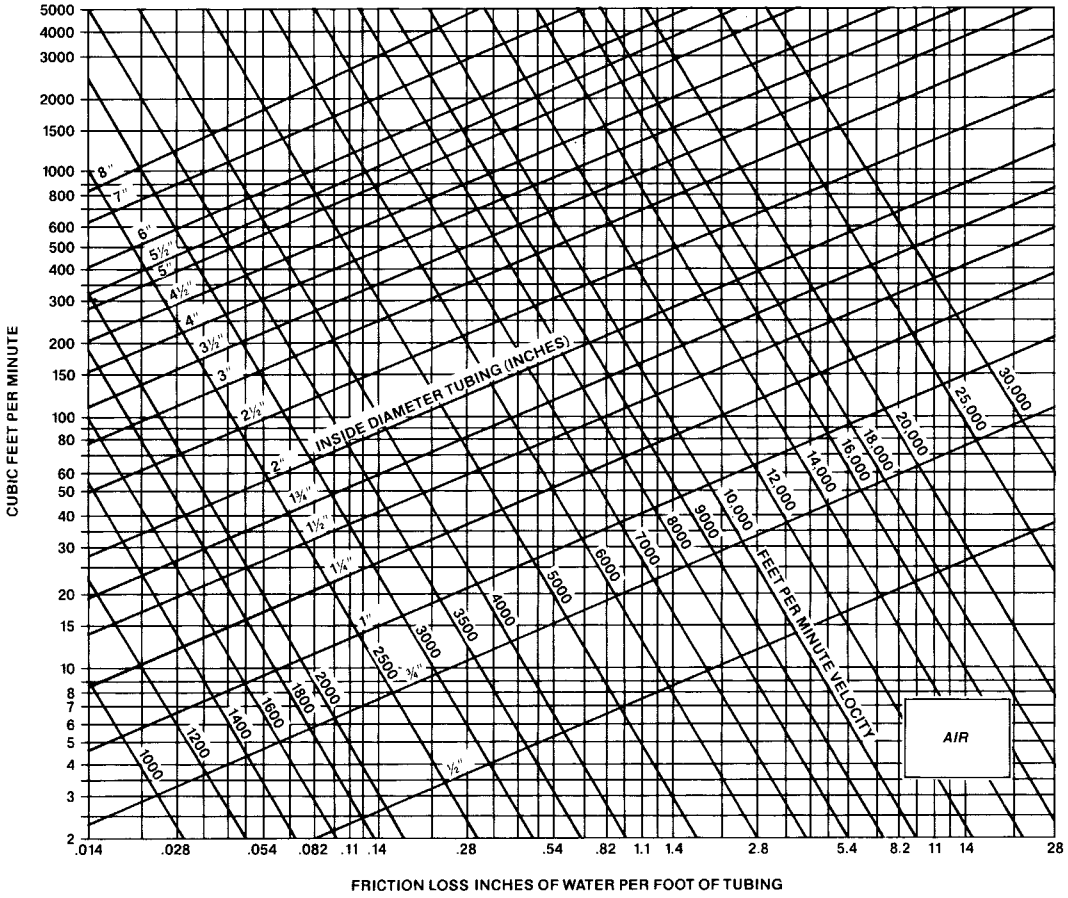
## Friction Loss Per Foot of Tubing




## 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 |

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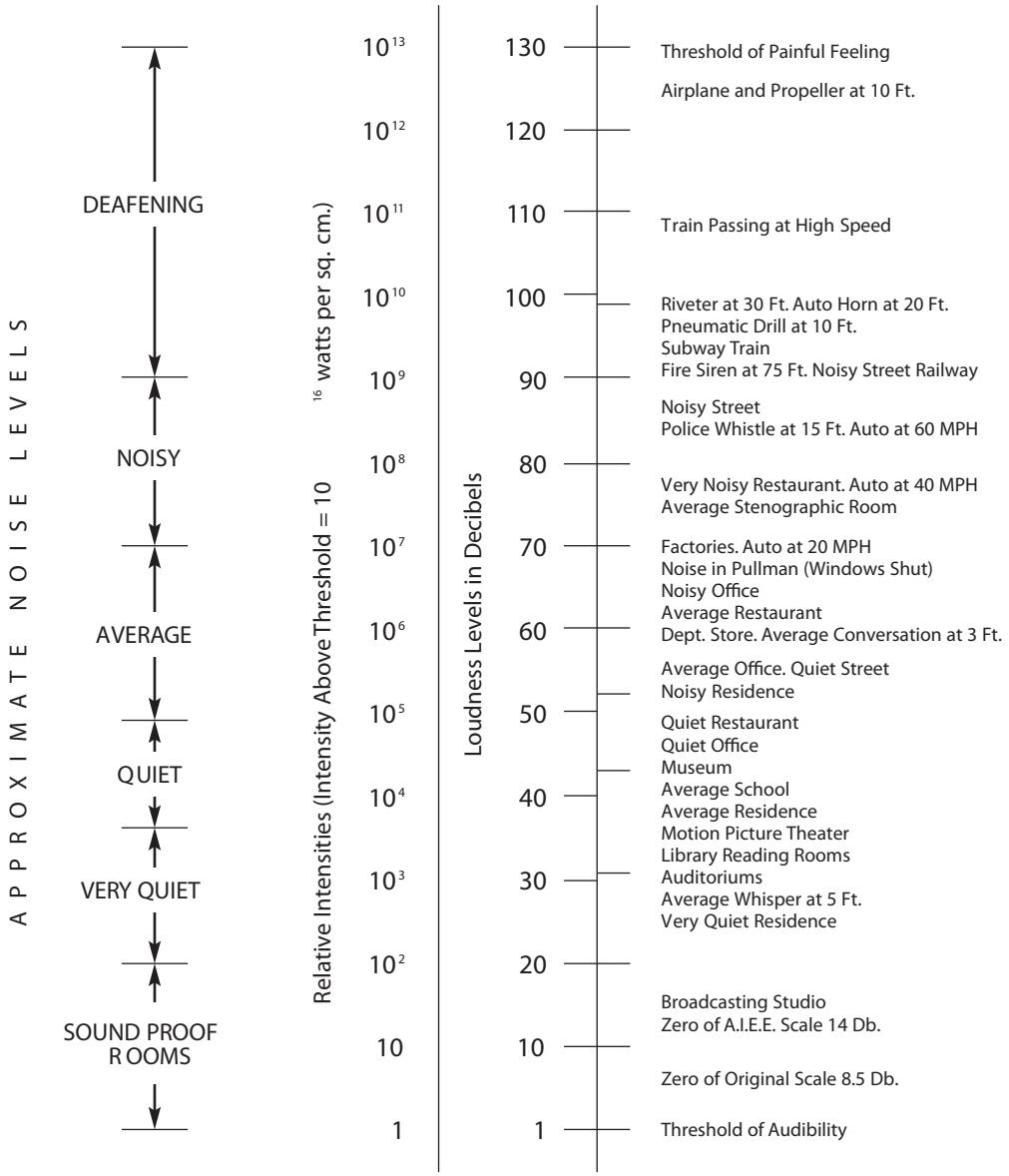
## Noise Facts

- 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 Nework)

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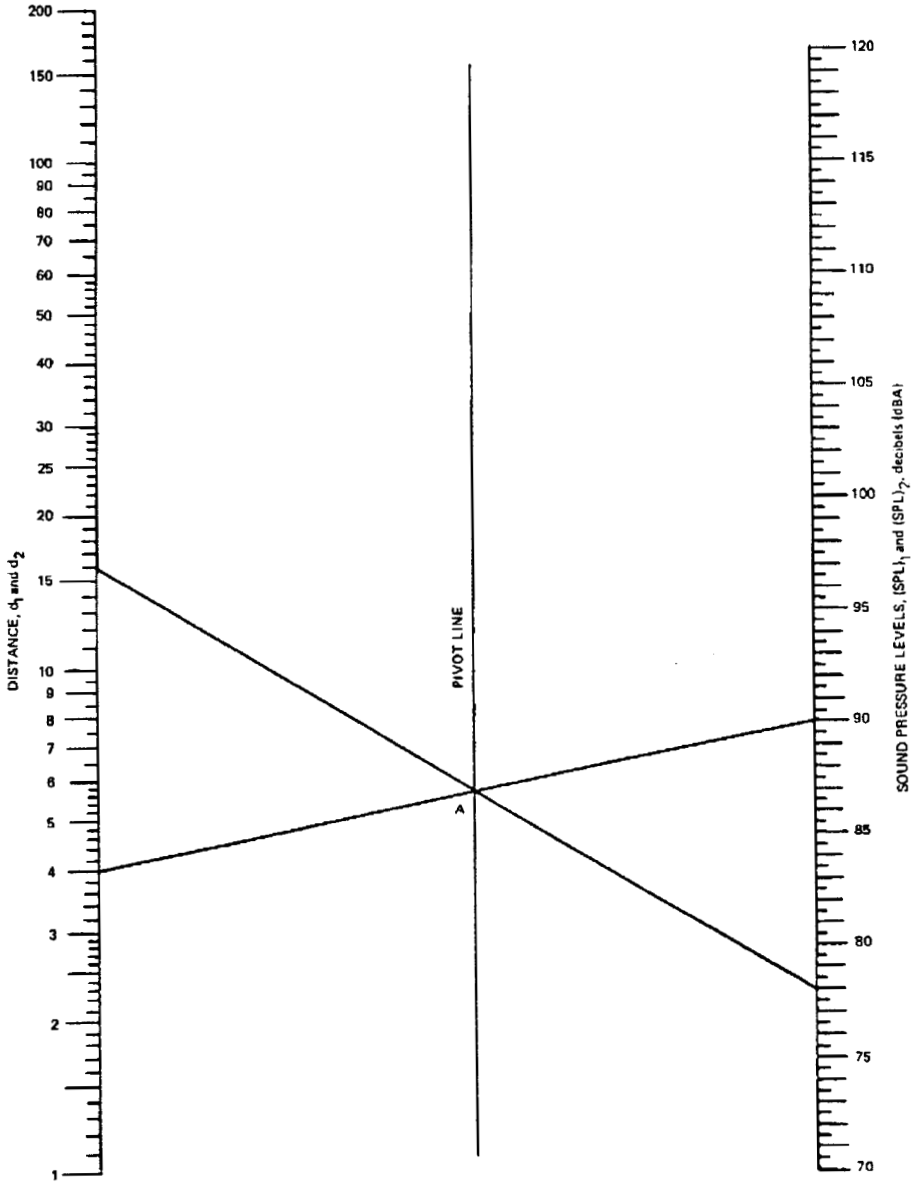
## Industrial Blower Noise Chart* in dBA

| 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 | 757 | 83-85 | 84-86 | S/P 9 | 90-91 | 90-91 |
| MF | 64-65 | 64-65 | 202 | 67-69 | 68-70 | 505 | 77-78 | 76-77 | 808 | 84-85 | 84-85 | 909 | 81-82 | 84-86 |
| RDC | 76-78 | 76-78 | 303 | 65-67 | 67-69 | 523 | 82-83 | 82-83 | 633 | 81-82 | 81-82 | 1233 | 84-85 | 84-85 |
| SL2 | 69-72 | 69-72 | 353 | 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 | 404 | 73-74 | 74-75 | 656 | 82-83 | 82-83 | 858 | 84-85 | 84-85 | 14 | 86-87 | 86-87 |
| SL5 | 76-79 | 76-79 | 454 | 76-77 | 75-76 | 6 | 85-86 | 85-86 | 833 | 82-84 | 82-84 | S/P 15 | 91-92 | 91-92 |

* Average at 1 meter, 4 places around the blower

## 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.

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