cincinnati fan

OEM and Industrial Air Handling Specialist

ENGINEERING DATA

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Visit us at www.cincinnatifan.com for more information.

Catalog ENG-409 Supersedes ENG-203

AMCA International Member

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I. TERMS AND DEFINITIONS

AHP. – Air Horsepower, is work done by the fan expressed as horsepower.

$$AHP = \frac{CFM \times TP}{6356}$$

BHP. – Brake Horsepower, is the horsepower absorbed by the fan.
BTU. – British Thermal Unit, is the amount of heat required to raise one pound of water from 63˚F to 64˚F.
CFM. – Cubic Feet Per Minute, is the volume of air moved per minute.
Capture Velocity – The air velocity at any point in front of a hood or at the hood opening nec-essary to overcome opposing air currents and capture the contaminated air by causing it to flow into the hood.
Conveying Velocity – The minimum air velocity required to move or transport particles within a duct system. Measured in feet per minute.
Drive Losses – Power lost in overcoming friction from the belt, pulley and bearing friction.
EDR. – Equivalent Direct Radiation, is the amount of heating surface which will give off 240 BTU. per hour.
FPM. – Feet Per Minute, is the velocity of the airstream.
Final Temperature – is the temperature of air after passing over heating coils under specified conditions.
Free Air Delivery – is the condition under which a fan operates when no static pressure or resistance is present.
HP. – Horsepower, is the actual rated output of the fan motor used.
ME. – Mechanical Efficiency, is the ratio of horsepower absorbed (BHP) to horsepower delivered by the fan (AHP).

$$ME = \frac{AHP}{BHP}$$

Plenum Chamber – is an air compartment maintained under pressure to serve one or more distributing ducts.
RPM. – Revolutions Per Minute, is the number of times the fan shaft revolves per minute.
Replacement Air – The term has been used in the same context as supply air, make-up, and intake air. It introduces fresh outside air into a structure to replace air exhausted from fans.
Standard Air – is air which weighs .075 pounds per cubic foot, which is dry air at 70˚F dry bulb with a barometric pressure of 29.92 inches of mercury.
SE. – Static Efficiency, is expressed as

$$SE = \frac{CFM \times SP}{6356 \times BHP}$$

SP. – Static Pressure, is a measure of the force exerted by the fan in moving air through any ventilating system.
Stall – A region of instability on a fan performance curve. Evidence of this region is a dip in the performance curve, also a drop in the BHP curve. It is caused by the separation of the air flow from the surface of the propeller blade or fan wheel.
Shut Off – is the point of operation where the fan flow rate is zero.
System – The path through which air is pushed or pulled. This normally includes ducts, coils, filter, plenum changer, etc., through which air flows. A system can be as simple as inducing air motion into a space or a network of ducts providing air for multiple locations.
TE. – or Total Efficiency, may be expressed as

$$TE = \frac{CFM \times TP}{6356 \times BHP}$$

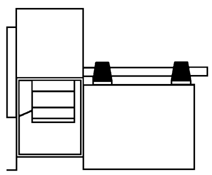
TS. – Tip-Speed, is the peripheral speed in feet per minute of a propeller tip or fan wheel at any specified RPM.
TP. – Total Pressure, is the sum of the static pressure (SP), and velocity pressure (VP) at any given point in a ventilating system.
V. – Velocity, is equal to the flow rate (CFM) divided by the cross-sectional area of the air flow. V = CFM ÷ Area (Sq. Ft.).
VP. – Velocity Pressure, is equal to the kinetic energy per unit volume of the flowing air. It can be calculated from the formula.

$$VP = \left[\frac{FPM}{4005}\right]^2$$

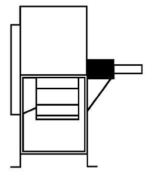
Transport Velocity – See Conveying Velocity.

II. FAN ARRANGEMENTS AS DEFINED BY AMCA

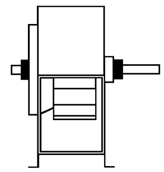
SW - Single Width   DW - Double Width   SI - Single Inlet   DI - Double Inlet



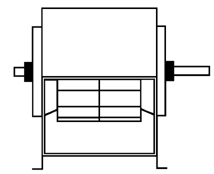
ARR. 1 SWSI For belt drive or direct connecdtion. Impeller overhung. Two bearings on base.



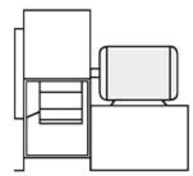
ARR. 2 SWSI For belt drive or direct connection. Impeller overhung. Bearings in bracket supported by fan housing.



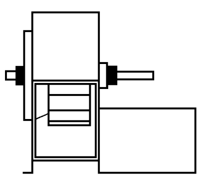
ARR. 3 SWSI For belt drive or direct connection. One bearing on each side and supported by fan housing.



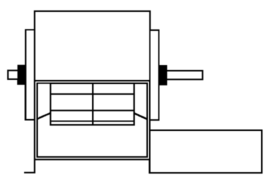
ARR. 3 DWDI For belt drive or direct connection. One bearing on each side and supported by fan housing.



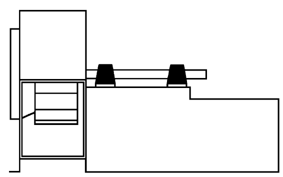
ARR. 4 SWSI For direct drive. Impeller overhung on prime mover shaft. No bearings on fan. Prime mover base mounted or integrally connected.



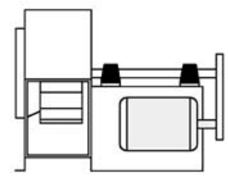
ARR. 7 SWSI For belt drive or direct connecdtion.Arrangement 3 plus base for prime mover.



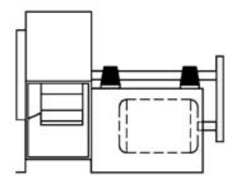
ARR. 7 DWDI For belt drive or direct connection.Arrangement 3 plus base for prime mover.



ARR. 8 SWSI For belt drive or direct connecdtion.Arrangement 1 plus extended base for prime mover.

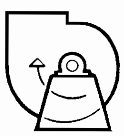


ARR. 9 SWSI For belt drive. Impeller overhung, two bearings, with prime mover outside base.

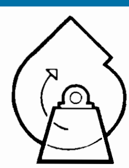


ARR. 10 SWSI For belt drive. Impeller overhung two bearings, with prime mover inside base.

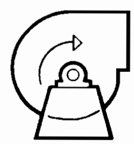
III. ROTATION & DISCHARGE DESIGNATIONS



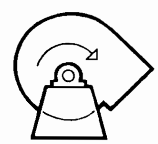
Clockwise
Up Blast
CW 360



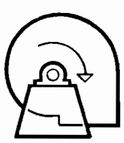
Clockwise
Top Angular Up
CW 45



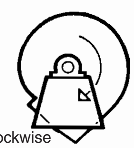
Clockwise
Top Horizontal
CW 90



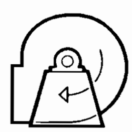
Clockwise
Top Angular Down
CW 135



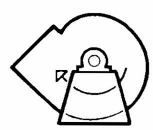
Clockwise
Down Blast
CW 180



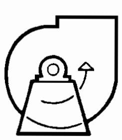
Clockwise
Bottom Angular Down
CW 225



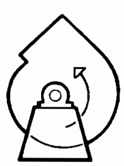
Clockwise
Bottom Horizontal
CW 270



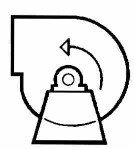
Clockwise
Bottom Angular Up
CW 315



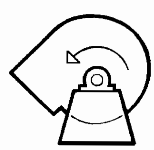
Counterclockwise
Up Blast
CCW 360



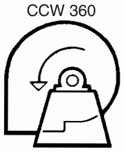
Counterclockwise
Top Angular Up
CCW 45



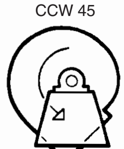
Counterclockwise
Top Horizontal
CCW 90



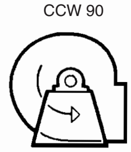
Counterclockwise
Top Angular Down
CCW 135



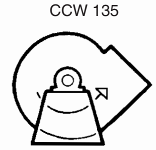
Counterclockwise
Down Blast
CCW 180



Counter clockwise
Bottom Angular Down
CCW 225



Counterclockwise
Bottom Horizontal
CCW 270

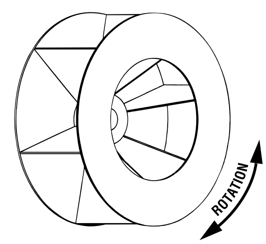


Counterclockwise
Bottom Angular Up
CCW 315

Notes:

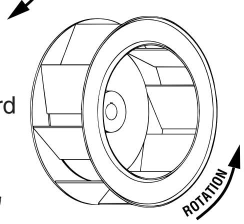
1. **DIRECTION OF ROTATION IS DETERMINED FROM DRIVE SIDE OF FAN.**
2. On single inlet fans, drive side is always considered as the side opposite fan inlet.
3. On double inlet fans with drives on both sides, drive side is that with the higher powered drive unit.
4. Direction of discharge is determined in accordance with diagrams. Angle of discharge is referred to the vertical axis of fan and designated in degrees from such standard reference axis. Angle of discharge may be any intermediate angle as required.
5. For fan inverted for ceiling suspension, or side wall mounting, direction of rotation and discharge is determined when fan is resting on floor.

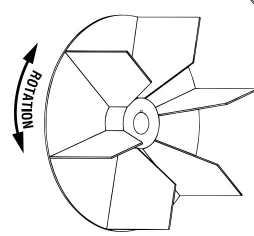
IV. WHEEL TYPES



Shrouded
Radial Blade

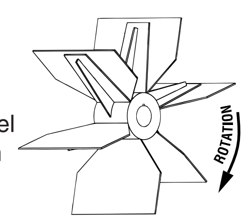
Backward
Inclined

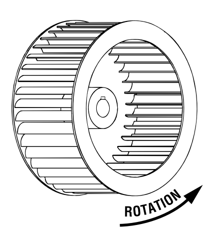




Open Radial
Blade

Open Paddle Wheel
(Not available from
Cincinnati Fan)





Forward Curve
(Squirrel Cage)

V. FAN LAWS AND FORMULAS

BASIC FAN LAWS

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

CORRECTION FOR DENSITY RAREFICATION

When negative static pressure exists on the inlet side of a fan, additional correction for a lower density should be made. We suggest this correction be made when the negative pressure is 20"WG or more. When the negative pressure is less than 20", this factor is usually considered negligible unless the system designer is calculating to extremely close tolerance. Chart at right shows correction factors for negative inlet pressure. The factors apply to static pressure and brake horsepower in the same manner as temperature and altitude corrections.

CORRECTION FACTORS FOR RAREFICATION [negative inlet pressure]

Static pressure	Factor
5"	1.01
10"	1.03
15"	1.04
20"	1.05
25"	1.07
30"	1.08
35"	1.09
40"	1.11
50"	1.14
60"	1.17

TO CALCULATE:

Velocity = CFM ÷ Duct Area (in Sq. Ft.)

ALTERNATE METHOD:

$$\text{Velocity} = \frac{\text{CFM} \times 144}{\text{Duct area (in sq. in.)}}$$

CFM = Velocity x duct area (in sq. ft.)

ALTERNATE METHOD:

$$\text{CFM} = \frac{\text{Velocity x duct area (in sq. in.)}}{144}$$

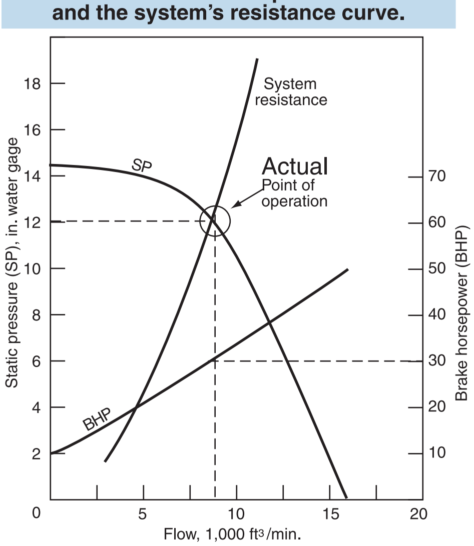
Tip Speed = Circumference x RPM

$$\text{BHP} = \frac{\text{Total Watts input x motor eff.}}{746}$$

$$\text{Mechanical Efficiency} = \frac{\text{TP} \times \text{CFM}}{6356 \times \text{BHP}} \times 100\%$$

$$\text{Static Efficiency} = \frac{\text{SP} \times \text{CFM}}{6356 \times \text{BHP}} \times 100\%$$

The fan's actual operating point is at the intersection of its static pressure curve and the system's resistance curve.



CALCULATION OF WR^2 (or WK^2) of FAN WHEEL

$$WR^2 = \left(\begin{matrix}\text{Wheel weight} \\ \text{in pounds}\end{matrix}\right) \times \left(\begin{matrix}\text{Wheel radius in} \\ \text{feet x GY}\end{matrix}\right)^2$$

GY equals: .90 for Forward curved wheels.
.70 for Backward inclined & shrouded radial wheels.
.67 for Open radial wheels.

WR^2 is expressed in: Pounds - $Ft.^2$

GUIDELINE FOR DETERMINING THE SPREAD & THROW OF A MANCOOLER

These calculations are for determining the velocity from a fan and also the width of the stream at a specific distance. While these values are influenced greatly by the presence or absence of walls, floors and obstructions, the following formulae will give a good approximation for most cases.

SPREAD:

$$W = .36L + \frac{d}{12}$$

W = Maximum width in feet of air-stream perpendicular to axis of rotation of the fan.

L = Distance from fan in feet.

d = Fan diameter in inches.

VELOCITY (Not less than 10 feet from fan):

(1) $k = 5 \left(\frac{2.5 \times CFM}{d}\right)^2$

(2) $^VLa = 1.15 \sqrt{\frac{k}{L}}$

(3) $^Vmax = \left(\frac{d}{73} + 1\right) {^VLa}$

k = Fan constant

^VLa = Average velocity across the width of the spread. L feet from the fan (Feet per minute).

^Vmax = Maximum velocity. L feet from the fan (Feet per minute).

CFM = Free Air Delivery of fan.

VI. TEMPERATURE - ALTITUDE CONVERSIONS

Fan performance tables are developed using standard air which is 70˚F., 29.92” barometric pressure and .075 lbs. per cubic foot. Density changes resulting from temperature or barometric pressure variations (such as higher altitudes) must be corrected to standard conditions before selecting a fan based on standard performance data.

Temperature and/or altitude conversion factors are used in making corrections to standard conditions.

Example:

Select a belt driven fan to deliver 1500 CFM at 8.6” SP at 200˚F., and 7000’ altitude.
STEP 1. From the table below, conversion factor is 1.63.
STEP 2. Correct static pressure is: 1.63 x 8.6” SP = 14” SP at standard conditions.
STEP 3. Check fan catalog for 1500 CFM at 14” SP. We select a belt driven fan at 3456 RPM and 5.15 BHP.
STEP 4. Correct the BHP for the lighter air: 5.15 ÷ 1.63 = 3.16 BHP. A 5 HP motor will suffice at 200˚F., and 7000’ but not at standard conditions. Special motor insulation may be required above 3500 feet altitude. Consult Factory.

Safe Operating Speeds:

When a fan moves air at temperatures substantially above 70˚F, the safe operating speed of the wheel and shaft could be exceeded. Most metals become characteristically weaker at high temperatures. There are maximum operating temperatures listed in suppliers catalogs for various fan types. The wheel or impeller speeds shown per fan size are maximum for that fan construction and should never be exceeded.

Bearings:

The weakest part of a fan is the bearing system, whether in a pillow block design on belt-drive fans or located within the motor on direct-drive fans. Temperatures above the fan’s maximum operating range can break down the lubricant in the bearing and cause the bearing to fail.

The location of bearings on the fan must be considered when moving high temperature air. Fans with bearings located in the air stream have temperature limitations. Such fans include: circulators, propeller fans, axial power roof ventilators, double inlet centrifugal fans and some tubeaxial fans. Fans designed for higher temperatures have the bearings located out of the air stream. Most single inlet centrifugal fans and centrifugal power roof ventilators are designed in this manner. Tubeaxial fans can handle high temperatures when there is a drive bearing tube installed in the air stream to isolate and protect the bearings.

With the addition of a shaft cooler wheel or heat slinger, a centrifugal fan’s temperature limits can be extended. The heat slinger absorbs heat from the fan shaft while circulating air over the inboard bearing to help keep it running cool.

Motors:

With class A rise, an enclosed motor would be expected to have less than 15˚C extra rise. With Class F rise, an enclosed motor would be expected to have about a 20˚C extra rise. Therefore, Class A, B, or F insulated motors could be protected to 9900 foot altitude by using next higher class of insulation (since there is a 20˚C. difference between allowable temperature of these classes of insulation).

Also, for high efficiency motors with 1.15 or higher service factor, derating to 1.0 service factor allows the motor to be used up to 9900 feet at up to 40˚C. ambient. Operating AC electric motors in up to 40˚C. (104˚F.) ambient and up to 3300 feet (1000 meters) is assumed normal. For every 330 feet (100 meters) above 3300 feet, a 1% extra temperature rise is expected. At 6600 feet, a 10% extra temperature rise is expected. At 9900 feet, a 20% extra temperature rise is expected.

The above deals with rise only. In fact, *higher altitudes* usually *have cooler ambient* temperature which *can offset reduced cooling* in thinner air, so we need to know expected ambient temperature as well as altitude to adequately assess the application.

One caution. DC motors need to be evaluated as to brush grade for good commutation at elevated locations due to different moisture content in the air as well as operating temperature.

AIR TEMP. DEG. F.	ALTITUDE IN FEET ABOVE SEA LEVEL																					
	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	10000	11000	12000
-50˚	.77	.79	.80	.81	.83	.85	.86	.88	.89	.91	.92	.94	.96	.98	1.00	1.02	1.04	1.06	1.08	1.12	1.16	1.21
-25˚	.82	.84	.85	.87	.89	.91	.92	.94	.95	.97	.98	1.01	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.20	1.24	1.29
0˚	.87	.89	.91	.92	.94	.96	.98	.99	1.01	1.03	1.05	1.06	1.09	1.10	1.13	1.15	1.17	1.19	1.22	1.26	1.31	1.37
40˚	.94	.96	.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.19	1.21	1.23	1.26	1.28	1.30	1.32	1.36	1.41	1.47
70˚	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.25	1.27	1.30	1.32	1.35	1.37	1.40	1.45	1.51	1.57
80˚	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.19	1.21	1.23	1.26	1.28	1.30	1.33	1.36	1.38	1.41	1.43	1.48	1.56	1.61
100˚	1.06	1.08	1.10	1.12	1.14	1.16	1.19	1.21	1.23	1.25	1.28	1.30	1.33	1.35	1.38	1.41	1.43	1.46	1.48	1.54	1.60	1.66
120˚	1.09	1.12	1.14	1.16	1.18	1.20	1.23	1.25	1.28	1.30	1.32	1.35	1.38	1.40	1.43	1.46	1.48	1.51	1.53	1.58	1.66	1.72
140˚	1.13	1.15	1.18	1.20	1.22	1.25	1.27	1.29	1.32	1.34	1.37	1.40	1.42	1.45	1.48	1.51	1.54	1.57	1.58	1.65	1.72	1.78
160˚	1.17	1.19	1.22	1.24	1.26	1.29	1.31	1.34	1.36	1.39	1.42	1.44	1.47	1.50	1.53	1.56	1.59	1.62	1.64	1.70	1.78	1.84
180˚	1.21	1.23	1.26	1.28	1.30	1.33	1.36	1.38	1.41	1.43	1.46	1.49	1.52	1.55	1.58	1.61	1.64	1.67	1.70	1.75	1.84	1.90
200˚	1.25	1.27	1.29	1.32	1.34	1.37	1.40	1.42	1.45	1.48	1.51	1.54	1.57	1.60	1.63	1.66	1.69	1.72	1.75	1.81	1.89	1.96
250˚	1.34	1.36	1.39	1.42	1.45	1.47	1.50	1.53	1.56	1.59	1.62	1.65	1.68	1.71	1.74	1.78	1.82	1.85	1.88	1.94	2.02	2.10
300˚	1.43	1.46	1.49	1.52	1.55	1.58	1.61	1.64	1.67	1.70	1.74	1.77	1.80	1.84	1.87	1.91	1.94	1.98	2.00	2.08	2.16	2.25
350˚	1.53	1.56	1.59	1.62	1.65	1.68	1.72	1.75	1.78	1.81	1.85	1.88	1.92	1.96	2.00	2.04	2.07	2.11	2.14	2.22	2.31	2.40
400˚	1.62	1.65	1.69	1.72	1.75	1.79	1.82	1.85	1.89	1.93	1.96	2.00	2.04	2.08	2.12	2.16	2.20	2.25	2.27	2.35	2.47	2.55
450˚	1.72	1.75	1.79	1.82	1.86	1.89	1.93	1.96	2.00	2.04	2.08	2.12	2.16	2.20	2.24	2.29	2.33	2.38	2.41	2.50	2.61	2.70
500˚	1.81	1.85	1.88	1.92	1.96	1.99	2.03	2.07	2.11	2.15	2.19	2.23	2.28	2.32	2.36	2.41	2.46	2.51	2.54	2.62	2.75	2.85
550˚	1.91	1.94	1.98	2.02	2.06	2.10	2.14	2.18	2.22	2.26	2.30	2.35	2.40	2.44	2.49	2.54	2.58	2.63	2.68	2.77	2.90	3.00
600˚	2.00	2.04	2.08	2.12	2.16	2.20	2.24	2.29	2.33	2.38	2.42	2.47	2.50	2.56	2.61	2.66	2.71	2.77	2.80	2.90	3.04	3.14
650˚	2.10	2.14	2.18	2.22	2.26	2.31	2.35	2.40	2.44	2.49	2.54	2.58	2.63	2.68	2.74	2.79	2.84	2.90	2.94	3.04	3.19	3.30
700˚	2.19	2.23	2.27	2.32	2.36	2.41	2.46	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.86	2.91	2.97	3.03	3.06	3.18	3.33	3.44
750˚	2.28	2.33	2.37	2.42	2.47	2.51	2.56	2.61	2.66	2.71	2.76	2.81	2.87	2.92	2.98	3.04	3.10	3.16	3.19	3.31	3.47	3.59

˚F = $9/5$C + 32 ABSOLUTE: RANKINE (R) R = F + 460
˚C = $5/9$(F – 32) ABSOLUTE: KELVIN (K) K = C + 273

VII. MATERIAL CONVEYING

Bulky materials such as those shown in Table 1, page 7, can be conveyed pneumatically using a Cincinnati Fan "RBE" series exhauster. Follow the steps below to determine the fan best suited for your application.

EXAMPLE: Assume a requirement to move 2400 pounds per hour of barley through 200 feet of straight, horizontal, round duct.
NOTE: For each 90˚ elbow in your duct system, add 20 feet of straight duct to determine total equivalent straight duct length.
For each 10 feet of vertical duct, add 10 feet to your total straight duct length.

I. Convert pounds per hour to pounds per minute: 2400 lbs/hr ÷ 60 = 40 lbs/min

II. Refer to Table 1, page 7. Find "barley" under material (column A) and read horizontally. Barley weighs 38 pounds per cubic foot (column B), requires 38 CFM of air per pound of material (column C) and a minimum of 5000 feet per minute conveying veloc-ity (column D).

III. Determine the minimum cubic feet per minute (CFM) requirements:

CFM/LB of Material		38	(from column C)
x lbs/Minute	=	x 40	(from step 1)
		1520	Total minimum CFM required @ 5000 ft/min conveying velocity (column D)

IV. Determine the system duct size and system static pressure requirements from Table 2, page 7. Read across the 5000 ft/min velocity line to the 8" duct size column since this is the first (smallest) duct size column over 1520 CFM.

We have selected 8" duct size with 1745 CFM (actual) and a velocity of 5000 ft/min.

The friction loss is 6.02" SP per 100' x 2 = 12.04" plus 3.5" SP suction pickup (column E, Table 1) = 15.54" total system static pressure for 200 feet of straight 8" duct.

V. Check fan rating tables for 1745 CFM at 15.54" SP at the lowest horsepower. From the RBE Industrial Exhauster catalog, we suggest a Model RBE-9. Interpolate 3499 RPM, 7.59 BHP.

VI. If material being conveyed will be going through the fan, the fan BHP can be significantly increased. The approximate increase is calculated as:

$$\text{Actual BHP} = \frac{\text{lbs/Minute of air} + \text{lbs/Minute of material}}{\text{lbs/Minute of air}} \times \text{Fan BHP (7.59, Step V)}$$

In this example: lbs/Minute of air = 1745 (Actual CFM, Step IV) x .075 lbs/ft^3 $\left(\frac{\text{Standard}}{\text{Density}}\right)$ = 130.9
lbs/Minute of material = 40

See note 3

Therefore: $\frac{130.9 + 40}{130.9} = \frac{170.9}{130.9} = 1.31 \times 7.59 = 9.94$ Actual BHP

NOTES: 1. For each 10 feet of vertical duct, add 10 feet to your total straight duct length.
2. For equivalent losses through elbows, see chart on page 9.
3. Make sure you use correct density for location of fan.

YOUR MATERIAL CONVEYING CALCULATIONS

(1) Material Being Conveyed — (1)________
(2) Pounds Conveyed/Hour — (2)________
÷ 60
(3) Pounds/Minute — (3) ________
(4) Feet of Straight Duct — (4)________ (Horizontal + 2 x vertical)
(5) Number of 90˚ Elbows x 20 Ft. — (5) +________
(6) Total Equivalent Feet of Duct — (6) ________
(7) Material Weight, lbs./Cu. Ft. (col. B) — (7) ________
(8) CFM/Pound of Material (col. C) — (8)________
(9) Pounds/Minute (step 3) — (9) x________
(10) Total Min. CFM Required — (10) ________
(11) Min. Conveying Velocity in FPM (col. D) — (11) ________
(12) Duct Size to Get Total CFM (step 10) @ Minimum Velocity (step 11) per table 2 — (12) ________ DUCT SIZE
(13) Actual CFM for Duct (step 12) — (13)*________ ACTUAL CFM*
(14) Friction Loss/100 Ft. — (14)________
(15) Total Equivalent Feet of Duct (step 6) (in 100's of feet) — (15) x________ (in 100's of feet)
____
(16) Suction Pickup in Inches of WC (col. E) — (16) +________
(17) Total System SP — (17) ________ TOTAL SYSTEM SP

NOTE: If conveying long, stringy material, be sure to specify open type wheel. Consult factory.

FAN MODEL TO GET #13 (Actual CFM) & #17 (Total SP) ABOVE ________

FAN RPM ________

ACTUAL FAN BHP________ (See VI above)

*Must be equal or greater than Step 10.

TABLE 1

A Material	B Approx. Weight (Lbs. per Cu. Ft.)	C CFM Per Lb. of Material	D Min. Conveying Velocity (In fpm*)	E Suction Pickup (Inches of W.C.)
Ashes, Coal	40	42	4500	3.0
Barley	38	38	5000	3.5
Beans, Soy	47	36	5200	4.0
Bran	16	56	3500	2.0
Cement, Portland	100	35	7000	5.0
Cinders, Coal	45	36	6000	4.0
Coal, Powdered	30	42	4000	3.0
Coffee, Beans	48	36	3500	3.0
Cork, Ground	15	59	3500	1.5
Corn, Cobs	25	44	5000	2.5
Corn, Meal	40	38	5500	3.5
Corn, Shelled	45	36	5500	3.5
Cotton, Dry	30	94	4000	2.0
Dust, Grinding	160-175	42	5000	3.0
Fruit, Dried	30	42	4000	3.0
Hair or Feathers, Dry	5	94	3000	1.5
Lime, Hydrated	53-64	42	5000	3.0
Malt, Dry	35	39	4800	3.0
Oats	26	44	4500	3.0
Plastic, Granulated	35	42	5400	3.0
Rags, Dry	30	42	4500	2.5
Salt, Coarse	48	36	5500	4.0
Sand, Dry	99	35	7000	5.0
Sawdust, Dry	7-15	63	3700	2.5
Wheat, Dry	48	37	5800	4.0
Wood Chips, Heavy	15-24	45	4500	3.0
Wood Shavings, Light	7-15	73	3400	2.0
Wool, Dry	5	94	5000	2.0

* Feet per minute

⚠ WARNING

Whereas fans are used in thousands of material conveying applications around the world, care must be used in their selection and location within each material conveying system. The material should be crushed, shredded or pulverized ***before*** it passes through the fan to eliminate premature fan housing, fan wheel and/or bearing failure which could cause severe personal injury and/or complete system failure. Please contact a Cincinnati Fan sales engineer in your area for correct, safe selection for your specific application.

TABLE 2

Friction Loss (FL) in Inches of Water per 100 Feet of Straight, Horizontal, Round Duct

VEL FPM	PIPE DIAMETER & AREA IN SQ. FT.																				
	4" .0873		5" .1364		6" .1963		7" .2673		8" .3491		10" .5454		12" .7854		14" 1.0690		16" 1.3963		18" 1.7671		20" 2.1817	
	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL
2600	227	3.10	355	2.36	511	1.89	695	1.57	908	1.33	1418	1.01	2042	0.81	2779	0.67	3630	0.57	4595	0.50	5672	0.44
2800	244	3.57	382	2.72	550	2.18	748	1.80	977	1.53	1527	1.17	2199	0.93	2993	0.77	3910	0.66	4948	0.57	6109	0.50
3000	262	4.07	409	3.10	589	2.48	802	2.06	1047	1.75	1636	1.33	2356	1.07	3207	0.88	4189	0.75	5301	0.65	6545	0.57
3200	279	4.60	436	3.51	628	2.81	855	2.33	1117	1.98	1745	1.50	2513	1.20	3421	1.00	4468	0.85	5655	0.73	6981	0.65
3400	297	5.16	464	3.93	668	3.15	909	2.61	1187	2.22	1854	1.69	2670	1.35	3635	1.12	4747	0.95	6008	0.82	7418	0.72
3500	305	5.46	477	4.16	687	3.33	935	2.76	1222	2.34	1909	1.78	2749	1.43	3742	1.18	4887	1.01	6185	0.87	7636	0.77
3600	314	5.76	491	4.39	707	3.51	962	2.91	1257	2.47	1963	1.88	2827	1.51	3848	1.25	5027	1.06	6362	0.92	7854	0.81
3700	323	6.06	505	4.62	726	3.70	989	3.06	1292	2.60	2018	1.98	2906	1.59	3955	1.32	5166	1.12	6538	0.97	8072	0.85
3800	332	6.38	518	4.86	746	3.89	1016	3.22	1326	2.74	2073	2.09	2985	1.67	4062	1.38	5306	1.18	6715	1.02	8290	0.90
4000	349	7.03	545	5.36	785	4.29	1069	3.55	1396	3.02	2182	2.30	3142	1.84	4276	1.53	5585	1.30	7069	1.12	8727	0.99
4200	367	7.72	573	5.88	825	4.71	1122	3.90	1466	3.31	2291	2.52	3299	2.02	4490	1.67	5864	1.42	7422	1.23	9163	1.08
4400	384	8.43	600	6.42	864	5.14	1176	4.26	1536	3.62	2400	2.76	3456	2.21	4704	1.83	6144	1.55	7775	1.35	9599	1.18
4500	393	8.80	614	6.70	884	5.36	1203	4.44	1571	3.78	2454	2.88	3534	2.30	4811	1.91	6283	1.62	7952	1.40	9817	1.23
4800	419	9.94	654	7.57	942	6.06	1283	5.02	1676	4.27	2618	3.25	3770	2.60	5131	2.16	6702	1.83	8482	1.59	10472	1.40
5000	436	10.75	682	8.19	982	6.55	1336	5.43	1745	4.61	2727	3.51	3927	2.81	5345	2.33	6981	1.98	8836	1.72	10908	1.51
5200	454	11.58	709	8.82	1021	7.06	1390	5.85	1815	4.97	2836	3.79	4084	3.03	5559	2.51	7261	2.13	9189	1.85	11345	1.63
5500	480	12.88	750	9.81	1080	7.85	1470	6.51	1920	5.53	3000	4.21	4320	3.37	5880	2.79	7679	2.37	9719	2.06	11999	1.81
5600	489	13.33	764	10.15	1100	8.13	1497	6.73	1955	5.72	3054	4.36	4398	3.49	5986	2.89	7819	2.46	9896	2.13	12217	1.87
5800	506	14.25	791	10.85	1139	8.69	1550	7.20	2025	6.12	3163	4.66	4555	3.73	6200	3.09	8098	2.63	10249	2.27	12654	2.00
6000	524	15.20	818	11.57	1178	9.27	1604	7.68	2094	6.52	3272	4.97	4712	3.98	6414	3.30	8378	2.80	10603	2.43	13090	2.13
7000	611	20.37	954	15.51	1374	12.42	1871	10.29	2443	8.74	3818	6.66	5498	5.33	7483	4.42	9774	3.75	12370	3.25	15272	2.86

VIII. AVERAGE AIR CHANGES REQUIRED FOR GOOD VENTILATION

Type	Minutes Per Change	Type	Minutes Per Change	Type	Minutes Per Change
Assembly Halls	2-10	Engine Rooms	1-3	Laboratories	1-5
Auditoriums	2-10	Factories	2-5	Laundries	1-3
Bakeries	2-3	Forge Shops	2-5	Offices	2-10
Boiler Rooms	1-5	Foundries	1-5	Packing Houses	2-5
Bowling Alleys	2-10	Garages	2-10	Plating Rooms	1-5
Churches	5-15	Generator Rooms	2-5	Toilets	2-5
Dairies	2-5	Gymnasiums	2-10	Transformer Rooms	1-5
Dance Halls	2-10	Kitchens - Hospital	2-5	Warehouses	2-10
Dry Cleaners	1-5	Kitchens - Restaurant	1-3		

Note: The above chart is a general guideline only.

Formula to determine fan capacity: CFM Required: $\frac{\text{Volume of space (WxLxH)}}{\text{No. of minutes per air change}}$

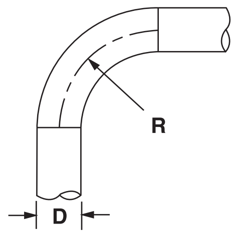
IX. RECOMMENDED VELOCITIES FOR EXHAUST HOODS

Area of Slot or Face (Sq. Ft.) x Velocity (FPM) = CFM Required

TYPE PROCESS	TYPE OF HOOD	Required Air Velocity (FPM) Average
Aluminum Furnaces	Enclosed hook, open on side Canopy hood	150-200 FPM over open face 200-250 FPM over face
Bottle Washing	Enclosed booth, open one side	150-250 FPM over face
Brass Furnaces	Enclosed hook, open one side Canopy hoods	200-250 FPM over open face 250-300 FPM over open face
Chemical Laboratories	Enclosed hook, door front Enclosed hook, open front Down draft, table type	100 FPM over door opening 100 to 150 FPM over face 150 to 200 FPM over table gross area
Degreasing	Canopy hood Slot type for tanks up to 4' wide (Slot one side)	150 to 200 CFM over face 2' width use 1500 to 2000 FPM thru 2" slot 3' width use 1500 to 2000 FPM thru 4" slot 4' width use 1500 to 2000 FPM thru 6" slot For tanks over 4' use slots on 4 sides
Driers	Canopy hood Slot type at each end continuous drier	125 to 150 FPM over face 150 to 200 FPM over 6" to 8" slot
Electric Welding	Enclosed booth, open front Canopy Hood	100 to 150 FPM over face 125 to 150 FPM over face
Electroplating	Canopy hood Slot type for tanks up to 4' wide (Slot one side)	125 to 175 FPM over face 2' width use 1500 to 2000 FPM thru 2" slot 3' width use 1500 to 2000 FPM thru 4" slot 4' width use 1500 to 2000 FPM thru 6" slot For tanks over 4' wide use slots on 4 sides
Foundry Shake Out	Enclosed booth, open front Down draft, grill type	150-200 FPM over face 300-500 FPM
Grain dust, wood, flour, etc.	Slot types Canopy hoods	2000 FPM thru 2" to 4" slot 500 to 600 FPM over face
Grinding (Disc) and sanding	Down draft, grill types Bench Types with slot one side	400 FPM over open face 2000-2500 FPM thru 4" slot
Hand forge	Canopy type hood Enclosed booth, one side	150-250 FPM over face 200-300 FPM over face
Kitchen Ranges	Canopy hoods	125 to 150 FPM over face
Metal Spraying	Enclosed hook, open one side	200-250 FPM over face
Paint Spraying	Enclosed booth, open one side	125 to 200 FPM over face
Paper Machine	Canopy type	100-300 FPM over face
Pickling Tanks	Canopy type Slot type for tanks up to 6' wide, slot one side only	200-250 FPM over face Minimum 4" slot 2000 to 2500 FPM thru slot
Quenching Tanks	Canopy type hoods	200 to 300 FPM over face
Rubber Mixing Rolls	Canopy type Slot type	150-200 FPM over face 2000 to 2400 FPM thru 2" slot
Soldering booths	Enclosed booth, open one side	150 to 200 FPM over face
Steam tanks	Canopy type Slot type for tanks up to 6' wide, slot one side only	200 FPM over face 1500-2000 FPM thru minimum 4" slot
Stone Cutting	Enclosed booth, open face	400-500 FPM over face
Varnish Kettles	Canopy type Slot type - all around slot	250-350 FPM over face 2" minimum slot 2000 FPM thru slot

X. DUCT DESIGN PRACTICES

Equivalent Resistance in Feet of Straight Pipe



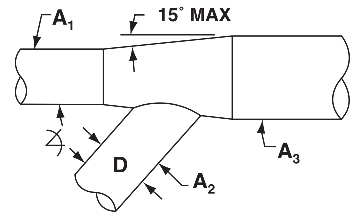
For
60° elbows – 0.67 x loss for 90°
45° elbows – 0.50 x loss for 90°
30° elbows – 0.33 x loss for 90°

Dia. of Duct (D)	90° Elbow Centerline Turn Ratio (R) *		
	1.5	2.0	2.5
3"	5	3	3
4	6	4	4
5	9	6	5
6	12	7	6
7	13	9	7
8	15	10	8
10	20	14	11
12	25	17	14
14	30	21	17
16	36	24	20
18	41	28	23
20	46	32	26
24	57	40	32
30	74	51	41
36	93	64	52
40	105	72	59
48	130	89	73

* Turn Ratio = No. of duct diameters

Equivalent Entry Losses

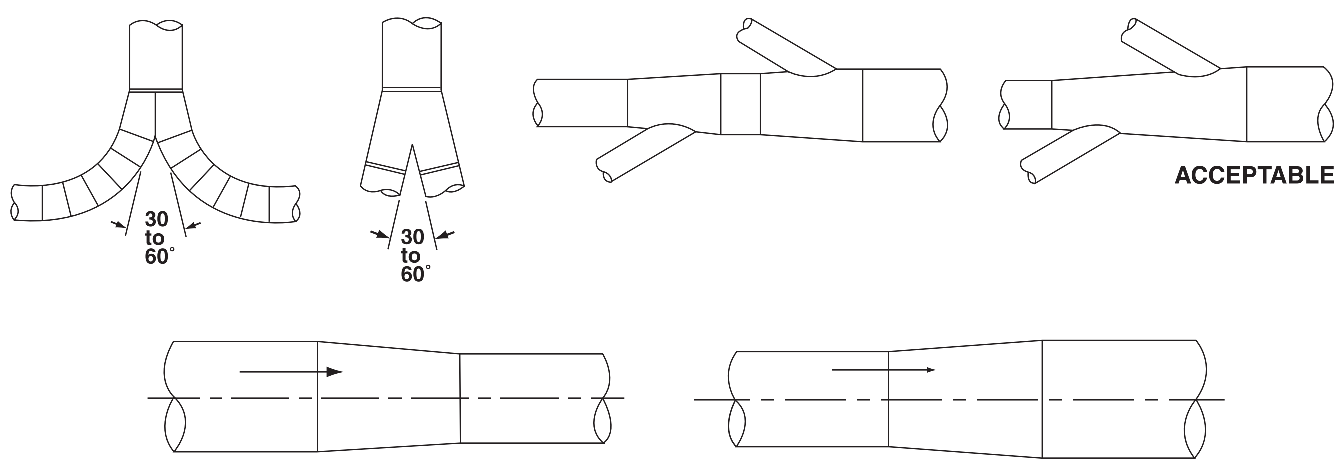
Expressed in feet of straight pipe



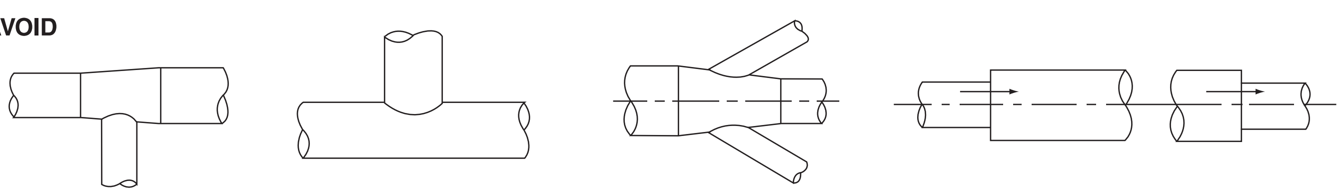
$A_3 = A_2 + A_1$ A = Area

Dia. of Duct (D)	∡ 30°	∡ 45°
4"	3'	5'
6"	5'	7'
8"	7'	11'
10"	9'	14'
12"	11'	17'
14"	13'	21'
16"	16'	25'
18"	18'	28'
20"	20'	32'
24"	24'	37'
28"	28'	46'
30"	31'	49'
32"	33'	53'

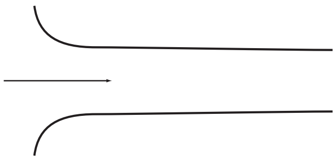
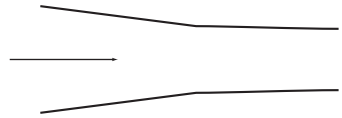
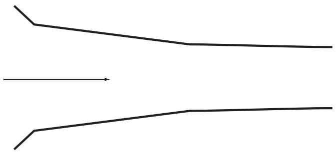
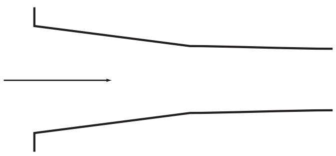
PREFERRED



AVOID



XI. TYPICAL ENTRANCE LOSSES

TYPE OF ORIFICE	DESCRIPTION	LOSS*	TYPE OF ORIFICE	DESCRIPTION	LOSS*
	Smooth, well rounded	5%		Unflanged cone, 15° per side	13%
	Two-cone, 45° & 15° per side	6%		Flanged pipe	50%
	Flanged cone, 15° per side	7%		Unflanged pipe	90%

*Loss is given in percent of velocity pressure (%VP)

XII. GUIDELINES FOR GOOD DUCT INSTALLATIONS

Air performance ratings in fan catalogs were derived from tests *and* test procedures in accordance with the latest Air Moving and Control Association (AMCA) standards. The test procedure used for centrifugal fans, for example, includes a straight outlet duct and open inlet. Laboratory test conditions are seldom, if ever, found in actual field installations. A poor fan inlet or outlet condition will result in an increase in system pressure losses which will reduce the fan's performance and decrease motor efficiency. Increased noise levels may also be caused by certain duct designs.

Open or Abrupt Discharge

When the exhaust air of a fan is discharged into an open area, large duct, or plenum chamber, the abrupt expansion of the air flow pattern and the sudden, reduced air velocity creates an air turbulence that increases the system static pressure which reduces fan performance. Up to 20% of the air volume can be lost due to a poor outlet condition. A duct extension with a minimum length of three times the fan wheel diameter should be added to the fan outlet.

Discharge Duct Turns

Duct turns (elbows) located near the fan discharge should always be in the direction of the fan rotation to minimize duct turbulence.

Air flow is also reduced when the elbow is too close to the fan discharge. A minimum length of 4 times the wheel diameter of straight duct should be installed between the fan discharge and an elbow.

Non-ducted Bower Inlets

The open inlet of a centrifugal fan too close to a wall or cabinet enclosure will reduce fan performance. Air is restricted and does not have easy access to the inlet. A minimum of one fan wheel diameter is recommended between the fan inlet and the wall. If two fans are installed within the same plenum or cabinet enclosure, and their inlets face each other, their inlets should be located a minimum of two wheel diameters apart.

Inlet Duct Turns

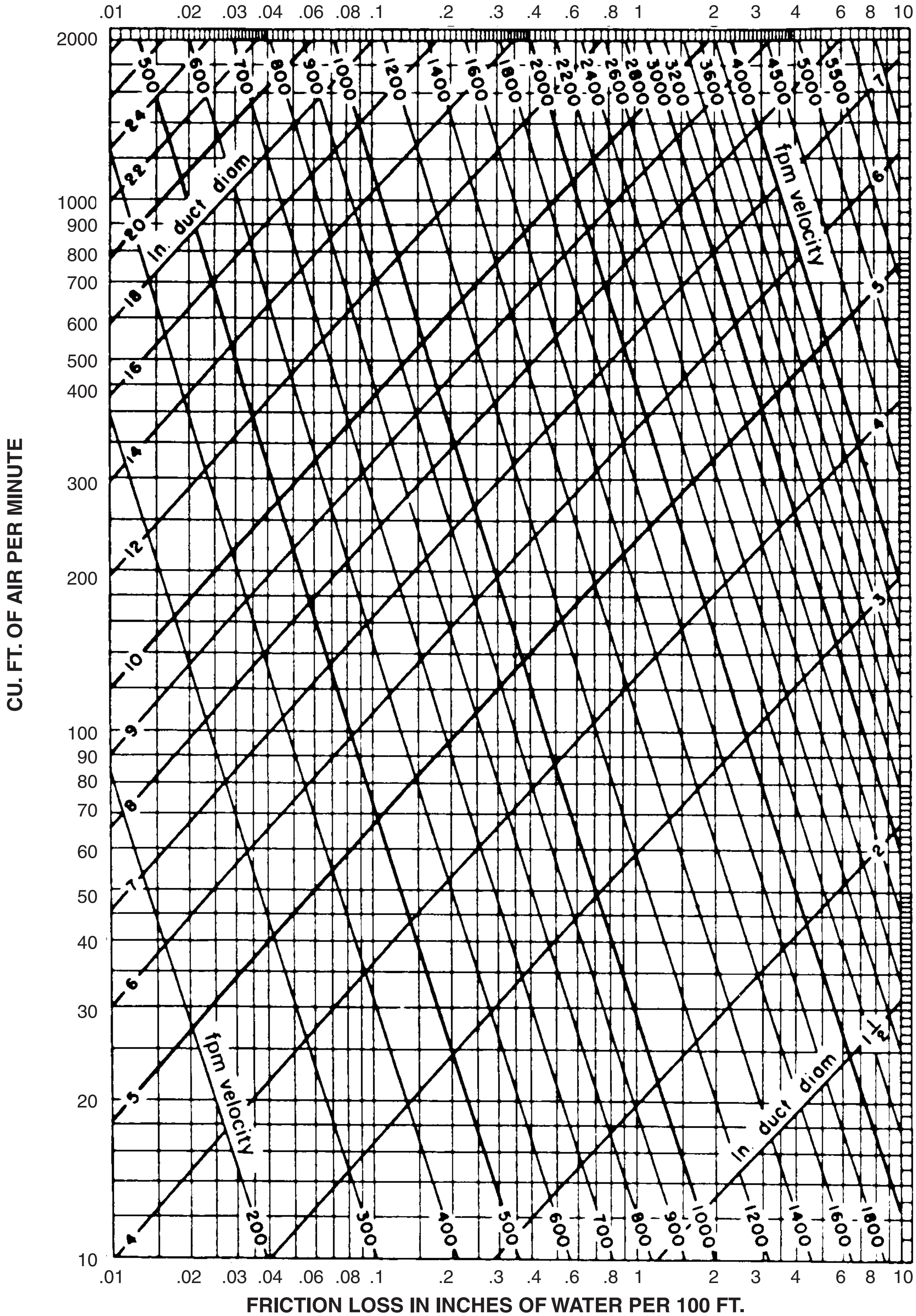
A duct turn (elbow) too close to the fan inlet reduces the fan's air performance. Air enters the fan inlet unevenly resulting in turbulence and limits the wheel's air handling efficiency. A minimum of one wheel diameter is recommended between the fan inlet and the end of the elbow if turning vanes have been installed. If there are no turning vanes in the elbow, a minimum of three wheel diameters should separate the fan inlet and the elbow.

Duct Inlet Spin

A major cause of reduced fan performance is an inlet duct connection that produces a spin or prerotation of the air entering the fan inlet. Inlet spin in the same direction of the fan wheel will reduce air volume and pressure ratings. Inlet spin in the opposite direction of the fan rotation will substantially increase the motor horsepower requirements. An ideal inlet condition is one which allows the air to enter the fan axially and evenly without spin in either direction.

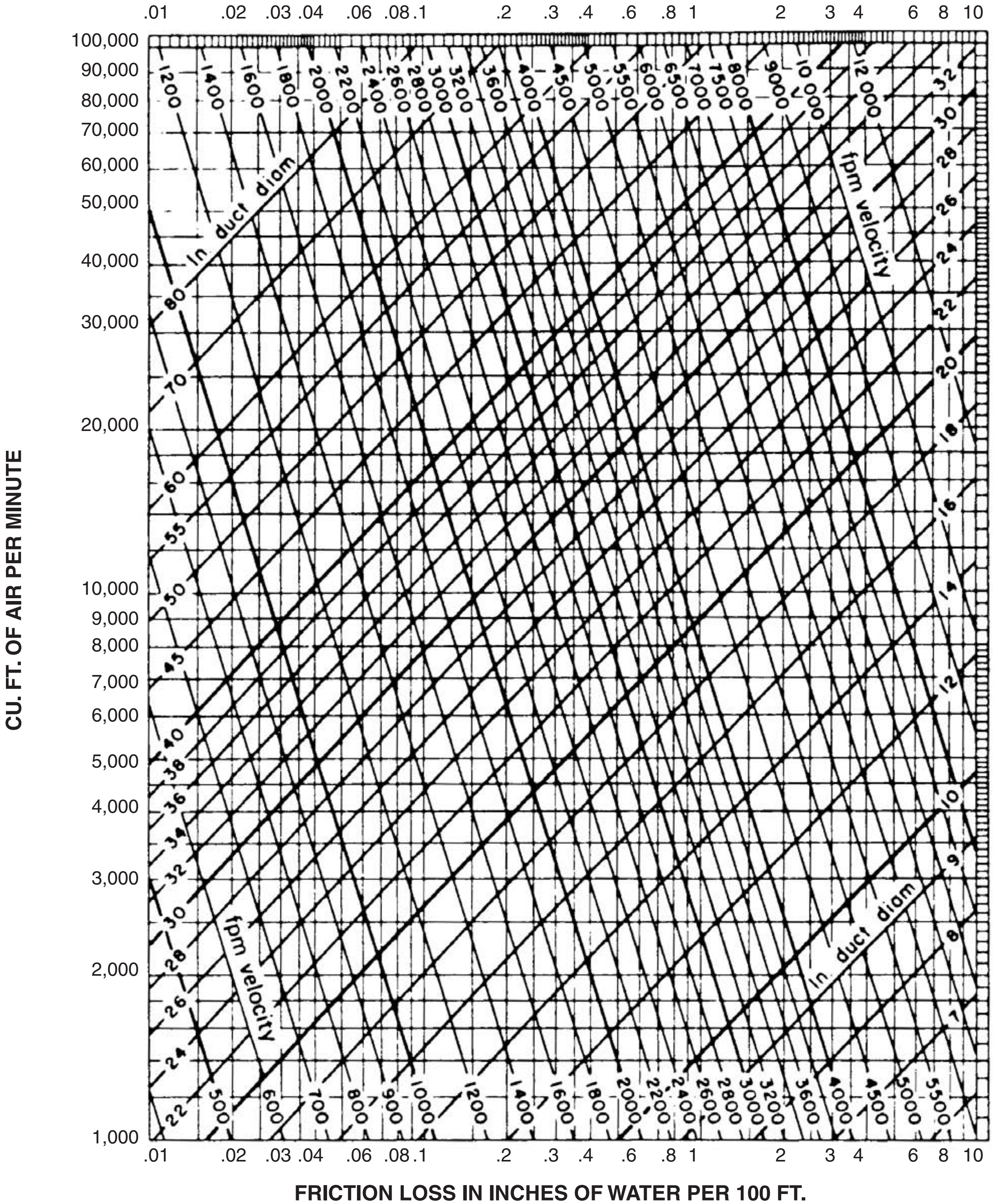
XIII. ESTIMATING STATIC PRESSURE - 10 to 2000 CFM

ROUND DUCT FRICTION CHART



XIV. ESTIMATING STATIC PRESSURE - 1000 to 100,000 CFM

ROUND DUCT FRICTION CHART (Continued)



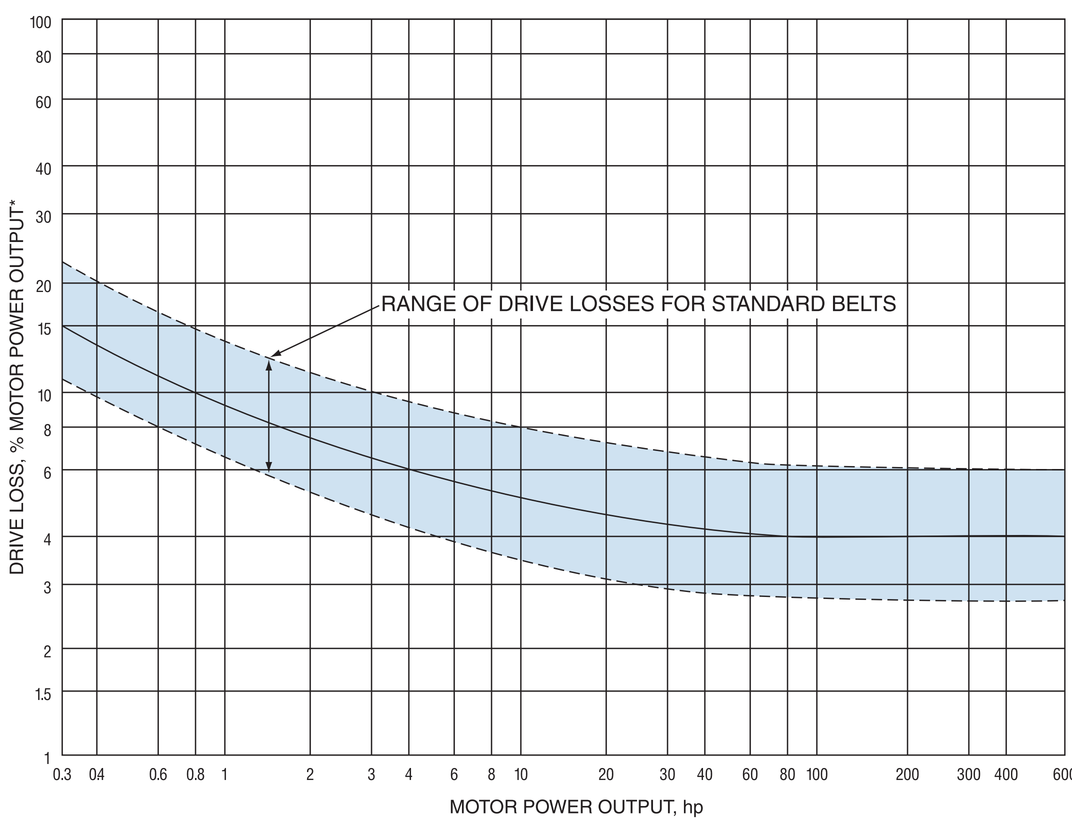
XV. NOISE FACTORS

This section includes a general list of good practices to follow when selecting and installing fans to minimize the noise produced from their operation.

Check list for quiet operation:

1. Design the fan system for minimum resistance to air flow. Regardless of the type of fan used, sound generation increases with increases in static pressure.
    a. Use larger heating or cooling coils, larger filter areas and larger size ducts.
    b. Avoid abrupt changes in air velocity by using long transition pieces when changing to another size duct.
    c. Avoid abrupt changes in direction of air flow by minimizing the number of turns in the duct run. If turns are required, use an elbow with a large turn radius and turning vanes. Minimum elbow radius should be equal to twice the duct diameter.
    d. Make all duct runs as short and direct as possible.
    e. Avoid elbows less than 4 wheel diameters away from fan discharge or less than 2 wheel diameters away from fan inlet.
2. Select a fan type suitable for the application.
3. When two sizes of the same fan type deliver the same air volume, select the larger size running at a slower speed.
4. Use vibration isolators and pads for fans and ductwork suitable for the application.
5. Avoid transmitting noise through a duct system. For general ventilation, inlet or outlet duct runs should not be directly connected to the fan. Isolate the connection with a rubber gasket. Whenever possible, leave a 1" gap between the fan and duct. Cover the gap with canvas or other suitable material to prevent air leaks.
6. Avoid mechanical noise.
    a. Tighten or strengthen vibrating panels.
    b. Keep bearings lubricated.
    c. Tighten belt(s) to proper tension. Do not overtighten.
    d. Align pulleys and shafts. Motor and fan shaft must be parallel.
    e. Tighten the setscrews in the wheel or impeller to their proper torque setting.
    f. Keep fan blades and wheels clean.
7. Locate fans away from people and the work area. Consider roof mounting.

XVI. APPROXIMATE BELT DRIVE LOSSES



HIGHER BELT SPEEDS TEND TO HAVE HIGHER LOSSES THAN LOWER BELT SPEEDS AT THE SAME HORSEPOWER.

* Drive losses are based on the conventional V-belt.

XVII. AREA AND CIRCUMFERENCE OF CIRCLES
AND SIDES OF SQUARES OF EQUAL AREAS

Diam. in Inches	AREA		CIRCUMFERENCE		One Side of a Square of Equal Area (in inches)	Diam. in Inches	AREA		CIRCUMFERENCE		One Side of a Square of Equal Area (in inches)
	Square Inches	Square Feet	In Inches	In Feet			Square Inches	Square Feet	In Inches	In Feet	
1	.7854	.0054	3.14	.2618	.89	51	2043	14.19	160.2	13.35	45.20
2	3.142	.0218	6.28	.5236	1.77	52	2124	14.75	163.4	13.61	46.08
3	7.069	.0491	9.42	.7854	2.66	53	2206	15.32	166.5	13.88	46.97
4	12.57	.0873	12.57	1.047	3.54	54	2290	15.90	169.6	14.14	47.86
5	19.63	.1364	15.71	1.309	4.43	55	2376	16.50	172.8	14.40	48.74
6	28.27	.1964	18.85	1.571	5.32	56	2463	17.10	175.9	14.66	49.63
7	38.48	.2673	21.99	1.833	6.20	57	2552	17.72	179.1	14.92	50.51
8	50.27	.3491	25.13	2.094	7.09	58	2642	18.35	182.2	15.18	51.40
9	63.62	.4418	28.27	2.356	7.98	59	2734	18.99	185.4	15.45	52.29
10	78.54	.5454	31.42	2.618	8.86	60	2827	19.63	188.5	15.71	53.17
11	95.03	.6600	34.56	2.880	9.75	61	2922	20.29	191.6	15.97	54.06
12	113.1	.7854	37.70	3.142	10.63	62	3019	20.97	194.8	16.23	54.91
13	132.7	.9218	40.84	3.403	11.52	63	3117	21.65	197.9	16.49	55.83
14	153.9	1.069	43.98	3.665	12.40	64	3127	22.34	201.1	16.76	56.72
15	176.7	1.277	47.12	3.927	13.29	65	3318	23.04	204.2	17.02	57.60
16	201.0	1.396	50.26	4.189	14.18	66	3421	23.76	207.3	17.28	58.49
17	227.0	1.576	53.41	4.451	15.06	67	3526	24.48	210.5	17.54	59.38
18	254.7	1.767	56.55	4.712	15.95	68	3632	25.22	213.6	17.80	60.26
19	283.5	1.969	59.69	4.974	16.84	69	3739	25.97	216.8	18.06	61.15
20	314.2	2.182	62.83	5.236	17.72	70	3848	26.73	219.9	18.33	62.04
21	346.3	2.405	65.97	5.498	18.61	71	3959	27.49	223.1	18.59	62.92
22	380.1	2.640	69.11	5.760	19.49	72	4072	28.27	226.2	18.85	63.18
23	415.5	2.885	72.26	6.021	20.38	73	4185	29.07	229.3	19.11	64.99
24	452.4	3.142	75.40	6.283	21.27	74	4301	29.87	232.5	19.37	65.58
25	490.9	3.409	78.54	6.545	22.15	75	4418	30.68	235.6	19.63	66.40
26	530.9	3.687	81.7	6.807	23.04	76	4536	31.50	238.8	19.90	67.35
27	572.5	3.976	84.8	7.069	23.93	77	4657	32.34	241.9	20.16	68.48
28	615.7	4.276	88.0	7.330	24.81	78	4778	33.18	245.0	20.42	69.15
29	660.5	4.587	91.1	7.592	25.70	79	4902	34.04	248.2	20.68	70.03
30	706.8	4.909	94.2	7.854	26.59	80	5027	34.93	251.3	20.94	70.89
31	754.7	5.241	97.4	8.116	27.47	81	5153	35.78	254.5	21.21	71.80
32	804.2	5.585	100.5	8.378	28.36	82	5281	36.67	257.6	21.47	73.35
33	855.3	5.940	103.7	8.639	29.25	83	5411	37.57	260.8	21.73	73.55
34	907.9	6.305	106.9	8.901	30.13	84	5542	38.48	263.9	21.99	74.45
35	962.1	6.681	110.0	9.163	31.02	85	5675	39.41	267.0	22.25	75.48
36	1017.8	7.069	113.1	9.425	31.90	86	5809	40.34	270.2	22.51	76.22
37	1075.2	7.467	116.2	9.686	32.79	87	5945	41.28	273.3	22.78	77.10
38	1134.1	7.876	119.4	9.948	33.68	88	6082	42.24	276.5	23.04	77.99
39	1194.5	8.296	122.5	10.21	34.56	89	6221	43.20	279.6	23.30	78.87
40	1256.6	8.727	125.7	10.47	35.45	90	6363	44.18	282.7	23.56	79.76
41	1320.2	9.168	128.8	10.73	36.33	91	6504	45.17	285.9	23.82	80.65
42	1385.4	9.621	131.9	10.99	37.22	92	6648	46.16	289.0	24.09	81.54
43	1452.2	10.08	135.1	11.26	38.11	93	6793	47.17	292.2	24.35	82.42
44	1520.5	10.56	138.2	11.52	38.99	94	6940	48.19	295.3	24.61	83.31
45	1509.4	11.04	141.4	11.78	39.88	95	7088	49.22	298.5	24.87	84.19
46	1661.9	11.54	144.5	12.04	40.76	96	7238	50.27	301.6	25.13	85.08
47	1734.9	12.05	147.7	12.30	41.65	97	7390	51.32	304.7	25.39	85.96
48	1809.5	12.51	150.8	12.57	42.58	98	7543	52.38	307.9	25.66	86.85
49	1885.7	13.09	153.9	12.83	43.42	99	7698	53.46	311.0	25.92	87.74
50	1963.5	13.64	157.1	13.09	44.31	100	7855	54.54	314.2	26.18	88.63

XVIII. ENGLISH AND METRIC CONVERSIONS

Pressures

In. Water Gauge (In. WG)	Pounds/Sq. In. (PSI)	In. Mercury (In. Hg.)	Pascals (Pa)	Millimeters W.G. (mm WG)	Millimeters Mercury (mm Hg)
1.0	.03602	.07334	248.36	25.40	1.8628
27.761	1.0	2.0360	6894.7	705.13	51.715
13.635	.49116	1.0	3386.4	346.33	25.40
.00403	.00015	.00030	1.0	.10227	.00750
.03937	.00142	.00289	9.7779	1.0	.07334
.53681	.01934	.03937	133.32	13.635	1.0

Velocity

Feet/Min. (fpm)	Miles/Hour (mph)	Meters/Min. (M/Min.)	Meters/Hr. (M/Hr.)
1.0	.01136	.30480	18.288
60.0	.68128	18.228	1093.7
88.0	1.0	26.822	1609.4
196.85	2.2369	60.0	3600.0
3.2808	.03728	1.0	60.0
.05468	.00062	.01667	1.0

Volume Flow Rates:

Cubic Ft./Min. (CFM)	Cubic Meter/Sec. (M^3/S)	Cubic Meters/Hr. ($M^3/Hr.$)
1.0	.000472	1.6990
.01667	.00000787	.02832
2118.9	1.0	3600.0
35.315	.01667	60.0
.58858	.00028	1.0
2.1189	.001	3.6

METRIC PREFIXES

deci	=	x	.1
centi	=	x	.01
mili	=	x	.001
micro	=	x	.000001
deca	=	x	10
hecto	=	x	100
kilo	=	x	1,000
mega	=	x	1,000,000

MISCELLANEOUS CONVERSION FACTORS

LENGTH

1 in = 2.54 cm
1 ft = .3048 m
1 yd = .9144 m
1 mi = 1.6093 Km
1 nau. mi = 1.1516 mi

AREA

1 in^2 = 6.4516 cm^2
1 Ft^2 = .0929 m^2
1 yd^2 =.8361 m^2
1 mi^2 = 2.5899 Km^2

POWER

1 hp = .746 KW
1 hp = 550 ft-lb/sec
1 hp = 33000 ft-lb/min
1 hp = 76.04 kg-m/sec
1 hpm = 75.00 Kg-m/sec

HEAT

1 Btu = 777.97 Ft-lb
1 hp = 2545 Btu/hr
1 hp = 1.014 metric hp
1 hp = .0761 boiler hp
1 kw = 3414 Btu/hr
1 Ton = 12000 Btu/hr

DENSITY

1 lb/ft^3 = 16.018 kg/m^3

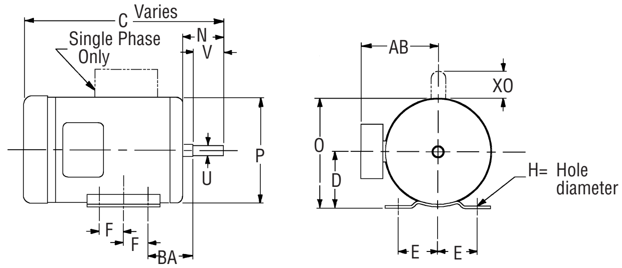
TIP SPEED

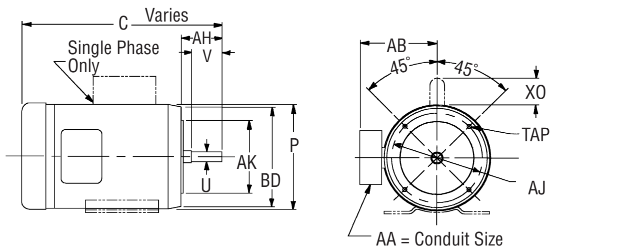
1 fpm = .0051 m/s

XIX. DECIMAL AND MILLIMETER EQUIVALENTS OF FRACTIONS

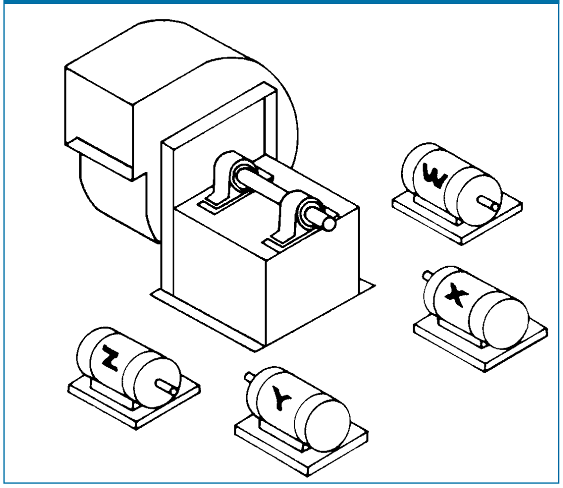
Inches: Fractions	Inches: Decimals	Millimeters	Inches: Fractions	Inches: Decimals	Millimeters
1/64	.015625	.397	33/64	.515625	13.097
1/32	.03125	.794	17/32	.53125	13.494
3/64	.046875	1.191	35/64	.546875	13.891
1/16	.0625	1.588	9/16	.5625	14.288
5/64	.078125	1.984	37/64	.578125	14.684
3/32	.09375	2.381	19/32	.59375	15.081
7/64	.109375	2.778	39/64	.609375	15.478
1/8	.125	3.175	5/8	.625	15.875
9/64	.140625	3.572	41/64	.640625	16.272
5/32	.15625	3.969	21/32	.65625	16.669
11/64	.171875	4.366	43/64	.671875	17.066
3/16	.1875	4.763	11/16	.6875	17.463
13/64	.203125	5.159	45/64	.703125	17.859
7/32	.21876	5.556	23/32	.71875	18.256
15/64	.234375	5.953	47/64	.734375	18.653
1/4	.250	6.350	3/4	.750	19.050
17/64	.265625	6.747	49/64	.765625	19.447
9/32	.28125	7.144	25/32	.78125	19.844
19/64.	.296875	7.541	51/64	.796875	20.241
5/16	.3125	7.938	13/16	.8125	20.638
21/64	.328125	8.334	53/64	.828125	21.034
11/32	.34375	8.731	27/32	.83475	21.431
23/64	.359375	9.128	55/64	.859375	21.828
3/8	.375	9.525	7/8	.875	22.225
25/64	.390625	9.922	57/64	.890625	22.622
13/32	.40625	10.319	29/32	.90625	23.019
27/64	.421875	10.716	59/64	.921875	23.416
7/16	.4375	11.113	15/16	.9375	23.813
29/64	.451325	11.509	61/64	.953125	24.209
15/32	.46875	11.906	31/32	.96875	24.606
31/64	.484375	12.303	63/64	.984375	25.003
1/2	.500	12.700	1	1.000	25.400

XX. MOTOR DIMENSIONS AND POSITIONS





Motor Positions with Relation to Fan



Dimensions in inches

NEMA FRAME	D	E	2F	H	N	U	AH	AJ	AK	BA	TAP	O	P	V	AA	AB	BB	BD	XO
42	2 5/8	1 3/4	1 11/16	9/32 SLOT	1 1/2	3/8	1 5/16	3 3/4	3	2 1/16	1/4-20	5	4 11/16	1 1/8	3/8	4 1/32	1/8	4 5/8	1 9/16
48	3	2 1/8	2 3/4	11/32 SLOT	1 7/8	1/2	1 11/16	3 3/4	3	2 1/2	1/4-20	5 7/8	5 11/16	1 1/2	1/2	4 3/8	1/8	5 5/8	2 1/4
56 56H	3 1/2	2 7/16	3 5	11/32 SLOT	2 7/16 2 1/8	5/8	2 1/16	5 7/8	4 1/2	2 3/4	3/8-16	6 7/8	6 5/8	1 7/8	1/2	5	1/8	6 1/2	2 1/4
143T 145T	3 1/2	2 3/4	4 5	11/32	2 1/2	7/8	2 1/8	5 7/8	4 1/2	2 1/4	3/8-16	6 7/8	6 5/8	2 1/4	3/4	5 1/4	1/8	6 1/2	2 1/4
182 184	4 1/2	3 3/4	4 1/2 5 1/2	13/32	2 11/16	7/8	2 1/8	5 7/8	4 1/2	2 3/4	3/8-16	8 11/16	7 7/8	2 1/4	3/4	5 7/8	1/8	6 1/2	2 3/8
182T 184T			4 1/2 5 1/2		3 9/16	1 1/8	2 5/8	7 1/4	8 1/2		1/2-13			2 3/4			1/4	9	
213 215	5 1/4	4 1/4	5 1/2 7	13/32	3 1/2	1 1/8	2 3/4	7 1/4	8 1/2	3 1/2	1/2-13	10 1/4	9 9/16	3	3/4	7 3/8	1/4	9	2 3/4
213T 215T			5 1/2 7		3 7/8	1 3/8	3 1/8							3 3/8					
254U 256U	6 1/4	5	8 1/4 10	17/32	4 1/16	1 3/8	3 1/2	7 1/4	8 1/2	4 1/4	1/2-13	12 7/8	12 15/16	3 3/4	1	9 5/8	1/4	10	—
254T 256T			8 1/4 10		4 5/16	1 5/8	3 3/4							4					
284U 286U	7	5 1/2	9 1/2 11	17/32	5 1/8	1 5/8	4 5/8	9	10 1/2	4 3/4	1/2-13	14 5/8	14 5/8	4 7/8	1 1/2	13 1/8	1/4	11 1/4	—
284T 286T			9 1/2 11		4 7/8	1 7/8	4 3/8							4 5/8					
284TS 286TS			9 1/2 11		3 3/8	1 5/8	3							3 1/4					
324U 326U	8	6 1/4	10 1/2 12	21/32	5 7/8	1 7/8	5 3/8	11	12 1/2	5 1/4	5/8-11	16 1/2	16 1/2	5 5/8	2	14 1/8	1/4	13 3/8	—
324T 326T			10 1/2 12		5 1/2	2 1/8	5							5 1/4					
324TS 326TS			10 1/2 12		3 15/16	1 7/8	3 1/2							3 3/4					
364U 365U	9	7	11 1/4 12 1/4	21/32	6 3/4	2 1/8	6 1/8	11	12 1/2	5 7/8	5/8-11	18 1/2	18 1/4	6 3/8	2 1/2	15 1/16	1/4	13 3/8	—
364T 365T			11 1/4 12 1/4		6 1/4	2 3/8	5 5/8							5 7/8					
364TS 365TS			11 1/4 12 1/4		4	1 7/8	3 1/2							3 3/4					
404U 405U	10	8	12 1/4 13 3/4	13/16	7 3/16	2 3/8	6 7/8	11	12 1/2	6 5/8	5/8-11	20 5/16	20 1/8	7 1/8	3	18	1/4	13 7/8	—
404T 405T			12 1/4 13 3/4		7 5/16	2 7/8	7							7 1/4					
404TS 405TS			12 1/4 13 3/4		4 1/2	2 1/8	4							4 1/4					
444U 445U	11	9	14 1/2 16 1/2	13/16	8 5/8	2 7/8	8 3/8	14	16	7 1/2	5/8-11	22 7/8	22 3/8	8 5/8	3	19 9/16	1/4	16 3/4	—
444T 445T			14 1/2 16 1/2		8 1/2	3 3/8	8 1/4							8 1/2					
447T 449T			20 25		8 15/16							22 15/16	23 3/4			21 11/16			
444TS 445TS			14 1/2 16 1/2		5 3/16	2 3/8	4 1/2					22 7/8	22 3/8	4 3/4		19 9/16			
447TS 449TS			20 25		4 15/16							22 15/16	23 3/4		4NPT	21 11/16			

Highlighted dimensions are set by NEMA within each frame size. All other dimensions can vary depending on motor type and/or manufacturer.