ENGINEERING LETTER | E
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MISCELLANEOUS ENGINEERING DATA

The purpose of this Engineering Letter is to provide reference data commonly required in routine fan system computations.

BASIC FAN LAWS

Variable	When Speed Changes	When Density Changes
Volume	$CFM_2 = CFM_1 \left(\frac{RPM_2}{RPM_1}\right)$	Does Not Change
Pressure	$P_2 = P_1 \left(\frac{RPM_2}{RPM_1}\right)^2$	$P_2 = P_1 \left(\frac{D_2}{D_1}\right)$
Horsepower	$BHP_2 = BHP_1 \left(\frac{RPM_2}{RPM_1}\right)^3$	$BHP_2 = BHP_1 \left(\frac{D_2}{D_1}\right)$

FAN EFFICIENCY

Mechanical Efficiency	$= \frac{\text{Air Horsepower}_{out}}{\text{Shaft Horsepower}_{in}} \times 100\%$
Mechanical Efficiency	$= \frac{TP \times CFM}{6356 \times BHP} \times 100\%$
Static Efficiency	$= \frac{SP \times CFM}{6356 \times BHP} \times 100\%$

UNITS COMMONLY USED IN FAN APPLICATIONS

Pressure

In. WG	Pascals	Psi	In. HG	mm WG	mm HG	Atm
1	248.36	.03602	.07334	25.400	1.8628	.00245
.00403	1	.00015	.00030	.10227	.00750	.00001
27.761	6894.7	1	2.0360	705.13	51.715	.06805
13.635	3386.4	.49116	1	346.33	25.400	.03342
.03937	9.7779	.00142	.00289	1	.07334	.00010
.53681	133.32	.01934	.03937	13.635	1	.00132
407.98	101325	14.696	29.921	10363	760.00	1

Volume Flow

CFM	m^3/s	$m^3/min.$	$m^3/hr.$	l/s	l/min.
1	.000472	.02832	1.6990	.47195	28.317
2118.9	1	60.000	3600.0	1000.0	60000
35.314	.01667	1	60.000	16.667	1000
.58858	.00028	.01667	1	.27778	16.667
2.1189	.00100	.06000	3.6000	1	60.000
.03531	.00002	.00100	.06000	.01667	1

Velocity

ft./min.	m/s	m/min.	m/hr.	mph	Knots
1	.00508	.30480	18.288	.01136	.00987
196.85	1	60.000	3600.0	2.2369	1.9425
3.2808	.01667	1	60.000	.03728	.03238
.05468	.00028	.01667	1	.00062	.00054
88.000	.44704	26.822	1609.4	1	.86839
101.34	.51479	30.887	1853.2	1.1516	1

Rotating Speed

RPM	rps
1	.01667
60.000	1

Density

$lbs./ft.^3$	Kg/m^3
1	16.018
.06243	1

Power

HP	Watts
1	.7457
1.341	1

PRESSURE EQUIVALENTS

Inches Water	Inches Mercury	Ounces Per Sq. In.	Pounds Per Sq. In.	Millimeters Water
1	.0733	.5763	.0360	25.4
2	.1467	1.153	.0720	50.8
3	.2200	1.729	.1081	76.2
4	.2934	2.305	.1441	101.6
5	.3667	2.882	.1801	127.0
6	.4400	3.458	.2161	152.4
7	.5134	4.034	.2522	177.8
8	.5867	4.611	.2882	203.2
9	.6601	5.187	.3242	228.6
10	.7334	5.763	.3602	254.0
11	.8067	6.340	.3962	279.4
12	.8801	6.916	.4323	304.8
13	.9534	7.493	.4683	330.2
14	1.027	8.069	.5043	355.6
15	1.100	8.645	.5403	381.0
16	1.173	9.222	.5763	406.4
17	1.247	9.798	.6124	431.8
18	1.320	10.374	.6484	457.2
19	1.393	10.951	.6844	482.6
20	1.467	11.527	.7204	508.0
21	1.540	12.103	.7565	533.4
22	1.613	12.680	.7925	558.8
23	1.687	13.256	.8285	584.2
24	1.760	13.832	.8645	609.6
25	1.834	14.409	.9005	635.0
26	1.907	14.985	.9366	660.4
27	1.980	15.561	.9726	685.8
28	2.054	16.238	1.009	711.2
29	2.127	16.714	1.045	736.6
30	2.200	17.290	1.081	762.0
31	2.274	17.867	1.117	787.4
32	2.347	18.443	1.153	812.8
33	2.420	19.019	1.189	838.2
34	2.494	19.596	1.225	863.6
35	2.567	20.172	1.261	889.0
36	2.640	20.748	1.297	914.4
37	2.714	21.325	1.333	939.8
38	2.787	21.901	1.369	965.2
39	2.860	22.478	1.405	990.6
40	2.934	23.054	1.441	1016.0
41	3.007	23.630	1.477	1041.4
42	3.080	24.207	1.513	1066.8
43	3.154	24.783	1.549	1092.2
44	3.227	25.359	1.585	1117.6
45	3.300	25.936	1.621	1143.0

DENSITIES OF SATURATED AIR

Temp. (°F.)	Density (lbs./ft.^{3})	Temp. (°F.)	Density (lbs./ft.^{3})
-20	.09027	100	.0619
-10	.08824	110	.06741
0	.08632	120	.06552
10	.08445	130	.06349
20	.08264	140	.06132
30	.08090	150	.05895
40	.07921	160	.05634
50	.07753	170	.05346
60	.07589	180	.05036
70	.07425	190	.04667
80	.07262	200	.04270
90	.07094	212	.03730

VELOCITY PRESSURES (At Standard Density .075 lbs./ft.^{3})

Velocity (FPM)	VP (In. Water)	Velocity (FPM)	VP (In. Water)
500	.016	3000	.561
600	.022	3200	.638
700	.031	3400	.721
800	.040	3600	.808
900	.050	3800	.900
1000	.062	4000	.998
1100	.075	4200	1.10
1200	.090	4400	1.21
1300	.105	4600	1.32
1400	.122	4800	1.44
1500	.140	5000	1.56
1600	.160	5200	1.69
1700	.180	5400	1.82
1800	.202	5600	1.96
2000	.249	5800	2.10
2200	.302	6000	2.24
2400	.359	6200	2.40
2600	.421	6400	2.55
2800	.489	6600	2.72
		6800	2.88

FAN SYSTEM EFFECT FACTORS

Pressure Drop, Inches Water Gauge

Air Velocity (FPM)	Round, Mitred Elbow			Square-Duct Elbow			
	Two-piece	Multi-piece		W/Out Turning Vanes		With Turning Vanes	
		$\frac{R}{D}=1$	$\frac{R}{D}=2$	$\frac{R}{D}=1$	$\frac{R}{D}=2$	$\frac{R}{D}=1$	$\frac{R}{D}=2$
Elbow On The Inlet							
3000	1.8	0.7	0.6	0.7	0.5	0.3	0.1
4000	3.2	1.3	1.0	1.3	0.8	0.6	0.3
5000	5.0	1.8	1.5	1.8	1.3	0.8	0.4
Elbow (2) Duct Diameters From The Inlet							
3000	1.2	0.4	0.3	0.4	0.3	0.2	0.1
4000	2.0	0.7	0.6	0.7	0.5	0.4	0.2
5000	3.0	1.0	0.8	1.1	0.7	0.5	0.3
Elbow (5) Duct Diameters From The Inlet							
3000	0.6	0.2	0.2	0.2	0.1	0.1	0.0
4000	1.0	0.3	0.3	0.4	0.3	0.2	0.1
5000	1.5	0.5	0.5	0.5	0.4	0.3	0.2

FAN PRESSURES

$TP = SP + VP$

$TP_{fan} = TP_{outlet} - TP_{inlet}$

$SP_{fan} = SP_{outlet} - SP_{inlet} - VP_{inlet}$

VP = Velocity Pressure

TP = Total Pressure

SP = Static Pressure

ALTITUDE AND TEMPERATURE CORRECTION FACTORS
(Multiply Factor by SP at Conditions)

Air Temp. (°F.)	Altitude (feet)										
	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
0	.87	.91	.94	.98	1.01	1.05	1.09	1.13	1.17	1.22	1.26
50	.96	1.00	1.04	1.08	1.11	1.15	1.20	1.25	1.30	1.34	1.39
70	1.00	1.04	1.08	1.12	1.16	1.20	1.25	1.30	1.35	1.40	1.45
100	1.07	1.10	1.14	1.19	1.23	1.28	1.33	1.38	1.43	1.48	1.54
150	1.15	1.20	1.24	1.29	1.33	1.38	1.44	1.50	1.55	1.61	1.67
200	1.25	1.29	1.34	1.40	1.45	1.51	1.56	1.63	1.69	1.75	1.81
250	1.34	1.39	1.45	1.50	1.56	1.62	1.68	1.74	1.81	1.88	1.94
300	1.43	1.49	1.55	1.61	1.67	1.74	1.79	1.86	1.93	2.00	2.07
350	1.53	1.59	1.62	1.72	1.78	1.85	1.91	1.99	2.07	2.14	2.22
400	1.62	1.69	1.75	1.82	1.89	1.96	2.03	2.11	2.19	2.27	2.35
450	1.72	1.79	1.86	1.93	2.00	2.08	2.15	2.24	2.32	2.41	2.49
500	1.81	1.88	1.96	2.03	2.11	2.19	2.26	2.35	2.44	2.53	2.62
550	1.91	1.98	2.06	2.14	2.22	2.30	2.39	2.48	2.58	2.67	2.77
600	2.00	2.08	2.16	2.24	2.33	2.42	2.50	2.60	2.70	2.80	2.90
650	2.10	2.18	2.26	2.35	2.44	2.54	2.62	2.73	2.84	2.94	3.05
700	2.19	2.27	2.36	2.46	2.55	2.65	2.74	2.85	2.94	3.01	3.18
750	2.28	2.37	2.47	2.56	2.66	2.76	2.81	2.96	3.08	3.19	3.31
800	2.38	2.48	2.57	2.66	2.76	2.86	2.98	3.09	3.21	3.33	3.45
850	2.47	2.57	2.67	2.77	2.87	2.96	3.09	3.21	3.33	3.46	3.58
900	2.56	2.66	2.76	2.87	2.97	3.07	3.20	3.33	3.46	3.58	3.71
950	2.66	2.77	2.87	2.98	3.09	3.19	3.33	3.46	3.59	3.72	3.86
1000	2.76	2.87	2.98	3.09	3.20	3.31	3.45	3.59	3.73	3.86	4.00

WEIGHTS OF MATERIALS, MEAN VALUES

Material	Density lbs./ft.^{3}	Material	Density lbs./ft.^{3}	Material	Density lbs./ft.^{3}	Material	Density lbs./ft.^{3}
Air	.0749	Cinders	43	Gravel, loose, piled	120	Salt, gran, and piled	48
Aluminum	165	Clay, loose, dry	63	Grit blast dust	160	Saltpeter	80
Aluminum chips	48	moist	110	Gypsum, compressed	152	Sand, dry, loose	99
Antimony	414	Coal, anthracite	98	loose	70	Sand, wet	110
Asbestos	153	anthracite, piled	54	Iron, gray cast	442	Sandstone	144
Asbestos, loose	64	bituminous	85	Iron ore, loose	150	Sandstone, crushed	82
Ashes, coal, dry	40	bituminous, piled	47	Lead	710	Sawdust	7-15
Ashes, wood, dry	47	Coffee	48	Lead oxide (red)	567	Shale, riprap	105
Bakelite, Laminated	86	Coke	75	Leather	56	Shavings, planer	7-15
wood filler	85	Coke, piled	28	Lime	53-64	Slag, Iron	172
asbestos filler	118	Coke, dry, crushed	15	Limestone	163	Slag, granulated	60
crushed	43	Concrete, cinder	97	Lucite	74	Slate	172
Baking powder	56	stone	142	Magnesia	214	Soda ash	74
Bauxite, dry, crushed	43	Copper	556	Magnesium	109	Soda ash, granulated	30
Borax	109	Copper ore, crushed	190	Manganese ore, crushed	259	Sodium carbonate	91
Borax, dry, crushed	75	Copper oxide	190	Marble, crushed	95	Sodium nitrate	141
Brass	530	Cork	15	Mica	183	Sodium sulphate	167
Brass chips	163	Corn meal	40	Monel metal	556	Starch	95
Brick, masonry	118	Corundum, alundum	247	Natural gas	0.04475	granulated	35
Bronze	509	Cotton, baled	93	Nickel	547	Steel	487
Bronze, phosphor	554	loose	30	Nylon	70	Sucrose	100
Calcium, carbonate	177	Dolomite	181	Paper	58	Sugar, bulk	55
Calcium chloride	134	Duralumin	175	Strawboard or		Sulphur	126
Calcium sulphate	185	Earth, dry and loose	76	newspaper	33-44	Sulphur, crushed	50
Carbide, dry, crushed	50	Earth, moist & loose	78	Paraffin	56	Talc	170
Carborundum	195	Emery	250	Peat, dry	30	Tar, bituminous	69
Carborundum, loose	140	Feldspar	160	Phosphate, ground	75	Tile	113
Caustic soda	88	Feldspar, crushed	88	Porcelain	150	Tin	457
Celluloid	90	Ferrous, grind dust	125	Potash	60	Tobacco	16
Cellulose	94	Flour, compressed barreled	47	Quartz	165	Water	62.4
Cement, loose	94	loose	28	Quartz, ground	84	Zinc	443
Cereals, bulk barley, corn	37	Fullers earth, dry	30	Resin	67	Zinc oxide	350
oats	26	Glass, crown	160	Rubber, India	58		
rye, wheat	48	Glass, flint	215	compound	115		
Chalk	142	pyrex	140	hard	75		
Charcoal, hardwood	34	ground	90	hard sponge	30		
softwood	23	Granite	165	tire reclaim, solid	74		
broken	12	loose, piled	96	tire reclaim, shred	27		
		Graphite	132				

MISCELLANEOUS CONVERSION FACTORS

Pressure	Area
1 Pa = 1 N/m^2 1 Pa = 10 dy/cm^2 1 psi. = 0.0703 kg/cm^2 1 $lb./ft.^2$ = 4.884 kg/m^2	1 $in.^2$ = 6.4516 cm_2 1 $ft.^2$ = 0.0929 m_2 1 $yd.^2$ = 0.8361 m_2 1 $mi.^2$ = 2.5899 km_2
Length	**Volume**
1 mil. = 0.0254 mm 1 in. = 2.54 cm 1 ft. = 0.3048 m 1 mi. = 1.6093 km 1 nau. mi. = 1.1516 mi.	1 $in.^3$ = 16.3871 cm_3 1 $ft.^3$ = 0.0283 m_3 1 $ft.^3$ = 7.48 gal. 1 $ft.^3$ = 28.316 l. 1 $yd.^3$ = 0.7646 m_3 1 oz. = 29.57 ml. 1 gal. = 3.785 l. 1 gal. U.S. = 0.833 Imp. gal.
Energy	**Metric Prefixes**
1 Btu = 777.97 ft.-lb. 1 HP = 2545 Btu/Hr. 1 HP = 1.014 metric HP 1 HP = 0.0761 boiler HP 1 KW = 3414 Btu/Hr. 1 Ton = 12000 Btu/Hr.	deci = x 0.1 centi = x 0.01 mili = x 0.001 micro = x 0.000001 deca = x 10.0 hecto = x 100.00 kilo = x 1000.00
Mass	
1 lb. = 453.5924 g.	

U. S. INCH

Fraction	Decimal	MM
1/16	0.06250	1.588
1/8	0.12500	3.175
3/16	0.18750	4.763
1/4	0.25000	6.3 50
5/16	0.31250	7.938
3/8	0.37500	9.525
7/16	0.4375	11.113
1/2	0.5000	12.700
9/16	0.56250	14.288
5/8	0.62500	15.875
11/16	0.68750	17.463
3/4	0.75000	19.050
13/16	0.81250	20.638
7/8	0.87500	22.225
15/16	0.93750	23.813
1	1.00000	25.400

METAL SHEET AND PLATE DATA

Mild Steel, Stainless T-1, INX			Aluminum	
Gauge	**Thickness**	**Weight ($lbs./ft.^2$)**	**Gauge**	**Weight ($lbs./ft.^2$)**
1"	1.0	40.8	.250	3.50
3/4"	.75	30.6	.190	2.65
5/8"	.625	25.5	.160	2.24
1/2"	.50	20.4	.125	1.75
3/8"	.375	15.3	.100	1.40
1/4"	.250	10.2	.080	1.12
7 (3/16")	.1875	7.5		
10	.1345	5.625		
12	.1046	4.375		
14	.0747	3.125		
16	.0598	2.50		
18	.0478	2.0		

SHAFTING DATA (Mild Steel, Stainless)

Diameter (in.)	Weight (lbs./ft.)
5/8	1.04
1	2.67
1 3/16	3.77
1 7/16	5.52
1 11/16	7.60
1 15/16	10.02
2 3/16	12.78
2 7/16	15.87
2 11/16	19.29
2 15/16	23.04
3 3/16	27.13
3 7/16	31.55
3 15/16	41.40
4 7/16	52.58
4 15/16	65.10
5 7/16	78.95
6	96.13

ELECTRICAL FORMULAS

$$\text{Volts (E)} = \text{Amps. (I)} \times \text{Ohms (R)}$$

$$\text{BHP (3 phase)} = \frac{\text{Volts x Amps. x 1.732 x Eff. x Power Factor}}{746}$$

$$\text{BHP (1 phase)} = \frac{\text{Volts x Amps. x Eff. x Power Factor}}{746}$$

$$\text{Torque (lb.-ft.)} = \frac{\text{Horsepower x 5250}}{\text{RPM}}$$

TEMPERATURE CONVERSION

°C = (°F - 32) ÷ 1.8 °K
= °C + 273.15
°F = (°C x 1.8) + 32 °R
= °F + 459.67