Pressure Application

Problem: A pressure source is used to agitate a plating tank of corrosive chemicals. Depth of liquid in the tank is 6 ft. A pipe with forty 1/32-in. diameter holes placed at bottom of tank will discharge air and promote agitation of the fluid. The pump must be oil-less so that no oil contamination will be introduced.

Solution:

1 .Required pressure is determined by depth of fluid in the tank; 1 in. H^20 = 0.0361 psi, so 6 ft H^20 = 6 x 12 X 0.0361 = 2.6 psi. To overcome losses, plan on 3 to 5 psi.
2. Using 5 psi, we find from a compressed air handbook that a 1/32-in. diameter hole will pass 0.25 cfm.
3. Total air usage at 5 psi will be 40 x 0.25 = 10 cfm.
4. From Table 13, a Gast Model 1550 oil-less compressor operating at 1440 rpm will meet the requirement (10 cfm at 5 psi).

Pressure Application

Problem: An environmental air monitoring agency requires a-quiet, portable compressor to pump a mixture of 90 percent air and 10 percent hydrogen sulfide from its container at atmospheric pressure to a 1/32-in. diameter jet at 25 psi minimum. What model should be selected?

Solution:

1 .A handbook shows that a 1/32-in. orifice will pass 0.56 cfm at 25 psi and 0.7 cfm at 35 psi.
2. Since hydrogen sulfide is toxic, a sealed compressor is desirable.
3. The diaphragm pump is a commonly available sealed type.
4. Checking the flow data in Table 14 for Model DOA-101, we find by interpolation that it produces 0.62 cfm minimum at 25 psi and 0.47 cfm at 35 psi.
5. Therefore, Model DOA-101 will meet all flow and pressure requirements.
6. Hydrogen sulfide gas does not affect the diaphragm material.
7. Model DOA-101 is quiet (55 dBA at 25 psi) and is the final choice.

Vacuum Application

Problem: Slabs of marble weighing 250 lb. are to be loaded and unloaded from a flat bed truck at the rate of one per minute. Vacuum will be used to protect the surface of the slabs. Since it will be mounted on the truck, the vacuum lifter is to be powered by a gasoline engine. A manufacturer of vacuum lifting devices is contacted.

Solution:

1. A basic design value for vacuum lifting is 20 in. Hg, which is equivalent to 20 x 0.4913 = 9.83 lb. of lifting force per square inch of suction cup area.
2. Two vacuum cups will be used as a safety feature so that the load can still be carried should one cup become damaged or inoperative.
3. If one cup leaks, then the pump selected must be large enough to compensate for the air leaking into the vacuum holding system.
4. For 9.83 lb. of lifting force per square inch, a vacuum cup must have an area of 250 9.83 = 25.43 sq. in. to hold the load.
5. The diameter of a circle with an area of 25.43 sq. in. is 5.7 in. Since the manu facturer has a standard 6-in. vacuum cup, he decides to use it.
6. The orifice in the center of the vacuum cup is 1/8 in. in diameter permitting an air flow of 4.7 cfm when providing a differential of 20 in. Hg.
7. The pump chosen must be large enough to compensate for a potential leak of this amount and still draw a vacuum of 20 in. Hg on the remaining cup. Table 15 indicates that a separate drive Gast Model 2065 (5.0 cfm at 20 in. Hg) will do the job and can be driven by belt from the gasoline engine.
8. Assuming a tubing system 3/4 in. in diameter and 25 ft. long, a volume of 0.08 cu. ft. must be evacuated in 10 seconds, the time allotted for evacuation in the one-slab-per-minute specification. Model 2065 does the job.

Vacuum Application

Problem: Design a vacuum palletizer for loading and unloading pallets of small boxes 12 by 12 in. that can weigh as much as 80 lb. each. The pallet is 48 in. square, and when the lifter comes down, there can be any combination of boxes on a particular layer. They will always be positioned according to a set pattern.

Cycle time is once every 4 minutes.

Solution:

1 .Using 10 in. Hg as the basic design requirement, we get 10 x 0.4913 = 4.91 lb. of lifting force per square inch of suction cup.
2. A vacuum cup with an area of 80/4.91 = 16.3 sq. in. is required to lift each box.
3. A 4.56 in. diameter sucker cup would do the job with no safety factor.
4. For a 50 percent safety factor, 5.6 in. diameter cups would be needed. A standard diameter, such as 6 in., should be selected.
5. The orifice in the sucker cups is 1/16 in., permitting an air flow of 0.74 cfm at 10 in. Hg (for each of the 16 cups).
6. Because we are going to lift from one to 16 cartons, we must select a pump that will accommodate the flow from 15 open cups. Hence, it must pump at least 15 x 0.74= 11.1 cfm at 10 in. Hg.

7. The pump is mounted on the carrier or lifting head so the system contains less than 1 cu. ft.
8. From Table 15, we see that a Gast Model 2565 pump can be used (flow 13.5 cfm at 10 in. Hg).

Combined Vacuum-Pressure Application

Problem: A vacuum forming machine requires both a pressure and vacuum source. Pressure is used to raise the 100-lb. heater plate 12 in. in 10 seconds, using an air cylinder with 3 sq. in. area. Vacuum of 15 in. Hg is used to draw heated plastic sheet down into the mold, which has a volume of 1/2 cu. ft. The mold vacuum level of 15 in. Hg is to be attained within 2 minutes. The pump selected must be compact with no V-belt drives.

Solution:

1. A 50 psi piston type compressor can be operated with one cylinder at pressure and the other at vacuum providing that the sum of the operating pressure in psi and 1/2 the vacuum duty in in. Hg does not exceed 50.
2. Pressure required in the 3 sq. in. cylinder to raise the 100 lb. heater plate is 100/3 = 33 psi. (Use 40 psi, since pressure exceeding 33 psi will be needed to raise the plate.)
3. To move the 3 sq. in. cylinder 12 in. requires a volume of 3 x 12 or 36 cu. in. of air at 40 psi.
4. Converting 36 cu. in. air at 40 psi to free air, use P1V1 = P2V2. (P1 and P2 expressed as absolute pressure, or gauge pressure + 14.7 psi).

$$(40 + 14.7)(36) = (14.7)(V2)$$
$$V_2 = (54.7/14.7)(36) = 134 \text{ cu. in.}$$
$$134 \text{ cu. in.}/1728 = 0.078 \text{ cu. ft.}$$
$$0.078 \text{ cu. ft. in 10 sec.} = 0.078 \times 60/10 = 0.46 \text{ cfm}$$

5. Therefore, for the pressure portion of the problem, we need a source to provide 0.5 cfm at 40 psi.
6. The vacuum portion requires a source that will pump 1/4 to 1/2 cfm at 15 in. Hg. (A pump with a capacity of 1/2 cfm at 15 in. Hg will lower a 1/2 cu. ft. volume from atmospheric pressure to 15 in. Hg in one minute).
7. A pressure of 40 psi requires a piston-type pump. From Table 16 we see that the two-cylinder Gast Model 2LBB would produce from one cylinder 1/2 x 1.50 = 0.75 cfm at 40 psi, exceeding the minimum requirement of 0.5 cfm.
8. The vacuum cylinder will produce about 1/2 the open flow of one cylinder. For Model 2LBB, this is 1/2 of 2.4 cfm, or 1.2 cfm cylinder. Again, this exceeds the requirements of 1/4 to 1/2 cfm at 15 in. Hg.
9. Checking that the effect of combined duties is less than 50, we have 40 psi + 15 in. Hg/2 = 47.5.
10. Final choice is the 2LBB-10-M200X, a motor-mounted, compact piston type unit.

APPENDIX

Nomenclature

V_{vc} = volume of expanded air, cu ft
V = volume of free air, cu ft
P = pressure (psi)
P_a = absolute pressure (psia)
P_1 = inlet (or original) absolute pressure
P_2 = discharge (or final) absolute pressure
V_1 = inlet (or original) volume
V_2 = discharge (or final) volume
T_1 = inlet (or original) absolute temperature
T_2 = discharge (or final) absolute temperature
m = mass
T = absolute temperature (^{o}Rankine or ^{o}Kelvin)
R = 0.08207 lit-atm per mole-^{o}K

Gas Law Units

Pressures Used in Gas Laws

Positive Gauge Pressure is the pressure above atmospheric pressure (measured in psig).

Negative Gauge Pressure (vacuum) is the difference between atmospheric pressure and the pressure remaining in the evacuated system (measured in inches Hg or negative psig).

Absolute Pressure is the pressure above a perfect vacuum condition measured in psia. When using gas laws, pressure must be absolute pressure values.

Metric Units -in metric systems pressures are given in "bars" equal to 14.50 psi. The unit of force is the newton, and the unit of area is the square meter. One bar is 10,000 newtons per square meter.

Temperatures Used in Gas Laws

Absolute Temperature is the temperature above absolute zero, the point where all thermal activity ceases. Such a perfect gas would exert no pressure if kept at a constant volume. In U.S. units, absolute temperature is given in degrees Rankine (^{o}R), and absolute zero is equivalent to - 460^o F.

NOTE: In metric units, absolute zero is - 273^{o}C, and absolute temperatures are given in degrees Kelvin (^{o}K).

Conversions to and from degrees Rankine and degrees Kelvin are made as follows:

^{o}R = ^{o}F + 460
^{o}F = ^{o}R - 460

^{o}K = ^{o}C + 273
^{o}C = ^{o}K - 273

Volume Measurements for Gas Laws

For the General Gas Law, the volume unit must correspond to the value of R used. For example, when the value 53.3 is used, volume must be in cubic feet.

For other laws, the only requirement is that all volumes be given in the same units. For example, receiver tank volumes are sometimes given in gallons. To convert gallons into cubic feet, simply multiply by 0.1337.

Gas Laws

As discussed in section 1, the relationships of pressure, volume, and temperature of a quantity of air are interrelated. The first three laws cover conditions where the quantity or mass of air is constant. The fourth law (General Law) provides for computation involving change in the mass of air.

Boyle's Law

$$P_1V_1 = P_2V_2$$

This basic law covers the relationship between changes in pressure and volume when temperature remains constant.

Variations:

(a) $V_2 = \frac{P_1V_1}{P_2}$

(b) $P_2 = \frac{P_1V_1}{V_2}$

(c) Free air calculation:

$$V_{FA} = V \times \frac{(P + 14.7 \text{ psi})}{14.7 \text{ psi}}$$

Charles' Law

$$\frac{P_1}{P_2} = \frac{T_1}{T_2} \quad : \quad \frac{V_1}{V_2} = \frac{T_1}{T_2}$$

The basic forms above cover changes in pressure and volume caused by temperature changes. A pressure change is calculated for a system where the volume is constant. A volume change is calculated where the pressure remains constant.

Variations:

(a) $P_2 = \frac{P_1 \times T_2}{T_1}$

(b) $V_2 = \frac{V_1 \times T_2}{T_1}$

(c) $T_2 = \frac{P_2 \times T_1}{P_1}$

(d) $T_2 = \frac{V_2 \times T_1}{V_1}$

Combined Gas Law

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

The above basic form combines Charles' and Boyle's Laws to cover variation of all variables.

Variations:

(a) $P2 = \frac{P_1V_1}{V_2} \times \frac{T_2}{T_1}$

(b) $V2 = \frac{P_1V_1}{P_2} \times \frac{T_2}{T_1}$

(c) $T2 = \frac{P_2V_2}{P_1V_1} \times T_1$

General Gas Law or Equation of State of an Ideal Gas

$$mR = \frac{PV}{T}$$

The above basic form includes the effect of mass (in pounds). The right-hand portion of the equation is the same as the Combined Gas Law. R is a constant that varies with the gas being considered and the units used. For air in units of the U.S. system (T in degrees Rankine, V in cubic feet, m in pounds mass, and P in pounds per square foot absolute-to obtain psfa, multiply psia by 144), R has the value 53.3.

Variation:

$$PV = nRT$$

In this variation, n represents the amount of gas in moles. A mole is 6.02 X 1021 molecules; its weight in grams equals the molecular weight of the gas. This makes R independent of the gas involved. In metric units (T in degrees Kelvin, V in liters, and P in atmospheres), R has the value 0.08207.

Terms of either form of the General Gas Law may be manipulated mathematically as required to find the value of any single variable.

Flow Measurements

The volume of air delivered by a compressor or removed by a vacuum pump is given in cubic feet per minute (cfm). This may be either cfm at actual temperature and pressure or standard cubic feet of air per minute (scfm)-that is, cfm at atmospheric pressure and a standard temperature of 68^{o}F (20^{o}C). (For utmost accuracy, scfm also requires correction to a standard humidity of 36 percent.)

The term "free air" is often used interchangeably with "standard air." Strictly speaking, "free air" refers to air at ambient conditions - the conditions at a compressor's intake or a vacuum pump's discharge port. These conditions vary somewhat from day to day.

In the metric system, flow may be given in terms of cubic meters per second, cubic decimeters (liters) per second, or cubic centimeters per second. (One cubic meter per second =35.31 cu ft /sec; one cubic meter per hour= 0.588 cfm).

Force and Mass

In the U.S. system, the unit of force is the pound (lb.). The unit of mass is the slug. In the metric system, the unit of force is the newton (n), which equals 0.225 lb. The unit of mass is the kilogram (kg), equal to 0.06849 slug. At the earth's surface, a kilogram weighs about 2.2 lb.

Power

The units of power are horsepower (hp) and watts (w) or kilowatts (kw). One U.S. horsepower equals 0.746 kw and 1.014 metric horsepower.

Air Pressure Tables

Air pressure losses (in U.S. and metric units) resulting from friction, pipe bends, and in components are given in Tables A-1 through A-6. Tables A-7 and A-8 give air flow through orifices of various sizes.

Table A–1

Loss of Air Pressure (PSI) Because of Friction (per 100 feet of pipe, 100 PSI initial pressure) (U.S. Units)

CFM Free Air (14.7 PSI)	Equivalent CFM Compressed Air (100 + 14.7 (PSI)	Nominal Pipe Diameter, Inside (Inches) Loss of pressure (PSI)					
		1/2	3/4	1	1 1/4	1 1/2	2
10	1.28	1.38	0.09	0.03	0.007		
20	2.56	1.42	0.34	0.10	0.026	0.012	
30	3.84	3.13	0.74	0.23	0.056	0.026	
40	5.13	5.55	1.28	0.38	0.096	0.044	0.013
50	6.41	8.65	2.00	0.60	0.146	0.067	0.020
60	7.69		2.84	0.84	0.210	0.095	0.027
70	8.97		3.85	1.12	0.280	0.130	0.036
80	10.25		5.01	1.44	0.360	0.160	0.046
90	11.53		6.40	1.85	0.450	0.200	0.058
100	12.82		7.80	2.21	0.550	0.250	0.069
125	16.02		12.40	3.41	0.850	0.380	0.107
150	19.22		18.10	4.91	1.200	0.540	0.150
175	22.43			6.80	1.640	0.730	0.200
200	25.63			8.79	2.120	0.950	0.260
250	32.04				3.300	1.480	0.400
300	38.45				4.710	2.100	0.570
350	44.86				6.450	2.860	0.770
400	51.26				8.300	3.700	0.990
450	57.67					4.650	1.270
500	64.08					5.790	1.560
600	76.90					8.45	2.230
700	89.71						3.000
800	102.50						4.000
900	115.30						5.050
1,000	128.20						6.200

Table A–2

Loss of Air Pressure (Kg/cm^2) Because of Friction (Per 30 Meters of Pipe and 7 Kg/cm^2 Initial Pressure) (Metric Units)

Liters Free Air Per Min	Equivalent Liters Per Minute Compressed Air	Nominal Pipe Diameter, Inside (Millimeters) Loss of pressure (kg/cm^2)					
		12.7 mm	19.1 mm	25.4 mm	31.8 mm	38.1 mm	50.8 mm
300	37	0.027	0.006	0.002	0.0005		
600	75	0.100	0.024	0.007	0.0018	0.0008	
850	110	0.220	0.053	0.016	0.0039	0.0018	
1,150	150	0.390	0.090	0.027	0.0067	0.0031	0.0009
1,400	180	0.608	0.140	0.042	0.010	0.0047	0.0014
1,700	218		0.200	0.059	0.015	0.0067	0.0019
2,000	255		0.270	0.079	0.020	0.0091	0.0025
2,300	290		0.350	0.100	0.025	0.0110	0.0032
2,550	330		0.450	0.130	0.032	0.0140	0.0041
3,000	364		0.550	0.155	0.038	0.0160	0.0049
3,500	455		0.870	0.240	0.060	0.0270	0.0075
4,250	540		1.270	0.346	0.065	0.0380	0.0105
5,000	640			0.480	0.115	0.0510	0.0140
5,700	730			0.615	0.150	0.0670	0.0180
7,000	900				0.232	0.1040	0.0280
8,500	1,100				0.332	0.1480	0.0400
10,000	1,300				0.455	0.2000	0.0540
11,000	1,500				0.585	0.2600	0.0700
13,000	1,700					0.3260	0.0890
14,000	1,855					0.4100	0.1090
17,000	2.250					0.5950	0.1560
20,000	2.620						0.2100
23,000	3,000						0.2800
25,000	3,400						0.3550
30,000	3,760						0.4350

Table A–3

Loss of Air Pressure Due to pipe Bends (per 100 Feet of Straight Pipe) (U.S. Units)

Angle of pipe bend	Nominal Pipe Diameter, Inside (Inches) Loss of pressure (PSI)					
	1/2	3/4	1	1 1/4	1 1/2	2
90^0	1.60	2.00	2.50	3.40	4.00	5.10
45^0	0.73	0.92	1.18	1.55	1.85	2.35

Table A–4

Loss of Air Pressure Due to pipe Bends (per 30 Meters of Straight Pipe) (Metric Units)

Angle of pipe bend	Nominal Pipe Diameter, Inside (Millimeters) Loss of pressure (kg/cm^2) 12.7 mm	19.1 mm	25.4 mm	31.8 mm	38.1 mm	50.8 mm
90^0	0.48	0.60	0.75	1.02	1.20	1.53
45^0	0.22	0.28	0.35	0.47	0.56	0.71

Table A–5

Flow of Air Through Orifice, CFM, With Discharge of Orifice at Atmospheric Pressure of 14.7 lb. / in.^{2} Absolute and 70^{0}F (U.S. Units)

SUPPLY PSI (GAUGE)	Orifice size (Inches) 1/32	1/16	3/32	1/8	5/32	3/16	7/32	1/4	9/32	5/16
65	1.15	4.49	10.10	17.90	27.90	40.30	55.20	71.80	89.90	111.70
70	1.21	4.77	10.80	19.10	29.70	42.80	58.80	76.40	95.70	118.80
75	1.30	5.06	11.40	20.20	31.50	45.40	62.30	81.00	105.50	126.00
80	1.37	5.35	12.10	21.10	33.30	48.00	65.80	85.60	107.40	133.10
85	1.44	5.64	12.70	22.50	35.10	50.60	69.40	90.30	113.20	140.30
90	1.52	5.92	13.40	23.70	36.90	53.20	72.90	94.80	119.00	147.50
95	1.59	6.21	14.00	24.80	38.70	55.70	76.50	99.40	124.90	154.60
100	1.66	6.50	14.70	26.00	40.50	58.30	80.00	104.60	130.70	161.80
125	2.03	7.94	17.90	31.70	49.50	71.40	97.78	127.10	159.80	197.50
150	2.40	9.28	21.20	37.50	58.40	84.40	115.40	150.40	189.00	233.30

Table A–6

Flow of Air Through Orifice, Liters Per Minute, With Discharge of Orifice Pressure of 14.7 lb. / in.^{2} Absolute and 70^{0}F (U.S. Units)

SUPPLY PSI (GAUGE)	1/32	1/16	3/32	1/8	5/32	3/16	7/32	1/4	9/32	5/16
4.57	32.4	127.2	283.2	507.0	798.0	1,146.0	1,560.0	2,028.0	2,541.0	3,156.0
4.92	34.2	135.6	306.0	540.0	840.0	1,230.0	1,662,0	2,160.0	2,736.0	3,360.0
5.27	36.6	143.4	322.8	571.2	891.0	1,284.0	1,761.0	2,292.0	2,976.0	3,570.0
5.62	39.0	151.8	342.0	597.0	942.0	1,356.0	1,860.0	2,418.0	3,036.0	3,768.0
5.98	40.8	159.6	360.0	636.0	993.0	1,431.0	1,962.0	2,556.0	3,204.0	3,978.0
6.33	43.2	167.4	379.8	678.0	1,044.0	1,518.0	2,061.0	2,676.0	3,372.0	4,170.0
6.68	45.0	176.4	396.0	702.0	1,095.0	1,573.2	2,163.0	2,808.0	3,528.0	4,374.0
7.03	46.8	183.6	416.4	741.0	1,146.0	1,650.0	2,142.0	2,958.0	3,690.0	4,575.0
8.79	57.6	225.0	507.0	897.0	1,401.0	2,016.0	2,760.0	3,600.0	4,518.0	5,580.0
10.55	67.8	262.8	600.00	1,062.0	1,650.0	2,385.0	3,264.0	4,251.0	5,34.0	6,600.0

Conversion Factors

Length

	in.	ft.	yd.	mile	mm.	cm.	m.	km.
1 in.	1	0.0833	0.0278	-	25.40	2.540	0.0254	-
1 ft.	12	1	0.333	-	304.8	30.48	0.3048	-
1 yd.	36	3	1	-	914.4	91.44	0.9144	-
1 mile	-	5280	1760	1	-	-	1609.3	1.609
1 mm	0.0394	0.0033	-	-	1	0.100	0.001	-
1 cm.	0.3937	0.0328	0.0109	-	10	1	0.01	-
1 m.	39.37	3.281	1.094	-	1000	100	1	0.001
1 km.	-	3281	1904	0.6214	-	-	1000	1

Area

	sq. in.	sq. ft.	acre	sq. mile	sq. cm.	sq. m
1 sq. in	1	0.0069	-	-	6.452	-
1 sq. ft	144	1	-	-	929.0	0.0929
1 acre	-	43,560	1	0.0016	-	4047
1 sq. mile	-	-	640	1	-	-
1 sq. cm.	0.1550	-	-	-	1	0.0001
1 sq. m.	1550	10.75	-	-	10,000	1

Volume

	cu. in.	cu. ft.	cu. yd.	cu. cm.	cu. meter	liter	US gal.	Imp. gal
1 cu. In.	1	-	-	16.387	-	0.0164	-	-
1 cu. ft.	1728	1	0.0370	28,317	0.0283	28.32	7.481	6.229
1 cu. yd	46,656	27	1	-	0.7646	764.5	202.0	168.2
1 cu. cm.	0.0610	-	-	1	-	0.0010	-	-
1 cu. m.	61,023	35.31	1.308	1,000,000	1	999.97	264.2	220.0
1 liter	61,025	0.0353	-	1000.028	0.0010	1	0.2642	0.2200
1 US gal.	231	0.1337	-	3785.4	-	3.785	1	0.8327
1 Imperial Gallon	277.4	0.1605	-	4546.1	-	4.546	1.201	1

Weight

	grain	oz.	lb.	ton	g.	kg.	metric ton
1 grain	1	-	-	-	0.0648	-	-
1 oz.	437.5	1	0.0625	-	28.35	0.0283	-
1 lb.	7000	16	1	0.0005	453.6	0.4536	-
1 ton	-	32,000	2000	1	-	907.2	0.9072
1 g.	15.43	0.0353	-	-	1	0.001	-
1 kg.	-	35.27	2.205	-	1000	1	0.001
1 metric ton	-	35,274	2205	1.1023	-	1000	1

Pressure

	lb. / sq. in	lb. / sq. ft	int. atm.	kg / cm^2	mm Hg at 32^0F	in. Hg at 32^0 F
1 lb/sq. in.	1	144	-	0.0703	51.713	2.035
1 lb/sq. ft.	0.00694	1	-	-	0.3591	0.0141
1 international atmosphere	14.696	2116.2	1	0.0333	760	29.92
1 kg / sq. cm.	14.223	2048.1	0.9678	1	735.56	28.95
1 mm. Hg.*	0.0193	2.785	-	-	1	0.039
1 in. Hg.	0.4912	70.73	0.0334	0.0345	25.400	1

*Also known as 1 torr.

Power

	hp	watt	kw	Btu / min.	Btu / hr.	ft-lb / sec.	ft - lb / min.	g. cal / sec.	metric hp
1 hp	1	745.7	0.7475	42.41	2544.5	550	33,000	178.2	1.014
1 watt	-	1	0.001	0.0569	3.413	0.7376	44.25	0.2390	0.00136
1 kw	1.3410	1000	1	56.88	3412.8	737.6	44.254	239.0	1.360
1 Btu/min.	-	-	-	1	60	12.97	778.2	4.203	0.0239
1 ,metric hp	0.9863	735.5	0.7355	41.83	2509.8	542.5	32.550	175.7	1

GLOSSARY

Absolute Pressure
In pressure or vacuum systems, absolute pressure is the pressure above a perfect vacuum condition (zero pressure). In a pressure system, it is equal to the positive gauge pressure plus atmospheric pressure. In a vacuum system, it is equal to the negative gauge pressure subtracted from atmospheric pressure. U.S. units for absolute pressure are pounds per square inch, absolute (psia).

Actuator, Linear
Converts fluid energy into linear mechanical force and motion. Usually consists of a movable element, such as piston and piston rod operating within a close-fitting cylindrical bore.

Actuator, Rotary
Converts fluid energy input to mechanical output. Rotates an output shaft through a fixed arc to produce oscillating power.

Adiabatic
A change, such as expansion or compression, without loss or gain of heat. Any sufficiently fast process is approximately adiabatic.

Air Compressor
Device that causes a gas to flow against a pressure; converts mechanical force and motion into pneumatic fluid power. An air pump.

Air Motor
A device that converts the flow of pressurized air into continuous
rotary motion or torque.

Atmosphere
Unit of pressure that will support a column of mercury 29.92 inches high at O^{o}C, sea-level, and latitude 45^{o}. Actual day-to-day atmospheric pressure fluctuates about this value.

Atmospheric Pressure
Pressure exerted by the atmosphere in all directions, equal at sea level to about 14.7 psi.

Back Pressure
Resistance to flow in a system.

Barometer
Device for measuring atmospheric pressure at a specific location.

Barometric Pressure
The reading, in inches of mercury (in. Hg), showing atmospheric
pressure at a given location.

Brake Horsepower
The actual or useful horsepower of an engine, usually determined from the force exerted on a dynamometer connected to the drive shaft.

Boyle's Law
The absolute pressure of a fixed mass of gas varies inversely as the volume, provided the temperature remains constant. $P_1V_1 = P_2V_2$

Charles' Law
The volume of a given mass of gas is directly proportional to its absolute temperature, provided the pressure on the gas is held constant. $V_1/T_1 = V_2/T_2$- (Also, $P_1/T_1 = P_2/T_2$ at constant volume.)

Check Valve
In simplest form, a two-way directional valve. It permits free flow in one direction and blocks flow in the reverse direction. Can function as either a directional or pressure control device.

Clearance Volume
The space between a piston and cylinder head at full compression.

Compressed Air
Air that has been reduced in volume and exerts a gauge pressure.

Dessicant Dryer
An absorption material that removes moisture from air.

Differential Pressure
Difference in pressure between two points in a system or component.

Differential Pressure Switch
Switch with a low pressure and high pressure adjustment; fluid pressure actuates an electric switch to perform functions.

Displacement
The total volume swept by the repetitive motion of the pumping element. Displacement per revolution is determined by size of the pumping chamber(s). Displacement per minute also depends on compressor speed. Displacement is meaningful only in positive displacement compressors.

Efficiency, Volumetric
Ratio of actual capacity to theoretical displacement multiplied by 100 percent.

Filter, Air Intake
Device whose primary function is the retention by a porous medium of insoluble contaminants from a fluid. Installed at intake port of compressor or vacuum pump.

Fluid Mechanics
The grouping of hydrodynamics (mechanics of liquids) and pneumatics (mechanics of gases). A fluid is any gas or liquid, the shape of which yields to pressure.

Fluid Power
Energy transmitted and controlled through use of a pressurized fluid within an enclosed circuit.

Fluid Power Horsepower
Power that is proportional to the product of gauge pressure (or vacuum) and air flow rate.

Flow Rate
The quantity of fluid passing a point per unit of time. In pneumatics, this is commonly represented by cfm (cubic feet per minute).

Force
That which can impose a change of velocity on a material body. It is a vector quantity indicating magnitude and direction. Force is theoretically proportional to the mass of the body acted on and the acceleration produced.

Free Air
Air under the atmospheric conditions (including temperature) at any specific location.

FRL
Filter/Regulator/Lubricator. Used in pneumatic systems, this combination filters particles and separates moisture from incoming air; regulates the supply pressure; and lubricates the air by adding oil vapor.

Gauge Pressure (Positive)
The pressure differential above atmospheric pressure (see pressure gauge).

Gauge Pressure (Negative)
The difference between pressure remaining in an evacuated system and atmospheric pressure (see vacuum gauge). Also known as -gauge vacuum" or "vacuum level." In effect, it is the pressure drop produced by evacuating the system. Measured in inches of mercury (in. Hg). Caution: It is a potentially misleading term which must be carefully defined when used; negative pressure (absolute) doesn't exist.

General Gas Law
Obtained by combining Boyle's Law and Charles' Law, and is used to compute change in volume, pressure, and temperature of a gas. Essentially, it states that the product of pressure and volume, divided by the temperature, remains constant.

Head
Energy per pound caused by pressure, velocity, or elevation. The height of a column or body of fluid above a given point expressed in linear units. Often used to indicate gauge pressure. Pressure is equal to the height multiplied by the density of the fluid.

Hydrostatic Pressure
The pressure exerted equally in all directions at points within a confined fluid (liquid or gas). It is the only stress possible in a fluid at rest.

Isothermal
Compression or expansion of a gas taking place at constant temperature. In practice, this is a slow process because of the time required to remove heat generated by compression or to replace heat absorbed by expansion.

Kinetic Energy
The energy a body possesses by virtue of its motion. Kinetic energy is added to a fluid either by rotating it at high speed or by providing an impulse in a direction of flow.

Lubricator
Pneumatic component that lubricates by injecting atomized oil into the air stream.

Manometer
A differential pressure gauge in which pressure is indicated by height of a liquid column of known density. Pressure is equal to the difference in vertical height between two connected columns multiplied by the density of the manometer liquid.

Maximum Pressure Rating
Highest pressure level recommended for a compressor.

Maximum Vacuum Rating
Highest vacuum level recommended for a vacuum pump.

Muffler (Exhaust)
A low-restriction flow-through device that reduces air line noise. It also traps moisture (and oil, in lubricated systems).

Nonpositive Displacement
(Of compressor or vacuum pump). One that uses kinetic energy to create pressure gradients (slopes) for moving air.

Open Capacity
The volume of air exhausted per minute when there is no vacuum or pressure load on the pump, expressed in cfm.

PSIA
Pounds per square inch absolute-pressure measured from a state with a total absence of air (see absolute pressure).

PSIG
Pounds per square inch gauge-pressure above or below (vacuum) atmospheric pressure.

Pascal's Law
A pressure applied to a confined fluid at rest is transmitted with equal intensity throughout the fluid at right angles to containing surfaces.

Pneumatic Fluid Power
The energy transmitted and controlled through use of a pressurized fluid within an enclosed circuit.

Positive Displacement
(Of a compressor or vacuum pump.) One that moves a specific volume of air for each cycle of operation.

Power
The rate of which work is being done. Simply expressed by the
formula: Power= Work/Time

Power Takeoff
Any rotating shaft for driving other machines.

Pressure
Force per unit area acting on a surface, usually expressed inpounds per square inch (psi) or in megaPascals (MPa).

Pressure Differential
Difference in pressure between two points in a system or component.

Pressure Drop
Any reduction in pressure from normal value.

Pressure Gauge
A device that displays the pressure level in a system. Most gauges use atmospheric pressure as a reference level and measure the difference between the actual pressure and atmospheric pressure; the readout is called "gauge pressure." (A gauge that reads below atmospheric is called a vacuum gauge).

Pressure Relief Valve
A valve that provides modulated venting of excess pressure, instead of building up abnormal pressures in the system.

Pressure Regulator
A valve that provides modulated venting of excess pressure, instead of building up abnormal pressures in the system.

Pressure Switch
An electroical switch operated by fluid pressure.

Quick Exhaust Valve
A valve that releases air directly to the atmosphere, bypassing the directional valve. This reduces backpressure resistance.

Rated Capacity (Pressure)
The cfm of free air delivered by a compressor at rated speed. Usually given for pressures ranging from 0 psig to the maximum pressure rating.

Rated Capacity (Vacuum)
The cfm of free air exhausted by a vacuum pump at rated speed. Usually given for vacuums ranging from 0 in. Hg to the maximum vacuum rating.

Rated Pressure
The qualified operating pressure recommended for a component or system by the manufacturer.

Receiver Tank
Container in which gas is stored under pressure or vacuum as a source of pneumatic fluid power. Accommodates sudden or unusually high system demands. Prevents frequent on/off cycling of an air compressor or vacuum pump and absorbs pulsations.

Regulator
Device to control flow of gases, thus controlling the magnitude of the force and torque produced by the actuator.

Safety Valve
A valve that opens to its full capacity to provide a rapid and large reduction in pressure a when predetermined value is exceeded.

Solenoid Valve
A valve operated by an electromagnetic drive.

Standard Air
Air at a temperature of 68^0F, a pressure of 14.70 psia, and a relative humidity of 36 percent.

Surge Point
In centrifugal blowers, an unstable condition occurring at about 50 percent of rated flow when backpressure temporarily exceeds the pressure ratio developed by the compressor.

Vacuum
A space containing air or other gas at less than atmospheric pressure; usually expressed in inches of mercury (in. Hg).

Vacuum Gauge
Device for determining the pressure level in a partial vacuum.

Vacuum Pump
A device that pulls air out of a closed container or system.

Vacuum Relief Valve
A valve that controls system vacuum level. It operates by providing a modulated flow of atmospheric air into the system.

Valve
Device that controls fluid flow direction, pressure, or flow rate.

Volumetric Efficiency
The ratio of a pump's actual delivery to its computed fluid delivery multiplied by 100 percent.

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