

Spencer®

Bulletin 127C.1

Capacity Temperature Pressure- Equalization



A large blue circle with a grid pattern, resembling a gauge or dial, is positioned in the center of the text. The background features faint, overlapping numbers and letters, suggesting a technical or industrial theme.

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Quick Reference Technical Data

For over 120 years, The Spencer Turbine Company has specialized in innovative solutions to air and gas handling problems. Spencer's product line includes multistage, high-efficiency cast centrifugal blowers and exhausters, fabricated single stage and multistage blowers and vacuum producers, regenerative blowers, central and mobile vacuum systems, custom electrical control panels and related product accessories.

This guide is designed to serve as a quick reference for conversion factors and technical data and to assist in your Spencer product selection. For information regarding specific applications or requirements, please contact your local Spencer representative.

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Spencer's in-house product development and test facility is also available for customer application studies and performance testing using machines up to 2000 HP. Their highly skilled technical staff works closely with customers to interpret air handling problems and to analyze requirements for new or improved products.

Utilizing state-of-the-art equipment, including a computerized data acquisition system, information about a machine's air volume, pressure, temperature, speed, electrical usage and other fundamental properties is collected. Typical assignments include:

- dry bulk material handling feasibility studies
- blower system evaluation
- machine performance testing
- air consumption computation
- vacuum system design aid and testing
- air volume and differential pressure determination
- pneumatic conveying studies
- air velocity measurement
- laminar flow element testing
- sound and vibration analysis
- ASME Code testing
- controls/VFD testing
- valve testing

Useful Formulae

Pressure to Vacuum Conversion

If Blower is to be operated as an exhauster, discharging against atmospheric pressure, the vacuum developed would be:

$$\text{Vacuum (lbs/sq in)} = \frac{P \text{ (lbs/sq in)} \times 14.7}{P \text{ (lbs/sq in)} + 14.7}$$

P is the pressure the Blower would develop when intake is at atmospheric pressure.

NOTE: These formulae are presented to assist in the determination of a machine rating and are for approximation only. For more accurate calculations the head formula should be used. When selecting a machine to deliver the desired rating, please contact your Spencer Representative or The Spencer Turbine Company. They will use the computer selection program, STAMP®.

To provide most reliable operation, Spencer designs its machines to the ICFM requirement at the minimum density and the horsepower requirement at the maximum density when throttled.

Spencer Blower ratings are based on machines handling standard air (70°F and 14.7 psi atmospheric pressure) and on 60 Hz current (3500 and 1750 nominal machine RPM). Operating conditions which differ from those just stated will require a given machine to be built to meet a standard conditions rating according to the following formulae:

Developed Pressure Correction For Other Than Standard

*1. Temperature (P = psi; T = °F)

$$P_1 = P_2 \left(\frac{T_2 + 460}{T_1 + 460} \right) \text{ where}$$

P₁ = required pressure at **standard** conditions

P₂ = required pressure at temperature T₂

T₁ = 70°F (standard temperature)

T₂ = temperature of inlet air or gas

Note: Inlet temperatures below 70°F will cause a Blower to exceed its pressure rating and may call for a motor of larger horsepower. Consult Factory.

*2. Atmospheric Pressure (altitude correction) (P = psi)

$$P_1 = P_2 \left(\frac{14.7}{P \text{ atm}} \right) \text{ where}$$

P₁ = required pressure at **standard** conditions

P₂ = required pressure at existing atm pressure

14.7 = atmospheric pressure at sea level (standard)

P atm = atmospheric pressure at elevation in question
(see chart)

Note: In the unusual event of below-sea-level operating conditions a Blower will exceed its pressure rating and may call for a motor of larger horsepower. Consult Factory.

* With a given ICFM, brake horsepower varies directly as the pressure.

$$\frac{BHP_1}{BHP_2} = \frac{P_1}{P_2}$$

*3. Specific Gravity (correction for gas other than air).

Applies to gas boosters only. (P = psi)

$$P_1 = P_2 \left(\frac{1.00}{SG} \right) \text{ where}$$

P₁ = required pressure at **standard** conditions

P₂ = required pressure handling gas other than air

1.00 = specific gravity of **standard** air

SG = specific gravity of gas being handled

Note: Handling a gas whose specific gravity is above 1.00 will cause a Blower to exceed its pressure rating and may call for a motor of larger horsepower. Consult Factory.

*4. Combination of Formulae 1-3 (P = psi; T = °F)

$$P_1 = P_2 \left(\frac{T_2 + 460}{T_1 + 460} \right) \left(\frac{14.7}{P \text{ atm}} \right) \left(\frac{1.00}{SG} \right)$$

Note: Any factor not differing from standard conditions may be removed from formula 4.

ICFM (ACFM) to SCFM Conversion

SCFM (standard cubic feet per minute), ICFM (inlet cubic feet per minute) and ACFM (actual cubic feet per minute) are three volume designations which are the subject of much confusion and misconception and probably result in more blower design miscalculation than any other design factors.

SCFM means flow rate in cubic feet per minute of air at standard conditions. (Standard conditions for air are 70°F, 14.7 psia and 36% relative humidity.) It is, in reality, an indication of the weight of air used to compute the amount of air needed in a particular process. Combustion air is a good example.

ICFM refers to the equivalent flow of air (in cubic feet per minute) for which a particular blower is designed. It is a volumetric capacity. When a Blower is operating in an atmosphere of standard air (*Relative humidity affects ICFM*), ICFM and SCFM have the same numerical value. ACFM is another abbreviation for ICFM for a Blower or gas booster.

ICFM capacity does not change for a given machine. However, when operating conditions differ from standard, ICFM (ACFM) and SCFM take on different values. This ICFM (ACFM) to SCFM relationship is affected by a variety of factors according to the following formulae:

5. Temperature (T = °F)

$$\text{SCFM} = \text{ICFM} @ \text{machine rating} \left(\frac{T_1 + 460}{T_2 + 460} \right)$$

where T₁ = 70°F (standard temperature)

T₂ = temperature of inlet air or gas

6. Atmospheric Pressure (altitude correction) (P = psi)

$$\text{SCFM} = \text{ICFM} @ \text{machine rating} \left(\frac{P \text{ atm}}{14.7} \right)$$

where P atm = atmospheric pressure at elevation in question (see chart)

14.7 = atmospheric pressure at sea level (standard)

7. Combination of Formulae 5 & 6 (P = psi; T = °F)

$$\text{SCFM} = \text{ICFM} \left(\frac{T_1 + 460}{T_2 + 460} \right) \left(\frac{P \text{ atm}}{14.7} \right)$$

Pressure at Other Temperatures

Pressure and vacuum ratings are good for 70°F inlet temperature only. The chart may be used to determine pressure developed at other than standard temperature. For example, at 70°F, a 5 lb machine produces 5 psi. At 100°F the same machine produces only 4.7 psi.

The following table was derived by using the head formula.

P_1		Approximate Developed Pressure, P_2 (lb/sq in) at Other Temperatures (T_2)												
"Hg	psi	0° F	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
1.018	0.5	0.577	0.565	0.553	0.541	0.530	0.520	0.510	0.500	0.491	0.482	0.473	0.465	0.456
1.527	0.75	0.866	0.848	0.830	0.812	0.796	0.780	0.765	0.750	0.736	0.722	0.709	0.696	0.684
2.036	1.0	1.156	1.131	1.107	1.084	1.062	1.040	1.020	1.000	0.981	0.963	0.945	0.928	0.912
2.545	1.25	1.447	1.415	1.384	1.355	1.327	1.301	1.275	1.250	1.226	1.203	1.181	1.160	1.139
3.054	1.5	1.738	1.699	1.662	1.627	1.593	1.561	1.530	1.500	1.471	1.444	1.417	1.391	1.367
3.563	1.75	2.029	1.984	1.940	1.899	1.860	1.822	1.785	1.750	1.716	1.684	1.653	1.623	1.594
4.072	2.0	2.321	2.269	2.219	2.171	2.126	2.082	2.040	2.000	1.961	1.924	1.888	1.854	1.820
4.581	2.25	2.613	2.554	2.498	2.444	2.392	2.343	2.296	2.250	2.206	2.164	2.124	2.085	2.047
5.090	2.5	2.905	2.840	2.777	2.717	2.659	2.604	2.551	2.500	2.451	2.404	2.359	2.315	2.273
5.599	2.75	3.199	3.126	3.056	2.990	2.926	2.865	2.806	2.750	2.696	2.644	2.594	2.546	2.499
6.108	3.0	3.492	3.412	3.336	3.263	3.193	3.126	3.062	3.000	2.941	2.884	2.829	2.776	2.725
6.617	3.25	3.786	3.699	3.616	3.536	3.460	3.387	3.317	3.250	3.186	3.124	3.064	3.007	2.951
7.126	3.5	4.080	3.986	3.896	3.810	3.727	3.648	3.573	3.500	3.430	3.363	3.299	3.237	3.177
8.144	4.0	4.671	4.561	4.457	4.358	4.262	4.171	4.084	4.000	3.920	3.842	3.768	3.696	3.628
10.180	5.0	5.855	5.716	5.583	5.456	5.334	5.218	5.107	5.000	4.898	4.799	4.705	4.614	4.527
12.216	6.0	7.046	6.875	6.712	6.557	6.408	6.266	6.130	6.000	5.875	5.755	5.641	5.530	5.424
14.252	7.0	8.242	8.039	7.845	7.660	7.484	7.315	7.154	7.000	6.852	6.710	6.574	6.444	6.318
16.288	8.0	9.444	9.207	8.982	8.767	8.562	8.366	8.179	8.000	7.829	7.664	7.507	7.355	7.210
18.324	9.0	10.651	10.379	10.121	9.876	9.641	9.418	9.204	9.000	8.805	8.617	8.438	8.265	8.100
20.360	10.0	11.862	11.556	11.264	10.987	10.723	10.471	10.230	10.000	9.780	9.569	9.367	9.174	8.988

The following table was derived by using the head formula.

P_1		Approximate Developed Pressure, P_2 (lb/sq in) at Other Temperatures (T_2)												
"Hg	psi	130° F	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°	240°	250°
1.018	0.5	0.449	0.441	0.434	0.427	0.420	0.413	0.407	0.401	0.395	0.389	0.383	0.377	0.372
1.527	0.75	0.673	0.661	0.650	0.639	0.629	0.619	0.610	0.600	0.591	0.582	0.574	0.565	0.557
2.036	1.0	0.896	0.881	0.866	0.852	0.838	0.825	0.812	0.799	0.787	0.775	0.764	0.753	0.742
2.545	1.25	1.120	1.100	1.082	1.064	1.047	1.030	1.014	0.998	0.983	0.968	0.954	0.940	0.926
3.054	1.5	1.343	1.320	1.297	1.276	1.255	1.235	1.215	1.196	1.178	1.160	1.143	1.126	1.110
3.563	1.75	1.566	1.539	1.512	1.487	1.463	1.439	1.416	1.394	1.373	1.352	1.332	1.312	1.293
4.072	2.0	1.788	1.757	1.727	1.698	1.670	1.643	1.617	1.592	1.567	1.543	1.520	1.497	1.476
4.581	2.25	2.011	1.976	1.942	1.909	1.877	1.847	1.817	1.789	1.761	1.734	1.708	1.682	1.658
5.090	2.5	2.233	2.194	2.156	2.119	2.084	2.050	2.017	1.985	1.954	1.924	1.895	1.867	1.839
5.599	2.75	2.455	2.412	2.370	2.330	2.291	2.253	2.217	2.181	2.147	2.114	2.082	2.051	2.021
6.108	3.0	2.676	2.629	2.584	2.540	2.497	2.456	2.416	2.377	2.340	2.304	2.269	2.234	2.201
6.617	3.25	2.898	2.847	2.797	2.749	2.703	2.658	2.615	2.573	2.532	2.493	2.455	2.418	2.382
7.126	3.5	3.119	3.064	3.010	2.958	2.908	2.860	2.813	2.768	2.724	2.682	2.640	2.600	2.562
8.144	4.0	3.561	3.497	3.436	3.376	3.319	3.263	3.209	3.157	3.107	3.058	3.010	2.965	2.920
10.180	5.0	4.443	4.362	4.284	4.208	4.135	4.065	3.997	3.931	3.868	3.806	3.746	3.688	3.632
12.216	6.0	5.321	5.223	5.128	5.036	4.948	4.862	4.780	4.700	4.623	4.548	4.476	4.406	4.338
14.252	7.0	6.197	6.081	5.969	5.861	5.756	5.656	5.558	5.464	5.374	5.286	5.201	5.118	5.038
16.288	8.0	7.070	6.936	6.806	6.681	6.561	6.445	6.332	6.224	6.119	6.018	5.920	5.825	5.733
18.324	9.0	7.941	7.788	7.640	7.498	7.362	7.230	7.102	6.979	6.861	6.746	6.635	6.527	6.423
20.360	10.0	8.809	8.637	8.472	8.313	8.159	8.011	7.869	7.731	7.598	7.469	7.345	7.224	7.108

Formulas below can be used to compute developed pressure at temperature other than 70°F:

$$P_2 = \frac{P_1 \times (460 + T_1)}{(460 + T_2)} \quad \text{where} \quad \left\{ \begin{array}{l} P_1 = \text{rated pressure, at temperature } T_1 \text{ (70°F)} \\ P_2 = \text{developed at temperature } T_2 \end{array} \right.$$

Pressure at Higher Altitudes

Pressure and vacuum ratings are good for sea level (14.7 psi atm pressure) only. This chart may be used to determine pressure developed at altitudes above sea level. For example, a 5 lb machine produces 5 psi at seal level. At 5000' elevation, the same machine produces only 4.160 psi.

The following table was derived by using the head formula.

Related Pressure at 14.7 lbs abs		Developed Pressure, P ₂ (lb/sq in) at Higher Altitudes																			
"Hg	psi	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	9500	10000 ft
1.018	0.5	0.491	0.482	0.473	0.465	0.456	0.448	0.440	0.432	0.424	0.416	0.408	0.401	0.393	0.386	0.378	0.371	0.364	0.357	0.350	0.344
1.527	0.75	0.736	0.723	0.710	0.697	0.684	0.672	0.660	0.648	0.636	0.624	0.612	0.601	0.590	0.579	0.568	0.557	0.546	0.536	0.525	0.515
2.036	1.0	0.981	0.964	0.946	0.929	0.912	0.896	0.880	0.863	0.848	0.832	0.817	0.801	0.786	0.771	0.757	0.742	0.728	0.714	0.701	0.687
2.545	1.25	1.227	1.205	1.183	1.161	1.140	1.120	1.099	1.079	1.060	1.040	1.021	1.002	0.983	0.964	0.946	0.928	0.910	0.893	0.876	0.859
3.054	1.5	1.472	1.445	1.419	1.394	1.369	1.344	1.319	1.295	1.271	1.248	1.225	1.202	1.179	1.157	1.135	1.114	1.092	1.071	1.051	1.031
3.563	1.75	1.717	1.686	1.656	1.626	1.597	1.568	1.539	1.511	1.483	1.456	1.429	1.402	1.376	1.350	1.324	1.299	1.274	1.250	1.226	1.202
4.072	2.0	1.963	1.927	1.892	1.858	1.825	1.792	1.759	1.727	1.695	1.664	1.633	1.603	1.573	1.543	1.514	1.485	1.456	1.428	1.401	1.374
4.581	2.25	2.208	2.168	2.129	2.091	2.053	2.016	1.979	1.943	1.907	1.872	1.837	1.803	1.769	1.736	1.703	1.670	1.638	1.607	1.576	1.546
5.090	2.5	2.454	2.409	2.366	2.323	2.281	2.240	2.199	2.159	2.119	2.080	2.041	2.003	1.966	1.929	1.892	1.856	1.820	1.786	1.751	1.718
5.599	2.75	2.699	2.650	2.602	2.555	2.509	2.464	2.419	2.375	2.331	2.288	2.245	2.204	2.162	2.121	2.081	2.041	2.002	1.964	1.926	1.890
6.108	3.0	2.944	2.891	2.839	2.787	2.737	2.688	2.639	2.590	2.543	2.496	2.450	2.404	2.359	2.314	2.270	2.227	2.184	2.143	2.102	2.061
6.617	3.25	3.190	3.132	3.075	3.020	2.965	2.911	2.859	2.806	2.755	2.704	2.654	2.604	2.555	2.507	2.460	2.413	2.366	2.321	2.277	2.233
7.126	3.5	3.435	3.373	3.312	3.252	3.193	3.135	3.078	3.022	2.967	2.912	2.858	2.805	2.752	2.700	2.649	2.598	2.549	2.500	2.452	2.405
8.144	4.0	3.926	3.854	3.785	3.717	3.649	3.583	3.518	3.454	3.391	3.328	3.266	3.205	3.145	3.086	3.027	2.969	2.913	2.857	2.802	2.749
10.180	5.0	4.907	4.818	4.731	4.646	4.562	4.479	4.398	4.317	4.238	4.160	4.083	4.006	3.931	3.857	3.784	3.712	3.641	3.571	3.503	3.436
12.216	6.0	5.889	5.782	5.677	5.575	5.474	5.375	5.277	5.181	5.086	4.992	4.899	4.808	4.718	4.628	4.541	4.454	4.369	4.285	4.203	4.123
14.252	7.0	6.870	6.745	6.623	6.504	6.387	6.271	6.157	6.044	5.933	5.824	5.716	5.609	5.504	5.400	5.297	5.196	5.097	4.999	4.904	4.810
16.288	8.0	7.851	7.709	7.570	7.433	7.299	7.167	7.036	6.908	6.781	6.656	6.532	6.410	6.290	6.171	6.054	5.939	5.825	5.714	5.604	5.497
18.324	9.0	8.833	8.672	8.516	8.362	8.211	8.063	7.916	7.771	7.629	7.488	7.349	7.212	7.076	6.943	6.811	6.681	6.553	6.428	6.305	6.184
20.360	10.0	9.814	9.636	9.462	9.291	9.124	8.958	8.795	8.635	8.476	8.320	8.165	8.013	7.863	7.714	7.568	7.423	7.282	7.142	7.005	6.871

Variations in pressure with changes in altitude are directly proportional to the relative density of the air.

Formulas below can be used to compute developed pressure at temperature other than 70°F:

$$P_{\text{atm}} = \frac{14.7 P_2}{P_1} \quad \text{where} \quad \begin{cases} P_1 = \text{rated psi @ 14.7 abs} \\ P_2 = \text{developed psi @ the altitude indicated} \end{cases}$$

Temperature at Higher Altitudes

Blowers are rated at standard air: .075 lbs/cubic ft; 70°F at sea level; therefore, pressures corrected to standard conditions must be used when selecting Blowers from rating tables or curves. **Caution:** size motor for highest density (lowest temperatures and lowest factor) condition at which it is expected to operate.

Listed below are the factors to convert to standard conditions. The following table was derived by using the head formula.

Altitude (Feet) Above Sea Level											
Air Temp. (F)	Sea Level	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
0°	0.87	0.88	0.90	0.91	0.93	0.95	0.97	0.98	1.00	1.02	1.04
40°	0.94	0.96	0.98	1.00	1.01	1.03	1.05	1.07	1.09	1.11	1.13
70°	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20
80°	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.23
100°	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.23	1.25	1.27
120°	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.25	1.27	1.29	1.32
140°	1.14	1.16	1.18	1.20	1.22	1.25	1.27	1.29	1.32	1.34	1.37
160°	1.17	1.20	1.22	1.24	1.26	1.29	1.31	1.34	1.36	1.39	1.41
180°	1.21	1.24	1.26	1.28	1.31	1.33	1.36	1.38	1.41	1.43	1.46
200°	1.25	1.28	1.30	1.32	1.35	1.37	1.40	1.43	1.45	1.48	1.51
250°	1.35	1.38	1.40	1.43	1.45	1.48	1.51	1.54	1.57	1.60	1.63
300°	1.45	1.48	1.50	1.53	1.56	1.59	1.62	1.65	1.68	1.71	1.74
350°	1.55	1.58	1.61	1.64	1.67	1.70	1.73	1.76	1.80	1.83	1.86
400°	1.65	1.68	1.71	1.74	1.77	1.81	1.84	1.88	1.91	1.95	1.98
450°	1.75	1.78	1.81	1.85	1.88	1.92	1.95	1.99	2.03	2.07	2.11
500°	1.85	1.88	1.92	1.95	1.99	2.03	2.07	2.10	2.14	2.19	2.23
550°	1.95	1.98	2.02	2.06	2.10	2.14	2.18	2.22	2.26	2.31	2.35
600°	2.05	2.09	2.13	2.17	2.21	2.25	2.29	2.34	2.38	2.43	2.47
650°	2.15	2.19	2.23	2.27	2.32	2.36	2.41	2.45	2.50	2.55	2.60
700°	2.25	2.29	2.34	2.38	2.43	2.47	2.52	2.57	2.62	2.67	2.72
750°	2.35	2.40	2.44	2.49	2.54	2.59	2.64	2.69	2.74	2.79	2.85
800°	2.46	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.86	2.91	2.97

HP₁ = HP₂ x factor where HP₁ = horsepower at standard conditions
HP₂ = horsepower at operating conditions

P₁ = P₂ x factor where P₁ = pressure at standard conditions
P₂ = pressure at operating conditions

Value of Mercury Column

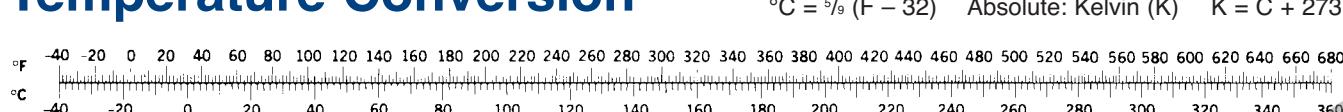
at 70° F in equivalent inches of water, ounces and pounds per square inch.

"Hg	"Water	Ounces	psi	"Hg	"Water	Ounces	psi	"Hg	"Water	Ounces	psi	"Hg	"Water	Ounces	psi
0.1	1.36	.785		4.9	66.64	38.489		9.8	133.28	76.979		15.0	204.00	117.825	
0.2	2.72	1.571		5.0	68.00	39.275		9.9	134.64	77.764		15.1	205.36	118.610	
0.3	4.08	2.356		5.102	69.36	40.060	2½	10.0	136.00	78.550		15.2	206.72	119.396	
0.4	5.44	3.142		5.2	70.72	40.846		10.1	137.36	79.335		15.305	208.08	120.181	7½
0.5	6.80	3.927		5.3	72.08	41.631		10.204	138.72	80.121	5	15.4	209.44	120.967	
0.509	6.92	4.000	1¼	5.4	73.44	42.417		10.3	140.08	80.906		15.5	210.80	121.752	
0.6	8.16	4.713		5.5	74.80	43.202		10.4	141.44	81.692		15.6	212.16	122.538	
0.7	9.52	5.498		5.602	76.16	43.988	2¾	10.5	142.80	82.477		15.7	213.52	123.323	
0.8	10.88	6.284		5.7	77.52	44.773		10.6	144.16	83.263		15.805	214.88	124.109	7¾
0.9	12.24	7.069		5.8	78.88	45.559		10.704	145.52	84.048		15.9	216.24	124.894	
1.0	13.60	7.855		5.9	80.24	46.344		10.8	146.88	84.834		16.0	217.60	125.680	
1.018	13.84	8.000	1½	6.0	81.60	47.130		10.9	148.24	85.619		16.1	218.96	126.465	
1.1	14.96	8.640		6.1	82.96	47.915		11.0	149.60	86.405		16.2	220.32	127.251	
1.2	16.32	9.426		6.108	83.04	48.000	3	11.1	150.96	87.190		16.306	221.68	128.036	8
1.3	17.68	10.211		6.2	84.32	48.701		11.204	152.32	87.976		16.4	223.04	128.822	
1.4	19.04	10.997		6.3	85.68	49.486		11.3	153.68	88.761		16.5	224.40	129.608	
1.5	20.40	11.782		6.4	87.04	50.272		11.4	155.04	89.547		16.6	225.76	130.394	
1.527	20.76	12.000	¾	6.5	88.40	51.057		11.5	156.40	90.332		16.7	227.12	131.180	
1.6	21.76	12.568		6.6	89.76	51.843		11.6	157.76	91.118		16.8	228.48	131.966	
1.7	23.12	13.353		6.617	89.96	52.000	3¼	11.704	159.12	91.903		16.906	229.84	132.752	8½
1.8	24.48	14.139		6.7	91.12	52.628		11.8	160.48	92.689		17.0	231.20	133.538	
1.9	25.48	14.924		6.8	92.48	53.414		11.9	161.84	93.474		17.1	232.56	134.324	
2.0	27.20	15.710		6.9	93.84	54.199		12.0	163.20	91.260		17.2	233.92	135.110	
2.036	27.68	16.000	1	7.0	95.20	54.985		12.1	164.56	95.045		17.3	235.28	135.896	
2.1	28.56	16.495		7.1	96.56	55.770		12.2	165.92	95.831		17.406	236.64	136.682	8½
2.2	29.92	17.281		7.126	96.88	56.000	3½	12.216	166.08	96.000	6	17.5	238.00	137.468	
2.3	31.28	18.066		7.2	97.92	56.556		12.3	167.28	96.616		17.6	239.36	138.254	
2.4	32.64	18.852		7.3	99.28	57.341		12.4	168.64	97.402		17.7	240.72	139.040	
2.5	34.00	19.637		7.4	100.64	58.127		12.5	170.00	98.187		17.8	242.08	139.826	
2.545	34.60	20.000	1¼	7.5	102.00	58.912		12.6	171.36	98.973		17.906	243.44	140.612	8¾
2.6	35.36	20.423		7.6	103.36	59.698		12.7	172.72	99.758		18.0	244.80	141.398	
2.7	36.72	21.208		7.635	103.80	60.000	3¾	12.725	173.00	100.000		18.1	246.16	142.184	
2.8	38.08	21.994		7.7	104.72	60.483		12.8	174.08	100.544		18.2	247.52	142.970	
2.9	39.44	22.779		7.8	106.08	61.269		12.9	175.44	101.329		18.3	248.88	143.756	
3.0	40.80	23.565		7.9	107.44	62.054		13.0	176.80	102.115		18.324	249.12	144.000	9
3.054	41.52	24.000	1½	8.0	108.80	62.840		13.1	178.16	102.900		18.4	250.24	144.542	
3.1	42.16	24.350		8.1	110.16	63.625		13.2	179.52	103.686		18.5	251.60	145.328	
3.2	43.52	25.136		8.144	110.72	64.000	4	13.234	179.92	104.000		18.6	252.96	146.114	
3.3	44.88	25.921		8.2	111.52	64.411		13.3	180.88	104.471		18.7	254.32	146.900	
3.4	46.24	26.707		8.3	112.88	65.196		13.4	182.24	105.257		18.8	255.68	147.686	
3.5	47.60	27.492		8.4	114.24	65.982		13.5	183.60	106.042		18.906	257.04	148.472	9½
3.563	48.44	28.000	1¾	8.5	115.60	66.767		13.6	184.96	106.828		19.0	258.40	149.258	
3.6	48.96	28.278		8.6	116.96	67.553		13.7	186.32	107.613		19.1	259.76	150.044	
3.7	50.32	29.063		8.653	117.64	68.000	4¼	13.743	186.84	108.000		19.2	261.12	150.830	
3.8	51.68	29.849		8.7	118.32	68.338		13.8	187.68	108.399		19.3	262.48	151.616	
3.9	53.04	30.634		8.8	119.68	69.124		13.9	189.04	109.184		19.407	263.84	152.402	9½
4.0	54.40	31.420		8.9	121.04	69.909		14.0	190.40	109.970		19.5	265.20	153.188	
4.072	55.36	32.000	2	9.0	122.40	70.695		14.1	191.76	110.775		19.6	266.56	153.974	
4.1	55.76	32.205		9.1	123.76	71.480		14.2	193.12	111.541		19.7	267.92	154.760	
4.2	57.12	32.991		9.162	124.56	72.000	4½	14.252	193.76	112.000		19.8	269.28	155.546	
4.3	58.48	33.776		9.2	125.12	72.266		14.3	194.48	112.326		19.907	270.64	156.332	9¾
4.4	59.84	34.562		9.3	126.48	73.051		14.4	195.84	113.112		20.0	272.00	157.118	
4.5	61.20	35.347		9.4	127.84	73.837		14.5	197.20	113.897		20.1	273.36	157.904	
4.581	62.28	36.000	2¼	9.5	129.20	74.622		14.6	198.56	114.683		20.2	274.72	158.690	
4.6	62.56	36.133		9.6	130.56	75.408		14.7	199.92	115.468		20.3	276.08	159.476	
4.7	63.92	36.918		9.671	131.48	76.000	4¾	14.805	201.28	116.254		20.363	276.84	160.000	10
4.8	65.28	37.704		9.7	131.92	76.193		14.9	202.64	117.039					

Example: To find how many inches of mercury is equal to 3 psi, locate 3 under the psi column and read 6.108 under the inches of mercury column. A reading of 6.0 inches on the other hand is somewhat less than 3 psi, but more than 2¾ psi.

Temperature Conversion

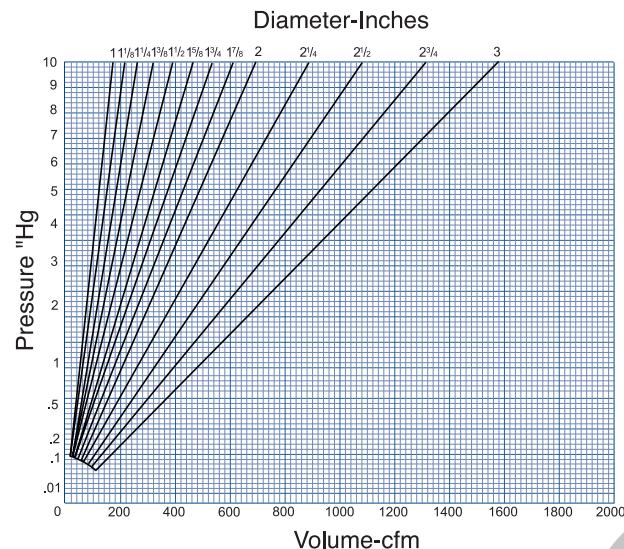
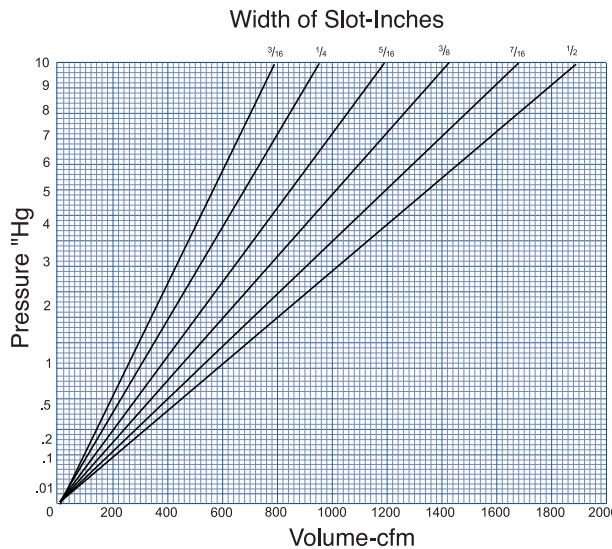
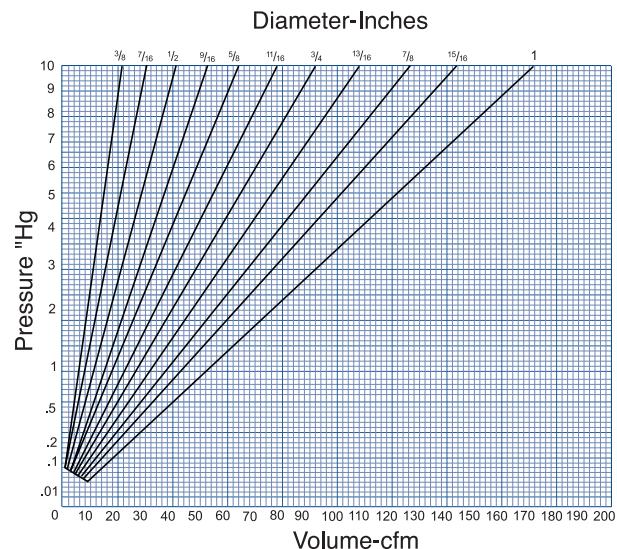
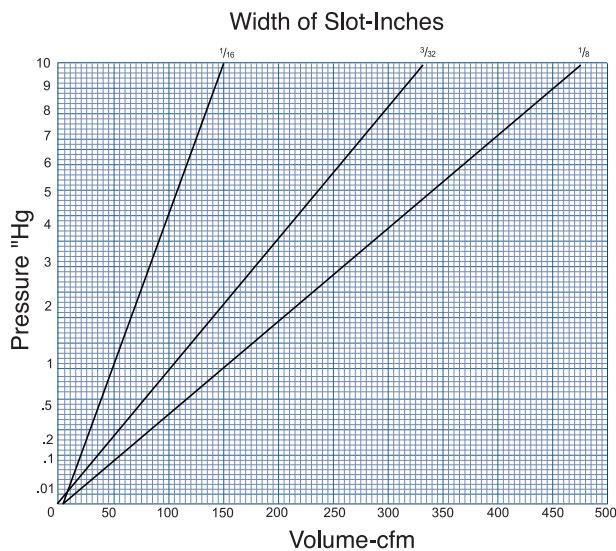
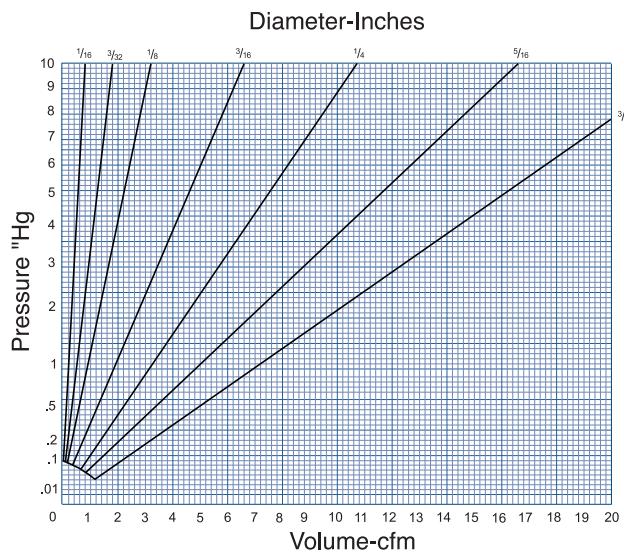
$$\begin{aligned} {}^{\circ}\text{F} &= \frac{5}{9} \text{C} + 32 \\ \text{Absolute: Rankin (R)} &= \text{Absolute: Kelvin (K)} \\ \text{R} &= \text{F} + 460 \\ \text{C} &= \frac{5}{9} (\text{F} - 32) \\ \text{Absolute: Kelvin (K)} &= \text{C} + 273 \end{aligned}$$



Orifice Capacity Tables

The graphs at the right indicate the amount of air which will pass through various sized, round, sharp-edged orifices in $\frac{1}{8}$ inch steel plate at a given pressure.

The graphs below reflect flow through slots. Volume is given in cfm per linear foot.



Orifice Equivalent Table

Equivalent as to Flow

The figure at the intersection of any column and row gives the number of small orifices equivalent in total area to one larger orifice of a diameter and area shown in the left hand columns.

Area Sq Inch	Orifice Dia Inch	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
.1963	1/2	1.								
.2485	9/16	1.26	1.							
.3068	5/8	1.57	1.24	1.						
.3712	11/16	1.87	1.48	1.19	1.					
.4418	3/4	2.17	1.72	1.39	1.16	1.				
.5185	13/16	2.65	2.10	1.69	1.42	1.22	1.			
.6013	7/8	3.07	2.43	1.96	1.64	1.41	1.16	1.		
.6903	15/16	3.54	2.81	2.26	1.90	1.63	1.34	1.16	1.	
.7854	1	4.13	3.28	2.64	2.21	1.90	1.56	1.35	1.17	1.

Equalization of Pipes

Equivalent as to Flow

The figure at the intersection of any column and row gives the number of smaller size lines necessary to pass the same volume with the same line loss as the single larger line.

Dia Inch	Alternate line diameter in inches															
	1	2	2 1/2	3	4	5	6	7	8	9	10	12	14	16	18	20
2	5.7	1														
2 1/2	9.9	1.7	1													
3	15.6	2.8	1.6	1												
4	32.0	5.7	3.2	2.1	1											
5	55.9	9.9	5.7	3.6	1.7	1										
6	88.2	15.6	8.9	5.7	2.8	1.6	1									
7	130	22.9	13.1	8.3	4.1	2.3	1.5	1								
8	181	32.0	18.3	11.7	5.7	3.2	2.1	1.4	1							
9	243	43.0	24.6	15.6	7.6	4.3	2.8	1.9	1.3	1						
10	316	55.9	32	20.3	9.9	5.7	3.6	2.4	1.7	1.3	1					
11	401	70.9	40.6	25.7	12.5	7.2	4.6	3.1	2.2	1.7	1.3					
12	499	88.2	50.5	32.0	15.6	8.9	5.7	3.8	2.8	2.1	1.6	1				
13	609	108	61.7	39.1	19.0	10.9	7.1	4.7	3.4	2.5	1.9	1.2				
14	733	130	74.2	47.0	22.9	13.1	8.3	5.7	4.1	3.0	2.3	1.5	1			
15	871	154	88.2	55.9	27.2	15.6	9.9	6.7	4.8	3.6	2.8	1.7	1.2			
16		65.7	32.0	18.3	11.7	7.9	5.7	4.2	3.2	2.1	1.4	1				
17		76.4	37.2	21.3	13.5	9.2	6.6	4.9	3.8	2.4	1.6	1.2				
18		88.2	43.0	24.6	15.6	10.6	7.6	5.7	4.3	2.8	1.9	1.3	1			
19		101	49.1	28.1	17.8	12.1	8.7	6.5	5.0	3.2	2.1	1.5	1.1			
20		115	55.9	32.0	20.3	13.8	9.9	7.4	5.7	3.6	2.4	1.7	1.3	1		
22		146	70.9	40.6	25.7	17.5	12.5	9.3	7.2	4.6	3.1	2.2	1.7	1.3		
24		181	88.2	50.5	32.0	21.8	15.6	11.6	8.9	5.7	3.8	2.8	2.1	1.6	1	
26		221	108	61.7	39.1	26.6	19.0	14.2	10.9	7.1	4.7	3.4	2.5	1.9	1.2	
28		266	130	74.2	47.0	32.0	22.9	17.1	13.1	8.3	5.7	4.1	3.0	2.3	1.5	1.2
30		316	154	88.2	55.9	38.0	27.2	20.3	15.6	9.9	6.7	4.8	3.6	2.8	1.7	
36		499	243	130	88.2	60.0	43.0	32.0	24.6	15.6	10.6	7.6	5.7	4.3	2.8	
42		733	357	205	130	88.2	63.2	47.0	36.2	19.0	15.6	11.2	8.3	6.4	4.1	
48			499	286	181	123	88.2	62.7	50.5	32.0	21.8	15.6	11.6	8.9	5.7	
54			670	383	243	165	118	88.2	67.8	43.0	29.2	20.9	15.6	12.0	7.6	
60			871	499	316	215	154	115	88.2	55.9	38.0	27.2	20.3	15.6	9.9	

Friction Loss Chart

This chart may be used to compute friction losses in a piping system. For example, determine the friction loss incurred when 70 cfm flows through a 2" pipe, 50' long.

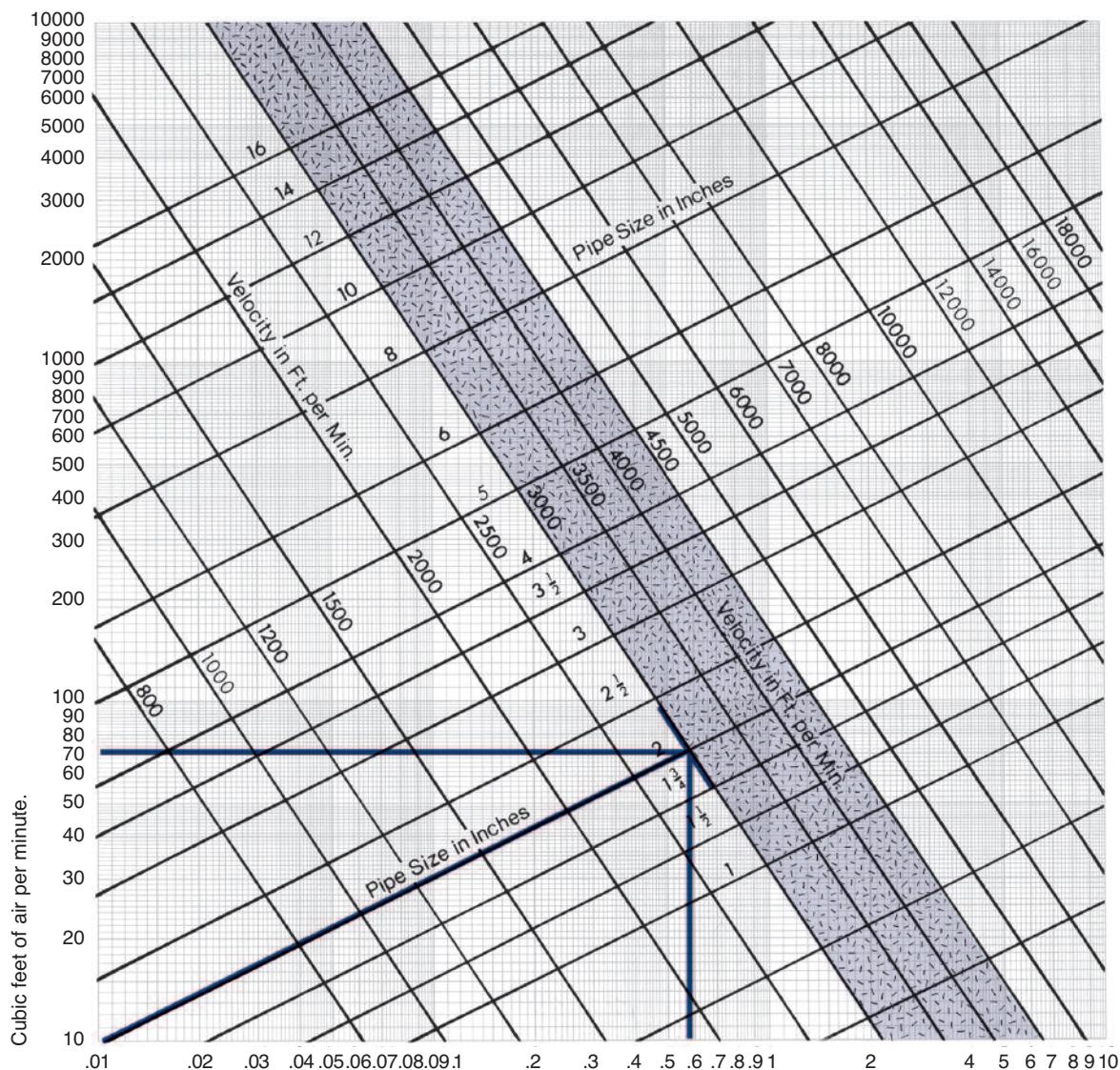
Step 1: Intersect 70 cfm and the sloping line for 2" pipe as shown.

Step 2: Drop a vertical from this point of intersection and read the loss/100' of line, in this case, .60Hg/100'.

Step 3: Multiply the loss/100' of line by the length of run/100'. The loss for 50', then, is

$$.60 \left(\frac{\text{length of run}}{100'} \right) = .60 \left(\frac{50'}{100'} \right) = 0.30'' \text{ Hg.}$$

Also: Velocity in the line may be read from the negatively sloping lines on the graph. Here, to get 70 cfm through a 2" line, the air must travel at a velocity of approximately 3000 fpm.



Friction loss in "Hg per 100 ft of line with inlet air at 70 °F and 14.7 psia.

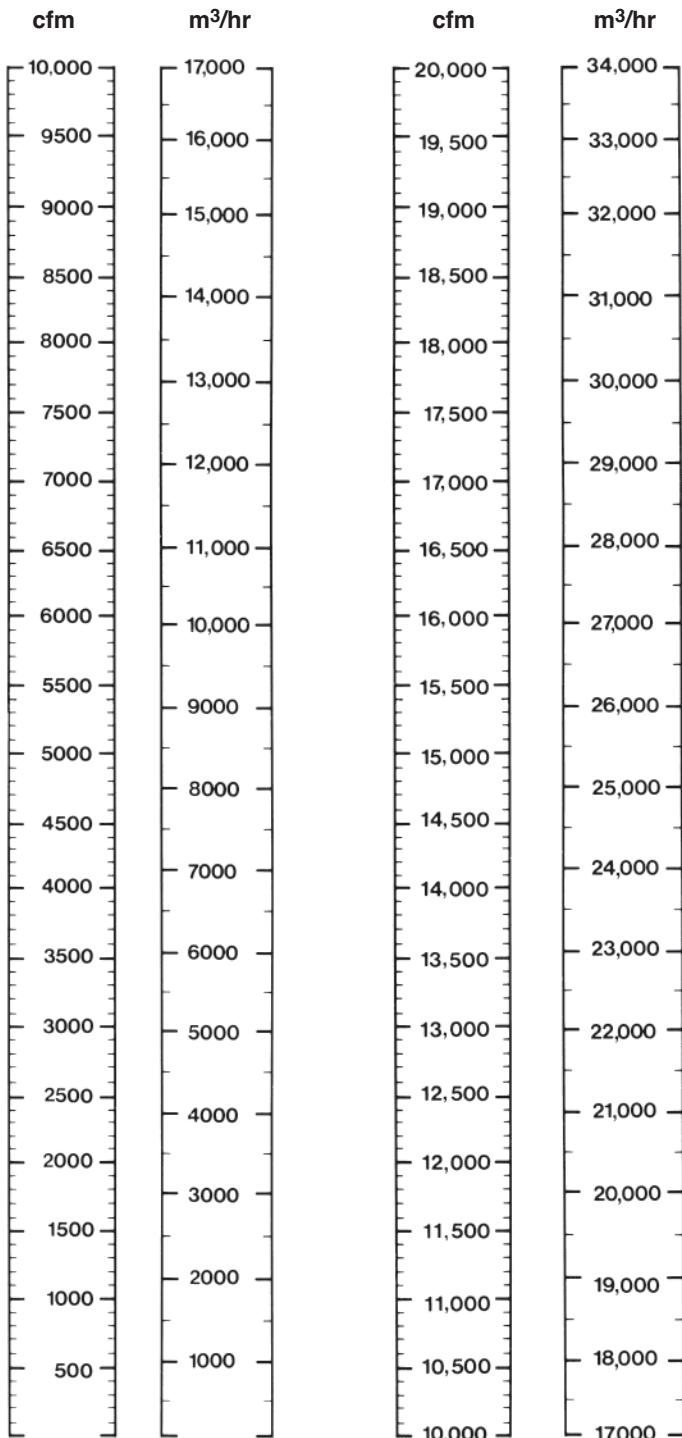
Useful Conversion Factors

Multiply	By	To Obtain
lbs/sq inch (psi)	2.036	inch mercury
lbs/sq inch (psi)	27.684	inch water
lbs/sq inch (psi)	5.17	cm mercury
lbs/sq inch (psi)	70.317	cm water
lbs/sq inch (psi)	0.0703	kg/sq cm
lbs/sq inch (psi)	703.09	kg/m ²
lbs/sq inch (psi)	6.84	kilo-pascals
oz/sq inch	1.732	inch water
oz/sq inch	0.127	inch mercury
oz/sq inch	0.323	cm mercury
oz/sq inch	4.394	cm water
inch water	0.0735	inch mercury
inch water	0.576	oz/sq inch
inch water	0.036	lbs/sq inch
inch water	2.5	cm water
mm. water	1.0	kg/m ²
inch mercury	7.855	oz/sq inch
inch mercury	0.491	lb/sq inch
inch mercury	13.58	inch water
inch mercury	2.54	cm mercury
inch mercury	345.3	kg/m ²
gal water	8.33	lbs
gal	0.1337	ft ³
ft ³	7.48	gals
ft ³	0.0283	m ³
horsepower	746.0	watts
kilowatts	1.341	horsepower
m ³ /min	35.3	cfm
cfm	1.6992	m ³ /hr

Absolute Pressure at Altitudes Above Sea Level Based on U.S. Standard Atmosphere

Altitude Feet	Inch Hg	Pressure psi
0	29.92	14.70
500	29.28	14.43
600	29.38	14.38
700	29.18	14.33
800	29.07	14.28
900	28.97	14.23
1,000	28.86	14.18
1,500	28.33	13.90
2,000	27.82	13.67
2,500	27.31	13.41
3,000	26.81	13.19
3,500	26.32	12.92
4,000	25.84	12.70
4,500	25.36	12.45
5,000	24.89	12.23
5,500	24.43	12.00
6,000	23.98	11.77
6,500	23.53	11.56
7,000	23.09	11.34
7,500	22.65	11.12
8,000	22.22	10.90
8,500	21.80	10.70
9,000	21.38	10.50
9,500	20.98	10.90
10,000	20.58	10.10
10,500	20.18	9.91
11,000	19.70	9.73
11,500	19.40	9.53
12,000	19.03	9.35
12,500	18.65	9.15
13,000	18.29	8.97
13,500	17.93	8.81
14,000	17.57	8.63
14,500	17.22	8.46
15,000	16.88	8.28

Volume Equivalents



Useful Conversion Factors

Pressure Equivalents

