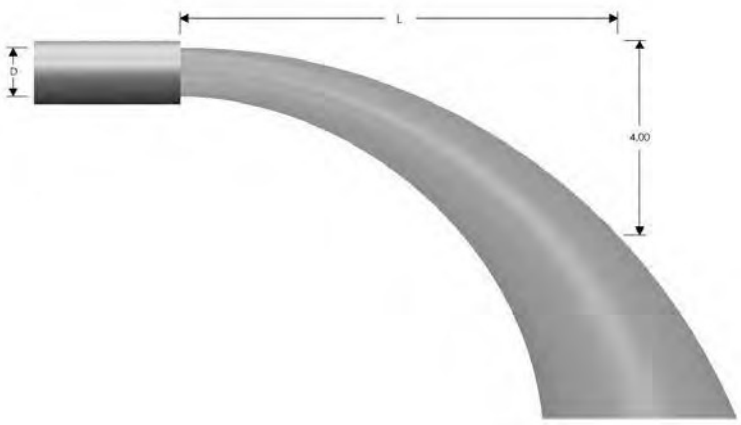
Water Data and Formulas



1 gallon water = 231 cubic inches = 8.333 pounds

1 pound of water = 27.7 cubic inches

1 cubic foot water = 7.5 gallons = 62.5 pounds (salt water weighs approximately 64.3 pounds per cubic foot)

Pounds per square inch at bottom of a column of water = height of column in feet x .434

1 miner's inch = 9 to 12 gallons per minute

Horsepower to Raise Water
If pumping liquid other than water, multiply the gallons per minute below by the liquids specific gravity

$$\text{Horsepower} = \frac{\text{gallons per minute x total head in feet}}{3960}$$

Gallons Per Minute through a Pipe
GPM = .0408 x pipe diameter inches^2 x feet/minute water velocity

Weight of Water in a Pipe
Pounds water = pipe length feet x pipe diameter inches^2 x .34

L Distance (inches)	Gallons per Minute Discharge for a Given Nominal Pipe Diameter D (inches)				
	5	6	8	10	12
5	163	---	---	---	---
6	195	285	---	---	---
7	228	334	580	---	---
8	260	380	665	1060	---
9	293	430	750	1190	1660
10	326	476	830	1330	1850
11	360	525	915	1460	2020
12	390	570	1000	1600	2220
13	425	620	1080	1730	2400
14	456	670	1160	1860	2590
15	490	710	1250	2000	2780
16	520	760	1330	2120	2960
17	550	810	1410	2260	3140
18	590	860	1500	2390	3330
19	620	910	1580	2520	3500
20	650	950	1660	2660	3700
21	685	1000	1750	2800	3890
22	720	1050	1830	2920	4060
23	750	1100	1910	3060	4250
24	---	1140	2000	3200	4440

Water Discharge Table

This table is intended for general reference and general applicability only, and should not be relied upon as the sole or precise source of information available with respect to the subject covered. The user should also refer to and follow manufacturer's specific instructions and recommendations with regard to such information, where they exist.

Flow of water through 100 foot lengths of hose, Straight-Smooth Bore - U.S. Gallons per minute

PSI at Hose Inlet	Nominal Hose ID Diameters - Inches							
	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"	6"
20	26	47	76	161	290	468	997	2895
30	32	58	94	200	360	582	1240	3603
40	38	68	110	234	421	680	1449	4209
50	43	77	124	264	475	767	1635	4748
60	47	85	137	291	524	846	1804	5239
75	53	95	154	329	591	955	2035	5910
100	62	112	180	384	690	1115	2377	6904
125	70	126	203	433	779	1258	2681	7788
150	77	139	224	478	859	1388	2958	8593
200	90	162	262	558	1004	1621	3455	10038

Figures are to be used as a guide since the hose inside diameter tolerance, the type of fittings used, and orifice restriction all influence the actual discharge. Thus, variations plus or minus from the table may be obtained in actual service.

Conversion Table - Feet of Water to Inches of Mercury

Feet of Water	1	2	4	6	8	10	12	14	16	20	22	24	26	28	30	32	34
Inches of Mercury	0.9	1.8	3.5	5.3	7.1	8.8	10.6	12.4	14.1	17.7	19.4	21.2	23.0	24.8	26.5	28.3	30.0

Feet Head of Water to PSI

Feet Head	Pounds per Square Inch	Feet Head	Pounds per Square Inch	Feet Head	Pounds per Square Inch	Feet Head	Pounds per Square Inch
1	0.43	15	6.50	100	43.31	250	108.27
2	0.87	20	8.66	110	47.64	300	129.93
3	1.30	25	10.83	120	51.97	350	151.58
4	1.73	30	12.99	130	56.30	400	173.24
5	2.17	40	17.32	140	60.63	500	216.55
6	2.60	50	21.65	150	64.96	600	259.85
7	3.03	60	25.99	160	69.29	700	303.16
8	3.46	70	30.32	170	73.63	800	346.47
9	3.90	80	34.65	180	77.96	900	389.78
10	4.33	90	38.98	200	86.62	1000	433.00

Note: One foot of water at 62° F equals 0.433 PSI.
To find the PSI for any feet head not given in the table, multiply the feet head by 0.433.

Maximum Recommended Air Flow (SCFM) Through ANSI Standard Weight Schedule 40 Metal Pipe

The flow values in the table below are based on a pressure drop of 10% of the applied pressure per 100 feet of pipe for 1/8", 1/4", 3/8", and 1/2" pipe sizes; and a pressure drop of 5% of the applied pressure per 100 feet of pipe for 3/4", 1", 1-1/4", 2", 2-1/2", 3" pipe sizes. The table gives recommended flows for pipe sizes at listed pressures and should be used to determine appropriate piping for air systems.

Applied Pressure **PSI**	Nominal Standard Pipe Size										
	1/8"	*1/4"*	*3/8"*	*1/2"*	*3/4"*	*1"*	*1-1/4"*	*1-1/2"*	*2"*	*2-1/2"*	*3"*
5	0.5	1.2	2.7	4.9	6.6	13	27	40	80	135	240
10	0.8	1.7	3.9	7.7	11.0	21	44	64	125	200	370
20	1.3	3.0	6.6	13.0	18.5	35	75	110	215	350	600
40	2.5	5.5	12.0	23.0	34.0	62	135	200	385	640	1100
60	3.5	8.0	18.0	34.0	50.0	93	195	290	560	900	1600
80	4.7	10.5	23.0	44.0	65.0	120	255	380	720	1200	2100
100	5.8	13.0	29.0	54.0	80.0	150	315	470	900	1450	2600
150	8.6	20.0	41.0	80.0	115.0	220	460	680	1350	2200	3900
200	11.5	26.0	58.0	108.0	155.0	290	620	910	1750	2800	5000
250	14.5	33.0	73.0	135.0	200.0	370	770	1150	2200	3500	6100

Air Supply Requirements (operating pressure: 90 PSI)

Tool	Class	Typical Air Consumption (CFM)	Hose Size (inches)		
			0-10 ft.	10-50 ft.	50-200 ft.
Paving Breakers	25 lb. 35 lb. 60 lb. 80 lb.	45 50 65 80	1/2 1/2 1/2 3/4	1/2 3/4 3/4 3/4	3/4 3/4 1 1
Claydiggers		45	1/2	1/2	3/4
Hand Drills	8 lb. 15 lb.	20 32	3/8 3/8	3/8 1/2	1/2 1/2
Rock (Sinker) Drills	45 lb. 55 lb.	105 130	3/4 3/4	3/4 1	1 1
Tampers	5" butt 6" butt	20 30	3/8 1/2	1/2 1/2	1/2 3/4
Sump Pump Sludge Pump	3 HP Ejector	100 90	3/4 1	3/4 1	1 1
Vibrators	2-1/2" 3"	60 60	1 1	1 1	1 1
Chipping Hammers		25	3/8	1/2	1/2
Impact Wrenches	3/8" sq. dr. 1/2" 3/4" 1"	10 15 25 50	5/16 5/16 3/8 1/2	3/8 3/8 1/2 3/4	3/8 1/2 1/2 3/4
Drills	1/4" - 1/2"	22	3/8	3/8	1/2
Grinders	die/burr small angle 3 HP vertical	20 20 75	3/8 3/8 1/2	3/8 3/8 3/4	1/2 1/2 1

CFM vs PSI for Nozzles

Gauge PSI	CFM Free Air Flow @ Nozzle Diameter (Inch)							
	1/64	1/32	3/64	1/16	3/32	1/8	3/16	1/4
1	.03	.11	.2	.4	1.0	1.7	3.9	6.8
5	.06	.24	.5	1.0	2.2	3.9	8.7	15.4
10	.08	.34	.8	1.4	3.1	5.4	12.3	21.8
15	.10	.42	.9	1.6	3.7	6.6	15.0	26.7
20	.12	.48	1.1	1.9	4.2	7.7	17.1	30.8
25	.13	.54	1.2	2.2	4.7	8.6	19.4	34.5
30	.16	.63	1.4	2.5	5.6	10.0	22.5	40.0
40	.19	.77	1.7	3.1	6.8	12.3	27.5	49.1
50	.22	.91	2.0	3.6	8.2	14.5	32.8	58.2
60	.26	1.05	2.3	4.2	9.4	16.8	37.5	67.0
70	.29	1.19	2.7	4.8	10.7	19.0	43.0	76.0
80	.33	1.33	3.0	5.3	11.9	21.2	47.5	85.0
90	.36	1.47	3.3	5.9	13.1	23.5	52.5	94.0
100	.40	1.61	3.7	6.4	14.5	25.8	58.3	103.0
110	.43	1.76	3.9	7.0	15.7	28.0	63.0	112.0
120	.47	1.90	4.30	7.6	17.0	30.2	68.0	121.0
130	.50	2.04	4.6	8.1	18.2	32.4	73.0	130.0
140	.54	2.17	4.9	8.7	19.5	34.5	78.0	138.0
150	.57	2.33	5.2	9.2	20.7	36.7	83.0	147.0
175	.66	2.65	5.9	10.6	23.8	42.1	95.0	169.0
200	.76	3.07	6.9	12.2	27.5	48.7	110.0	195.0

PSI = pounds/square inch; CFM = cubic feet/minute

Formulas

Air Velocity in a Pipe

Using the equation and typical values of V, D and L explained to the right approximate values of P are computed as follows:

Velocity Ft/Sec	Pipe Diameter in Inches, 10' long				
	1	2	4	6	10
1	.0004	.0002	.0001	.00007	.00004
2	.0016	.0008	.0004	.00030	.00016
5	.0100	.0050	.0025	.00170	.0010
10	.0400	.0200	.0100	.00670	.0040
15	.0900	.0450	.0225	.01500	.0090
20	.1600	0080	.0400	.02700	.0160
25	.2500	.1250	.0625	.04170	.0250
30	.3600	.1800	.0900	.06000	.0360

$$V = \sqrt{\frac{25{,}000\ DP}{L}}$$

V = air velocity in feet per second
D = pipe inside diameter in inches
L = length of pipe in feet
P = pressure loss due to air friction in ounces/square inch

formula from B.F.Sturtevant Company

Air Volume Discharged from Pipe

CFM = air volume in cubic feet per minute
V = air velocity in feet per second as determined in the equation at the top of this page
A = cross section area of pipe in square feet

$$CFM = 60VA$$

Boyle's Law

If temperature is kept constant, the volume of a given mass of gas is inversely proportional to the pressure which is exerted upon it.

$$\frac{\text{Initial Pressure}}{\text{Final Pressure}} = \frac{\text{Final Volume}}{\text{Initial Volume}}$$

Suggested Pipe Size for Compressed Air Flow at 100 PSI Length of Run, Feet

SCFM Air Flow	25	50	75	100	150	200	300	500	1000	Compressor HP
4	½	½	½	½	½	½	½	¾	¾	1
12	½	½	½	¾	¾	½	¾	1	1	3
20	¾	¾	¾	¾	1	¾	1	1¼	1¼	5
30	¾	¾	1	1	1	1	1¼	1¼	1¼	7½
40	¾	1	1	1	1¼	1	1¼	1½	1½	10
60	1	1	1¼	1¼	1¼	1¼	1½	1½	2	15
80	1	1¼	1¼	1¼	1½	1¼	1½	2	2	20
100	1¼	1¼	1½	1½	1½	1½	2	2	2½	25
120	1¼	1½	1½	1½	2	1½	2	2½	2½	30
160	1¼	1½	1½	2	2	1½	2½	2½	3	40
200	1½	2	2	2	2	2	2½	3	3	50
240	1½	2	2	2	2½	2	2½	3	3	60
300	2	2	2	2½	2½	2	3	3	3½	75
400	2	2½	2½	2½	3	2½	3	3½	4	100
500	2	2½	2½	3	3	2½	3½	3½	4	125

On a compressed air distribution system, pressure losses greater than 3% are considered excessive, and a well-designed system having a steady rate of air flow is usually designed for not more than a 1% loss or 1 PSI for a 100 PSI system. The pipe size depends not only on the volume of air flow but how far it must be carried. To hold the distribution loss to 1 PSI, pipes of larger diameter must be used on longer runs to carry the same flow that can be handled by smaller pipes on shorter runs.

Figures in the body of the chart above are pipe sizes recommended on a 100 PSI system to carry air with less than 1 PSI loss. When measuring lengths of runs, add 5' of length for each pipe fitting. If carrying 120 PSI pressure these sizes will carry slightly more air than shown, or pressure loss will be slightly less than 1 PSI. If carrying 80 PSI pressure these pipes will carry slightly less air at 1 PSI pressure loss than shown in the chart.

The left column of the chart shows the volume of air to be carried. It is difficult to estimate the air flow volume to be carried in each leg of the distribution system. This varies with the application. On some applications, like in a large plant with many legs in the distribution system serving dozens of air-operated machines, the air usage may be at a fairly steady rate. Other applications, usually on small systems, may have to carry a high surge of air if several machines happen to be operated at the same time. Then there may be a period with almost no flow.

To make a realistic estimate of air flow volume, the far right column of the chart showing compressor HP may be used. On steady pumping, a compressor will produce a minimum of 4 SCFM air flow for each 1 HP of capacity. This is a conservative figure, as most compressors will produce 5 or 6 SCFM.

For example, a 25 HP compressor will produce at least 100 SCFM of air as shown in the far left column on the same line as 25 HP.

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Air Receiver Capacities

If your tank is not listed in the table to the right, use the following formula to calculate the tank size (gallons) and then estimate the cubic feet tank capacity at a given pressure from the table above.

$$\text{Tank Gallons} = \frac{\text{Tank Height} \times (\text{Tank Radius})^2}{73.53}$$

Height and Radius are in inches

Tank Size (inches)	Tank Size (gallons)	Gauge Pressure on Tank (PSI)			
		0	**100**	**150**	**200**
		Cubic Feet Tank Capacity			
12 x 24	10	1.3	11	15	19
14 x 36	20	2.7	21	30	39
16 x 36	30	4.0	31	45	59
20 x 48	60	8.0	62	90	117
20 x 63	80	10.7	83	120	156
24 x 68	120	16.0	125	180	234
30 x 84	240	32.0	250	360	467

Air Hose Friction

Hose Size (inches)	CFM thru 50' Hose	Gauge Pressure - Pounds/sq inch			
		50	**70**	**90**	**110**
		PSI Loss Over 50' Hose Length			
½"	20	1.8	1.0	.8	.6
	30	5.0	3.4	2.4	2.0
	40	10.1	7.0	5.4	4.3
	50	18.1	12.4	9.5	7.6
	60	+	20.0	14.8	12.0
	70	+	28.4	22.0	17.6
	80	+	+	30.5	24.6
	90	+	+	41.0	33.3
	10	+	+	+	44.5
	110	+	+	+	+
¾"	20	04	.2	.2	.1
	30	.08	.5	.4	.3
	40	1.5	.9	.7	.5
	50	2.4	1.5	1.1	.9
	60	3.5	2.3	1.6	1.3
	70	4.4	3.2	2.3	1.8
	80	6.5	4.2	3.1	2.4
	90	8.5	5.5	4.0	3.1
	100	11.4	7.0	5.0	3.9
	110	14.2	8.8	6.2	4.9
	120	+	11.0	7.5	5.9
	130	+	+	9.0	7.1
1"	20	.1	0	0	0
	30	.2	.1	.1	.1
	40	.3	.2	.2	.2
	50	.5	.4	.3	.2
	60	.8	.5	.4	.3
	70	1.1	.7	.6	.4
	80	1.5	1.0	.7	.6
	90	2.0	1.3	.9	.7
	100	2.6	1.6	1.2	.9
	110	3.5	2.0	1.4	1.1
	120	4.8	2.5	1.7	1.3
	130	7.0	3.1	2.0	1.5

PSI = pressure in pounds/square inch
CFM = air flow in cubic feet/minute

+ pressure loss is too great and therefore the combination of Hose Size, CFM, and Gauge Pressure is not recommended. Gauge Pressures the indicated air pressure in pounds/square inch, at the source (i.e. the air compressor receiver tank)