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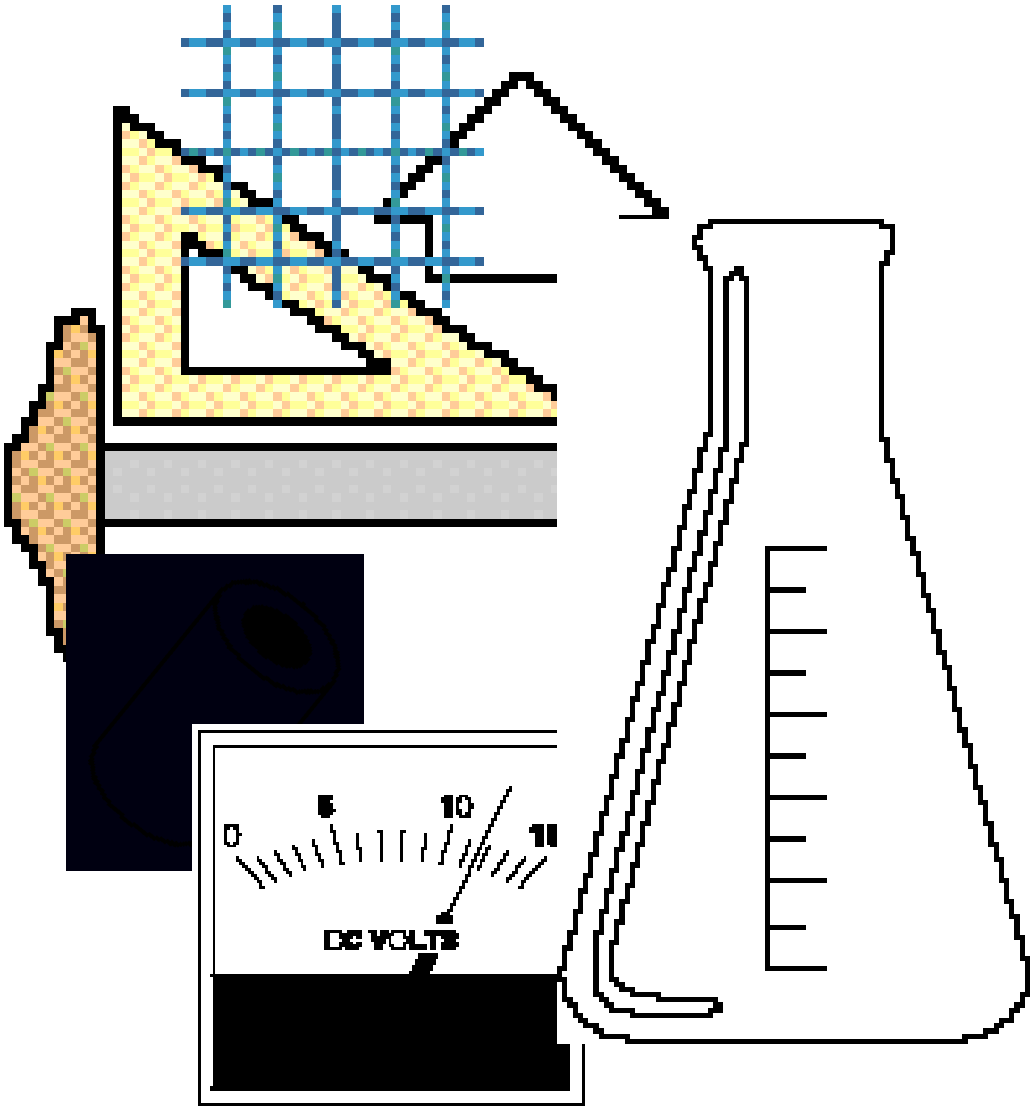
Technical Data Reference



For use with Industrial Fluid Handling Equipment

IPC Technical Specifications

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FLUID FLOW NOMOGRAPH

Fluid flow systems may be analyzed by the use of this fluid flow nomograph in conjunction with the following tables and Graco pump performance curves to give detailed answers on line loss, line size selection, pump selection, air consumption and required air pressures. Refer to page 1-26 for Pressure Drop calculator formula.

Three factors affecting fluid flow are used:

FLOW RATE—G.P.M.

VISCOSITY—C.P.S.

"D" FACTOR

The required factor for standard sizes of smooth I.D. hose, pipe and tubing have been calculated. Specific size used is located on the graph.

Directions

1 Obtain viscosity in poise or centipoise and locate on viscosity line.

2 Draw a line connecting the viscosity and desired flow in gallons per minute and intersect the reference line.

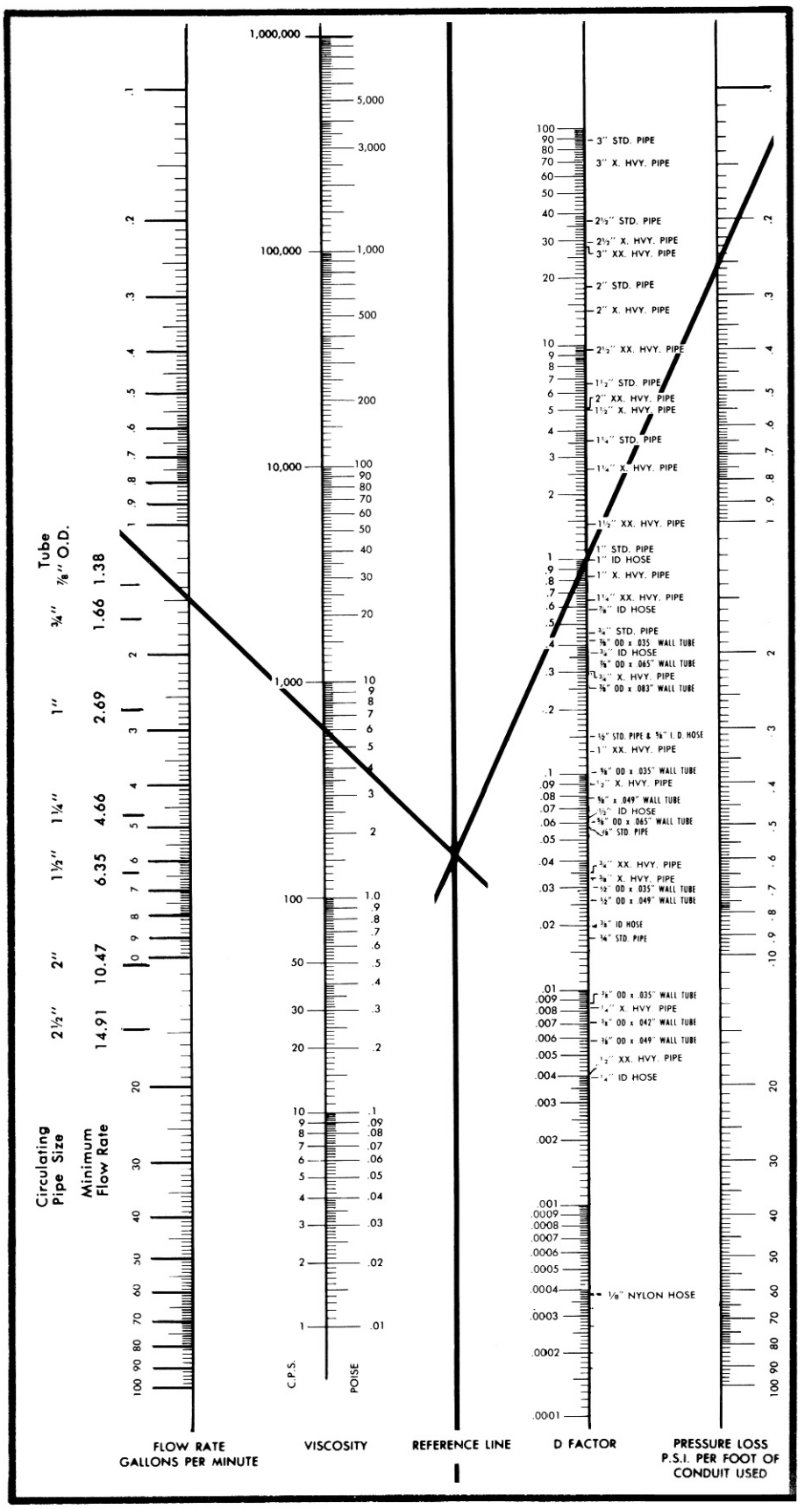
3 Draw a line connecting the inside diameter of the type tubing or hose used to the point on the reference line.

4 The intersection of the line with the pressure loss line indicates the resultant pressure loss per foot of conduit used in pounds per square inch.

Example:

Viscosity = 600 Centipoise
Deliver = 1.5 GPM
Standard Pipe = 1 in.
Resultant Pressure Loss = 0.25 PSI per foot

5 Multiply the total length of line by the resultant pressure loss per foot to obtain the total pressure loss caused by fluid flow through the conduit.



PRESSURE DROP

Calculate pressure drop in pipe or tube length by use of the following formula:

$$P = \frac{0.0273\ QVL}{D^4}$$

Where:

P = Pressure drop in pounds per square inch (PSI)
Q = Flow rate in gallons per minute (GPM)
L = Length of pipe in feet
V = Viscosity of fluid in poise
D^4 = Tube or pipe factor (4th power of diameter in inches)

TUBE AND PIPE FACTORS

Tube or Pipe Size (inches)	Factor D^4
1/4 I.D. Nylon Tube	0.0039
1/4 Schedule 40 Pipe	0.18
3/8 Schedule 40 Pipe	0.059
1/2 Schedule 40 Pipe	0.15
3/4 Schedule 40 Pipe	0.46
1 Schedule 40 Pipe	1.21
1-1/4 Schedule 40 Pipe	3.6
1-1/2 Schedule 40 Pipe	6.65
2 Schedule 40 Pipe	18.3

PUMP SELECTION

Following the analysis of line flow conditions through the use of the nomograph, and arriving at a total line pressure loss, consideration should then be given to pressure loss created by valves, fittings and elevation of lines.

If a sufficient number of values and fittings are incorporated in the system to materially affect the total line loss, add to the total line length, the equivalent length of line of each valve or fitting.

EQUIVALENT RESISTANCE OF VALVES AND FITTINGS

Nominal Pipe Size Inches	Inside Diameter Inches	Equivalent Length of Standard Pipe in Feet							
		Gate Valve	Globe Valve	Angle Valve	45° Elbow	90° Elbow	180° Close Ret.	Tee Thru Run	Tee Thru Branch
1/2	0.622	0.41	18.5	9.3	0.78	1.67	3.71	0.93	3.33
3/4	0.824	0.54	24.5	12.3	1.03	2.21	4.90	1.23	4.41
1	1.049	0.69	31.2	15.6	1.31	2.81	6.25	1.56	5.62
1 1/4	1.380	0.90	41.0	20.5	1.73	3.70	8.22	2.06	7.40
1 1/2	1.610	1.05	48.0	24.0	2.15	4.31	9.59	2.40	8.63
2	2.067	1.35	61.5	30.8	2.59	5.55	12.3	3.08	11.6
2 1/2	2.469	1.62	73.5	36.8	3.09	6.61	14.7	3.68	13.2
3	3.068	2.01	91.5	45.8	3.84	8.23	18.2	4.57	16.4
4	4.026	2.64	120	60.0	5.03	10.8	23.9	6.00	21.6

The pressure loss per foot of conduit, as found on the nomograph, when multiplied by the total line length (actual length and length added for the valves and fittings) will give the pressure loss of the conduit.

Pressure loss due to elevations in the fluid line is accounted for by adding 0.5 psi per foot of vertical rise to the pressure loss calculation.

As specific gravity increases beyond 1.0 psi (water). The pressure loss per foot may also increase.

MINIMUM FLOW RATES

Circulation of paints and similar materials containing pigments or fillers requires fluid flow velocities high enough to maintain the contained particles in suspension. A velocity of 60 feet per minute has been accepted as a minimum velocity to maintain suspension. For convenience, minimum flow rates for various size conduits have been calculated and tabulated.

Circulating Line Size	Minimum Flow Rate
1/4" std. pipe	0.325 gpm
3/8" std. pipe	0.595 gpm
5/8" O.D. x .035" wall tube	0.75 gpm
1/2" std. pipe	0.95 gpm
7/8" O.D. x .035" wall tube	1.58 gpm
3/4" std. pipe	1.66 gpm
1" O.D. x .035" wall tube	2.12 gpm
1" std. pipe	2.69 gpm
1 1/4" std. pipe	4.66 gpm
1 1/2" std. pipe	6.35 gpm
2" std. pipe	10.5 gpm

To calculate minimum flow rates for other conduit sizes: Flow rate (GPM) — 3.11 x Inside Area, $In.^2$.

APPROXIMATE VISCOSITIES OF COMMON LIQUID AND SEMI-SOLID MATERIALS

Common Liquid and Semi-Solid Materials (Centipoise Viscosity at 70°)	Viscosity In Centipoise
ACETONE	.3
ADIPRENE (URETHANE)	35,000
BENZINE	.5
CORN SYRUP	110,000
ETHYLENE GLYCOL	16
GLUE (HOT MELT)	30,000,000
HONEY	3,000
INK	45,000
KETCHUP (HEINZ BRAND)	*50,000
LACQUER	1,100-250
LINSEED OIL (BOILED)	64
LINSEED OIL (RAW)	28
METHYL ETHYL KETONE	.4
MILK	3
MUSTARD (FRENCH'S BRAND)	*70,000
OIL (AUTO—LUBRICATING)	
SAE 10	65
SAE 20	125
SAE 30	200
SAE 40	319
SAE 50	540
SAE 60	1,000
SAE 70	1,600
SAE 80 (Transmission Grades)	240
SAE 90 (Transmission Grades)	590
SAE 140 (Transmission Grades)	2,200
OIL—CASTOR	1,000-240
OIL—CORE	29
OIL—CORN (MAZOLA BRAND)	72
OIL CRUDE	15
OIL SOYBEAN	160
PEANUT BUTTER (SKIPPY BRAND)	*250,000
SALAD DRESSING (MIRACLE WHIP BRAND)	*250,000
SHORTENING (CRISCO BRAND)	*1,200,000
SULPHURIC ACID (100%)	.2
SYRUP (KARO BRAND—DARK)	3,200
SYRUP (KARO BRAND—LIGHT)	2,500
SYRUP (LOG CABIN BRAND—MAPLE)	144
TOLUOL	.6
TOMATO PASTE	*190,000
TURPENTINE	1
VARNISH (SPAR)	420
VASELINE PETROLEUM JELLY	64,000
WATER	1
XYLOL	.6

VISCOSITY CONVERSION CHART

Poise	CENTIPOISE	DuPont Parlin 7	DuPont Parlin 10	Fisher 1	Fisher 2	Ford Cup 3	Ford Cup 4	Gardner Holdt Bubble	Gardner Lithographic	Krebs Units KU	Saybolt Universal SSU	Zahn 1	Zahn 2	Zahn 3	Zahn 4	Zahn 5	Sears Craftsman Cup	Redwood No. 1 Sec.	Engler Degrees	Saybolt Furol Sec	Redwood No. 2 Sec.
.1	10	27	11	20			5	A-4			60	30	16					54	1.84		
.15	15	30	12	25			8	A-3			80	34	17					70	2.35		
.2	20	32	13	30	15	12	10				100	37	18					98	2.90		
.25	25	37	14	35	17	15	12	A2			130	41	19					106	3.48		
.3	30	43	15	39	18	19	14	A1			160	44	20					125	4.10		
.4	40	50	16	50	21	25	18	A			210	52	22				19	165	5.39		
.5	50	57	17		24	29	22			30	260	60	24				20	203	6.78		
.6	60	64	18		29	33	25	8		33	320	68	27				21	245	8.05	30.8	
.7	70		20		33	36	28			35	370		30				23	286	9.40	35.0	30.05
.8	80		22		39	41	31	C		37	430		34				24	327	10.60	40.0	34.00
.9	90		23		44	45	32			38	480		37	10			26	368	11.80	44.7	37.85
1.0	100		25		50	50	34	D		40	530		41	12	10		27	409	14.25	47.8	41.90
1.2	120		30		62	58	41	E		43	580		49	14	11		31	485	15.95	58.2	49.80
1.4	140		32			66	45	E		46	690		58	16	13		34	570	18.55	66.8	57.90
1.6	160		37				50	G		48	790		66	18	14		38	645	21.10	76.4	66.00
1.8	180		41				54		000	50	900		74	20	16		40	735	23.90	86.3	74.15
2.0	200		45				58	H		52	1000		82	23	17	10	44	815	26.75	95.8	82.35
2.2	220						62	I		54	1100			25	18	11		900	28.15	104.6	90.00
2.4	240						65	J		56	1200			20	12	12		985	33.60	113.5	97.75
2.6	260						68			58	1280			30	21	13		1060	34.65	124.5	105.60
2.8	280						70	K		59	1380			32	22	14		1140	37.25	137.5	114.90
3.0	300						74	L		60	1475			34	24	15		1235	39.85	143.2	123.75
3.2	320							M			1530			36	25	16		1300	42.35	151.8	131.65
3.4	340							N			1630			39	26	17		1390	45.00	161.3	139.50
3.6	360							O		62	1730			41	28	18		1465	47.75	171.5	149.00
3.8	380										1850			43	29	19		1550	50.10	180.0	157.55
4.0	400							P		64	1950			46	30	20		1635	52.45	189.5	166.35
4.2	420										2050			48	32	21		1695	52.95	199.5	171.65
4.4	440							Q			2160			50	33	22		1790	54.20	209.5	183.50
4.6	460							R		66	2270			52	34	23		1837	60.60	218.4	188.65
4.8	480								00	67	2380			54	36	24		1950	63.85	228.9	198.75
5.0	500							S		68	2480			57	37	25		2045	65.95	239.4	208.85
5.5	550							T		69	2660			63	40	27		2240	72.85	259.7	229.95
6.0	600							U		71	2900			68	44	30		2433	79.50	287.6	248.50
7.0	700									74	3375				51	35		2850	92.30	332.4	289.60
8.0	800								0	77	3880				58	40		3270	106.45	380.1	329.75
9.0	900							V		81	4300				64	45		3690	119.50	427.8	368.85
10.0	1000							W		85	4600					49		4000	133.50	479.6	408.70
11.0	1100									88	5200					55					

VISCOSITY CONVERSION CHART CONTINUED

Poise	CENTIPOISE	DuPont Parlin 7	DuPont Parlin 10	Fisher 1	Fisher 2	Ford Cup 3	Ford Cup 4	Gardner Holdt Bubble	Gardner Lithographic	Krebs Units KU	Saybolt Universal SSU	Zahn 1	Zahn 2	Zahn 3	Zahn 4	Zahn 5	Sears Craftsman Cup	Redwood No. 1 Sec.	Engler Degrees	Saybolt Furol Sec	Redwood No. 2 Sec.
12.0	1200									92	5620					59					
13.0	1300							X		95	6100					64					
14.0	1400								1	96	6480										
15.0	1500									98	7000										
16.0	1600									100	7500										
17.0	1700									101	8000										
18.0	1800							Y			8500										
19.0	1900										9000										
20.0	2000									103	9400										
21.0	2100										9850										
22.0	2200										10300										
23.0	2300							Z	2	105	10750										
24.0	2400									109	11200										
25.0	2500							Z-1		114	11600										
30.0	3000									121	14500										
35.0	3500							Z-2	3	129	16500										
40.0	4000									133	18500										
45.0	4500							Z-3		136	21000										
50.0	5000										23500										
55.0	5500										26000										
60.0	6000							Z-4	4		28000										
65.0	6500										30000										
70.0	7000										32500										
75.0	7500										35000										
80.0	8000										37000										
85.0	8500										39500										
90.0	9000										41000										
95.0	9500										43000										
100.0	10000							Z-5	5		46500										
110.0	11000										51000										
120.0	12000										55500										
130.0	13000										60000										
140.0	14000										65000										
150.0	15000							Z-6			69500										
160.0	16000										74000										
170.0	17000										80000										
180.0	18000										83500										
190.0	19000										88000										
200.0	20000										93000										
300.0	30000										140000										

All viscosity comparisons are as accurate as possible with existing information. Comparisons are made with materials having a specific gravity of one.

To extend range of only the kinematic Saybolt Universal, Redwood No. 1 and Engler Scales: Multiply by 10, the viscosities on these scales between 100 and 1000 Centistokes on the Kinematic Scale and the corresponding viscosities on the other 3 scales. For further extension multiply these scales as above by 100 or a higher power of 10.

(Example:
1500 Centistrokes = 150 X 10 CS 695 X 10 SUS)

TABLE ON pH VALUES

pH VALUES

The acidity or alkalinity of a solution is expressed by its pH value. A neutral solution such as water has a pH value of 7.0. Decreasing pH values from 7.0 to 0.0 indicate increasing acidity and increasing pH values from 7.0 to 14.0 indicate increasing alkalinity. Since the pH value denotes the acidity or alkalinity of a liquid, it gives some indication of the materials required in constructing a pump to handle the liquid. The pH value alone, however, is not conclusive. Many other factors must be considered. However, as an approximate guide, Table A may be found helpful.

TABLE A

pH Value	Material of Construction
0 to 4	Corrosion Resistant Alloy Steels.
4 to 6	All Bronze.
6 to 8	Bronze Fitted or Standard Fitted.
8 to 10	All Iron.
10 to 14	Corrosion Resistant Alloys.

The following tables give approximate pH values. From "Modern pH and Chlorine Control", W.A. Taylor & Co., by permission.

TABLE OF APPROXIMATE pH VALUES.

ACIDS

Hydrochloric, N	0.1	Formic, 0.1N	2.3
Hydrochloric, 0.1N	1.1	Lactic, 0.1N	2.4
Hydrochloric, 0.01N	2.0	Acetic, N	2.4
Sulfuric, N	0.3	Acetic, 0.1N	2.9
Sulfuric, 0.1N	1.2	Acetic, 0.01N	3.4
Sulfuric, 0.01N	2.1	Benzoic, 0.01N	3.1
Orthophosphoric, 0.1N	1.5	Alum, 0.1N	3.2
Sulfurous, 0.1N	1.5	Carbonic, (saturated)	3.8
Oxalic, 0.1N	1.6	Hydrogen sulfide, 0.1N	4.1
Tartaric, 0.1N	2.2	Arsenious (saturated)	5.0
Malic, 0.1N	2.2	Hydrocyanic, 0.1N	5.1
Citric, 0.1N	2.2	Boric, 0.1N	5.2

BASES

Sodium hydroxide, N	14.0	Ammonia, N	11.6
Sodium hydroxide, 0.1N	13.0	Ammonia, 0.1N	11.1
Sodium hydroxide, 0.01N	12.0	Ammonia, 0.01N	10.6
Potassium hydroxide, N	14.0	Potassium cyanide, 0.1N	11.0
Potassium hydroxide, 0.1N	13.0	Magnesia (saturated)	10.5
Potassium hydroxide, 0.01N	12.0	Sodium sesquicarbonate, 0.1N	10.1
Sodium metasilicate, 0.1N	12.6	Ferrous hydroxide (saturated)	9.5
Lime (saturated)	12.4	Calcium carbonate (saturated)	9.4
Trisodium phosphate, 0.1N	12.0	Borax, 0.1N	9.2
Sodium carbonate, 0.1N	11.6	Sodium bicarbonate, 0.1N	8.4

BIOLOGIC MATERIALS

Blood, plasma, human	7.3-7.5	Duodenal contents, human	4.8-8.2
Spinal fluid, human	7.3-7.5	Feces, human	4.6-8.4
Blood whole, dog	6.9-7.2	Urine, human	4.8-8.4
Saliva, human	6.5-7.5	Milk, human	6.6-7.6
Gastric contents, human	1.0-3.0	Bile, human	6.8-7.0

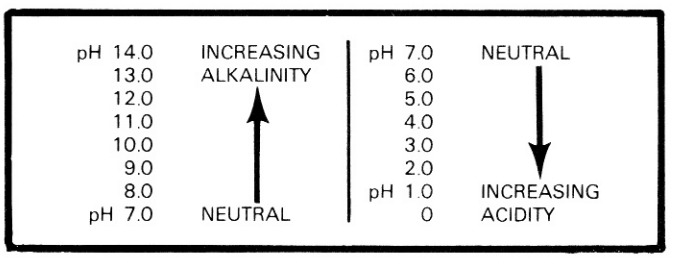
TABLE ON pH VALUES CONTINUED

FOODS

Apples	2.9-3.3	Milk, cows	6.3-6.6
Apricots	3.6-4.0	Olives	3.6-3.8
Asparagus	5.4-5.8	Oranges	3.0-4.0
Bananas	4.5-4.7	Oysters	6.1-6.6
Beans	5.0-6.0	Peaches	3.4-3.6
Beers	4.0-5.0	Pears	3.6-4.0
Blackberries	4.9-5.5	Peas	5.8-6.4
Bread, white	5.0-6.0	Pickles, sour	3.0-3.4
Beets	4.9-5.5	Pickles, dill	3.2-3.6
Butter	6.1-6.4	Pimento	4.6-5.2
Cabbage	5.2-5.4	Plums	2.8-3.0
Carrots	4.9-5.3	Potatoes	5.6-6.0
Cheese	4.8-6.4	Pumpkin	4.8-5.2
Cherries	3.2-4.0	Raspberries	3.2-3.6
Cider	2.9-3.3	Rhubarb	3.1-3.2
Corn	6.0-6.5	Salmon	6.1-6.3
Crackers	6.5-8.5	Sauerkraut	3.4-3.6
Dates	6.5-8.5	Shrimp	6.8-7.0
Eggs, fresh white	7.6-8.0	Soft drinks	2.0-4.0
Flour, wheat	5.5-6.5	Spinach	5.1-5.7
Gooseberries	2.8-3.0	Squash	5.0-5.4
Grapefruit	3.0-3.3	Strawberries	3.0-3.5
Grapes	3.5-4.5	Sweet potatoes	5.3-5.6
Hominy (lye)	6.8-8.0	Tomatoes	4.0-4.4
Jams, fruit	3.5-4.0	Tuna	5.9-6.1
Jellies, fruit	2.8-3.4	Turnips	5.2-5.6
Lemons	2.2-2.4	Vinegar	2.4-3.4
Limes	1.8-2.0	Water, drinking	6.5-8.0
Maple syrup	6.5-7.0	Wines	2.8-3.8

pH FACTOR

The pH of a solution is a measurement of its hydrogen ion concentration and is indicitive of its degree of acidity or alkalinity. Values of pH range from 0 to 14.0 with the middle of the range, 7.0, being neutral.



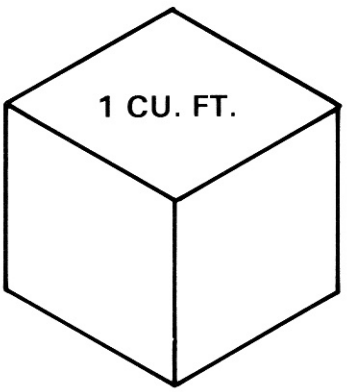
COMPRESSED AIR DATA

When a pump uses 10 cfm at 100 psi, it is using 10 cubic feet per minute of free air that has been compressed to 2.46 cubic feet at 100 psi. The pump is then actually using 2.46 cubic feet at 100 psi, but the measurement of its consumption is on the basis of "free air" taken into the compressor of 10 cfm.

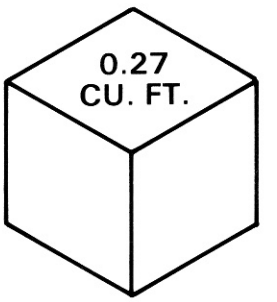
Compressed air is measured on the basis of the volume used per unit time (cubic feet per minute) at a given pressure (psi). The reference to volume of compressed air is always a measurement of air in its free state; i.e., atmospheric condition.

The description above illustrates the economical benefit of operating a pump at the lowest air pressure that will adequately meet the needs of pump output.

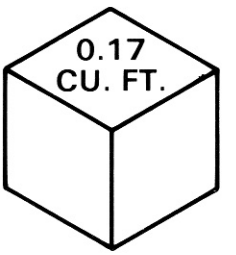
Compressed air is not unlike flowing fluids in that pressure is lost in transmission piping and hoses. The following chart aids in choosing piping and hose to minimize pressure drop in air lines.



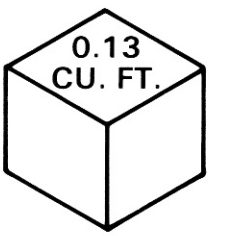
1 Cu. ft. of free air



1 Cu. ft. of air
@ 40 psi pressure



1 Cu. ft. of air
@ 70 psi pressure



1 Cu. ft. of air
@ 100 psi pressure

FRICTION OF AIR IN PIPES

Air pressure loss, psi in 100 ft. of clean commercial steel pipe.

CFM of Free Air	Nominal Pipe Diameter														
	1/2 Inch			3/4 Inch			1 Inch			1 1/4 Inches			1 1/2 Inches		
	80 lb.	100 lb.	125 lb.	80 lb.	100 lb.	125 lb.	80 lb.	100 lb.	125 lb.	80 lb.	100 lb.	125 lb.	80 lb.	100 lb.	125 lb.
10	.46	.38	.31	.11	.09	.08	.04	.03	.02	.0086	.0071	.0058			
20	1.74	1.42	1.17	.41	.34	.28	.13	.10	.08	.032	.026	.021	.014	.012	.010
30	3.84	3.13	2.54	.90	.74	.60	.28	.23	.19	.068	.056	.046	.031	.026	.021
40	6.93	5.55	4.53	1.55	1.28	1.05	.46	.38	.31	.116	.096	.079	.053	.044	.036
50	10.7	8.65	7.01	2.42	2.00	1.62	.73	.60	.49	.18	.146	.120	.081	.067	.055
60				3.47	2.84	2.33	1.02	.84	.69	.25	.21	.17	.12	.095	.070
70				4.73	3.85	3.14	1.36	1.12	.92	.34	.28	.23	.16	.13	.10
80				6.14	5.01	4.08	1.76	1.44	1.18	.44	.36	.30	.20	.16	.14
90				7.75	6.40	5.17	2.23	1.85	1.49	.55	.45	.37	.25	.20	.17
100				9.62	7.80	6.33	2.69	2.21	1.81	.66	.55	.45	.30	.25	.20
125				15.5	12.4	9.8	4.18	3.41	2.79	1.03	.85	.69	.46	.38	.32
150				23.0	18.1	14.4	5.75	4.91	3.99	1.47	1.20	.99	.65	.54	.44
175							8.10	6.80	5.45	2.00	1.64	1.32	.90	.73	.60
200							10.9	8.79	7.11	2.58	2.12	1.73	1.15	.95	.70
250										4.05	3.30	2.67	1.82	1.48	1.70

FRICTION OF AIR IN HOSE

(Including drop through standard hose fittings)

Air Flow Cubic Feet Per Minute	10' of 1/4" Hose	8' of 5/16" Hose	10' of 3/8" Hose	12 1/2' of 1/2" Hose	25' of 1/2" Hose	50' of 1/2" Hose	12 1/2' of 3/4" Hose	25' of 3/4" Hose	50' of 3/4" Hose	50' of 1/2" Hose+ 10' of 1/4" Hose	50' of 1/2" Hose+ 10' of 3/8" Hose	50' of 1/2" Hose+ 8' of 5/16" Hose	50' of 1/2" Hose+ 12 1/2' of 1/2" Hose	50' of 3/4" Hose+ 25' of 1/2" Hose	50' of 3/4" Hose+ 12 1/2' of 3/4" Hose
	Pressure Drop — Pounds per Sq. In. — Based on 100 Pounds per Sq. In. Line Pressure														
10 to 11	5.0	.9								5.3	.7	1.4			
11 to 12	5.9	1.0								6.2	.8	1.6			
12 to 13	6.8	1.2	.4							7.2	.9	1.9			
13 to 14	8.0	1.4	.5							8.4	1.1	2.2			
14 to 15	9.3	1.6	.6							9.8	1.3	2.5			
15 to 16		1.9	.7								1.5	2.9			
16 to 18		2.4	.8								1.9	3.5	1.7		
18 to 20		3.0	1.0								2.4	4.5	2.0		
20 to 25		4.3	1.4	.7	1.0	1.3					3.5	6.4	2.6	1.3	
25 to 30		6.6	2.1	1.0	1.5	2.3					5.2	9.8	3.8	1.9	
30 to 35		9.5	3.1	1.3	2.1	3.6					7.3		5.3	2.6	
35 to 40			4.2	1.7	2.8	5.2					9.6		7.1	3.5	
40 to 50			6.3	2.4	4.1	8.0								5.2	1.8
50 to 60			9.6	3.7	6.3									7.8	2.3
60 to 70				5.3	9.0		.9	1.4	1.9						3.0
70 to 80				7.1			1.1	1.7	2.5						3.7
80 to 90				9.0			1.4	2.2	3.2						4.6
90 to 100							1.7	2.7	4.0						5.0
100 to 120							2.3	3.5	5.6						7.9
120 to 140							3.2	4.8	8.0						
140 to 160							4.3	6.6							
160 to 180							5.6	8.7							
180 to 200							7.2								

IRON PIPE AND STEEL TUBING DATA

Standard iron pipe is designated by its nominal inside diameter, namely, 1/8", 1/4", 3/8", 1/2", 3/4", 1", 1 1/4", 1 1/2", 2", 2 1/2", 3", etc. While errors in the early manufacture of pipe have caused inconsistencies in the smaller pipe inside diameters, the size designations have still been retained.

Three weights of pipe; standard, extra heavy, and double extra heavy are in common use and all three have the same outside diameter. The added wall thickness for the heavier pipe therefore reduces the inside diameter. Cast steel fittings are recommended for extra heavy pipe and forged steel fittings for double extra heavy pipe.

Steel tubing is designated by its outside diameter and its wall thickness. While it is available in a wide range of sizes, 3/8", 1/2", 5/8", 7/8" and 1" O.D., tubes are quite commonly used as fluid lines. Choice of wall thickness is practically unlimited and is governed by the working pressures encountered.

HYDRAULIC TUBING

When Power Pack is located within 100 feet from pumps, the following tubing sizes will be adequate:

Hydraulic Power Supply Flow Rate	Supply Tubing Requirements	Return Tubing Requirements
0-12 GPM	3/4" x .065" Wall	1" x .083" Wall
12-20 GPM	1" x .083" Wall	1 1/4" x .109" Wall
20-30 GPM	1 1/8" x .095" Wall	1 1/2" x .120" Wall
30-40 GPM	1 1/4" x .109" Wall	1 3/4" x .155" Wall
40-50 GPM	1 1/2" x .120" Wall	2" x .190" Wall

NOTE: When power supply is located within 100' - 200' of pumps, use one size larger tubing.

STEEL TUBING—MAXIMUM WORKING PRESSURES (P.S.I.)

	WALL THICKNESS												
O.D.	.025"	.028"	.032"	.035"	.042"	.049"	.058"	.065"	.072"	.083"	.095"	.109"	.125"
1/8"	6000	6700	7680	8430	9920	11750	x	x	x	x	x	x	x
3/16"	4000	4470	5100	5610	6750	7850	x	x	x	x	x	x	x
1/4"	2980	3350	3830	4200	5040	5890	7000	7850	x	x	x	x	x
5/16"	2410	2690	3080	3370	4040	4710	5610	6290	6950	8010	x	x	x
3/8"	1990	2240	2560	2800	3360	3920	4660	5240	5790	6660	7640	8720	9990
13/32"	1845	2070	2360	2585	3100	3620	4285	4800	5320	6130	7015	8050	9235
7/16"	1715	1920	2190	2400	2880	3360	4000	4500	4960	5720	6550	7490	8580
1/2"	1490	1675	1920	2100	2520	2940	3500	3925	4340	5000	5720	6540	7500
9/16"	1330	1490	1705	1870	2240	2620	3110	3490	3860	4450	5090	5810	6660
5/8"	1200	1340	1535	1680	2020	2350	2800	3140	3470	4000	4580	5230	6000
11/16"	1090	1220	1395	1530	1830	2135	2530	2835	3140	3620	4145	4755	5455
3/4"	1000	1120	1280	1400	1640	1960	2320	2600	2880	3320	3800	4360	5000
7/8"	860	960	1090	1200	1440	1680	1985	2225	2465	2845	3255	3740	4285
1"	750	840	960	1050	1260	1470	1740	1950	2160	2490	2850	3270	3750
1 1/8"	665	747	854	935	1120	1310	1545	1735	1920	2215	2535	2910	3330

Note: The values above are based on an allowable fibre stress of 15,000 psi. For approximate bursting pressures, multiply thes factor of 3.3.

STANDARD PIPE DATA (Schedule 40)

NOMINAL DIAMETER (INCHES)	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
ACTUAL OUTSIDE DIAMETER (Inches)	0.405	0.540	0.675	0.840	1.050	1.315	1.660	1.90	2.375	2.875	3.5
ACTUAL INSIDE DIAMETER (Inches)	0.269	0.364	0.493	0.622	0.824	1.049	1.380	1.61	2.067	2.469	3.068
INSIDE AREA (Square Inches)	0.06	0.10	0.19	0.30	0.53	0.86	1.49	2.04	3.36	4.79	7.39
WORKING PRESSURE* (P.S.I.)	2820	2172	1797	1731	1434	1348	1124	1017	864	940	822
U.S. GALLONS IN ONE LINEAL FOOT	0.003	0.005	0.010	0.016	0.028	0.045	0.077	0.106	0.174	0.248	0.383
FEET OF PIPE CONTAINING ONE U.S.GALLON	333.7	185.1	100.8	63.33	36.12	22.21	12.87	9.45	5.74	4.02	2.59
WEIGHT PER FOOT (Pounds)	0.244	0.424	0.567	0.850	1.13	1.68	2.27	2.72	3.65	5.79	7.58

*Reference pressure rating—6:1 safety factor

EXTRA HEAVY PIPE DATA (Schedule 80)

NOMINAL DIAMETER (INCHES)	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
ACTUAL OUTSIDE DIAMETER (Inches)	0.405	0.540	0.675	0.840	1.050	1.315	1.660	1.90	2.375	2.875	3.5
ACTUAL INSIDE DIAMETER (Inches)	0.215	0.302	0.423	0.546	0.742	0.957	1.278	1.500	1.939	2.323	2.90
INSIDE AREA (Square Inches)	0.036	0.071	0.141	0.231	0.425	0.710	1.28	1.75	3.0	4.24	6.6
WORKING PRESSURE* (P.S.I.)	3977	2937	2488	2333	1954	1814	1533	1403	1222	1280	1142
U.S. GALLONS IN ONE LINEAL FOOT	0.0018	0.0037	0.008	0.012	0.022	0.0375	0.0675	0.09	0.15	0.225	0.345
FEET OF PIPE CONTAINING ONE U.S.GALLON	534.7	266.5	133.3	82.0	44.4	26.6	14.8	11.1	6.66	4.40	2.90
WEIGHT PER FOOT (Pounds)	0.314	0.538	0.738	1.09	1.47	2.2	3.0	3.6	5.0	7.7	10.25

*Reference pressure rating—6:1 safety factor

DOUBLE EXTRA HEAVY PIPE DATA

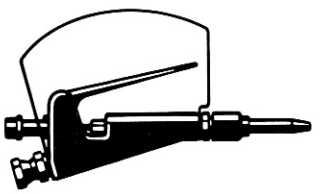
NOMINAL DIAMETER (INCHES)	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
ACTUAL OUTSIDE DIAMETER (Inches)	0.840	1.050	1.315	1.660	1.90	2.375	2.875	3.5
ACTUAL INSIDE DIAMETER (Inches)	0.252	0.434	0.599	0.896	1.10	1.50	1.77	2.30
INSIDE AREA (Square Inches)	0.050	0.148	0.282	0.630	0.950	1.77	2.46	4.15
WORKING PRESSURE* (P.S.I.)	4666	3910	3629	3068	2807	2560	2446	2285
U.S. GALLONS IN ONE LINEAL FOOT	0.0026	0.0075	0.015	0.033	0.049	0.092	0.127	0.216
FEET OF PIPE CONTAINING ONE U.S.GALLON	381.8	133.2	66.6	30.3	20.2	10.8	7.84	4.53
WEIGHT PER FOOT (Pounds)	1.71	2.44	3.66	5.21	6.40	9.03	13.7	18.6

*Reference pressure rating—6:1 safety factor

COVERAGE PER GALLON FOR VARIOUS FILM THICKNESSES, RIBBON AND BEAD SIZES

Wet Film Thickness	Gals./1000 Square Ft.	Square Ft. /Per Gal.
1″	630	1.6
3/4″	490	2.0
1/2″	315	3.0
7/16″	290	3.5
3/8″	240	4.0
5/16″	200	5.0
1/4″	160	6.0
3/16″	125	8.0
5/32″	100	10.0
1/8″	80	12.0
3/32″	63	16.0
1/16″	40	25.0
.060″ (60 mils)	40	26.0
1/32″	20	50.0
.030″ (30 mils)	20	52.0
.015″ (15 mils)	10	170.0
.010″ (10 mils)	6.5	160.0
.005″ (5 mils)	3.1	320.0
.003″ (3 mils)	1.5	533.0
.001″ (1 mil)	2/3	1600.0

Ribbon Size	Gals./1000 Lineal Ft.	Lineal Ft. Per Gal.
1/1000″ x 1″	0.05	19200
10/1000″ x 1″	0.50	1920
30/1000″ x 1″	1.60	625
60/1000″ x 1″	3.20	312
1/64″ x 1″	.80	1200
1/32″ x 1″	1.70	600
1/16″ x 1″	3.30	300
1/8″ x 1″	6.50	150
1/4″ x 1″	13.00	75
1/2″ x 1″	26.00	37

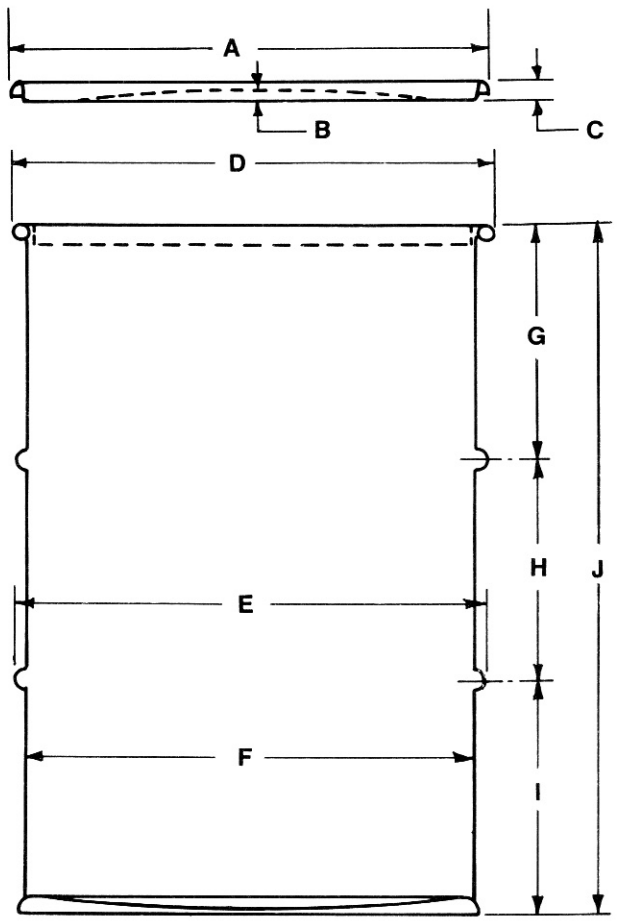


Bead Size (Dia.)	Gals./1000 Lineal Ft.	Lineal Ft. Per Gal.
1/16″	0.16	6000
3/32″	0.36	2700
1/8″	0.64	1500
3/16″	1.44	675
1/4″	2.55	375
5/16″	3.98	240
3/8″	5.74	165
1/2″	10.20	95
5/8″	15.92	50
3/4″	22.95	35
1″	40.80	19

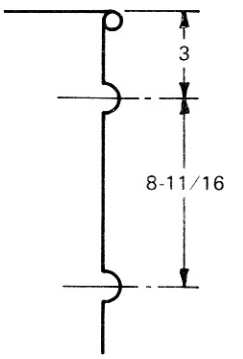
DRUM SPECIFICATIONS

Excerpts from American Standards Association, Inc., Specifications for Metal Drums and Pails, MH 2.1-1959 through MH 2.10-1959; MH 2.11-1960 through MH 2.14-1960. Sponsor — Steel Shipping Container Institute.

FULL REMOVABLE HEAD UNIVERSAL DRUMS



*Canadian 220 liter drum I.D. is 22-1/2".



Detail of configuration for three-rollng hoop 55-gal. drum.

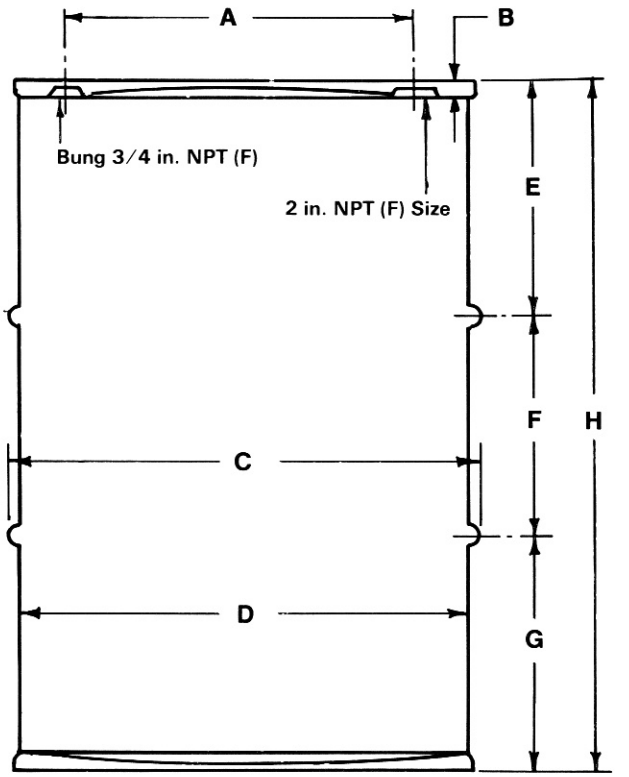
Size	Imperial Size	Volume (gal. U.S.)	Body Material	Dimensions (inches)									
				A	B	C	D	E	F	G	H	I	J
55-gal. (U.S.)	45-gal.	57.2-57.75	Steel 18 gage	23 11/16		7/8	23 1/2	23 17/32	22 1/2	11 7/8	11	11 7/8	34 3/4
55-gal.[1] (U.S.)	45-gal	59.28-59.85	Steel 18 gage	23 11/16		7/8	23 1/2	23 27/32	22 1/2	12 1/2	11	12 1/2	36
55-gal. (U.S.)	45-gal	57.2-57.75	Steel 18 gage	23 11/16	3/8	7/8	23 1/2	23 27/32	22 1/2		11	11 11/16	34 3/8
30-gal. (U.S.)	25-gal	31.2-31.45	Steel 18 gage	19 7/16	3/8	7/8	19 1/4	19 19/32	18 1/4	8 7/8	11	8 7/8	28 3/4
30-gal. (U.S.)	25-gal	31.2-31.45	Steel 19 gage	19 7/16		7/8	19 1/4	19 19/32	18 1/4	8 7/8	11	8 7/8	28 3/4
16-gal. (U.S.)		16	Steel 20 gage	14 3/4		5/8	14 9/16	14 7/8	13 15/16	7 5/8	11	8	26 5/8
16-gal.[2] (U.S.)		16.64-16.89	Steel 20 gage	14 3/4		Lug Cover	14 9/16	14 7/8	13 15/16	7 5/8	11	8	26 5/8

*See inset for special dimensions

[1]also 400-lb. edible fats drum

[2]also 120-lb. grease drum

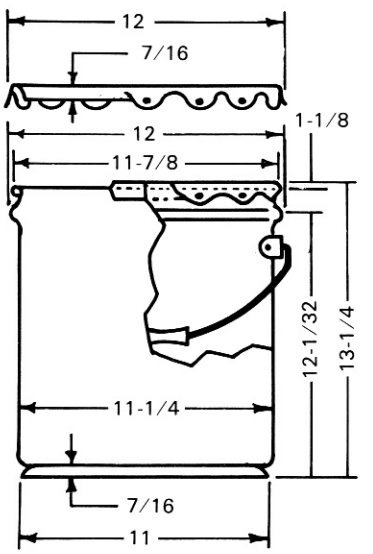
TIGHT HEAD UNIVERSAL DRUMS (NON-REMOVEABLE COVER)



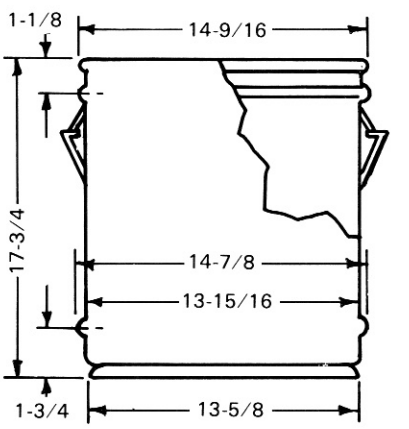
Size	Imperial Size	Volume (gal. U.S.)	Body Material	Dimensions (inches)							
				A	B	C	D	E	F	G	H
55-gal. (U.S.)	45-gal.	57.2-57.75	Steel 18 gage	17 1/4-17 3/4	3/4	23 7/16	22 1/2	11 7/8	11	11 7/8	34 3/4
55-gal. (U.S.)	45-gal.	57.2-57.75	Steel 16 gage	17 1/4-17 3/4	7/8	23 7/16	22 1/2	12 1/32	11	12 1/32	35 1/16
55-gal. (U.S.)	45-gal.	57.2-57.75	Steel 16 gage	17 1/4-17 3/4	3/4	23 7/16	22 1/2	11 29/32	11	11 29/32	34 13/16
30-gal. (U.S.)	25-gal.	31.2-31.5	Steel 19 gage	13-13 1/2	3/4	19 3/16	18 1/4	8 15/16	11	8 15/16	28 7/8
16-gal. (U.S.)		16.64-16.89	Steel 20 gage	9-9 3/8		14 7/8	13 15/16	7 7/8	11	8	26 7/8

5 AND 10-GALLON UNIVERSAL PAILS

Size	Volume (gals. U.S.)	Body Material
5-gal (U.S.) Lug Cover	5.2-5.45	Steel 24 gage
10-gal. (U.S.) Open Head		Steel 22 gage



5-gal, lug cover, universal pail



10-gal., open head, drop handle pail

FILTRATION

WHAT IS FILTRATION?

In a hydraulic system filtration is the removal of contaminants from the fluid. The better the filtration, the longer the component life.

In general, the filter that removes the most contaminants is the best filter. The degree of filtration is usually expressed in terms of the size (in microns) of the smallest particle that will not pass through the filter.

In a hydraulic system, a 25 micron filter is adequate. A 10 micron filter is better. A 5 micron filter is better than a 10 micron. A 2 micron filter is better than a 5 micron filter.

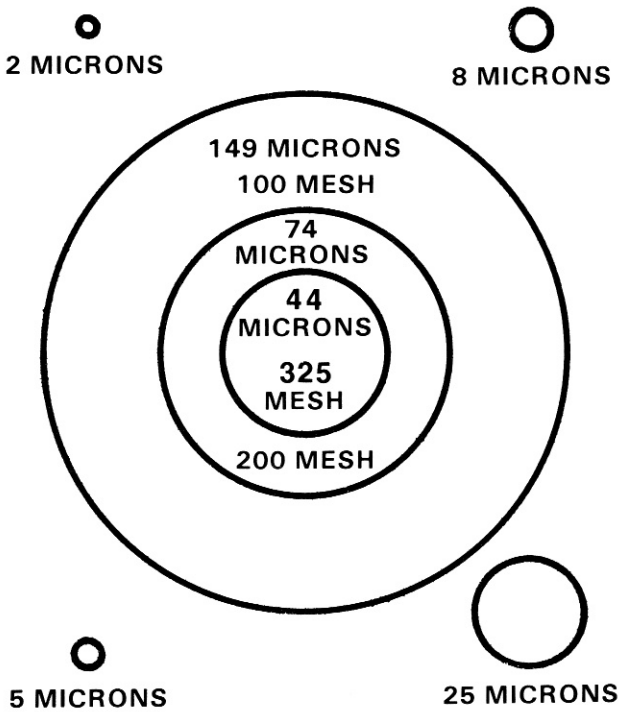
Selection of the ideal filter size depends not only on degree of filtration but also on the cost of filtration. Fine filtration requires almost constant maintenance. It also causes excessive pressure drops which contribute to inefficiencies in the system. When deciding which filter is most ideal for the Graco type of hydraulic system, all these factors were considered.

The result was the inclusion of a 10 micron element with each return line filter supplied as part of a hydraulic power supply. The 10 micron filter optimizes filtration and efficiency while it minimizes maintenance costs.

This filter is located in the return line. It has a W.P. Of 300 P.S.I. and shall never be placed in any part of the system where it can be subjected to greater pressures; e.g., upstream side of return line ball valve. Important note: *No valving shall ever be located on the down-stream side of the return line filter.* By locating this filter in the return line, we can be assured that any contaminants remaining in the tubing after installation shall never reach the vane pump. The return line filter also eliminates the need for high cost-high pressure filters in the supply line.

RELATIVE SIZE OF MICRONIC PARTICLES

MAGNIFICATION 500 TIMES



RELATIVE SIZES

Lower Limit of Visibility (Naked Eye)	40 Microns
White Blood Cells	25 Microns
Red Blood Cells	8 Microns
Bacteria (Cocci)	2 Microns

LINEAR EQUIVALENTS

1 Inch	25.4 Millimeters	25,400 Microns
1 Millimeter	.0394 Inches	1,000 Microns
1 Micron	25,4000 of an Inch	.001 Millimeters
1 Micron	3.94×10^{5}	.000039 Inches

SCREEN SIZES

Meshes Per Linear Inch	U.S. Sieve No.	Opening In Inches	Opening In Microns
52.36	50	.0117	297
72.45	70	.0083	210
101.01	100	.0059	149
142.86	140	.0041	105
200.00	200	.0029	74
270.26	270	.0021	53
323.00	325	.0017	44
		.00039	10
		.000019	.5

WIRE SCREEN DATA FOR FILTERS

MESH	MICRON	OPENING INCHES	WIRE DIA. INCHES	OPEN AREA
5	3000	.159	.041	36%
7-1/2	1980	.079	.054	35%
10	1480	.075	.025	35%
16	975	.045	.018	34%
20	750	.035	.015	36%
30	500	.022	.011	35%
40	375	.015	.010	36%
50	300	.011	.009	36%
60	238	.010	.0065	30.5%
80	175	.007	—	—
100	149	.006	.0045	30.3%
140	100	.004	—	—
200	74	.0029	.0021	29.2%
250	60	.0024	.0016	36%
270	50	.0021	.0016	32.1%
325	40	.0017	.0014	30.5%
400	35	.0015	—	—

GENERAL CONVERSION DATA

MISCELLANEOUS CONVERSION FACTORS

TO CONVERT FROM	TO	MULTIPLY BY
Centimeters	feet	.03280
Centimeters	inches	.3937
Centimeters/min.	feet/min.	1.9684
Centimeters/sec.	feet/sec.	.03281
Cubic centimeters	cu. ft.	3.5314×10^{-5}
Cubic centimeters	cu. in.	.06102
Cubic centimeters	gallons (liq.)	.0002642
Cubic feet	gallons (liq.)	7.4805
Cubic feet	cubic in.	1728
Cubic feet/min.	g.p.m.	7.4805
Cubic inches	gallons	.004329
Cubic inches	cubic cm.	16.387
Cubic inches	cubic ft.	.0005787
Cubic meters	gallons (liq.)	264.17
Cubic meters	cu. cm.	1×10^{6}
Cubic meters	cu. ft.	35.31
Cubic meters	cu. in.	61,023.38
Feet	centimeters	30.48006
Feet	meters	.3048006
Feet of water	atmosphere	.02949
Feet of water	psi	.433
Feet/hr	miles/hour	.00018933
Feet/min.	meters/min.	.3048
Feet/min.	miles/hour	.01136
Feet/second	miles per hour	.681818
Gallons	cubic cm.	3,785.43
Gallons	cubic in.	231
Gallons	gallon (Imp.)	.83268
Gallons	cu. ft.	.13368
Gallons/min.	cu. ft./min.	.13368
Inches	feet	.083333
Inches	meters	.0254
Inches	millimeters	25.40005
Inches	mils	1000
Kilograms	pounds	2.2046
Kilograms/sq. cm.	psi	14.2233
Kilograms/sq. mm.	psi	1422.33
Liters	gallons	.264178
Meters	feet	3.2808
Meters	inches	39.37
Poise	centipoise	100.0
Pounds water	gallons	.11985
PSI	atmospheres (bar)	.06804
Square inches	sq. cm.	6.4516
Square inches	sq. ft.	.006944
Square inches	sq. mm.	645.163
Square millimeters	sq. in.	.0015499

To find diameter of a circle, multiply circumference by .31831.
To find circumference of a circle, multiply diameter by 3.1416.
To find area of a circle, multiply square of diameter by .7854.
To find surface of a sphere, multiply square of diameter by 3.1416.
To find side of an equal square, multiply diameter by .8862.
To find cubic inches in a sphere, multiply cube of diameter by .5236.
To find how many gallons are contained in a pipe or cylinder, divide the cubic contents by 231.
To find the cubic contents of a cylinder or pipe, multiply the area by the height or depth.

GENERAL CONVERSION DATA CONTINUED

AVERAGE ABSOLUTE ATMOSPHERIC PRESSURE

Altitude Above Sea Level	PSIA	IN Hg
0	14.7	29.9
500	14.4	29.4
1,000	14.2	28.9
1,500	13.9	28.3
2,000	13.7	27.8
3,000	13.2	26.8
4,000	12.7	25.9
5,000	12.2	24.9
6,000	11.7	24.0
7,000	13.3	23.1

METRIC PREFIXES

Mega	= 1,000,000
Kilo	= 1,000
Hecto	= 100
Deca	= 10
Deci	= .1
Centi	= .01
Milli	= .001
Micro	= .000,001

TEMPERATURE

(1.8 x °C) + 32	= °F
.555 (°F -32°)	= °C
Degrees Kelvin -273.2	= Degrees Centigrade

MISC.

Heat of Fusion Water = 144 BTU/Lb
Heat of Vaporization of Water = 970 BTU/Lb

VISCOSITY CONVERSION (APPROX)

Absolute Viscosity (Centipoise) = Kinematic Viscosity (Centistokes)
Specific Gravity

SSU x 0.216	=
Saybolt Furol x 2.16	=
Redwood Std x .237	=
Redwood Admiralty x 2.34	=
Engler-Degrees x 7.45	= Centistokes
Ford Cup #4 x 3.76	=
MacMichael x .415	=
Stormer x 2.81	=

FLOW

Lbs of Water/Hr x .002 = Gal Min
Gal/Min x 500 = Lbs of Water/Hr

Lbs of Fluid/Hr
x .002 = Gal Min
Specific Gravity

Liter Min x .264	= Gal/Min (US)
GPM x 3.785	= Liters/Min
Cu Meters/Hr x 4.4	= Gal/Min (US)
Gal/Min x 227	= C Meters/Hr
Kg of Water/Min x .264	= Gal/Min (US)
Gal Min x 3.8	= Kg of Water/Min

POWER

T (Ft Lb x RPM = T (In Lb) x RPM

$$HP = \frac{5250}{63025}$$

$$HP = \frac{\text{Disp (Gals) x RPM x PSI}}{1714 \times EFF}$$

Horsepower x .746	= Kilowatts
Horsepower x 42.44	= BTU/Min
Metric Horsepower x .9863	= Horsepower

LENGTH

Mils x .001	= Inches
Meters x 3.281	= Feet
Centimeters x .394	= Inches
Millimeters x .0394	= Inches
Microns x .0000394	= Inches

PRESSURE

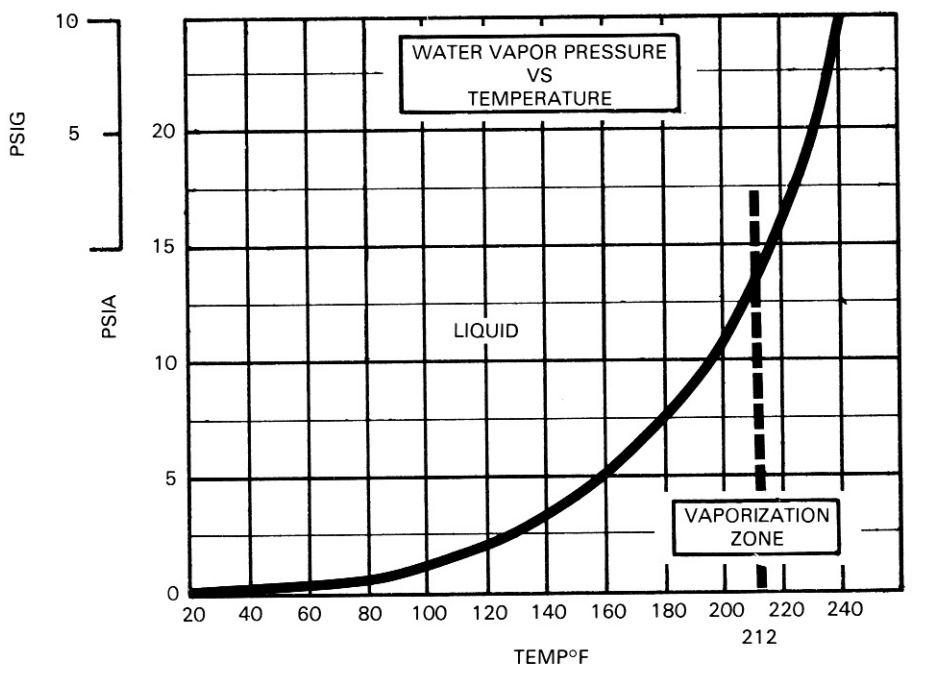
Ft of Water x .433	= PSI
PSI x 2.31	= Ft of Water
Inches Hg x .491	= PSI
Inches Hg x 1.133	= Ft of Water
ATM x 14.7	= PSI
ATM x 33.9	= Ft of Water
Kg/Sq cm x 14.22	= PSI
Meters of Water x 1.42	= PSI
ATM x 760	= mm Hg
mm Hg x .039	= Inches Hg
Bar x 14.5	= PSI
Newton/Meter^2 x 1	= Pascal
PSI x 6.9	= kPa (Kilopascal)
kPa x .145	= PSI

VOLUME

Lbs Water x .119	= Gal
Gal (Brit) x 1.2	= Gal (US)
Gal x 128	= Fluid Ounces
Cubic Ft x 7.48	= Gal
Cubic In x .00433	= Gal
Gal x 3.785	= Liters
Liter x .264	= Gal
Cubic Meters x 264.2	= Gallons
Cubic Meter x 1000	= Liter
Liters x 1000	= Cubic Centimeters
Cubic Centimeters x .0338	= Fluid Ounces
Fluid Ounces x 29.57	= Cubic Centimeters

MASS

Gal of Water x 8.336	= Lbs
Cubic Ft of Water x 62.4	= Lbs
Ounces x .0625	= Lbs
Kilograms x 2.2	= Lbs
Lbs x .454	= Kilograms
Metric Ton x 2205	= Lbs



MILLIMETER-INCH EQUIVALENTS

MM	Inches		MM	Inches		MM	Inches	
1	0.0394	1/32	51	2.0079	2	101	3.9764	3 31/32
2	0.0787	3/32	52	2.0472	2 1/16	102	4.0157	4 1/32
3	0.1181	1/8	53	2.0866	2 3/32	103	4.0551	4 1/16
4	0.1575	5/32	54	2.1260	2 1/8	104	4.0945	4 3/32
5	0.1969	3/16	55	2.1654	2 5/32	105	4.1339	4 1/8
6	0.2362	1/4	56	2.2047	2 7/32	106	4.1732	4 3/16
7	0.2756	9/32	57	2.2441	2 1/4	107	4.2126	4 7/32
8	0.3150	5/16	58	2.2835	2 9/32	108	4.2520	4 1/4
9	0.3543	11/32	59	2.3228	2 5/16	109	4.2913	4 9/32
10	0.3937	13/32	60	2.3622	2 3/8	110	4.3307	4 11/32
11	0.4331	7/16	61	2.4016	2 13/32	111	4.3701	4 3/8
12	0.4724	15/32	62	2.4409	2 7/16	112	4.4094	4 13/32
13	0.5118	1/2	63	2.4803	2 15/32	113	4.4488	4 7/16
14	0.5512	9/16	64	2.5197	2 17/32	114	4.4882	4 1/2
15	0.5906	19/32	65	2.5591	2 9/16	115	4.5276	4 17/32
16	0.6299	5/8	66	2.5984	2 19/32	116	4.5669	4 9/16
17	0.6693	21/32	67	2.6378	2 5/8	117	4.6063	4 19/32
18	0.7087	23/32	68	2.6772	2 11/16	118	4.6457	4 21/32
19	0.7480	3/4	69	2.7165	2 23/32	119	4.6850	4 11/16
20	0.7874	25/32	70	2.7559	2 3/4	120	4.7244	4 23/32
21	0.8268	13/16	71	2.7953	2 25/32	121	4.7638	4 3/4
22	0.8661	7/8	72	2.8346	2 27/32	122	4.8031	4 13/16
23	0.9055	29/32	73	2.8740	2 7/8	123	4.8425	4 27/32
24	0.9449	15/16	74	2.9134	2 29/32	124	4.8819	4 7/8
25	0.9843	31/32	75	2.9528	2 15/16	125	4.9213	4 29/32
26	1.0236	1 1/32	76	2.9921	3	126	4.9606	4 31/32
27	1.0630	1 1/16	77	3.0315	3 1/32	127	5.0000	5
28	1.1024	1 3/32	78	3.0709	3 1/16	128	5.0394	5 1/32
29	1.1417	1 5/32	79	3.1102	3 1/8	129	5.0787	5 3/32
30	1.1811	1 3/16	80	3.1496	3 5/32	130	5.1181	5 1/8
31	1.2205	1 7/32	81	3.1890	3 3/16	131	5.1575	5 5/32
32	1.2598	1 1/4	82	3.2283	3 7/32	132	5.1969	5 3/16
33	1.2992	1 5/16	83	3.2677	3 9/32	133	5.2362	5 1/4
34	1.3386	1 11/32	84	3.3071	3 5/16	134	5.2756	5 9/32
35	1.3780	1 3/8	85	3.3465	3 11/32	135	5.3150	5 5/16
36	1.4173	1 13/32	86	3.3858	3 3/8	136	5.3543	5 11/32
37	1.4567	1 15/32	87	3.4252	3 7/16	137	5.3937	5 13/32
38	1.4961	1 1/2	88	3.4646	3 15/32	138	5.4331	5 7/16
39	1.5354	1 17/32	89	3.5039	3 1/2	139	5.4724	5 15/32
40	1.5748	1 9/16	90	3.5433	3 17/32	140	5.5118	5 1/2
41	1.6142	1 5/8	91	3.5827	3 19/32	141	5.5512	5 9/16
42	1.6535	1 21/32	92	3.6220	3 5/8	142	5.5906	5 19/32
43	1.6929	1 11/16	93	3.6614	3 21/32	143	5.6299	5 5/8
44	1.7323	1 23/32	94	3.7008	3 11/16	144	5.6693	5 21/32
45	1.7717	1 25/32	95	3.7402	3 3/4	145	5.7087	5 23/32
46	1.8110	1 13/16	96	3.7795	3 25/32	146	5.7480	5 3/4
47	1.8504	1 27/32	97	3.8189	3 13/16	147	5.7874	5 25/32
48	1.8898	1 7/8	98	3.8583	3 27/32	148	5.8268	5 13/16
49	1.9291	1 15/16	99	3.8976	3 29/32	149	5.8661	5 7/8
50	1.9685	1 31/32	100	3.9370	3 15/16	150	5.9055	5 29/32

MM	Inches		MM	Inches		MM	Inches	
151	5.9449	5 15/16	201	7.9134	7 29/32	251	9.8819	9 7/8
152	5.9843	5 31/32	202	7.9528	7 15/16	252	9.9213	9 29/32
153	6.0236	6 1/32	203	7.9921	8	253	9.9606	9 31/32
154	6.0630	6 1/16	204	8.0315	8 1/32	254	10.0000	10
155	6.1024	6 3/32	205	8.0709	8 1/16	255	10.0394	10 1/32
156	6.1417	6 5/32	206	8.1102	8 1/8	256	10.0787	10 3/32
157	6.1811	6 3/16	207	8.1496	8 5/32	257	10.1181	10 1/8
158	6.2205	6 7/32	208	8.1890	8 3/16	258	10.1575	10 5/32
159	6.2598	6 1/4	209	8.2283	8 7/32	259	10.1969	10 3/16
160	6.2992	6 5/16	210	8.2677	8 9/32	260	10.2362	10 1/4
161	6.3386	6 11/32	211	8.3071	8 5/16	261	10.2756	10 9/32
162	6.3780	6 3/8	212	8.3465	8 11/32	262	10.3150	10 5/16
163	6.4173	6 13/32	213	8.3858	8 3/8	263	10.3543	10 11/32
164	6.4567	6 15/32	214	8.4252	8 7/16	264	10.3937	10 13/32
165	6.4961	6 1/2	215	8.4646	8 15/32	265	10.4331	10 7/16
166	6.5354	6 17/32	216	8.5039	8 1/2	266	10.4724	10 15/32
167	6.5748	6 9/16	217	8.5433	8 17/32	267	10.5118	10 1/2
168	6.6142	6 5/8	218	8.5827	8 19/32	268	10.5512	10 9/16
169	6.6535	6 21/32	219	8.6220	8 5/8	269	10.5906	10 19/32
170	6.6929	6 11/16	220	8.6614	8 21/32	270	10.6299	10 5/8
171	6.7323	6 23/32	221	8.7008	8 11/16	271	10.6693	10 21/32
172	6.7717	6 25/32	222	8.7402	8 3/4	272	10.7087	10 23/32
173	6.8110	6 13/16	223	8.7795	8 25/32	273	10.7480	10 3/4
174	6.8504	6 27/32	224	8.8189	8 13/16	274	10.7874	10 25/32
175	6.8898	6 7/8	225	8.8583	8 27/32	275	10.8268	10 13/16
176	6.9291	6 15/16	226	8.8976	8 29/32	276	10.8661	10 7/8
177	6.9685	6 31/32	227	8.9370	8 15/16	277	10.9055	10 29/32
178	7.0079	7	228	8.9764	8 31/32	278	10.9449	10 15/16
179	7.0472	7 1/16	229	9.0157	9 1/32	279	10.9843	10 31/32
180	7.0866	7 3/32	230	9.0551	9 1/16	280	11.0236	11 1/32
181	7.1260	7 1/8	231	9.0945	9 3/32	281	11.0630	11 1/16
182	7.1654	7 5/32	232	9.1339	9 1/8	282	11.1024	11 3/32
183	7.2047	7 7/32	233	9.1732	9 3/16	283	11.1417	11 5/32
184	7.2441	7 1/4	234	9.2126	9 7/32	284	11.1811	11 3/16
185	7.2835	7 9/32	235	9.2520	9 1/4	285	11.2205	11 7/32
186	7.3228	7 5/16	236	9.2913	9 9/32	286	11.2598	11 1/4
187	7.3622	7 3/8	237	9.3307	9 11/32	287	11.2992	11 5/16
188	7.4016	7 13/32	238	9.3701	9 3/8	288	11.3386	11 11/32
189	7.4409	7 7/16	239	9.4094	9 13/32	289	11.3780	11 3/8
190	7.4803	7 15/32	240	9.4488	9 7/16	290	11.4173	11 13/32
191	7.5197	7 17/32	241	9.4882	9 1/2	291	11.4567	11 15/32
192	7.5591	7 9/16	242	9.5276	9 17/32	292	11.4961	11 1/2
193	7.5984	7 19/32	243	9.5669	9 9/16	293	11.5354	11 17/32
194	7.6378	7 5/8	244	9.6063	9 19/32	294	11.5748	11 9/16
195	7.6772	7 11/16	245	9.6457	9 21/32	295	11.6142	11 5/8
196	7.7165	7 23/32	246	9.6850	9 11/16	296	11.6535	11 21/32
197	7.7559	7 3/4	247	9.7244	9 23/32	297	11.6929	11 11/16
198	7.7953	7 25/32	248	9.7638	9 3/4	298	11.7323	11 23/32
199	7.8346	7 27/32	249	9.8031	9 13/16	299	11.7717	11 25/32
200	7.8740	7 7/8	250	9.8425	9 27/32	300	11.8110	11 13/16

FAHRENHEIT-CENTIGRADE CONVERSION TABLE

Fahr.	Centi.	Fahr.	Centi.	Fahr.	Centi.
—20	—28.9	88	31.1	196	91.1
—18	—27.8	90	32.2	198	92.2
—16	—26.7	92	33.3	200	93.3
—14	—25.6	94	34.4	202	94.4
—12	—24.4	96	35.6	204	95.6
—10	—23.3	98	36.7	206	96.7
—8	—22.2	100	37.8	208	97.8
—6	—21.1	102	38.9	210	98.9
—4	—20.	104	40.	212	100.
—2	—18.9	106	41.1	214	101.1
0	—17.8	108	42.2	216	102.2
2	—16.7	110	43.3	218	103.3
4	—15.6	112	44.4	220	104.4
6	—14.4	114	45.6	222	105.6
8	—13.3	116	46.7	224	106.7
10	—12.2	118	47.8	226	107.8
12	—11.1	120	48.9	228	108.9
14	—10.	122	50.	230	110.
16	—8.9	124	51.1	232	111.1
18	—7.8	126	52.2	234	112.2
20	—6.7	128	53.3	236	113.3
22	—5.6	130	54.4	238	114.4
24	—4.4	132	55.6	240	115.6
26	—3.3	134	56.7	242	116.7
28	—2.2	136	57.8	244	117.8
30	—1.1	138	58.9	246	118.9
32	0.	140	60.	248	120.
34	1.1	142	61.1	250	121.1
36	2.2	144	62.2	252	122.2
38	3.3	146	63.3	254	123.3
40	4.4	148	64.4	256	124.4
42	5.6	150	65.6	258	125.6
44	6.7	152	66.7	260	126.7
46	7.8	154	67.8	262	127.8
48	8.9	156	68.9	264	128.9
50	10.	158	70.	266	130.
52	11.1	160	71.1	268	131.1
54	12.2	162	72.2	270	132.2
56	13.3	164	73.3	272	133.3
58	14.4	166	74.4	274	134.4
60	15.6	168	75.6	276	135.6
62	16.7	170	76.7	278	136.7
64	17.8	172	77.8	280	137.8
66	18.9	174	78.9	282	138.9
68	20.	176	80.	284	140.
70	21.1	178	81.1	286	141.1
72	22.2	180	82.2	288	142.2
74	23.3	182	83.3	290	143.3
76	24.4	184	84.4	292	144.4
78	25.6	186	85.6	294	145.6
80	26.7	188	86.7	296	146.7
82	27.8	190	87.8	298	147.8
84	28.9	192	88.9	300	148.9
86	30.	194	90.		

DECIMAL EQUIVALENTS

1/64	.0156	33/64	.5156
1/32	.0312	17/32	.5312
3/64	.0468	35/64	.5468
1/16	.0625	9/16	.5625
5/64	.0781	37/64	.5781
3/32	.0937	19/32	.5937
7/64	.1093	39/64	.6093
1/8	.125	5/8	.625
9/64	.1406	41/64	.6406
5/32	.1562	21/32	.6562
11/64	.1718	43/64	.6718
3/16	.1875	11/16	.6875
13/64	.2031	45/64	.7031
7/32	.2187	23/32	.7187
15/64	.2343	47/64	.7343
1/4	.250	3/4	.750
17/64	.2656	49/64	.7656
9/32	.2812	25/32	.7812
19/64	.2968	51/64	.7968
5/16	.3125	13/16	.8125
21/64	.3281	53/64	.8281
11/32	.3437	27/32	.8437
23/64	.3593	55/64	.8593
3/8	.375	7/8	.875
25/64	.3906	57/64	.8906
13/32	.4062	29/32	.9062
27/64	.4218	59/64	.9218
7/16	.4375	15/16	.9375
29/64	.4531	61/64	.9531
15/32	.4687	31/32	.9687
31/64	.4843	63/64	.9843
1/2	.500	1	1.

COMPARATIVE EQUIVALENTS OF LIQUID MEASURES AND WEIGHTS

Measures and Weights for Comparison	MEASURE AND WEIGHT EQUIVALENTS OF ITEMS IN FIRST COLUMN						
	U.S. Gallon	Imperial Gallon	Cubic Inch	Cubic Foot	Cubic Meter	Liter	Pound
U.S. Gallon	1.	.83	231.	.13	.004	3.79	8.33
Imperial Gallon	1.20	1.	277.27	.16	.005	4.54	10.
Cubic Inch	.004	.004	1.	.00057	.000016	.02	.036
Cubic Foot	7.48	6.24	1728.	1.	.028	28.31	62.36
Cubic Meter	264.17	220.05	61023.	35.32	1.	1000.	2200.54
Liter	.26	.22	61.023	.04	.001	1.	2.20
Pound	.12	.1	27.72	.016	.00045	.45	1.