AIR OPERATED DOUBLE DIAPHRAGM

PUMP ENGINEERING HANDBOOK

NPT 1"
EXHAUST

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Index

Introduction

Many engineers, consultants, sales people and technicians who work with air-powered diaphragm pumps have occasions to refer to various charts, tables, curves and other data which is scattered throughout various books and publications. This handbook has been prepared in order to bring much of this information into a convenient and easy-to-use form. Hopefully the information contained in this handbook will be useful in both the office and plant. We have made this handbook specifically for air-powered diaphragm pumps and the people who use them. There will be reprints at a later date, so please let us know of any omissions or errors.

Edited by: David Hollen and Vaughn Mullet

Hydraulic Data

Return to Index

Some Guidance On Pump Selection

1-1/2" Pump

[Feet] [Meters]

DISCHARGE HEAD

100 PSI
85 PSI
70 PSI
60 PSI
45 PSI
30 PSI

50 SCFM
90 SCFM
20 SCFM

WATER DISCHARGE
Data based on 1-ft. flooded suction, ambient water.
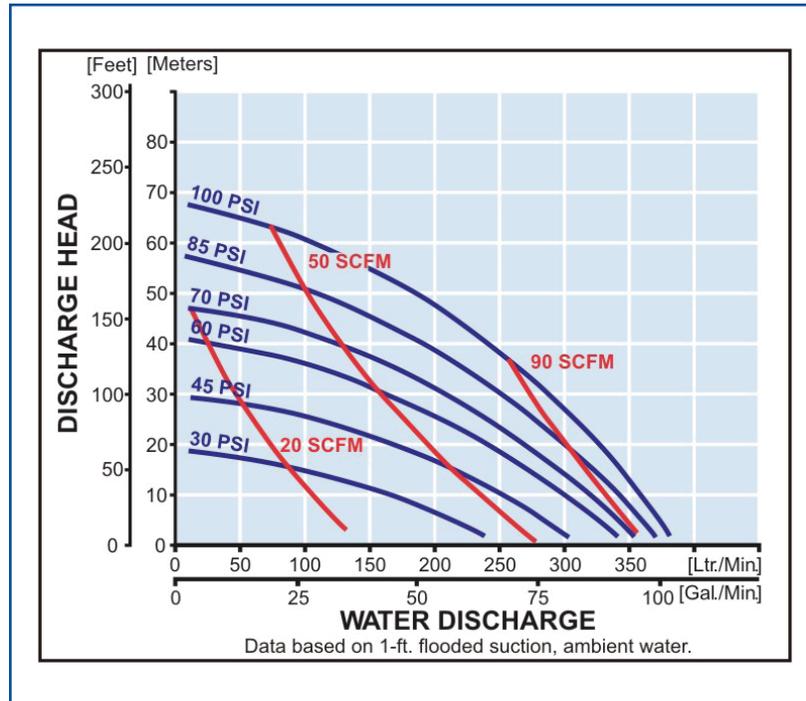
To prolong diaphragm life and optimize performance, one should recommend specifying a pump with a capacity approximately 1.5 times larger than required. This will prevent over speeding and lower liquid velosities thus extending diaphragm life and limiting abrasive wear on liquid end components.

To determine if a particular pump's performance meets your requirements, first determine the desired supply air pressure. The relation between the discharge pressure head and discharge volume at various air pressures is plotted on the performance curve with solid line.

Next, determine if the desired discharge volume and discharge pressure head fall under the selected supply air pressure curve. If so, the pump is adequate for your needs; if not, a larger capacity pump and/or higher supply pressure is required.

The dashed lines on the performance curve indicate air consumption at the desired discharge pressure head and discharge volume. Note that consumption is not affected by air supply pressure.

All test data in this product guide are at normal temperature (70°F) using fresh water and 1 ft. flooded suction. Discharge volume and discharge head may vary according to the characteristics (viscosity, specific gravity, etc.) of the liquid.

On the above performance curve, we have sized a pump for a system requiring 60 GPM @ 75' TDH. Please note that at this point on the performance curve the pump will require 60 PSIG air pressure and 35 SCFM air volume.

Common Terms and Definitions

The term "head' by itself is rather misleading. It is commonly taken to mean the difference in elevation between the suction level and the discharge level of the liquid being pumped. Although this is partially correct, it does not include all of the conditions that should be included to give an accurate description.

FRICTION HEAD
– is the pressure expressed in feet of liquid or lbs./sq. in. needed to overcome the resistance to the flow in the pipe and fittings.

SUCTION LIFT
– exists when the source of supply is below the center of the pump.

SUCTION HEAD/FLOODED SUCTION
– exists when the source of supply is above the center line of the pump. Also referred to as positive suction.

STATIC SUCTION LIFT
– is the vertical distance from the center line of the pump down to the free level of the liquid source.

STATIC SUCTION HEAD
– is the vertical distance from the center line of the pump up to the free level of the liquid source.

STATIC DISCHARGE HEAD
– is the vertical elevation from the center line of the pump to the point of free discharge.

DYNAMIC SUCTION LIFT
– includes static suction lift, friction head loss, and velocity head.

DYNAMIC SUCTION HEAD
– includes static suction head minus friction head minus velocity head.

DYNAMIC DISCHARGE HEAD
– includes static discharge head plus friction head plus velocity head.

TOTAL DYNAMIC HEAD
– includes the dynamic discharge head plus dynamic suction lift or minus dynamic suction head.

VELOCITY HEAD
– is the head needed to accelerate the liquid. Knowing the velocity of the liquid, the velocity head loss can be calculated by a simple formula Head=V^2/2g in which g is acceleration due to gravity or 32.16 ft/sec^2.

SPECIFIC GRAVITY
Direct ratio of any liquid's weight to the weight of water at 62°F. Water at 62°F weighs 8.33# per gallon and is designated 1.0 sp. gr.

VISCOSITY
Property of a liquid that resists any force tending to produce flow. It is the evidence of cohesion between the particles of a fluid which causes a liquid to offer resistance analogous to friction. An increase in the temperature usually reduces the viscosity; conversely, a temperature reduction usually increases the viscosity. Pipe friction loss increases as viscosity increases.

EFFECTS OF VISCOSITY
Viscous liquids tend to reduce pump efficiency, reduce capacity and increase pipe friction.

Head Requirement Calculation Guide

Required Head = Pipe Friction Loss ± Altitude Change ± Static Pressure Change

Pipe Friction Loss is always positive and is the head loss in feet due to friction resistance between the pipe walls and the moving liquid.

Altitude Change is the elevation difference in feet between the free liquid levels of the supply source and the pump. If the receiver level is higher than the supply level, altitude change is positive. If the pump level is lower than the supply, altitude change is negative.

Static Pressure Change is the difference in PSIG between gauge pressures of the supply vessel and the receiver. If the receiver gauge pressure is higher than that of the supply vessel, the static pressure change is positive. If the receiver gauge pressure is lower than that of the supply vessel, the static pressure change is negative.

Static head change is found by multiplying the gauge difference by $\dfrac{2.31}{\text{Specific Gravity}}$

Pumping Head Required for a given capacity in gallons per minute is determined as follows:

1. List all pipe fittings in separate groups according to pipe size. Save any special components (such as heat exchanges or filters) having manufacturer's head loss data for Step 6.
2. Convert fittings to equivalent lengths of pipe for each pipe size.
3. Add actual pipe length to equivalent pipe lengths of each pipe size.
4. Convert total equivalent pipe length (result of Step 3) to head loss for each pipe size according to the following formula:

$$\text{Head loss} = \frac{\text{Friction loss per 100 feet of pipe}}{100} \times \text{total equivalent pipe length}$$

5. Add friction losses for all pipe sizes together.
6. Add head loss of special components.
7. Add altitude change.
8. Convert static pressure change to feet (static head change) according to following formula:

$$\text{Static head change} = \text{Static pressure change (PSIG)} \times \frac{2.31}{\text{Specific Gravity}}$$

9. Add static head change (Step 8) to head total (thru Step 7). The resulting figure is the required pumping head or total dynamic head.

Net Positive Suction Head (NPSH)

NPSH combines all the factors limiting the suction side of a pump; internal pump losses, static suction lift, friction losses, vapor pressure and atmospheric conditions. It is important to differentiate between NPSH REQUIRED and NPSH AVAILABLE.

REQUIRED NPSH is a factor designed into a pump and measurable in the test laboratory by the manufacturer.

AVAILABLE NPSH is the term for providing sufficient pressure on the pump suction, at the inlet port centerline, to prevent "boiling." It is a function of the pumping system and consists of: pressure on the liquid at its source, the elevation of the liquid with respect to the inlet centerline, losses in the suction piping and vapor pressure of the liquid.

If the available NPSH is not equal to, or greater than, that required by the pump, it must be increased. This may be accomplished by increasing the static head, increasing pressure on the liquid supply surface, decreasing friction loss, or decreasing liquid temperature.

Determining NPSH Available

$$\text{NPSHA} = (\text{Barometer} + \text{Gauge} - \text{Vapor Pressure}) \times \frac{2.31}{\text{Specific Gravity}} \pm \text{Static Height} - \text{Pipe Loss}$$

BAROMETER valve in pounds per square inch absolute (PSIA) should be the lowest likely reading for the area where the pump will be installed. (Use table, page 9, to convert barometer reading in inches of mercury to PSIA.)

GAUGE PRESSURE (PSIG) is the pressure in pounds per square inch ABOVE atmospheric pressure on the surface of the liquid in the supply vessel.

VAPOR PRESSURE is the value in pounds per square inch absolute (PSIA) at which the liquid will boil at a given temperature.

STATIC HEIGHT is the distance in feet between the pump suction centerline and the surface level of the liquid in the supply vessel. If the surface level of the liquid is higher than the pump suction, static height is positive. If the surface level of the liquid is lower than the pump suction, static height is negative.

PIPE LOSS is the friction loss in feet between the supply vessel and the pump.

The NPSH information provided here is for general use will all pumps. However, when using a diaphragm pump (reciprocating pump) some additional allowances must be made. This additional requirement is "Acceleration Head." This is the head required to accelerate the liquid column on each suction stroke so that there will be no separation of this column in the pump or suction line.

If this minimum condition is not met, the pump may experience a fluid knock caused when the liquid column, which has a vapor space between it and the diaphragm, overtakes the receding diaphragm. This knock occurs approximately two-thirds of the way through the suction stroke.

If sufficient acceleration is provided for the liquid to completely follow the motion of the receding face of the diaphragm, this knock will disappear.

If there is insufficient head to meet minimum acceleration requirement of NPSH, the pump will experience cavitation resulting in loss of volumetric efficiency; also, damage may occur due to the forces in collapsing the gas or vapor bubbles.

Acceleration Head

Acceleration head — reciprocating pumps

Acceleration head is the head required to accelerate the fluid column is a function of the length of the suction line, the average velocity in this line, the cycle speed, the type of pump, and the relative elasticity of the fluid and the pipe; and it may be calculated as follows:

$$h_a = \frac{LVnC}{Kg}$$

where:

h_a = Acceleration head in feet

L = Length of suction line in feet

V = Velocity in suction line in fps

n = Pump speed in cycles per minute (cpm)

*C = Constant (for the type of pump)

C = 0.200 for duplex single-acting (diaphragm pump)

= 0.115 for duplex double-acting

= 0.066 for triplex single or double-acting

= 0.040 for quintuplex single or double-acting

= 0.028 for septuplex single or double-acting

= 0.022 for nonuplex single or double-acting

*K = A factor representing the reciprocal of the fraction of the theoretical acceleration head which must be provided to avoid a noticeable disturbance in the suction line: (K = 2.5 for hot oil, 2.0 most hydrocarbons, 1.5 amine, glycol, water, 1.4 deaerated water, 1.0 urea and liquids with small amounts of entrained gases).

g = Gravitation constant (32.174 ft/sec2)

A pulsation dampener properly installed in close proximity to the pump can absorb the cyclical flow variation and reduce the pressure fluctuation in the suction pipe to that corresponding to a length of 5 to 15 pipe diameters, if properly adjusted.

There is a similar pressure fluctuation on the discharge side of every diaphragm pump, but it cannot be analyzed as readily because of the greater influence of liquid and piping elasticity and the smaller diameter and much greater length of the discharge line in most applications. However, a pulsation dampener can be just as effective in absorbing the flow variation on the discharge side of the pump, as on the suction side, and should be used if pressure-fluctuation and piping vibration is a problem.

Example: A diaphragm pump running at 65 cycles per minute (50 gpm) with 20' of 2-1/2" suction pipe, the equation would be as follows:

$$\frac{20' \text{ (suction line length) x 3.35 (velocity) x 64 (cycles per minute) x 0.2}}{1.4 \text{ (water factor) x 32.174 (gravitational constant)}} = \frac{875.6}{45.04} = 19.44'$$

The total acceleration head is 19.44 feet.

This number can be both a positive and a negative number in the same application.

During the initiation of the intake stroke it will be a negative because the liquid in the suction line is at rest, and this number represents the energy to overcome the inertia of the liquid at rest.

At the end of the intake stroke, this will be a positive number because the liquid will be in motion and when the diaphragm comes to the end of its intake stroke, this is the energy required to decelerate the liquid. At this point there will be a pressure spike equivalent to this number.

A suction stabilizer is especially critical when using PTFE diaphragms.

yamada

Correcting Pump Head for Specific Gravity

1. Pump requirement must be expressed in feet of head. If requirement is given in pounds per square inch (PSI), it may be converted to feet using this formula:

$$\text{Ft. of Water} = \text{PSI} \times \frac{2.31}{\text{Specific Gravity}}$$

2. Select pump from performance curve.
3. Note pump air requirements.

Specific Gravity Conversion Tables

To convert degrees API to specific gravity (liquids lighter than water)

To convert degrees Baumé to specific gravity (liquids heavier than water)

$$\text{Sp. Gr.} = \frac{141.5}{131.5 + \text{Degrees API}}$$

$$\text{Sp. Gr.} = \frac{145}{145 - \text{Degrees Baumé}}$$

CONVERSION TABLE BAUMÉ

Specific Gravity — Weight per Gallon for liquids **HEAVIER** than water

Baumé	Specific Gravity	Wght. per Gal.	Baumé	Specific Gravity	Wght. per Gal.	Baumé	Specific Gravity	Wght. per Gal.	Baumé	Specific Gravity	Wght. per Gal.	Baumé	Specific Gravity	Wght. per Gal.
0	1.000	8.33	10	1.074	8.95	20	1.160	9.67	30	1.260	10.50	40	1.381	11.51
1	1.006	8.38	11	1.082	9.02	21	1.169	9.74	31	1.271	10.59	45	1.450	12.08
2	1.014	8.45	12	1.090	9.28	22	1.178	9.82	32	1.283	10.69	50	1.526	12.72
3	1.021	8.51	13	1.098	9.15	23	1.188	9.90	33	1.294	10.78	55	1.611	13.42
4	1.028	8.57	14	1.106	9.22	24	1.198	9.98	34	1.306	10.88	60	1.705	14.21
5	1.035	8.62	15	1.115	9.29	25	1.208	10.07	35	1.318	10.98	65	1.812	15.10
6	1.043	8.69	16	1.125	9.37	26	1.218	10.15	36	1.330	11.08	70	1.933	16.11
7	1.050	8.75	17	1.132	9.43	27	1.228	10.23	37	1.342	11.18	–	–	–
8	1.058	8.82	18	1.141	9.51	28	1.239	10.32	38	1.355	11.29	–	–	–
9	1.066	8.88	19	1.150	9.58	29	1.250	10.42	39	1.367	11.39	–	–	–

CONVERSION TABLE API

Specific Gravity — Weight per Gallon for liquids **LIGHTER** than water

API	Specific Gravity	Wght. per Gal.	API	Specific Gravity	Wght. per Gal.	API	Specific Gravity	Wght. per Gal.	API	Specific Gravity	Wght. per Gal.	API	Specific Gravity	Wght. per Gal.
10	1.000	8.33	31	0.871	7.25	52	0.7712	6.42	73	0.6926	5.76	91	.36	5.29
11	0.993	8.27	32	0.865	7.21	53	0.7670	6.39	74	0.6893	5.73	92	.633	5.27
12	0.986	8.21	33	0.860	7.16	54	0.7637	6.35	75	0.6859	5.70	93	.630	5.25
13	0.979	8.16	34	0.855	7.12	55	0.7597	6.32	76	0.6826	5.68	94	.628	5.22
14	0.973	8.10	35	0.850	7.08	56	0.7556	6.28	77	0.6793	5.65	95	.625	5.20
15	0.966	8.04	36	0.845	7.03	57	0.7516	6.28	78	0.6750	5.62	96	.622	5.18
16	0.959	7.99	37	0.840	6.99	58	0.7476	6.22	79	0.6728	5.60	97	.619	5.15
17	0.953	7.94	38	0.835	6.95	59	0.7437	6.18	80	0.6696	5.57	98	.617	5.13
18	0.946	7.88	39	0.830	6.91	60	0.7398	6.15	81	0.6665	5.54	99	.614	5.11
19	0.940	7.83	40	0.825	6.87	61	0.7359	6.12	82	.06634	5.52	100	.611	5.09
20	0.934	7.78	41	0.820	6.83	62	0.7310	6.09	83	0.6603	5.49	–	–	–
21	0.928	7.73	42	0.816	6.79	63	0.7283	6.06	84	0.6572	5.47	–	–	–
22	0.921	7.68	43	0.811	6.75	64	0.7246	6.03	85	0.6541	5.44	–	–	–
23	0.916	7.63	44	0.806	6.71	65	0.7209	5.99	86	0.6511	5.42	–	–	–
24	0.910	7.58	45	0.802	6.68	66	0.7172	5.96	87	.06481	5.39	–	–	–
25	0.904	7.53	46	0.797	6.64	67	0.7136	5.93	88	0.6452	5.37	–	–	–
26	0.898	7.48	47	0.793	6.60	68	0.7090	5.90	89	0.6422	5.34	–	–	–
27	0.893	7.43	48	0.788	6.56	69	0.7065	5.87	90	0.6393	5.32	–	–	–
28	0.887	7.39	49	0.784	6.53	70	0.7020	5.85	–	–	–	–	–	–
29	0.882	7.34	50	0.780	6.49	71	0.6995	5.82	–	–	–	–	–	–
30	0.876	7.30	51	0.775	6.46	72	0.6950	5.79	–	–	–	–	–	–

Properties of Water

PROPERTIES OF WATER

Temp °F	Absolute Vapor Pressure Psi.	Absolute Vapor Pressure Ft. Water	Specific Gravity (Water at 39.2°F = 1.000)	Temp. °F	Absolute Vapor Pressure Psi.	Absolute Vapor Pressure Ft. Water	Specific Gravity (Water at 39.2°F = 1.000)
60	0.26	0.59	0.999	205	12.77	30.6	0.961
70	0.36	0.89	0.998	206	13.03	31.2	0.960
80	0.51	1.2	0.997	207	13.30	32.0	0.960
85	0.60	1.4	0.996	208	13.57	32.6	0.960
90	0.70	1.6	0.995	209	13.84	33.2	0.959
100	0.95	2.2	0.993	210	14.12	33.9	0.959
110	1.27	3.0	0.991	211	14.41	34.6	0.958
120	1.69	3.9	0.989	212	14.70	35.4	0.958
130	2.22	5.0	0.986	213	14.99	36.2	0.957
140	2.89	6.8	0.983	214	15.29	37.0	0.957
150	3.72	8.8	0.981	215	15.59	37.7	0.957
151	3.81	9.0	0.981	216	15.90	38.4	0.956
152	3.90	9.2	0.980	217	16.22	39.2	0.956
153	4.00	9.4	0.980	218	16.54	40.0	0.956
154	4.10	9.7	0.979	219	16.86	40.8	0.955
155	4.20	9.9	0.979	220	17.19	41.6	0.955
156	4.31	10.1	0.979	221	17.52	42.5	0.955
157	4.41	10.4	0.978	222	17.86	43.3	0.954
158	4.52	10.7	0.978	223	18.21	44.2	0.954
159	4.63	10.9	0.978	224	18.56	45.0	0.953
160	4.74	11.2	0.977	225	18.92	45.9	0.953
161	4.85	11.5	0.977	226	19.28	46.8	0.953
162	4.97	11.7	0.977	227	19.65	47.7	0.952
163	5.09	12.0	0.976	228	20.02	48.6	0.952
164	5.21	12.3	0.976	229	20.04	49.5	0.951
165	5.33	12.6	0.976	230	20.78	50.5	0.951
166	5.46	12.9	0.975	231	21.17	51.4	0.951
167	5.59	13.3	0.975	232	21.57	52.5	0.950
168	5.72	13.6	0.974	233	21.97	53.5	0.950
169	5.85	13.9	0.974	234	22.38	54.5	0.950
170	5.99	14.2	0.974	235	22.80	55.5	0.949
171	6.13	14.5	0.973	236	23.22	56.6	0.949
172	6.27	14.9	0.973	237	23.65	57.8	0.948
173	6.42	15.2	0.973	238	24.09	58.8	0.948
174	6.56	15.6	0.972	239	24.53	59.8	0.948
175	6.71	15.9	0.972	240	24.97	61.0	0.947
176	6.87	16.3	0.972	241	25.43	62.1	0.947
177	7.02	16.7	0.971	242	25.89	63.3	0.946
178	7.18	17.1	0.971	243	26.36	64.5	0.946
179	7.34	17.4	0.971	244	26.73	65.6	0.946
180	7.51	17.8	0.970	245	27.31	66.8	0.945
181	7.68	18.3	0.970	250	29.83	73.2	0.943
182	7.85	18.7	0.970	260	35.44	87.4	0.938
183	8.02	19.1	0.969	270	41.87	103.6	0.933
184	8.20	19.5	0.969	280	49.22	122.8	0.927
185	8.38	20.0	0.969	290	57.57	144.0	0.923
186	8.57	20.4	0.968	300	67.0	168.6	0.918
187	8.76	20.9	0.968	310	77.7	197.0	0.913
188	8.95	21.4	0.967	320	89.7	228.4	0.908
189	9.14	21.8	0.967	330	103.0	264.0	0.902
190	9.34	22.3	0.966	340	118.0	305.0	0.896
191	9.54	22.8	0.966	350	134.6	349.0	0.891
192	9.75	23.3	0.965	360	153.0	399.2	0.886
193	9.96	23.8	0.965	380	195.8	517.7	0.874
194	10.17	24.3	0.965	400	247.3	663.9	0.861
195	10.38	24.9	0.964	420	308.8	842.4	0.847
196	10.60	25.4	0.964	440	381.6	1058.5	0.833
197	10.83	25.9	0.963	460	466.9	1318.0	0.818
198	11.06	26.6	0.963	480	566.1	1630.5	0.802
199	11.29	27.1	0.963	500	580.8	2000.1	0.786
200	11.53	27.6	0.963	520	812.4	2445.5	0.767
201	11.77	28.2	0.962	540	962.5	2980.4	0.746
202	12.01	28.8	0.962				
203	12.26	29.4	0.962				
204	12.51	30.0	0.961				

ATMOSPHERIC PRESSURE AND BOILING POINT OF WATER AT VARIOUS ALTITUDES

Altitude (feet)	Barometer Inches Mercury	Atmospheric Pressure PSIA	Atmospheric Pressure (ft. water)	Boiling Point °F
−1000	31.0	15.2	35.1	213.8
−500	30.5	15.0	34.6	212.9
0.0	29.9	14.7	33.9	212.0
+500	29.4	14.4	33.3	211.1
+1000	28.9	14.2	32.8	210.2
+1500	28.3	13.9	32.1	209.3
+2000	27.8	13.7	31.5	208.4
+2500	27.3	13.4	31.0	207.4
+3000	26.8	13.2	30.4	206.5
+3500	26.3	12.9	29.8	205.6
+4000	25.8	12.7	29.2	204.7
+4500	25.4	12.4	28.8	203.8
+5000	24.9	12.2	2.82	202.9
+5500	24.4	12.0	27.6	201.9
+6000	24.0	11.8	27.2	201.0
+6500	23.5	11.5	26.7	200.1
+7000	23.1	11.3	26.2	199.2
+7500	22.7	11.1	25.7	198.3
+8000	22.2	10.9	25.2	197.4
+8500	21.8	10.7	24.7	196.5
+9000	21.4	10.5	24.3	195.5
+9500	21.0	10.3	23.8	194.6
+10000	20.6	10.1	23.4	193.7
+15000	16.9	8.3	19.2	184.0

VACUUM CONVERSION DATA

Vacuum Inches, Mercury	Equivalents PSIG	Equivalents Inches of Water	Equivalents Feet of Water	PSIA
30	14.70	407.70	33.90	0.00
29	14.21	393.60	32.80	0.49
28	13.72	380.05	31.60	0.98
27	13.23	366.40	30.50	1.47
26	12.74	352.90	29.40	1.96
25	12.25	339.30	28.30	2.45
24	11.76	325.70	27.10	2.94
23	11.27	312.10	26.00	3.43
22	10.78	298.60	24.90	3.92
21	10.29	285.06	23.70	4.41
20	9.80	271.40	22.60	4.90
19	9.31	257.80	21.50	5.39
18	8.82	244.30	20.30	5.88
17	8.33	230.70	19.20	6.37
16	7.84	217.70	18.00	6.86
15	7.35	203.60	17.00	7.35
14	6.86	190.02	15.80	7.84
13	6.37	176.40	14.70	8.33
12	5.88	162.80	13.50	8.82
11	5.39	149.30	12.40	9.31
10	4.90	135.70	11.30	9.80
9	4.41	122.10	10.20	10.29
8	3.92	108.50	9.00	10.75
7	3.43	95.00	7.90	11.27
6	2.94	81.40	6.80	11.76
5	2.45	67.80	5.70	12.25
4	1.96	54.20	4.50	12.74
3	1.47	40.70	3.40	18.23
2	0.98	27.10	2.30	13.72
1	0.49	13.60	1.13	14.21
0	0.00	0.00	0.00	14.70

Suction Lift Derate

Decrease in Pumping Rate for Specified Suction Lift

Decrease in Flow Rate as Suction Head Lift Rises
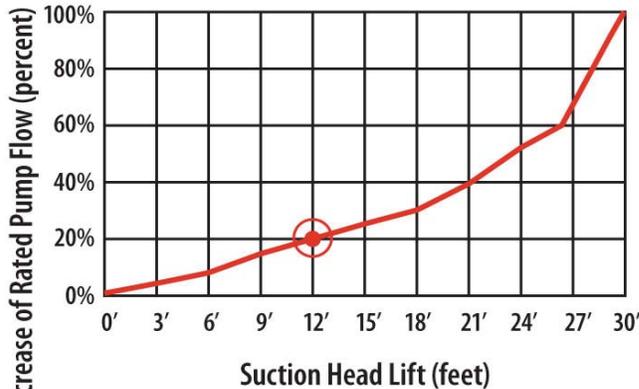
● Example: 20% loss of rated pump flow at 12-ft suction lift

Curve is applicable to 3/4" and larger pumps only.

EXAMPLE:

With a suction lift of 12 feet, the pumping rate decreases by approximately 20%. This figure varies with different pump configurations.

The derate curve is intended as a general guideline only for diaphragm pumps 3/4" and larger.

Due to the fact PTFE diaphragms do not have the flexing characteristics of rubber diaphragms, a shorter center rod is utilized. In turn, the capacity and suction lift capability of the PTFE fitted pump is decreased.

Diaphragm Pump Correction Factor For Viscous Liquids

Decrease in Flow Rate From Increase in Viscosity
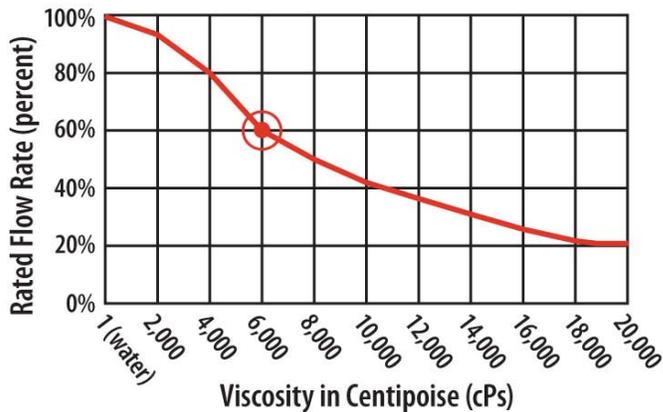
● Example: A fluid with viscosity of 6,000 cPs will transfer at 60% rated flow

Curve is applicable to 3/4" and larger pumps only.

Use the flow/capacity correction factor for selecting and determining the appropriate size diaphragm pump. Refer to the performance curves located in the sales brochure.

EXAMPLE: During the conveyance of a fluid with a viscosity of 6,000cPs, the pump rate decreases to 60% of its rated value (100% = water). Valid for 3/4" pumps and larger.

Capacity of Round Tanks

Dia.	Gals.	Area Sq. Ft.	Dia.	Gals.	Area Sq. Ft.	Dia.	Gals.	Area Sq. Ft.	Dia.	Gals.	Area Sq. Ft.
1' 0"	5.87	0.785	4' 0"	94.00	12.566	11' 0"	710.90	95.03	22' 0"	2843.60	380.13
1' 1"	6.89	0.922	4' 1"	97.96	13.095	11' 3"	743.58	99.40	22' 3"	2908.60	388.82
1' 2"	8.00	1.039	4' 2"	102.00	13.635	11' 6"	776.99	103.87	22' 6"	2974.30	397.61
1' 3"	9.18	1.227	4' 3"	106.12	14.186	11' 9"	811.14	108.43	22' 9"	3040.80	406.49
1' 4"	10.44	1.396	4' 4"	110.32	14.748	12' 0"	846.03	113.10	23' 0"	3108.00	415.48
1' 5"	11.79	1.576	4' 5"	114.61	15.321	12' 3"	881.65	117.86	23' 3"	3175.90	424.56
1' 6"	13.22	1.767	4' 6"	118.97	15.90	12' 6"	918.00	122.72	23' 6"	3244.60	433.74
1' 7"	14.73	1.969	4' 7"	123.42	16.50	12' 9"	955.09	126.78	23' 9"	3315.00	443.01
1' 8"	16.32	2.182	4' 8"	127.95	17.10	13' 0"	992.91	132.73	24' 0"	3384.10	452.39
1' 9"	17.99	2.045	4' 9"	132.56	17.72	13' 3"	1031.50	137.89	24' 3"	3455.00	461.86
1' 10"	19.75	2.640	4' 10"	137.25	18.35	13' 6"	1070.80	142.14	24' 6"	3526.60	471.44
1' 11"	21.58	2.885	4' 11"	142.02	18.99	13' 9"	1110.80	148.49	24' 9"	3598.90	481.11
2' 0"	23.50	3.142	5' 8"	188.66	25.22	14' 0"	1151.50	153.94	25' 0"	3672.00	490.87
2' 1"	25.50	3.409	5' 9"	194.25	25.97	14' 3"	1193.00	159.48	25' 3"	3745.80	500.74
2' 2"	27.58	3.687	5' 10"	199.92	26.73	14' 6"	1235.30	165.13	25' 6"	3820.30	510.71
2' 3"	29.74	3.976	5' 11"	205.67	27.49	14' 9"	1278.20	170.87	25' 9"	3895.60	527.77
2' 4"	31.99	4.276	6' 0"	211.51	28.27	15' 0"	1321.90	186.71	26' 0"	3971.60	530.93
2' 5"	34.31	4.587	6' 3"	229.50	30.68	15' 3"	13366.40	182.65	26' 3"	4048.40	541.19
2' 6"	36.72	4.909	6' 6"	248.23	35.18	15' 6"	1411.50	188.69	26' 6"	4125.90	551.55
2' 7"	39.21	5.241	6' 9"	267.69	35.78	15' 9"	1457.40	198.83	26' 9"	4204.10	562.00
2' 8"	41.78	5.585	7' 0"	287.88	38.48	16' 0"	1504.10	201.06	27' 0"	4283.00	572.66
2' 9"	44.43	5.940	7' 3"	308.81	41.28	16' 3"	1551.40	207.39	27' 3"	4362.70	583.21
2' 10"	47.16	6.305	7' 6"	330.48	44.18	16' 6"	1599.50	213.82	27' 6"	4443.10	593.96
2' 11"	49.98	6.681	7' 9"	352.88	47.17	16' 9"	1648.40	220.35	27' 9"	4524.30	604.81
3' 0"	52.88	7.069	8' 0"	376.01	50.27	19' 0"	2120.90	283.53	28' 0"	4606.20	615.75
3' 1"	55.86	7.467	8' 3"	399.80	53.46	19' 3"	2177.10	291.04	28' 3"	4688.80	626.80
3' 2"	58.92	7.876	8' 6"	424.48	56.75	19' 6"	2234.00	298.65	28' 6"	4772.10	637.94
3' 3"	62.06	8.296	8' 9"	449.82	60.13	19' 9"	2291.70	306.35	28' 9"	4856.20	649.18
3' 4"	65.28	8.727	9' 0"	475.89	63.62	20' 0"	2350.10	314.16	29' 0"	4941.00	660.52
3' 5"	68.58	9.168	9' 3"	502.70	67.20	20' 3"	2409.20	322.06	29' 3"	5026.60	671.96
3' 6"	71.97	9.621	9' 6"	530.24	70.88	20' 6"	2469.10	330.06	29' 6"	5112.90	683.49
3' 7"	75.44	10.085	9' 9"	558.51	74.66	20' 9"	2529.60	338.16	29' 9"	5199.90	695.13
3' 8"	78.99	10.559	10' 0"	587.52	78.54	21' 0"	2591.00	346.36	30' 0"	5287.70	706.86
3' 9"	82.62	11.045	10' 3"	617.26	82.52	21' 3"	2653.00	354.696	30' 3"	5376.20	718.69
3' 10"	86.33	11.541	10' 6"	640.74	86.59	21' 6"	2715.80	363.05	30' 6"	5465.40	730.62
3' 11"	90.13	12.048	10' 9"	678.95	90.76	21' 9"	2779.30	371.54	30' 9"	5555.40	742.64

To find the capacity of tanks greater than shown above, find a tank of one-half the size desired, and multiply its capacity by four, or find one one-third the size desired and multiply its capacity by 9.

Capacity of Square Tanks

DIMENSIONS IN FEET	CONTENTS IN GALLONS FOR DEPTH IN FEET							
	1'	4'	5'	6'	8'	10'	11'	12'
4 x 4	119.68	479.00	598.00	718.00	957.00	1197.00	1316.00	1436.00
5 x 5	187.00	748.00	935.00	1202.00	1516.00	1870.00	2057.00	2244.00
6 x 6	269.28	1077.00	1346.00	1616.00	2154.00	2693.00	2968.00	3231.00
7 x 7	366.52	1466.00	1833.00	2199.00	2922.00	3665.00	4032.00	4398.00
8 x 8	478.72	1915.00	2394.00	2872.00	3830.00	4787.00	5266.00	5745.00
9 x 9	605.88	2424.00	3029.00	3635.00	4847.00	6059.00	6665.00	7272.00
10 x 10	748.08	2992.00	3740.00	4488.00	5984.00	7480.00	8228.00	8976.00
11 x 11	905.08	3620.00	4525.00	5430.00	7241.00	9051.00	9956.00	10861.00
12 x 12	1077.12	4308.00	5386.00	6463.00	8617.00	10771.00	11848.00	12925.00

To find the capacity of a depth not given, multiply the capacity for one foot by the required depth in feet.

Theoretical Discharge of Nozzles in U.S. GPM

HEAD		Velocity of Discharge Feet Per Second	DIAMETER OF NOZZLE INCHES								
Pounds	Feet		1/16	1/8	3/16	1/4	3/8	1/2	5/8	3/4	7/8
10	23.1	38.6	0.37	1.48	3.32	5.91	13.3	23.6	36.9	53.1	72.4
15	34.6	47.25	0.45	1.81	4.06	7.24	16.3	28.9	45.2	65.0	88.5
20	46.2	54.55	0.52	2.09	4.69	8.35	18.8	33.4	52.2	75.1	102.0
25	57.7	61.0	0.58	2.34	5.25	9.34	21.0	37.3	58.3	84.0	114.0
30	69.3	66.85	0.64	2.56	5.75	10.2	23.0	40.9	63.9	92.0	125.0
35	80.8	72.2	0.69	2.77	6.21	11.1	24.8	44.2	69.0	99.5	135.0
40	92.4	77.2	0.74	2.96	6.64	11.8	26.6	47.3	73.8	106.0	145.0
45	103.9	81.8	0.78	3.13	7.03	12.5	28.2	50.1	78.2	113.0	153.0
50	115.5	86.25	0.83	3.30	7.41	13.2	29.7	52.8	82.5	119.0	162.0
55	127.0	90.4	0.87	3.46	7.77	13.8	31.1	55.3	86.4	125.0	169.0
60	138.6	94.5	0.90	3.62	8.12	14.5	32.5	57.8	90.4	130.0	177.0
65	150.1	98.3	0.94	3.77	8.45	15.1	33.8	60.2	94.0	136.0	184.0
70	161.7	102.1	0.98	3.91	8.78	15.7	35.2	62.5	97.7	141.0	191.0
75	173.2	105.7	1.01	4.05	9.08	16.2	36.4	64.7	101.0	146.0	198.0
80	184.8	109.1	1.05	4.18	9.39	16.7	37.6	66.8	104.0	150.0	205.0
85	196.3	112.5	1.08	4.31	9.67	17.3	38.8	68.9	108.0	155.0	211.0
90	207.9	115.8	1.11	4.43	9.95	17.7	39.9	70.8	111.0	160.0	217.0
95	219.4	119.0	1.14	4.56	10.2	18.2	41.0	72.8	114.0	164.0	223.0
100	230.9	112.0	1.17	4.67	10.0	18.7	42.1	74.7	117.0	168.0	229.0
105	242.4	125.0	1.20	4.79	10.8	19.2	43.1	76.5	120.0	172.0	234.0
110	254.0	128.0	1.23	4.90	11.0	19.6	44.1	78.4	122.0	176.0	240.0
115	265.5	130.9	1.25	5.01	11.2	20.0	45.1	80.1	125.0	180.0	245.0
120	277.1	133.7	1.28	5.12	11.5	20.5	46.0	81.8	128.0	184.0	251.0
125	288.6	136.4	1.31	5.22	11.7	20.9	47.0	83.5	130.0	188.0	256.0
130	300.2	139.1	1.33	5.33	12.0	21.3	48.0	85.2	133.0	192.0	261.0
135	311.7	141.8	1.36	5.43	12.2	21.7	48.9	86.7	136.0	195.0	266.0
140	323.3	144.3	1.38	5.53	12.4	22.1	49.8	88.4	138.0	199.0	271.0
145	334.8	146.9	1.41	5.62	12.6	22.5	50.6	89.9	140.0	202.0	275.0
150	346.4	149.5	1.43	5.72	12.9	22.9	51.5	91.5	143.0	206.0	280.0
175	404.1	161.4	1.55	6.18	13.9	24.7	55.6	98.8	154.0	222.0	302.0
200	461.9	172.6	1.65	6.61	14.8	26.4	59.5	106.0	165.0	238.0	323.0

Formulas & Conversions

Return to Index

English Standard to Metric

FLOW

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

$$\frac{\text{Lbs of Fluid/Hr}}{\text{Specific Gravity}} \times .002 = \text{Gal. Min}$$

Liters/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	= Cu Meters/Hr
Kg of Water/Min x .264	= gal/Min (US)
Gal/Min x 3.8	= Kg of Water/Min

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/Meter2 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

TEMPERATURE

(1.8 x 8C) + 32	= °F
.555 (°F – 32°)	= °C
Degrees Kelvin – 273.2	= Degrees Centigrade

LENGTH

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

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

POWER

$$HP = \frac{T\ (Ft\ Lb) \times RPM}{5250} = \frac{T\ (In\ Lb) \times RPM}{63025}$$

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

$$T(In\text{-}Lbs) = \frac{HP \times 5250}{RPM} \times 12$$

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

MISC

Average Absolute Atmospheric Pressure

Altitude Above Sea Level	PSIA	IN Hg
0 feet	14.7	29.9
500 feet	14.4	29.4
1,000 feet	14.2	28.9
1,500 feet	13.9	28.3
2,000 feet	13.7	27.8
3,000 feet	13.2	26.8
4,000 feet	12.7	25.9
5,000 feet	12.2	24.9
6,000 feet	11.7	24.0
7,000 feet	11.3	23.1

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

Metric Flow Formulas

Velocity: $V = \dfrac{Q}{A} = \dfrac{4Q}{\pi D^2} = \dfrac{1{,}273{,}240\ Q}{d2} = \dfrac{21.22\ q}{d2}$

velocity head: $h_v = \dfrac{V^2}{2\ g_c} = 0.050\ 99\ V^2 = \dfrac{0.082\ 66\ Q^2}{D^4} = \dfrac{22.958\ q^2}{d^4}$

head: $H = \dfrac{0.102\ kPa}{sp\ gr} = \dfrac{10.2\ B}{sp\ gr}$

power required: $P = \dfrac{Q(kPa)}{eff} = \dfrac{q(kPa)}{60{,}000\ x\ (eff)} = \dfrac{q(B)}{600(eff)} = \dfrac{q(H)\ sp\ gr}{6118(eff)}$

Reynolds no.: $R = \dfrac{VD}{v} = \dfrac{1000\ Vd}{k} = \dfrac{1{,}273{,}240\ Q}{Dk} = \dfrac{21{,}221\ q}{dk}$

Darcy friction formula: $H_f = \dfrac{fLV^2}{2\ g_c\ D} - \dfrac{0.082\ 66\ fLQ^2}{D^5} = \dfrac{22{,}965\ fLq^2}{d^5}$

Hazen & Williams friction formula: $H_f = 0.002\ 126L\left(\dfrac{100}{C}\right)^{1.85}\dfrac{Q^{1.85}}{D^{4.8655}} = 1214.6\ L\left(\dfrac{100}{C}\right)^{1.85}\dfrac{q^{1.85}}{d^{4.8655}}$

Symbols
To be used only with formulas above on this page

A = cross sectional area of pipe—m^2

B = pressure—bars = 100 kPa

C = Hazen & Williams friction factor

D = internal diameter of pipe—m

d = internal diameter of pipe—mm

eff = efficiency expressed as a decimal

f = friction factor for Darcy formula

g_c = acceleration due to gravity
    9.806 65m/sec^2

H = head in meters of liquid—m

H_f = friction loss in meters of liquid—m

h_v = velocity head in meters—m

k = kinematic viscosity—centistokes
    = 0.000 001 m^2/sec

kPa = pressure—kilopascals

L = length of pipe—meters—m

P = power for pumping—kilowatts—kW

Q = flow—m^3/sec

q = flow—liters per minute—L/min

R = Reynolds number

sp gr = density—kg/L–kg/dm^3–g/cm^3

V = velocity of flow—m/sec

v = kinematic viscosity—
    m^2/sec = 1,000,000 centistokes

United States Standard Baume Scales
Relation Between Baume Degrees and Specific Gravity

LIQUIDS HEAVIER THAN WATER

$$\text{Formula—sp gr} = \frac{145}{145 - °\text{ Baume}}$$

Baume degrees	Sp Gr 60° – 60°F	Baume degrees	Sp Gr 60° – 60°F	Baume degrees	Sp Gr 60° – 60°F	Baume degrees	Sp Gr 60° – 60°F
0	1.00000	20	1.16000	40	1.38095	60	1.70588
1	1.00694	21	1.16935	41	1.39423	61	1.72619
2	1.01399	22	1.17886	42	1.40777	62	1.74699
3	1.02113	23	1.18852	43	1.42157	63	1.76829
4	1.02837	24	1.19835	44	1.43564	64	1.79012
5	1.03571	25	1.20833	45	1.45000	65	1.81250
6	1.04317	26	1.21849	46	1.46465	66	1.83544
7	1.05072	27	1.22881	47	1.47959	67	1.85897
8	1.05839	28	1.23932	48	1.49485	68	1.88312
9	1.06618	29	1.25000	49	1.51042	69	1.90789
10	1.07407	30	1.26087	50	1.52632	70	1.93333
11	1.08209	31	1.27193	51	1.54255	71	1.95946
12	1.09023	32	1.28319	52	1.55914	72	1.98630
13	1.09848	33	1.29464	53	1.57609	73	2.01389
14	1.10687	34	1.30631	54	1.59341	74	2.04225
15	1.11538	35	1.31818	55	1.61111	75	2.07143
16	1.12403	36	1.33028	56	1.62921	76	2.10145
17	1.13281	37	1.34259	57	1.64773	77	2.13235
18	1.14173	38	1.35514	58	1.66667	78	2.16418
19	1.15079	39	1.36792	59	1.68605	79	2.19697

LIQUIDS LIGHTER THAN WATER

$$\text{Formula—sp gr} = \frac{140}{130 + °\text{ Baume}}$$

Baume degrees	Sp Gr 60° – 60°F	Baume degrees	Sp Gr 60° – 60°F	Baume degrees	Sp Gr 60° – 60°F	Baume degrees	Sp Gr 60° – 60°F
10	1.00000	30	0.87500	50	0.77778	70	0.70000
11	0.99291	31	0.86957	51	0.77348	71	0.69652
12	0.98592	32	0.86420	52	0.76923	72	0.69307
13	0.97902	33	0.85890	53	0.76503	73	0.68966
14	0.97222	34	0.85366	54	0.76087	74	0.68627
15	0.96552	35	0.84848	55	0.75676	75	0.68293
16	0.95890	36	0.84337	56	0.75269	76	0.67961
17	0.95238	37	0.83832	57	0.74866	77	0.67633
18	0.94595	38	0.83333	58	0.74468	78	0.67308
19	0.93960	39	0.82840	59	0.74074	79	0.66986
20	0.93333	40	0.82353	60	0.73684	80	0.66667
21	0.92715	41	0.81871	61	0.73298	81	0.66351
22	0.92105	42	0.81395	62	0.72917	82	0.66038
23	0.91503	43	0.80925	63	0.72539	83	0.65728
24	0.90909	44	0.80460	64	0.72165	84	0.65421
25	0.90323	45	0.80000	65	0.71795	85	0.65117
26	0.89744	46	0.79545	66	0.71428	86	0.64815
27	0.89172	47	0.79096	67	0.71066	87	0.64516
28	0.88608	48	0.78652	68	0.70707	88	0.64220
29	0.88050	49	0.78212	69	0.70352	89	0.63927

Relation Between Specific Gravity and Degree API at 60°F

$$\text{Specific Gravity} = \frac{141.5}{131.5 + °API}$$

Degrees A.P.I.	Specific Gravity	Degrees A.P.I.	Specific Gravity	Degrees A.P.I.	Specific Gravity
10	1.0000	40	0.8251	70	0.7022
11	0.9930	41	0.8203	71	0.6977
12	0.9861	42	0.8155	72	0.6952
13	0.9792	43	0.8109	73	0.6919
14	0.9725	44	0.8063	74	0.6886
15	0.9659	45	0.8017	75	0.6852
16	0.9593	46	0.7972	76	0.6819
17	0.9529	47	0.7927	77	0.6787
18	0.9465	48	0.7883	78	0.6754
19	0.9402	49	0.7839	79	0.6722
20	0.9340	50	0.7796	80	0.6690
21	0.9279	51	0.7753	81	0.6659
22	0.9218	52	0.7711	82	0.6628
23	0.9159	53	0.7669	83	0.6597
24	0.9100	54	0.7628	84	0.6566
25	0.9042	55	0.7587	85	0.6536
26	0.8984	56	0.7547	86	0.6506
27	0.8927	57	0.7507	87	0.6476
28	0.8871	58	0.7467	88	0.6446
29	0.8816	59	0.7428	89	0.6417
30	0.8762	60	0.7389	90	0.6388
31	0.8708	61	0.7351	91	0.6360
32	0.8654	62	0.7313	92	0.6331
33	0.8602	63	0.7275	93	0.6303
34	0.8550	64	0.7238	94	0.6275
35	0.8498	65	0.7201	95	0.6247
36	0.8448	66	0.7165	96	0.6220
37	0.8398	67	0.7128	97	0.6193
38	0.8348	68	0.7093	98	0.6166
39	0.8299	69	0.7057	99	0.6139
				100	0.6112

Relation Between Specific Gravity and Degrees Brix

Percent Sugar (Degrees Balling's or Brix) With Corresponding Specific Gravity and Degrees Baume. Temperature 60°F

Percent sugar Balling's or Brix 60°F–15.56°C	Specific Gravity 60° / 60°F	Degrees Baume 60°F	Percent sugar Balling's or Brix 60°F–15.56°C	Specific Gravity 60° / 60°F	Degrees Baume 60°F
0	1.0000	0.00	50	1.2328	27.38
1	1.0039	0.56	51	1.2384	27.91
2	1.0078	1.13	52	1.2439	28.43
3	1.0118	1.67	53	1.2496	28.96
4	1.0157	2.24	54	1.2552	29.48
5	1.0197	2.80	55	1.2609	30.00
6	1.0238	3.37	56	1.2667	30.53
7	1.0278	3.93	57	1.2724	31.05
8	1.0319	4.49	58	1.2782	31.56
9	1.0360	5.04	59	1.2841	32.08
10	1.0402	5.60	60	1.2900	32.60
11	1.0443	6.15	61	1.2959	33.11
12	1.0485	6.71	62	1.3019	33.63
13	1.0528	7.28	63	1.0379	34.13
14	1.0570	7.81	64	1.3139	34.64
15	1.0613	8.38	65	1.3200	35.15
16	1.0657	8.94	66	1.3261	35.66
17	1.0700	9.49	67	1.3323	36.16
18	1.0744	10.04	68	1.3384	36.67
19	1.0788	10.59	69	1.3447	37.17
20	1.0833	11.15	70	1.3509	37.66
21	1.0878	11.70	71	1.3573	38.17
22	1.0923	12.25	72	1.3636	38.66
23	1.0968	12.80	73	1.3700	39.16
24	1.1014	13.35	74	1.3764	39.65
25	1.1060	13.90	75	1.3829	40.15
26	1.1107	14.45	76	1.3894	40.64
27	1.1154	15.00	77	1.3949	41.12
28	1.1201	15.54	78	1.4025	41.61
29	1.1248	16.19	79	1.4091	42.10
30	1.1296	16.63	80	1.4157	42.58
31	1.1345	17.19	81	1.4224	43.06
32	1.1393	17.73	82	1.4291	43.54
33	1.1442	18.28	83	1.4359	44.02
34	1.1491	18.81	84	1.4427	44.49
35	1.1541	19.36	85	1.4495	44.96
36	1.1591	19.90	86	1.4564	45.44
37	1.1641	20.44	87	1.4633	45.91
38	1.1692	20.98	88	1.4702	46.37
39	1.1743	21.52	89	1.4772	46.34
40	1.1794	22.06	90	1.4842	47.31
41	1.1846	22.60	91	1.4913	47.77
42	1.1898	23.13	92	1.4984	48.23
43	1.1950	23.66	93	1.5055	48.69
44	1.2003	24.20	94	1.5126	49.14
45	1.2057	24.74	95	1.5198	49.59
46	1.2110	25.26	96	1.5270	50.05
47	1.2164	25.80	97	1.5343	50.49
48	1.2218	26.32	98	1.5416	50.94
49	1.2273	26.86	99	1.5489	51.39
			100	1.5563	51.93

Conversion Factors-Water Analysis

Examples: 5 Gr./gal. x 17.1 = 85.5 Ppm   103 Ppm x .07 = 7.21 Gr./Imp. Gal.

	Grains per U.S. Gallon	Grains per Imp. Gallon	Parts per Million or Mg./liter
Grains per U.S. Gal.	1.0000	1.20	17.1
Grains per Imp. Gal.	0.8350	1.00	14.3
Parts/Million or Milligrams/liter	0.0585	0.07	1.0

Pounds Per Cubic Foot at Various Specific Gravities

Specific Gravity	Lb. Per Cu. Ft.	Specific Gravity	Lb. Per Cu. Ft.	Specific Gravity	Lb. Per Cu. Ft.
0.90	56.16	1.40	87.36	1.90	118.56
0.91	56.78	1.41	87.98	1.91	119.18
0.92	57.41	1.42	88.61	1.92	119.81
0.93	58.03	1.43	89.23	1.93	120.43
0.94	58.66	1.44	89.86	1.94	121.06
0.95	59.28	1.45	90.48	1.95	121.68
0.96	59.90	1.46	91.10	1.96	122.30
0.97	60.53	1.47	91.73	1.97	122.93
0.98	61.15	1.48	92.35	1.98	123.55
0.99	61.78	1.49	92.98	1.99	124.18
1.00	62.40	1.50	93.60	2.00	124.80
1.01	63.02	1.51	94.22	2.01	125.42
1.02	63.65	1.52	94.85	2.02	126.05
1.03	64.27	1.53	95.47	2.03	126.67
1.04	64.90	1.54	96.10	2.04	127.30
1.05	65.52	1.55	96.72	2.05	127.92
1.06	66.14	1.56	97.34	2.06	128.54
1.07	66.77	1.57	97.97	2.07	129.17
1.08	67.39	1.58	98.59	2.08	129.79
1.09	68.02	1.59	99.22	2.09	130.42
1.10	68.64	1.60	99.84	2.10	131.04
1.11	69.26	1.61	100.46	2.11	131.66
1.12	69.89	1.62	101.09	2.12	132.28
1.13	70.51	1.63	101.71	2.13	132.91
1.14	71.14	1.64	102.34	2.14	133.54
1.15	71.76	1.65	102.96	2.15	134.16
1.16	72.38	1.66	103.58	2.16	134.78
1.17	73.01	1.67	104.21	2.17	135.41
1.18	73.63	1.68	104.83	2.18	136.03
1.19	74.26	1.69	105.46	2.19	136.66
1.20	74.88	1.70	106.08	2.20	137.28
1.21	75.50	1.71	106.70	2.21	137.90
1.22	76.13	1.72	107.33	2.22	138.53
1.23	76.75	1.73	107.95	2.23	139.15
1.24	77.38	1.74	108.58	2.24	139.78
1.25	78.00	1.75	109.20	2.25	140.40
1.26	78.62	1.76	109.82	2.26	141.02
1.27	79.25	1.77	110.45	2.27	141.65
1.28	79.87	1.78	111.07	2.28	142.27
1.29	80.50	1.79	111.70	2.29	142.90
1.30	81.12	1.80	112.32	2.30	143.52
1.31	81.74	1.81	112.94	2.31	144.14
1.32	82.37	1.82	113.57	2.32	144.77
1.33	82.99	1.83	114.19	2.33	145.39
1.34	83.62	1.84	114.82	2.34	146.02
1.35	84.24	1.85	115.44	2.35	146.64
1.36	84.86	1.86	116.06	2.36	147.26
1.37	85.49	1.87	116.69	2.37	147.89
1.38	86.11	1.88	117.31	2.38	148.51
1.39	86.74	1.89	117.94	2.39	149.14

Fahrenheit/Celsius Graph

$$\text{Deg. F.} = \frac{9}{5} \text{ Deg. C.} + 32. \qquad \text{Deg. C.} = \frac{5}{9} \text{ (Deg. F.} - 32)$$
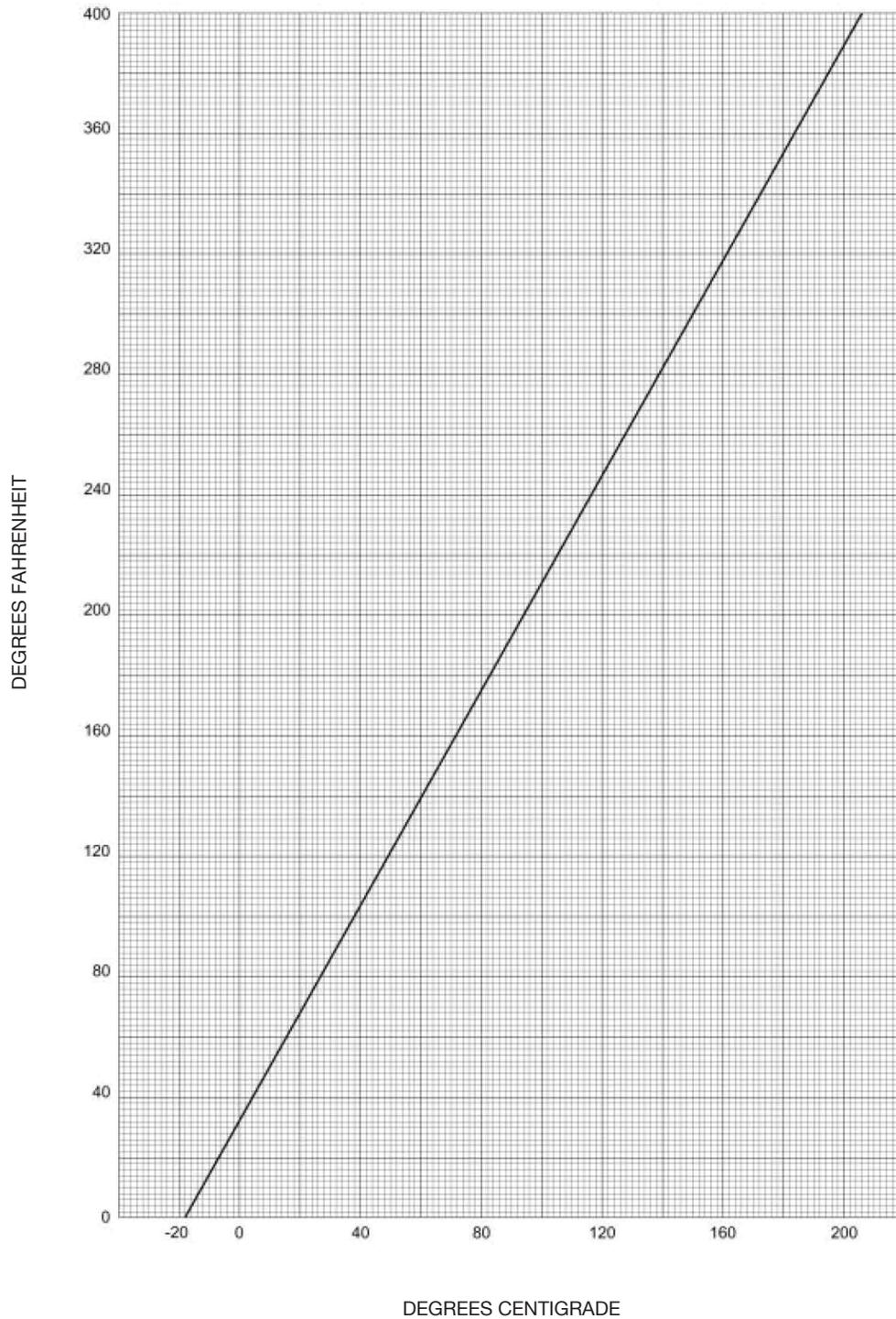
Conversion chart. Fahrenheit - Centigrade

Temperature Conversion Chart

Enter the table in the column marked "Temp" with the temperature either Fahrenheit or Celsius (Centigrade) that you wish to convert. if converting into Celsius, read the equivalent value in the column to the left. If converting into Fahrenheit, read the equivalent value in the column to the right.

°C	Temp	°F	°C	Temp	°F	°C	Temp	°F
-17.7	0	32.0	15.6	60	140.0	143	290	554
-17.2	1	33.8	16.1	61	141.8	149	300	572
-16.6	2	35.6	16.6	62	143.6	154	310	590
-16.1	3	37.4	17.1	63	145.4	160	320	608
-15.5	4	39.2	17.7	64	147.2	165	330	626
-15.0	5	41.0	18.2	65	149.0	171	340	644
-14.4	6	42.8	18.8	66	150.8	177	350	662
-13.9	7	44.6	19.3	67	152.6	182	360	680
-13.3	8	46.4	19.9	68	154.4	188	370	698
-12.7	9	48.2	20.4	69	156.2	193	380	716
-12.2	10	50.0	21.0	70	158.0	199	390	734
-11.6	11	51.8	21.5	71	159.8	204	400	752
-11.1	12	53.6	22.2	72	161.6	210	410	770
-10.5	13	55.4	22.7	73	163.4	215	420	788
-10.0	14	57.2	23.3	74	165.2	221	430	806
-9.4	15	59.0	23.8	75	167.0	226	440	824
-8.8	16	60.8	24.4	76	168.8	232	450	842
-8.3	17	62.6	25.0	77	170.6	238	460	860
-7.7	18	64.4	25.5	78	172.4	243	470	878
-7.2	19	66.2	26.2	79	174.2	249	480	896
-6.6	20	68.0	26.8	80	176.0	254	490	914
-6.1	21	69.8	27.3	81	177.8	260	500	932
-5.5	22	71.6	27.7	82	179.6	265	510	950
-5.0	23	73.4	28.2	83	181.4	271	520	968
-4.4	24	75.2	28.8	84	183.2	276	530	986
-3.9	25	77.0	29.3	85	185.0	282	540	1004
-3.3	26	78.8	29.9	86	186.8	288	550	1022
-2.8	27	80.6	30.4	87	188.6	293	560	1040
-2.2	28	82.4	31.0	88	190.4	299	570	1058
-1.6	29	84.2	31.5	89	192.2	304	580	1076
-1.1	30	86.0	32.1	90	194.0	310	590	1094
-0.6	31	87.8	32.6	91	195.8	315	600	1112
0.0	32	89.6	33.3	92	197.6	321	610	1130
0.5	33	91.4	33.8	93	199.4	326	620	1148
1.1	34	93.2	34.4	94	201.2	332	630	1166
1.6	35	95.0	34.9	95	203.0	338	640	1184
2.2	36	96.8	35.5	96	204.8	343	650	1202
2.7	37	98.6	36.1	97	206.8	349	660	1220
3.3	38	100.4	36.6	98	208.4	354	670	1238
3.8	39	102.2	37.1	99	210.2	360	680	1256
4.4	40	104.0	38	100	212	365	690	1274
4.9	41	105.8	43	110	230	371	700	1292
5.5	42	107.6	49	120	248	376	710	1310
6.0	43	109.4	54	130	266	382	720	1328
6.6	44	111.2	60	140	284	387	730	1346
7.1	45	113.0	65	150	302	393	740	1364
7.7	46	114.8	71	160	320	399	750	1382
8.2	47	116.6	76	170	338	404	760	1400
8.8	48	118.4	83	180	356	410	770	1418
9.3	49	120.2	88	190	374	415	780	1436
9.9	50	122.0	93	200	392	421	790	1454
10.4	51	123.8	99	210	410	426	800	1472
11.1	52	125.6	100	212	413	432	810	1490
11.5	53	127.4	104	220	428	438	820	1508
12.1	54	129.2	110	230	446	443	830	1526
12.6	55	131.0	115	240	464	449	840	1544
13.2	56	132.8	121	250	482	454	850	1562
13.7	57	134.6	127	260	500	460	860	1580
14.3	58	136.4	132	270	518	465	870	1598
14.8	59	138.2	138	280	536	471	880	1616

Decimal and Metric Equivalents

Equivalents of Common Fractions of an Inch

Fractional Inches	Decimal Inches	Metric (mm)
1/64	0.01562	0.397
1/32	0.03125	0.794
3/64	0.04688	1.191
1/16	0.06250	1.588
5/64	0.07812	1.984
3/32	0.09375	2.381
7/64	0.10938	2.778
1/8	0.12500	3.175
9/64	0.14062	3.572
5/32	0.15625	3.969
11/64	0.17188	4.366
3/16	0.18750	4.763
13/64	0.20312	5.159
7/32	0.21875	5.556
15/64	0.23438	5.953
1/4	0.25000	6.350
17/64	0.26562	6.747
9/32	0.28126	7.144
19/64	0.29688	7.541
5/16	0.31250	7.938
21/64	0.32812	8.334
11/32	0.34375	8.731
23/64	0.35938	9.128
3/8	0.37500	9.525
25/64	0.39062	9.922
13/32	0.40625	10.319
27/64	0.42188	10.716
7/16	0.43750	11.113
29/64	0.45312	11.509
15/32	0.46875	11.906
31/64	0.48438	12.303
1/2	0.50000	12.700
33/64	0.51562	13.097
17/32	0.53125	13.494
35/64	0.54688	13.891
9/16	0.56250	14.288
37/64	0.57812	14.684
19/32	0.59375	15.081
39/64	0.60938	15.478
5/8	0.62500	15.875
41/64	0.64062	16.272
21/32	0.65625	16.669
43/64	0.67188	17.066
11/16	0.68750	17.463
45/64	0.70312	17.859
23/32	0.71875	18.256
47/64	0.73438	18.653
3/4	0.75000	19.050
49/64	0.76562	19.447
25/32	0.78125	19.844
51/64	0.79688	20.241
13/16	0.81250	20.638
53/64	0.82812	21.034
27/32	0.84375	21.431
55/64	0.85938	21.828
7/8	0.87500	22.225
57/64	0.89062	22.622
29/32	0.90625	23.019
59/64	0.92188	23.416
15/16	0.93750	23.813
61/64	0.95312	24.209
31/32	0.96875	24.606
63/64	0.98438	25.003
1	1.00000	25.400

Friction Loss

Return to Index

yamada®

Friction Loss in Iron Pipe
Friction Loss Per 100 Feet for Water in New Wrought Iron or Schedule 40 Steel Pipe

1/4"
0.364" inside dia.

U.S. Gals. Per Min.	vel. V f.p.s.	vel. head $V^2/2g$ feet	frict. loss h_f feet
0.8	2.47	0.09	12.7
1.0	3.08	0.15	19.1
1.2	3.70	0.21	26.7
1.4	4.32	0.29	35.3
1.6	4.93	0.38	45.2
1.8	5.55	0.48	56.4
2.0	6.17	0.59	69.0
2.5	7.71	0.92	105.0
3.0	9.25	1.33	148.0
3.5	10.79	1.81	200.0
4.0	12.33	2.36	259.0
5.0	15.42	3.69	398.0

3/8"
0.493" inside dia.

U.S. Gals. Per Min.	vel. V f.p.s.	vel. head $V^2/2g$ feet	frict. loss h_f feet
1.4	2.35	0.09	7.85
1.6	2.68	0.11	10.1
1.8	3.02	0.14	12.4
2.0	3.36	0.18	15.0
2.5	4.20	0.27	22.6
3.0	5.04	0.39	31.8
3.5	5.88	0.54	42.6
4.0	6.72	0.70	54.9
5.0	8.40	1.10	83.5
6.0	10.08	1.58	118.0
7.0	11.80	2.15	158.0
8.0	13.40	2.81	205.0
9.0	15.10	3.56	258.0
10.0	16.80	4.39	316.0

1/2"
0.622" inside dia.

U.S. Gals. Per Min.	vel. V f.p.s.	vel. head $V^2/2g$ feet	frict. loss h_f feet
2.0	2.11	0.07	4.78
2.5	2.64	0.11	7.16
3.0	3.17	0.16	10.0
3.5	3.70	0.21	13.3
4.0	4.22	0.28	17.1
5.0	5.28	0.43	25.8
6.0	6.34	0.62	36.5
7.0	7.39	0.85	48.7
8.0	8.45	1.11	62.7
9.0	9.50	1.40	78.3
10.0	10.56	1.73	95.9
12.0	12.70	2.49	136.0
14.0	14.80	3.40	183.0
16.0	16.90	4.43	235.0

3/4"
0.824" inside dia.

U.S. Gals. Per Min.	vel. V f.p.s.	vel. head $V^2/2g$ feet	frict. loss h_f feet
3.0	1.81	0.05	2.50
3.5	2.11	0.07	3.30
4.0	2.41	0.09	4.21
5.0	3.01	0.14	6.32
6.0	3.61	0.20	8.87
7.0	4.21	0.28	11.8
8.5	4.81	0.36	15.0
9.0	5.42	0.46	18.8
10.0	6.02	0.56	23.0
12.0	7.22	0.81	32.6
14.0	8.42	1.10	43.5
16.0	9.63	1.44	56.3
18.0	10.80	1.82	70.3
20.0	12.00	2.25	86.1
22.0	13.20	2.72	104.0
24.0	14.40	3.24	122.0
26.0	15.60	3.80	143.0
28.0	16.80	4.41	164.0

CAUTION: No allowance has been made for age, differences in diameter resulting from manufacturing tolerances or any abnormal conditions of interior pipe surface. It is recommended that for commercial application a reserve or margin of safety to cover these effects be added to the values shown in the tables. Where no careful analysis of these effects are made a reserve of 15% is recommended.

Friction Loss Per 100 Feet for Water in New Wrought Iron or Schedule 40 Steel Pipe

1"
1.049" inside dia.

U.S. Gals. Per Min.	vel. V f.p.s.	vel. head V²/2g feet	frict. loss hf feet
6	2.23	0.08	2.68
8	2.97	0.14	4.54
10	3.71	0.21	6.86
12	4.45	0.31	9.62
14	5.20	0.42	12.8
16	5.94	0.55	16.5
18	6.68	0.69	20.6
20	7.42	0.86	25.1
22	8.17	1.04	30.2
24	8.91	1.23	35.6
25	9.27	1.34	38.7
30	11.1	1.93	54.6
35	13.0	2.63	73.3
40	14.8	3.43	95.0
45	16.7	4.34	119.0
50	18.6	5.35	146.0
55	20.4	6.46	176.0
60	22.3	7.71	209.0
65	24.2	9.10	245.0
70	26.0	10.49	283.0
75	27.9	12.10	324.0
80	29.7	13.70	367.0

1-1/4"
1.380" inside dia.

U.S. Gals. Per Min.	vel. V f.p.s.	vel. head V²/2g feet	frict. loss hf feet
10	2.15	0.72	1.77
12	2.57	0.10	2.48
14	3.00	0.14	3.28
16	3.43	0.18	4.20
18	3.86	0.23	5.22
20	4.29	0.29	6.34
22	4.72	0.35	7.58
24	5.15	0.41	8.92
25	5.36	0.45	9.6
30	6.44	0.64	13.6
35	7.51	0.87	18.2
40	8.58	1.14	23.5
45	9.65	1.44	29.4
50	10.7	1.79	36.0
55	11.8	2.16	43.2
60	12.9	2.57	51.0
65	13.9	3.02	59.6
70	15.0	3.50	68.8
75	16.1	4.03	78.7
80	17.2	4.58	89.2
85	18.2	5.15	100.0
90	19.3	5.79	112.0
95	20.4	6.45	125.0
100	21.5	7.15	138.0
120	25.7	10.3	197.0
140	30.0	14.0	267.0

1-1/2"
1.610" inside dia.

U.S. Gals. Per Min.	vel. V f.p.s.	vel. head V²/2g feet	frict. loss hf feet	U.S. Gals. Per Min.	vel. V f.p.s.	vel. head V²/2g feet	frict. loss hf feet
14	2.21	0.08	1.53	65	10.24	1.63	27.1
16	2.52	0.10	1.96	70	11.03	1.89	31.3
18	2.84	0.12	2.42	75	11.8	2.16	35.8
20	3.15	0.15	2.94	80	12.6	2.47	40.5
22	3.47	0.19	3.52	85	13.4	2.79	45.6
24	3.78	0.22	4.14	90	14.2	3.13	51.0
25	3.94	0.24	4.48	95	15.0	3.49	56.5
30	4.73	0.38	6.26	100	15.8	3.86	62.2
35	5.51	0.47	8.37	120	18.9	5.56	88.3
40	6.30	0.62	10.79	140	22.1	7.56	119.0
45	7.04	0.78	13.45	160	25.2	9.88	156.0
50	7.88	0.97	16.4	180	28.4	12.50	196.0
55	8.67	1.17	19.7	200	31.5	15.40	241.0
60	9.46	1.39	23.2				

CAUTION: No allowance has been made for age, differences in diameter resulting from manufacturing tolerances or any abnormal conditions of interior pipe surface. It is recommended that for commercial application a reserve or margin of safety to cover these effects be added to the values shown in the tables. Where no careful analysis of these effects are made a reserve of 15% is recommended.

Friction Loss Per 100 Feet for Water in New Wrought Iron or Schedule 40 Steel Pipe

2"
2.067" inside dia.

U.S. Gals. Per Min.	vel. V f.p.s.	vel. head V²/2g feet	frict. loss h_f feet
24	2.29	0.08	1.20
25	2.39	0.09	1.29
30	2.87	0.13	1.82
35	3.35	0.17	2.42
40	3.82	0.23	3.10
45	4.30	0.29	3.85
50	4.78	0.36	4.67
55	5.25	0.43	5.51
60	5.74	0.51	6.59
65	6.21	0.60	7.70
70	6.69	0.70	8.86
75	7.16	0.80	10.15
80	7.65	0.91	11.40
85	8.11	1.03	12.6
90	8.60	1.15	14.2
95	9.09	1.29	15.8
100	9.56	1.42	17.4
120	11.5	2.05	24.7
140	13.4	2.78	33.2
160	15.3	3.64	43.0
180	17.2	4.60	54.1
200	19.1	5.68	66.3
220	21.0	6.88	80.0
240	22.9	8.18	95.0
260	24.9	9.60	111.0
280	26.8	11.14	128.0
300	28.7	12.8	146.0

2-1/2"
2.469" inside dia.

U.S. Gals. Per Min.	vel. V f.p.s.	vel. head V²/2g feet	frict. loss h_f feet
25	1.68	0.04	0.54
30	2.01	0.06	0.75
35	2.35	0.09	1.00
40	2.68	0.11	1.28
45	3.02	0.14	1.60
50	3.35	0.17	1.94
60	4.02	0.25	2.72
70	4.69	0.34	3.63
80	5.36	0.45	4.66
90	6.03	0.57	5.82
100	6.70	0.70	7.11
120	8.04	1.00	10.0
140	9.38	1.39	13.5
160	10.7	1.79	17.4
180	12.1	2.26	21.9
200	13.4	2.79	26.7
220	14.7	3.38	32.2
240	16.1	4.02	38.1
260	17.4	4.72	44.5
280	18.8	5.47	51.3
300	20.1	6.28	58.5
350	23.5	8.55	79.2
400	26.8	11.2	103.0

3"
3.068" inside dia.

U.S. Gals. Per Min.	vel. V f.p.s.	vel. head V²/2g feet	frict. loss h_f feet	U.S. Gals. Per Min.	vel. V f.p.s.	vel. head V²/2g feet	frict. loss h_f feet
50	2.17	0.07	0.66	220	9.55	1.42	10.7
60	2.60	0.11	0.92	240	10.4	1.69	12.6
70	3.04	0.14	1.22	260	11.3	1.98	14.7
80	3.47	0.19	1.57	280	12.2	2.29	16.9
90	3.91	0.24	1.96	300	13.0	2.63	19.2
100	4.34	0.29	2.39	350	15.2	3.58	26.1
120	5.21	0.42	3.37	400	17.4	4.68	33.9
140	6.08	0.57	4.51	500	21.7	7.32	52.5
160	6.94	0.75	5.81	550	23.8	8.85	63.2
180	7.81	0.95	7.28	600	26.0	10.5	74.8
200	8.68	1.17	8.90	700	30.4	14.3	101.0

CAUTION: No allowance has been made for age, differences in diameter resulting from manufacturing tolerances or any abnormal conditions of interior pipe surface. It is recommended that for commercial application a reserve or margin of safety to cover these effects be added to the values shown in the tables. Where no careful analysis of these effects are made a reserve of 15% is recommended.

Friction Loss Per 100 Feet for Water in New Wrought Iron or Schedule 40 Steel Pipe

4" 4.026" inside dia.				5" 5.047" inside dia.			
U.S. Gals. Per Min.	vel. V f.p.s.	vel. head $V^2/2g$ feet	frict. loss h_f feet	U.S. Gals. Per Min.	vel. V f.p.s.	vel. head $V^2/2g$ feet	frict. loss h_f feet H_l
90	2.27	0.08	0.52	140	2.25	0.08	0.380
100	2.52	0.10	0.62	160	2.57	0.10	0.487
120	3.02	0.14	0.88	180	2.89	0.13	0.606
140	3.53	0.19	1.17	200	3.21	0.16	0.736
160	4.03	0.25	1.49	220	3.53	0.19	0.879
180	4.54	0.32	1.86	240	3.85	0.23	1.035
200	5.04	0.40	2.27	260	4.17	0.27	1.200
220	5.54	0.48	2.72	280	4.49	0.31	1.38
240	6.05	0.57	3.21	300	4.81	0.36	1.58
260	6.55	0.67	3.74	350	5.61	0.49	2.11
280	7.06	0.77	4.30	400	6.41	0.64	2.72
300	7.56	0.89	4.89	450	7.22	0.81	3.41
350	8.82	1.21	6.55	500	8.02	1.00	4.16
400	10.10	1.58	8.47	550	8.81	1.21	4.94
450	11.4	2.00	10.65	600	9.62	1.44	5.88
500	12.6	2.47	13.0	700	11.20	1.96	7.93
550	13.9	3.00	15.7	800	12.80	2.56	10.22
600	15.1	3.55	18.6	900	14.40	3.24	12.90
700	17.6	4.84	25.0	1000	16.00	4.00	15.80
800	20.2	6.32	32.4	1200	19.20	5.76	22.50
900	22.7	8.00	40.8	1400	22.50	7.83	30.40
1000	25.2	9.87	50.2	1600	25.70	10.20	39.50
				1800	28.80	12.90	49.70

Plastic pipe having a smoother wall will generate 15-20% less friction loss at any given flow rate.

Friction Loss Correction For Fittings

TURBULENT FLOW ONLY

FITTINGS			PIPE SIZE											
			1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5
REGULAR 90° ELL	SCREWED	STEEL	2.3	3.1	3.6	4.4	5.2	6.6	7.4	8.5	9.3	11.0	13.0	
		C.I.										9.0	11.0	
	FLANGED	STEEL			.92	1.2	1.6	2.1	2.4	3.1	3.6	4.4	5.9	7.3
		C.I.										3.6	4.8	
LONG RADIUS 90° ELL	SCREWED	STEEL	1.5	2.0	2.2	2.3	2.7	3.2	3.4	3.6	3.6	4.0	4.6	
		C.I.										3.3	3.7	
	FLANGED	STEEL			1.1	1.3	1.6	2.0	2.3	2.7	2.9	3.4	4.2	5.0
		C.I.										2.8	3.4	
REGULAR 45° ELL	SCREWED	STEEL	.34	.52	.71	.92	1.3	1.7	2.1	2.7	3.2	4.0	5.5	
		C.I.										3.3	4.5	
	FLANGED	STEEL			.45	.59	.81	1.1	1.3	1.7	2.0	2.6	3.5	4.5
		C.I.										2.1	2.9	
TEE-LINE FLOW	SCREWED	STEEL	.79	1.2	1.7	2.4	3.2	4.6	5.6	7.7	9.3	12.0	17.0	
		C.I.										9.9	14.0	
	FLANGED	STEEL			.69	.82	1.0	1.3	1.5	1.8	1.9	2.2	2.8	3.3
		C.I.										1.9	2.2	
TEE-BRANCH FLOW	SCREWED	STEEL	2.4	3.5	4.2	5.3	6.6	8.7	9.9	12.0	13.0	17.0	21.0	
		C.I.										14.0	17.0	
	FLANGED	STEEL			2.0	2.6	3.3	4.4	5.2	6.6	7.5	9.4	12.0	15.0
		C.I.										7.7	10.0	
180° RETURN BEND	SCREWED	STEEL	2.3	3.1	3.6	4.4	5.2	6.6	7.4	8.5	9.3	11.0	13.0	
		C.I.										9.0	11.0	
	REG FLANGED	STEEL			.92	1.2	1.6	2.1	2.4	3.1	3.6	4.4	5.9	7.3
		C.I.										3.6	4.8	
	LONG RAD. FLANGED	STEEL			1.1	1.3	1.6	2.0	2.3	2.7	2.9	3.4	4.2	5.0
		C.I.										2.8	3.4	
GLOBE VALVE	SCREWED	STEEL	21.0	22.0	22.0	24.0	29.0	37.0	42.0	54.0	62.0	79.0	110.0	
		C.I.										65.0	86.0	
	FLANGED	STEEL			38.0	40.0	45.0	54.0	59.0	70.0	77.0	94.0	120.0	150.0
		C.I.										77.0	99.0	
GATE VALVE	SCREWED	STEEL	.32	.45	.56	.67	.84	1.1	1.2	1.5	1.7	1.9	2.5	
		C.I.										1.6	2.0	
	FLANGED	STEEL								2.6	2.7	2.8	2.9	3.1
		C.I.										2.3	2.4	
ANGLE VALVE	SCREWED	STEEL	12.8	15.0	15.0	15.0	17.0	18.0	18.0	18.0	18.0	18.0	18.0	
		C.I.										15.0	15.0	
	FLANGED	STEEL			15.0	15.0	17.0	18.0	18.0	21.0	22.0	28.0	38.0	50.0
		C.I.										23.0	31.0	
SWING CHECK VALVE	SCREWED	STEEL	7.2	7.3	8.0	8.8	11.0	13.0	15.0	19.0	22.0	27.0	38.0	
		C.I.										22.0	31.0	
	FLANGED	STEEL			3.8	5.3	7.2	10.0	12.0	17.0	21.0	27.0	38.0	50.0
		C.I.										22.0	31.0	
COUPLING OR UNION	SCREWED	STEEL	.14	.18	.21	.24	.29	.36	.39	.45	.47	.53	.65	
		C.I.										.44	.52	
BELL MOUTH INLET		STEEL	.04	.07	.10	.13	.18	.26	.31	.43	.52	.67	.95	1.3
		C.I.										.55	.77	
SQUARE MOUTH INLET		STEEL	.44	.68	.96	1.3	1.8	2.6	3.1	4.3	5.2	6.7	9.5	13.0
		C.I.										5.5	7.7	
RE-ENTRANT PIPE		STEEL	.88	1.4	1.9	2.6	3.6	5.1	6.2	8.5	10.0	13.0	19.0	25.0
		C.I.										11.0	15.0	
SUDDEN ENLARGEMENT			$h = \dfrac{(V_1 - V_2)^2}{2g}$ FEET OF FLUID; IF V_2 - 0 $h = \dfrac{V_1{}^2}{2g}$ FEET OF FLUID											

Friction in Other Types of Pipe

The preceding tabulations for friction loss in pipes apply to new schedule #40 steel pipe and new asphalt-dipped cast-iron pipe as noted. Friction loss in other types of pipe vary from these values due to the difference in the average relative roughness of the interior surface of such pipes as commercially manufactured.

The following chart shows relative roughness factors $(\frac{e}{D})$ for new clean pipes as commercially manufactured plotted against pipe diameter in inches. The curves for schedule #40 steel pipe (absolute roughness 0.00015') and asphalt-dipped cast-iron pipe (absolute roughness 0.0004') on

which the previous Tables 1 and 2 are based are shown on this curve.

The ratio of the friction factor for any pipe to that for schedule #40 steel pipe may be used as a multiplier to adjust the friction losses shown in Table 1 to apply to the other type of pipe.

It must be recognized that various types of pipe as commercially manufactured are subject to a considerable variation in roughness.

Average values for good clean new pipe however yield the multipliers recommended in the following Table 5.

Multipliers to Apply to Values From Water Friction Loss Chart to Obtain Friction Loss in Other Types of Pipe or Conduit.

Type of New Conduit or Pipe	Multiplier to Apply to Table 1 Value of Friction Loss
Rubber lined hose	0.72
Spun cement line pipe	0.76
Spun bitumastic enameled pipe	0.76
Aluminum irrigation pipe	0.81
Transite pipe	0.85
Copper or Brass pipe	0.86
Seamless steel tubing	0.86
Glass tube or pipe	0.86
Schedule #40 steel pipe	1.00
Wood Stave pipe	1.15
Galvanized iron pipe	1.22
Vitrified pipe	1.36
Spiral riveted pipe (flow with lap)	1.40
Spiral riveted pipe (flow against lap)	1.70
Unlined linen hose	1.80

The multipliers in table provide for the difference in type of pipe only. They do not nclude deviations in internal diameter from schedule #40 steel pipe.

Relative Roughness Factors
for New Clean Pipes
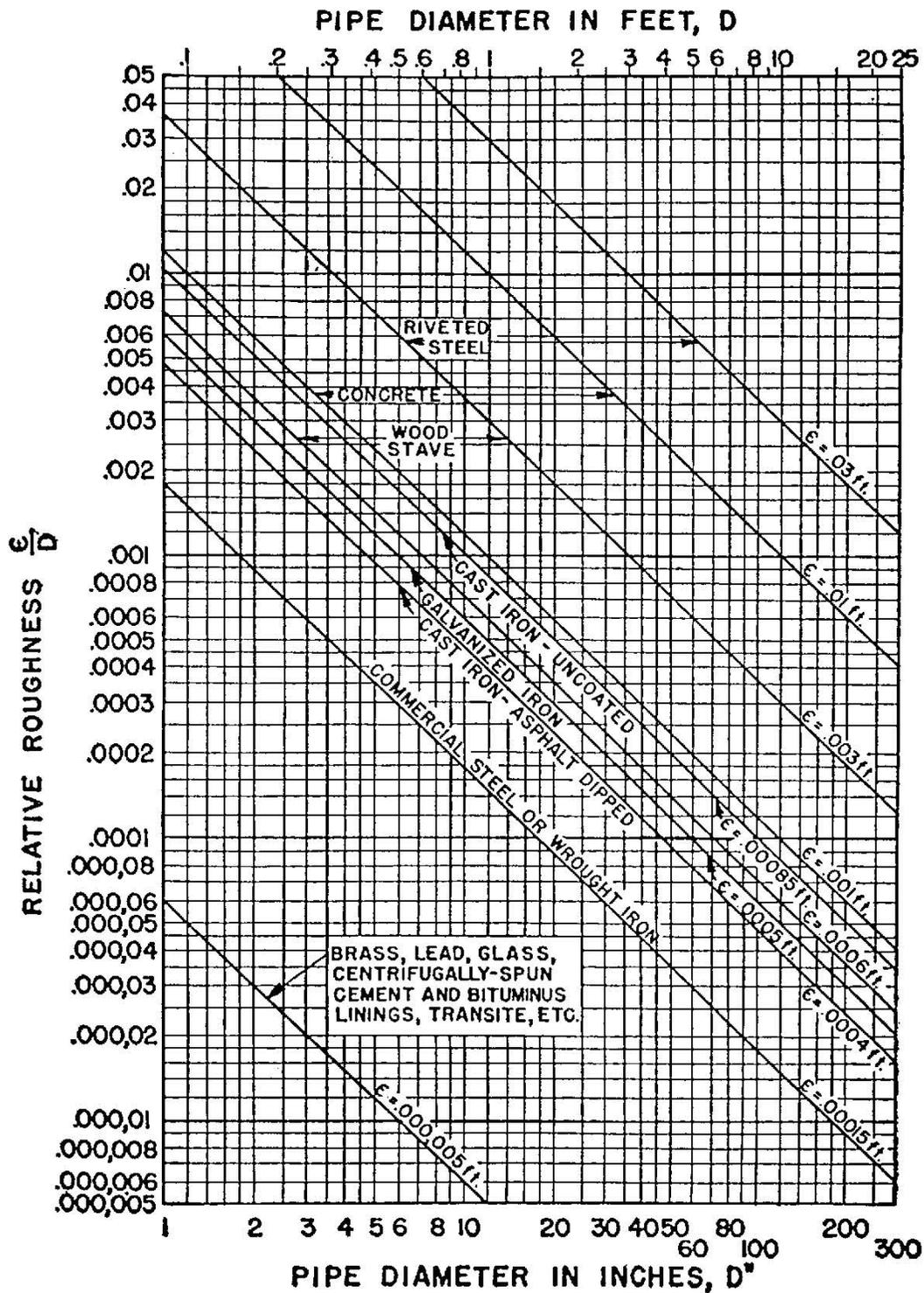
Friction Loss as Affected by Aging of Pipe

The deterioration of pipes with age depends upon the chemical properties of the liquid flowing and the characteristics of the material from which the pipe is made. In general, the flow carrying capacity of a pipe line decreases with age due to a roughening of the interior surface caused by corrosive products, tubercules and the like or an actual reduction in area caused by chemical deposits. The effect corresponds to a variation in friction factor due to increasing relative roughness.

A wide variation in waters over the country makes impossible any precise estimation of this aging effect. No reputable authority will go on record to endorse friction factors for other than new pipe. This fact, however, does not eliminate the deterioration of friction factor and some means of estimation is required. Wherever records are available on the aging effect of local or similar waters, it is recommended that they be studied and applied as a correction to the computation of friction loss for new pipe from the previous tables. This is a sound and logical approach for a specific problem.

In many instances either the economics of the project do not warrant the expense of this detailed investigation or there are no available records on local or similar waters. For those occasions, the following table may be used with caution and discretion. It is based upon the best known available data.

INCREASE IN FRICTION LOSS DUE TO AGING OF PIPE
Multipliers for use with Table 1

Age of Pipe in Years	Small Pipes 4" - 10"	Large Pipes 12" - 60"
NEW	1.00	1.00
5	1.40	1.30
10	2.20	1.60
15	3.60	1.80
20	5.00	2.00
25	6.30	2.10
30	7.25	2.20
35	8.10	2.30
40	8.75	2.40
45	9.25	2.60
50	9.60	2.86
55	9.80	3.26
60	10.00	3.70
65	10.05	4.25
70	10.10	4.70

It will be obvious that there is no sudden increase in aging effect between 10" and 12" pipe as indicated from the above table. The values shown are composites of many test grouped by the experimenter. A reasonable amount of interpretation and logic must be used in selecting and applying a multiplier for each specific problem. It must also be borne in mind that some test data on aging of pipe may vary up to fifty-percent from the averages as shown in the above table.

Table Friction Loss of Water Per 100 Feet of Flexible Pipe

SIZE	1/2"		3/4"		1"		1 1/4"		1 1/2"		2"		3"		4"	
GPM	Head in Feet	PSI	Head in Feet	PSI	Head in Feet	PSI	Head in Feet	PSI	Head in Feet	PSI	Head in Feet	PSI	Head in Feet	PSI	Head in Feet	PSI
1	1.50	.65	.32	.14	.09	.04										
2	5.08	2.20	1.13	.49	.30	.13	.09	.04								
3	10.51	4.55	2.40	1.04	.60	.26	.18	.08								
4	17.81	7.71	3.81	1.65	1.02	.44	.32	.14	.09	.04						
5	26.01	11.26	5.61	2.43	1.43	.62	.46	.20	.16	.07						
6	36.01	15.59	7.51	3.25	1.94	.84	.65	.28	.23	.10	.09	.04				
8	61.00	26.41	12.01	5.20	3.19	1.38	1.04	.45	.30	.13	.14	.06				
10	92.15	39.89	18.32	7.93	4.90	2.12	1.59	.69	.51	.22	.23	.10				
15			38.83	16.81	10.12	4.38	3.30	1.43	.76	.33	.49	.21				
20					16.52	7.15	5.50	2.38	1.55	.67	.83	.36	.12	.05		
25							8.11	3.51	2.54	1.10	1.22	.53	.18	.08		
30							10.81	4.68	3.81	1.65	1.69	.73	.25	.11	.09	.04
35							14.02	6.07	5.20	2.25	2.19	.95	.32	.14	.12	.05
40									6.61	2.86	2.80	1.21	.42	.18	.14	.06
45									8.92	3.86	3.40	1.47	.53	.23	.16	.07
50									10.12	4.38	4.09	1.77	.85	.37	.23	.10
60									11.92	5.16	5.71	2.47	1.11	.48	.30	.13
70											7.30	3.16	1.41	.61	.37	.16
80											9.22	3.99	1.80	.78	.46	.20
90											11.20	4.85	2.19	.95	.55	.24
100											13.91	6.02	3.30	1.43	.88	.38

Viscous Fluids

Return to
Index

Viscous Fluid Behavior

EFFECTIVE VISCOSITY is a term describing the real effect of
the viscosity of the ACTUAL fluid, at the SHEAR RATES which exist in
the pump and pumping system at the design conditions.

TYPE: Constant Viscosity at all Shear Rates.

NEWTONIAN FLUIDS

Viscosity is constant with change in Shear Rate or Agitation. Forces to cause motion increase proportionately as speed increases.

Fluids showing Newtonian behavior include water, mineral oils, syrups, hydrocarbons, resins.

TYPE: Decreasing Viscosity at Increasing Shear Rates

THIXOTROPIC FLUIDS

Along with the characteristic of the viscosity decreasing over a finite time as the sheer rate is constant, Thixotropic flow is also characterized by: Having a Yield Point; Plastic or pseudoplastic behavior; A tendency to rebuild viscosity or Yield Point on standing.

Typical fluids with the above characterisitics are paints, inks, caulking compounds, gels, slurry mixes, lotions, shampoo.

PLASTIC FLUIDS

This type of fluid always requires an initial force or stress which is called The Yield Point, before flow will start: With a Yield Point too high, flow may not start in a normal inlet system to the pump.

PSEUDO-PLASTIC FLUIDS

Viscosity decreases as shear rate increases. At any constant flow rate or Shear Rate, viscosity stays constant and is independent of time.

Type: Increasing Viscosity at Increasing Shear Rates.

DILATANT FLUIDS

Viscosity increases as shear rate increases. This fluid type needs to be pumped at very conservative pump speeds since rotary pumps have areas of high shear which may cause the product to reach a sufficient viscosity to stall the drive or in extreme cases mechanically damage the pump.

Some fluids showing dilatent behavior are high solids concentrations of clays, oxides and granular or crystalline materials.
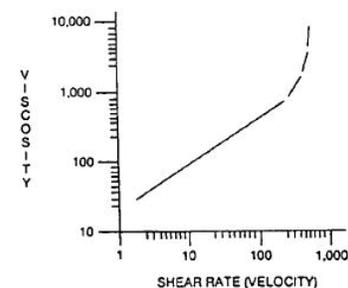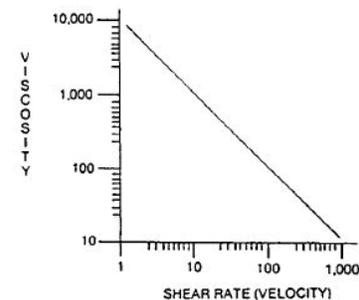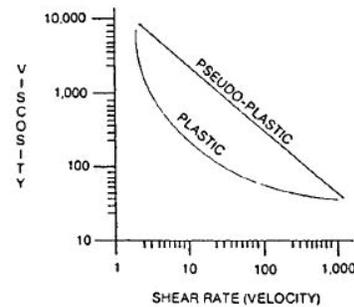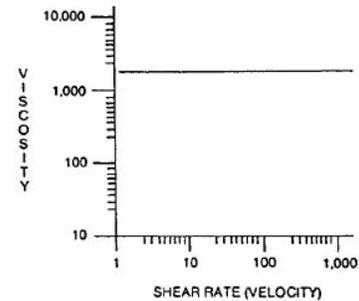
Shear Rate Information

FLOW RATE VS SHEAR RATE IN SANITARY & IRON PIPE

$$\text{BASED ON SHEAR RATE (SEC - 1)} = \frac{\text{FLOW RATE (GPM)}}{\text{PIPE RADIUS}^2 \text{ (IN.)}} = 4.9$$

— — — — — SANITARY PIPE

- - - - - - SCHEDULE 40 PIPE

FLOW RATE (GPM)
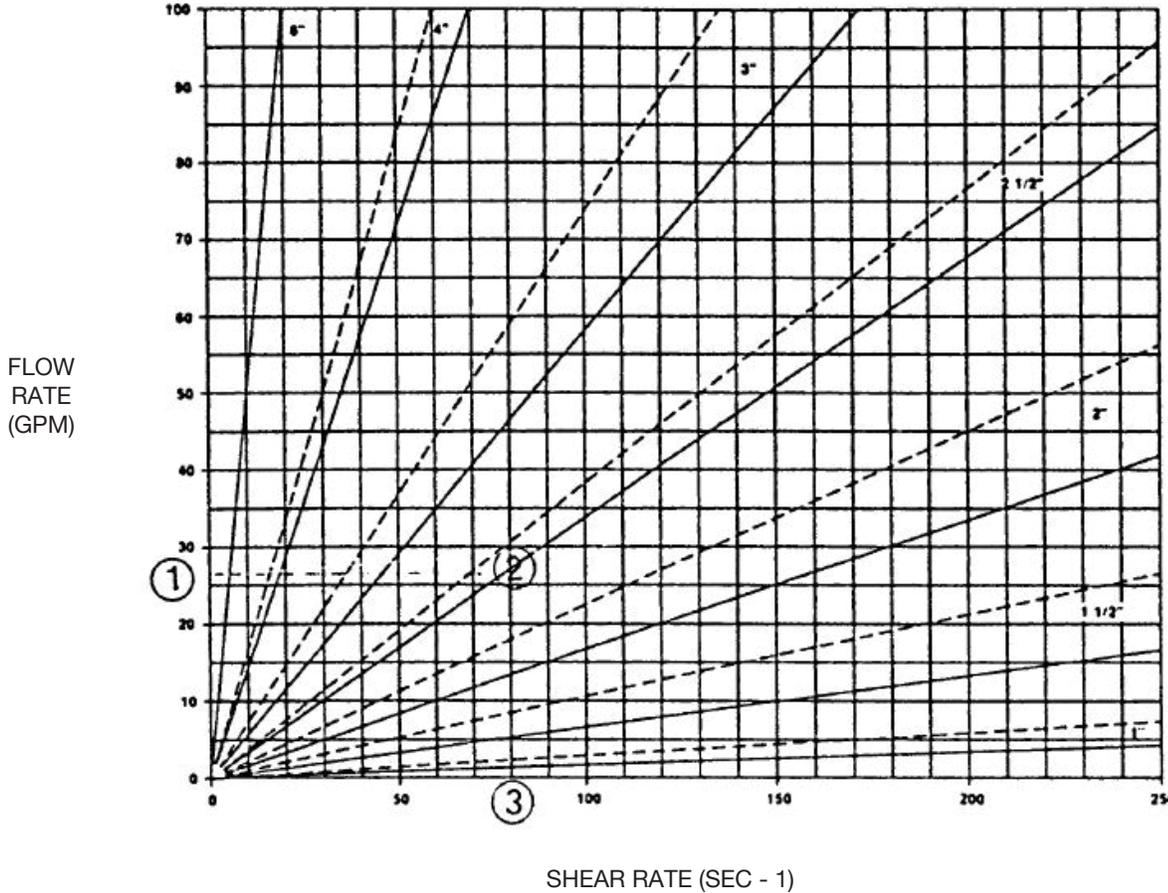
SHEAR RATE (SEC - 1)

NOTE: SCHEDULE 40 PIPE WILL CHANGE SHEAR RATE CONSIDERABLY

① From a known flow rate.

② At a selected line size.

③ Will establish a shear rate.

④ The effective Viscosity ④ is found using this Shear Rate ③ on the Viscosity Profile Curve Obtained from a viscomenter.

Calculating Shear Rate is a non-Newtonian fluid moving in a tube is complex. For a Newtonian fluid, the Shear Rate varies linearly from a maximum at the tube wall to zero at the center. In practice a very high percentage of fluids pumped are non-Newtonian. Plastic and pseupo-plastic types including Thixotropic fluids have higher Shear Rates near the wall and dilatant types have lower Shear Rates near the wall.

Viscosity Derate/Limitation

Diaphragm Pump Correction Factor For Viscous Liquids

Decrease in Flow Rate From Increase in Viscosity
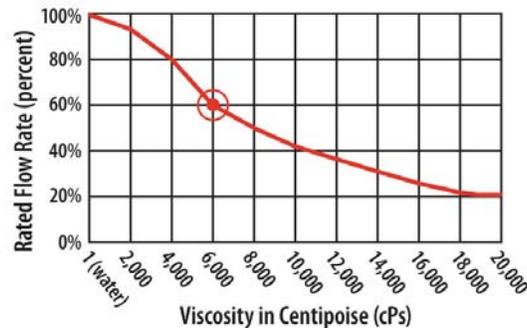
● Example: A fluid with viscosity of 6,000 cPs will transfer at 60% rated flow

Use the above flow/capacity correction factor for selecting and determining the appropriate size AODD pump. Refer to the performance curves located in the pump manufactures literature.

Example: During the conveyance of a fluid with a viscosity of 6,000 cPs, the pump rate decreases to 60% of its rated value (100% = water). Valid for 3/4" pumps & larger.

Maximum Viscosity Handling

As a general "rule of thumb" the smaller the pump the greater its' limitation on handling high vicosity material. The guide lines for pump/viscosity handling is as follows:

Pump Size	Suction Lift	Flooded Suction
1/4"	<500 cP	<500 cP
3/8" -1/2"	<3,000 cP	<15,000 cP
3/4"-1"	<8,000 cP	<40,000 cP
1-1/2", 2", 3"	<10,000 cP	<50,000 cP

Above limits may vary from application to application and are based on ball type check valves.

Typical pump dry suction lift, based on water, are as follows:

Pump Size	Suction Lift
1/4"	5' or less
3/8" —1/2"	7' - 10'
3/4"—1"	15' - 18'
1-1/2"—2"—3"	18' - 22'

Above figures are estimates only for use with pumps equipped with rubber elastomers. Pumps equipped with PTFE elastomers will not generate as much suction lift (vacuum) as pumps equipped with rubber elastomers. There are two reasons for this; 1) PTFE does not seal as well as rubber, which lowers the pump efficiency, and 2) pumps with PTFE diaphragms often have a shortened stroke length, which lowers the working volume of a pump.

The suction lift of a pump equipped with PTFE elastomers may be lowered by as much as 20% or more.

Viscosity & Specific Gravity
of Common Liquids

LIQUID	SPECIFIC GRAVITY	VISCOSITY S.S.U						
		40°F	60°F	80°F	100°F	120°F	140°F	160°F
Miscellaneous Liquids								
Water	1.0	31.5	31.5	31.5	31.5	31.5	31.5	31.5
Gasoline	.68 -.74	30	30	30	30	30	30	30
Jet Fuel	.74 -.85	35	35	35	35	35	35	35
Kerosene	.78 -.82	42	38	34	33	31	30	30
Turpentine	.86 -.87	34	33	32.8	32.6	32.4	32	32
Varnish Spar	.9	3500	1600	1000	650	530	250	230
Fuel and Diesel Oil								
No. 1 Fuel Oil	.82 -.95	40	38	35	33	31	30	30
No. 2 Fuel Oil	.82 -.95	70	50	45	40	–	–	–
No. 3 Fuel Oil	.82 -.95	90	68	53	45	40	–	–
No. 5A Fuel Oil	.82 -.95	1000	400	200	100	75	60	40
No. 5B Fuel Oil	.82 -.95	1300	600	490	400	330	290	240
No. 6 Fuel Oil	.82 -.95	–	70000	20000	9000	1900	900	500
No. 2D Diesel Fuel Oil	.82 -.95	100	68	53	45	40	36	35
No. 3D Diesel Fuel Oil	.82 -.95	200	120	80	60	50	44	40
No. 4D Diesel Fuel Oil	.82 -.95	1600	600	280	140	90	68	54
No. 5D Diesel Fuel Oil	.82 -.95	15000	5000	2000	900	400	260	160
Crankcase Oils - Automobile Lubricating Oils								
SAE 10	.88 -.935	1500-2400	600-900	300-400	170-220	110-130	75-90	60-65
SAE 20	.88 -.935	2400-9000	900-3000	400-1100	220-550	130-280	90-170	65-110
SAE 30	.88 -.935	9000-14000	3000-4400	1100-1800	550-800	280-400	170-240	110-150
SAE 40	.88 -.935	14000-19000	4400-6000	1800-2400	800-1100	400-550	240-320	150-200
SAE 50	.88 -.935	19000-45000	6000-10000	2400-4000	1100-1800	550-850	320-480	280-380
SAE 60	.88 -.935	45000-60000	10000-17000	4000-6000	1800-2500	850-1200	480-580	280-380
SAE 70	.88 -.935	60000-120000	17000-45000	6000-10000	2500-4000	1200-1800	580-900	380-500
Transmission Oils - Automobile Transmission Gear Lubricants								
SAE 20	.88 -.935	35000	12000	5000	2200	1200	650	400
SAE 30	.88 -.935	160000	50000	18000	7000	3300	1700	1000
SAE 90	.88 -.935	14000	5500	2200	1100	650	380	240
SAE 140	.88 -.935	35000	12000	5000	2200	1200	650	400
SAE 250	.88 -.935	160000	50000	18000	7000	3300	1700	1000

Viscosity & Specific Gravity
of Common Liquids

LIQUID	SPECIFIC GRAVITY	VISCOSITY S.S.U.		
		70°F	100°F	130°F
Sugar, Syrups, Molasses, etc.				
Corn Syrups	1.4 - 1.47	–	5,000-500,000	1,500-60,000
Glucose	1.35-1.44	–	35,000 - 100,000	10,000-13,000
Honey (Raw)	1.20	–	340	–
Molasses	1.40-1.49	–	1,300 - 250,000	700-75,000
Sugar Syrups 60 Brix	1.29	230	92	–
Sugar Syrups 62 Brix	1.30	310	111	–
Sugar Syrups 64 Brix	1.31	440	148	–
Sugar Syrups 66 Brix	1.33	650	195	–
Sugar Syrups 68 Brix	1.34	1000	275	–
Sugar Syrups 70 Brix	1.35	1650	400	–
Sugar Syrups 72 Brix	1.36	2700	640	–
Sugar Syrups 74 Brix	1.38	5500	1100	–
Sugar Syrups 76 Brix	1.39	10000	2000	–
Corn Starch 22 Baume	1.18	150	130	–
Corn Starch 24 Baume	1.20	600	440	–
Corn Starch 25 Baume	1.21	1400	800	–
Ink - Printers	1.0 - 1.38	–	2,500 - 10,000	1,100 - 3,000
Ink - Newspaper	–	–	5,500 - 8,000	2400
Tallow .	918	56 SSU at 212F		
Tars				
Coke Oven - Tar	1.12 +	3,000 - 8,000	650 -1,400	–
Gas House - Tar	1.16 - 1.3	15,000-300,000	2,000-20,000	–
Crude Oils				
Texas, Oklahoma .	81 -.916	100-700	34-210	–
Wyoming, Montana .	86-.88	100-1100	46-320	–
California .	78-.92	100-4500	34-700	–
Pennsylvania .	8 -.85	100-200	38-86	–
Glycol				
Propylene	1.038	240.6	–	–
Triethylene	1.125	185.7	–	–
Diethylene	1.12	149.7	–	–
Ethylene	1.125	88.4	–	–
Glycerine (100%)	1.26	2900	813	–
Phenol (Carbolic Acid) .	95 -1.00	60	–	–
Silciate of Soda	–	–	356-640	–
Sulfuric Acid (100%)	1.83	75	–	–

Viscosity & Specific Gravity
of Common Liquids

LIQUID	SPECIFIC GRAVITY	VISCOSITY S.S.U.						
		40°F	60°F	80°F	100°F	120°F	140°F	160°F
Other Oils								
Castor Oil	.96	36000	9000	3000	1400	900	400	300
Chinawood	.943	4000	1800	1000	580	400	300	200
Cocoanut	.925	1500	500	250	140	00	70	60
Cod	.928	1800	600	300	175	110	80	70
Corn	.924	1600	700	400	250	175	100	80
Cotton Seed	.88 -.925	1500	600	300	176	125	80	70
Cylinder	.82 -.95	60000	14000	6000	2700	1400	1000	400
Navy No. 1 Fuel Oil	.989	4000	1100	600	380	200	170	90
Navy No. 2 Fuel Oil	1.0	–	24000	8700	3500	1500	900	480
Gas	.887	180	90	60	50	45	–	–
Insulating	–	350	150	90	65	50	45	40
Lard	.912 -.925	1100	600	380	287	180	140	90
Linseed	.925 -.939	1500	500	250	143	110	85	70
Raw Menhadden	.933	1500	500	250	140	110	80	70
Neats Foot	.917	–	1000	430	230	160	100	80
Olive	.912 -.918	1500	550	320	200	150	100	80
Palm	.924	1700	700	380	221	160	120	90
Peanut	.920	1200	500	300	195	150	100	80
Quenching	–	2400	900	450	250	180	130	90
Rape Seed	.919	2400	900	450	250	180	130	90
Rosin	.980	28000	7800	3200	1500	900	500	300
Rosin (Wood)	1.09	Extremely Viscose						
Sesame	.923	1100	500	290	184	130	90	60
Soya Bean	.927 - .98	1200	475	270	165	120	80	70
Sperm	.883	360	250	170	110	90	70	60
Turbine (Light)	.91	500	350	230	150	–	–	–
Turbine (Heavy)	.91	3000	1400	700	330	200	150	100
Whale	.925	900	450	275	170	140	100	80

Pump Applications Guide

SOAP, DETERGENTS, PERFUMES, AND COSMETICS NAIC 325611 - 620

PRODUCT	VISCOSITY IN CPS
Cologne / Alcohol	0.8
Creams & Lotions	6,000
Dental Creme	80,000
Denture Cream Adhesive	10,000
Detergent	300-2,000
Detergent, Liquid	1-700
Hand & Acne Cream	2,500
Liquid Comet	4,000-6,000
Perfume & Essential Oils	4-300
Shampoo	6,000
Soap, Liquid	3,000
Soap, Lithium Base	300
Soap, Paste	16,000 - 22,000

PETROLEUM NAIC 324110

PRODUCT	VISCOSITY IN CPS
Bunker Oil	300
Butanediol	70
Chlorinated Oil	15
Coal Oil Mixture 50% Solids	5,000
Hexane	0.47
Hydrocarbons	500
Kerosene	5
Polybutane	5,000
Propane, Liquid	3
Tar No. 2	250
Toluene	5
Toluene & Acetone With Solvents	1

CHEMICALS NAIC 324110 - 325998

PRODUCT	VISCOSITY IN CPS
Acetone	0.6
Acetone Slurry	60,000
Acrylic & Water	2,500
Alkali Cellulose Slurry	60
Anhydrous Ammonia	0.8
Cellulose Acetate Dope	1,500
Color Pigment	20,000
Creosote	15
Dynstrol (White Jell)	4,000
Ethyl Acetate Water Saturated	1
Ethyl Alcohol Mach	1,000
Ethylene Glycol	60
Firefighting Foaming Agent	10
Gum	18,000
Hydrocarbon Maleic Resin	2,500
Hydrocarbon Peroxide (90%)	1
Isophytol	0.7
Kaolin Slurry (30% Solids)	5
Methanol Type Varnish	90 -5,000
Methylethyl Ketone	1
Methyl Cellulose Jell	4,000
Naptha Plasticizer	2,100
Neodol (3%)	1
Nitric Acid Slurry	45
Nitro Cellulose	50,000
Paratone 715	170,000
Percholoroethylene	1
Petrolatum with Sodium Sulfate Tomide	10,000
Phosphoric Acid (72%)	2,000
Phosphorous Oxychloride	30
Resin	100,000
Resin Type Binder (Glue)	60
Rubber, Dissolved	100
Rubber Solvent	250,000
Salt Solution	1
Silicone Compound	250

CHEMICALS NAIC 324110 - 325998 (CONT.)

PRODUCT OR LIQUID	VISCOSITY IN CPS
Sodium Hydroxide	140
Sodium Metasilicate	17
Styrene Monomer	0.5
Sulphonic Acid	1
Sulfur Slurry	870
Sulfuric Acid Dilute	1
Tetra Potassium Pyrophosphate	125
Tri-Acetate Cellulose	45,000-75,000
Trichloroethylene	1
Vinyl Butyl Lacquer	2,500
Wax Emulsion	12

DRUGS NAIC 325411 - 414

PRODUCT OR SUBSTANCE	VISCOSITY IN CPS
Blood Plasma	20
Vitamin Intermediate	15
Vitamin Slurry	10

MISCELLANEOUS FOOD PREPARATIONS NAIC 311710 - 311991

PRODUCT OR SUBSTANCE	VISCOSITY IN CPS
Coffee Extract	30
Cotton Seed Oil	40
Honey	5,500
Peanut Butter, Creamy	30,000
Peanut Butter, Crunchy	8,500
Salt Solution	1
Yeast	10,000
Yeast, Liquid	3,000
Yeast Slurry	180

BEVERAGE NAIC 311900 - 999

PRODUCT OR SUBSTANCE	VISCOSITY IN CPS
Beer	2
Coca-Cola Syrup	20
Cordials	50
Pepsi-Cola Syrup	20
Whiskey	1
Wine	1
Spent Yeast & Beer	1,200
Yeast	1,500

FATS & OILS NAIC 311224 - 225

PRODUCT OR SUBSTANCE	VISCOSITY IN CPS
Animal Fat	21
Caul Fat	20,000
Margarine	4-20
Oleic Stearic Acid	1,000
Vegetable Oil	30

BAKING NAIC 311812 - 999

PRODUCT OR SUBSTANCE	VISCOSITY IN CPS
Batter, Cake	2,500
Butter, Melted	18
Dough	1,000,000
Egg, Whole	60
Emulsifier	20
Frostings	10,000
Yeast Slurry, Active	180

CONFECTIONERY NAIC 311313 - 352

PRODUCT OR SUBSTANCE	VISCOSITY IN CPS
Cake Icing	10,000
Caramel	500
Caramel Candy	1,000
Caramel Rework	144,000
Caramel Invert Sugar & Corn Syrup	12,000
Chocolate	17,000
Chocolate Liquor	40
Chocolate With Nuts	2,400
Chocolate With Sugar	1,000
Cocoa Butter	20
Cocoa & Water	100
Corn Syrup 69-43	100,000
Corn Syrup 69-43	10,000
Corn Syrup 69-43	3,000
Corn Syrup Dilute	1,000
Frosting	2,000-10,000
Fructose	300-800
Glucose	80,000
Marshmallow	108
Molasses	7,000
Molasses & Shortening	45,000
Sugar, Liquid	150-10,000
Sugar Solution With 5% Chocolate	>1,000 @ 260°F
Sugar & Salt Solution	10
Sugar Syrup, 76 Brix	8,000
Sugar Syrup, 71 Brix	400

GRAIN MILL PRODUCTS NAIC 311111 - 611

PRODUCT OR SUBSTANCE	VISCOSITY IN CPS
Dog Food (Meat Emulsion)	22,000
Pet Food Slurry	1,500
Starch, Cooked	1,300
Starch Slurry	15

MEAT PRODUCTS NAIC 311611 - 999

PRODUCT OR SUBSTANCE	VISCOSITY IN CPS
Beef Stew	2,500
Beef Barbecue	2,000
Beef Skin With Dilute Acid & Water	50,000
Chicken, Ground	70,000
Egg Concentrate	200
Egg, Whole	20
Fish Egg Slurry	200
Herring Tidbits, Creamed	20,000
Meat Cooked With Gravy	2,000
Meat Emulsion (Semi-Frozen)	22,000
Meat Sauce	6,000
Monosodium Glutonate	50
Pork, Chopped Raw	30,000
Sausage Meat	20,000

DAIRY NAIC 311511 - 520

PRODUCT OR SUBSTANCE	VISCOSITY IN CPS
Butter, Soft	2,000
Cheese, Cottage	225-500
Cheese, Cream	5,000
Cheese Spread	40,000
Cheese, Synthetic	30,000
Cheese, Whey	5
Cream	38
Ice Cream Base	700
Milk	3
Milk, Skim Concentrate	3,000
Milk, Sweetened Condensed	10,000
Yogurt	200-10,000

CANNING NAIC 311421 - 999

PRODUCT OR SUBSTANCE	VISCOSITY IN CPS
Apple Filling	200
Beans, Cut Green	100
Bean Dip, Jalapeno	6,500
Citrus Concentrate (Semi-Frozen)	5,000
Date Filling	2,000
Fruit Jam	500
Fruit Pulp	5,000
Fruit Puree, Guava & Papaya	1,000
Fruit Suspended In Sugar	500
Grapes, Crushed Slurry	2,000
Grape Juice & Pulp	250
Grapefruit Juice Concentrate	250
Lecithin	3,000
Mayonnaise	5,000
Mayonnaise Premix	1,000
Mustard	2,000
Orange Juice Concentrate	20,000
Pineapple Concentrate	17,000
Pineapple Juice	100
Potatoes, Mashed	20,000
Potato Peeling Pulp Slurry	500
Potato & Carrots, Diced	150
Sugar Scum Undissolved	15
Tomato Juice	80
Tomatoes, Macerated	1,000
Tomato Paste	7,000

Viscosity Conversion Table

Seconds Saybolt Universal SSU	Kinematic Viscosity Centistokes *	Seconds Saybolt Furrol SSF	Seconds Redwood 1 (Standard)	Seconds Redwood 2 (Admirelty)	Degrees Engler	Degrees Barbay	Seconds Parlin Cup = 7	Seconds Parlin Cup = 10	Seconds Parlin Cup = 15	Seconds Parlin Cup = 20	Seconds Ford Cup = 3	Seconds Ford Cup = 4	Approx. Seconds Mac Michael	Approx. Gardner Holt Bubble	Seconds Zohn Cup = 1	Seconds Zohn Cup = 2	Seconds Zohn Cup = 3	Seconds Zohn Cup = 4	Seconds Zohn Cup = 5	Seconds Demmler Cup = 1	Seconds Demmler Cup = 10	Approx. Seconds Stormer 100 gm Load	Seconds Pratt and Lambert "F"
31	1.00	–	29	–	1.00	6200	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35	2.56	–	32.1	–	1.16	2420	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
40	4.30	–	36.2	5.10	1.31	1440	–	–	–	–	–	–	–	–	–	–	–	–	–	1.3	–	–	–
50	7.40	–	44.3	5.83	1.58	838	–	–	–	–	–	–	–	–	–	–	–	–	–	2.3	–	2.6	–
60	10.3	–	52.3	6.77	1.88	618	–	–	–	–	–	–	–	–	–	–	–	–	–	3.2	–	3.6	–
70	13.1	12.95	60.9	7.60	2.17	483	–	–	–	–	–	–	–	–	–	–	–	–	–	4.1	–	4.6	–
80	15.7	13.70	69.2	8.44	2.45	404	–	–	–	–	–	–	–	–	–	–	–	–	–	4.9	–	5.5	–
90	18.2	14.44	77.6	9.30	2.73	348	–	–	–	–	–	–	–	–	–	–	–	–	–	5.7	–	6.4	–
100	20.6	15.24	85.6	10.12	3.02	307	–	–	–	–	–	–	125	–	38	18	–	–	–	6.5	–	7.3	–
150	32.1	19.30	128	14.48	4.48	195	–	–	–	–	–	–	145	–	47	20	–	–	–	10.0	1.0	11.3	–
200	43.2	23.5	170	18.90	5.92	144	40	–	–	–	–	–	165	A	54	23	–	–	–	13.5	1.4	15.2	–
250	54.0	28.0	212	23.45	7.35	114	46	–	–	–	–	–	198	A	62	26	–	–	–	16.9	1.7	19	–
300	65.0	32.5	254	28.0	8.79	95	52.5	15	6.0	3.0	30	20	225	B	73	29	–	–	–	20.4	2.0	23	–
400	87.60	41.9	338	37.1	11.70	70.8	66	21	7.2	3.2	42	28	270	C	90	37	–	–	–	27.4	2.7	31	7
500	110.0	51.6	423	46.2	14.60	56.4	79	25	7.8	3.4	50	34	320	D	–	46	–	–	–	34.5	3.5	39	8
600	132	61.4	508	55.4	17.50	47.0	92	30	8.5	3.6	58	40	370	F	–	55	–	–	–	41	4.1	46	9
700	154	71.1	592	65.6	20.45	40.3	106	35	9.0	3.9	67	45	420	G	–	63	22.5	–	–	48	4.8	54	9.5
800	176	81.0	677	73.8	23.35	35.2	120	39	9.8	4.1	74	50	470	–	–	72	24.5	–	–	55	5.5	62	10.8
900	198	91.0	762	83.0	26.30	31.3	135	41	10.7	4.3	82	57	515	H	–	80	27	18	–	62	6.2	70	11.9
1000	220	100.7	896	92.1	29.20	28.2	149	43	11.5	4.5	90	62	570	I	–	88	29	20	13	69	6.9	77	12.4
1500	330	150	1270	138.2	43.80	18.7	–	65	15.2	6.3	132	90	805	M	–	–	40	28	18	103	10.3	116	16.8
2000	440	200	1690	184.2	58.40	14.1	–	86	19.5	7.5	172	118	1070	Q	–	–	51	34	24	137	13.7	154	22
2500	550	250	2120	230	73.0	11.3	–	108	24	9	218	147	1325	T	–	–	63	41	29	172	17.2	193	27.6
3000	660	300	2540	276	87.60	9.4	–	129	28.5	11	258	172	1690	U	–	–	75	48	33	206	20.6	232	33.7
4000	880	400	3380	368	117.0	7.05	–	172	37	14	337	230	2110	V	–	–	–	63	43	275	27.5	308	45
5000	1100	500	4230	461	146	5.64	–	215	47	18	425	290	2635	W	–	–	–	77	50	344	34.4	385	55.8
6000	1320	600	5080	553	175	4.70	–	258	57	22	520	350	3145	X	–	–	–	–	65	413	41.3	462	65.5
7000	1540	700	5920	645	204.5	4.03	–	300	67	25	600	410	3670	–	–	–	–	–	75	481	48	540	77
8000	1760	800	6770	737	233.5	3.52	–	344	76	29	680	465	4170	Y	–	–	–	–	86	550	55	618	89
9000	1980	900	7620	829	263	3.13	–	387	86	32	780	520	4700	–	–	–	–	–	96	620	62	695	102
10000	2200	1000	8460	921	292	2.82	–	430	96	35	850	575	5220	Z	–	–	–	–	–	690	69	770	113
15000	3300	1500	13700	–	438	2.50	–	650	147	53	1280	860	7720	Z2	–	–	–	–	–	1030	103	1160	172
20000	4400	2000	18400	–	584	1.40	–	860	203	70	1715	1150	10500	Z3	–	–	–	–	–	1370	137	1540	234

* Kinematic Viscosity (in centistokes) = $\dfrac{\text{Absolute viscosity (in centipoises)}}{\text{Density}}$

Above 250 SSUm use the following approximate conversion:

SSU = Centistokes ˇ 4.62

Above the range of this table and within the range of the viscosimeter, multiply their rating by the following factors to convert to SSU:

Viscosimeter	Factor
Saybolt Furol	10
Redwood Standard	1.095
Redwood Admiralty	10.87
Engler - Degrees	34.5

Viscosimeter	Factor
Parlin cup = 15	98.2
Parlin cup = 20	187.0
Ford cup = 4	17.4

Viscosimeter	Factor
Mac Michael	1.92 (approx.)
Demmler = 1	14.6
Demmler = 10	146.0
Stormer	13.0 (approx.)

Friction Loss in Head For Viscous Liquids
Loss In Feet Of Liquid Flowing In 100 Feet Of New Schedule 40 Steel Pipe

Gpm	Pipe Size	KINEMATIC VISCOSITY - SECONDS SAYBOLT UNIVERSAL													
		100	200	300	400	500	1000	2000	3000	4000	5000	6000	8000	10,000	15,000
3	1/2	25.9	54.5	81.5	108.1	136.3	272.6	545.2	815.4	1088.0	1360.6	1630.9	2176.0	—	—
	3/4	5.8	17.6	26.6	35.3	44.1	88.2	175.6	265.7	353.4	441.2	529.0	706.9	882.4	1323.6
	1	3.2	6.7	10.2	13.4	16.9	33.5	67.2	100.7	134.0	168.6	201.0	268.0	335.0	503.6
5	3/4	14.1	29.3	44.1	58.9	73.7	147.8	293.4	441.2	589.1	736.9	882.4	1178.1	1471.5	2208.4
	1	5.3	11.3	16.9	22.4	28.0	55.9	112.0	168.6	224.1	276.5	335.0	448.1	559.0	838.5
	1 1/4	1.8	3.7	5.5	7.6	9.5	18.7	37.4	56.1	75.1	93.8	112.5	150.2	187.1	281.8
7	3/4	19.6	41.3	61.9	82.5	103.0	205.6	411.2	619.1	824.7	1030.6	1235.9	1647.0	2060.5	—
	1	7.4	15.7	23.6	31.4	39.3	78.3	157.1	235.6	314.2	392.7	469.0	626.0	783.1	1175.8
	1 1/4	2.5	5.3	7.8	10.4	13.2	26.3	52.4	78.5	104.9	131.7	157.1	210.2	263.3	392.7
10	1	11.3	22.4	33.5	44.8	55.9	112.0	224.1	335.0	448.1	559.0	672.2	896.3	1120.4	1679.4
	1 1/4	3.7	7.6	11.3	15.0	18.7	37.4	75.1	112.5	150.2	187.1	224.1	300.3	374.2	561.3
	1 1/2	1.9	4.2	6.0	8.1	10.2	20.3	40.4	60.8	80.9	101.2	122.4	161.7	203.3	302.6
15	1	25.4	33.5	50.4	67.2	83.9	168.6	335.0	503.6	672.2	838.5	1007.2	1342.1	1679.4	—
	1 1/4	6.5	11.3	16.9	22.4	28.2	56.1	112.5	168.6	224.1	281.8	337.3	450.5	561.3	843.2
	1 1/2	3.0	6.0	9.0	12.2	15.2	30.3	60.8	91.0	122.4	152.5	182.5	242.6	302.6	455.1
20	1	41.6	41.6	67.2	89.6	112.0	224.1	448.1	672.2	896.3	1120.4	1342.1	1790.3	—	—
	1 1/2	5.3	8.1	12.2	16.2	20.3	40.4	80.9	122.4	161.7	203.3	242.6	323.4	404.3	607.5
	2	1.5	3.0	4.4	6.0	7.4	14.8	29.8	44.6	59.4	74.2	88.9	117.8	147.8	221.8
25	1 1/2	8.1	10.2	15.2	20.8	25.4	50.6	101.2	152.5	203.3	254.1	302.6	406.6	505.9	757.7
	2	2.3	3.7	5.5	7.4	9.2	18.5	37.2	55.7	74.2	92.9	111.3	147.8	184.8	279.5
	2 1/2	0.92	1.8	2.8	3.7	4.6	9.2	18.2	27.3	36.5	45.5	54.7	73.0	91.2	136.3
30	1 1/2	11.6	12.2	18.2	24.3	30.3	60.8	122.4	182.5	242.6	302.6	365.0	485.1	607.5	910.1
	2	3.2	4.4	6.7	9.0	11.1	22.2	44.6	66.8	89.0	111.3	134.0	177.9	221.8	335.0
	2 1/2	1.4	2.2	3.2	4.4	5.5	10.9	22.0	32.8	43.9	54.7	65.6	87.5	109.5	164.0
40	1 1/2	19.6	20.8	24.3	32.3	40.4	80.8	161.7	242.6	323.4	404.2	485.1	646.8	808.5	1215.1
	2	5.8	5.8	9.0	11.8	14.8	29.8	59.4	88.9	117.8	147.8	177.9	238.0	298.0	445.8
	2 1/2	2.5	3.0	4.4	5.8	7.4	14.6	29.1	43.9	58.4	73.0	87.5	117.8	145.5	219.4
50	1 1/2	28.9	32.3	32.3	40.4	50.6	101.2	203.3	302.6	404.3	505.9	607.5	808.5	1011.8	1517.7
	2	8.5	9.2	11.1	14.8	18.5	37.2	74.2	111.3	147.8	184.8	221.8	298.0	372.0	556.7
	2 1/2	3.7	3.9	5.5	7.4	9.2	18.2	36.5	54.7	73.0	91.2	109.5	145.5	182.5	272.6
60	2	11.6	13.4	13.4	17.8	22.2	44.6	89.0	134.0	177.9	221.8	268.0	355.7	445.8	667.6
	2 1/2	5.1	5.5	6.5	8.8	10.9	22.0	43.9	65.6	87.5	109.5	131.7	175.6	219.5	328.0
	3	1.8	1.8	2.8	3.7	4.6	9.2	18.5	27.5	36.7	46.0	55.2	73.5	92.0	138.6
70	2 1/2	6.5	7.4	7.9	10.2	12.7	25.7	51.1	76.7	102.1	127.1	152.5	203.3	256.4	383.5
	3	2.3	2.5	3.2	4.4	5.3	10.7	21.5	32.1	43.0	53.6	64.2	85.7	107.2	161.7
	4	0.62	0.72	1.1	1.5	1.8	3.7	7.2	10.9	14.5	18.2	21.7	28.9	36.0	54.3
80	2 1/2	8.3	9.7	9.7	11.8	14.6	29.1	58.4	87.5	117.8	145.5	175.6	233.3	291.1	439.0
	3	3.0	3.2	3.7	4.8	6.2	12.2	24.5	36.7	49.0	61.2	73.5	97.9	122.4	184.8
	4	0.83	0.83	1.2	1.7	2.1	4.2	8.3	12.5	16.6	20.6	24.7	33.0	41.3	61.9
100	2 1/2	12.2	14.1	14.8	14.8	18.5	36.5	73.0	109.5	145.5	182.5	219.5	293.4	365.0	547.5
	3	4.4	5.1	5.1	6.2	7.6	15.2	30.7	46.0	61.2	76.5	91.9	122.4	152.5	228.7
	4	1.2	1.3	1.5	2.1	2.5	5.1	10.4	15.5	20.6	25.9	31.0	41.3	51.5	77.4

TURBULENT FLOW RANGE ☐   LAMINAR OR VISCOUS FLOW RANGE ☐

Friction Loss in Head for Viscous Liquids
Loss In Feet Of Liquid Flowing In 100 Feet Of New Schedule 40 Steel Pipe
KINEMATIC VISCOSITY - SECONDS SAYBOLT UNIVERSAL

Gpm	Pipe Size	20,000	30,000	40,000	50,000	60,000	80,000	100,000	150,000	200,000	500,000
3	2	19.3	28.9	38.5	48.2	58	77	96	145	193	482
	2 1/2	9.5	14.2	19	23.7	28.4	37.9	47.4	71	95	237
	3	4	6	8	9.9	11.9	15.9	19.9	29.8	39.8	99
5	2	32	48.2	64	80	96	129	161	241	321	803
	2 1/2	15.8	23.7	31.6	39.5	47.4	63	79	118	158	395
	3	6.6	9.9	13.3	16.6	9.9	26.5	33	49.7	66	166
7	2	45.0	67	90	112	135	180	225	337	450	-
	2 1/2	22.1	33.2	44.2	55	66	88	111	166	221	553
	3	9.3	13.9	18.6	23.2	27.8	37.1	46.4	70	93	232
10	2 1/2	31.6	47.4	63	79	95	126	158	237	316	790
	3	13.3	19.9	26.5	33.1	39.8	53	66	99	133	331
	4	4.5	6.7	8.9	11.2	13.4	17.9	22.3	33.5	44.7	112
15	2 1/2	47.4	71	95	118	142	190	237	355	474	-
	3	19.9	29.8	39.8	49.7	60	80	99	149	199	497
	4	6.7	10.1	13.4	16.8	20.1	26.8	33.5	50	67	168
20	3	26.5	39.8	53	66	80	106	133	199	265	663
	4	8.9	13.4	17.9	22.3	26.8	35.7	44.7	67	89	223
	6	1.7	2.6	3.5	4.3	5.2	6.9	8.7	13	17.3	43.3
25	3	33.1	49.7	66	83	99	133	166	249	331	828
	4	11.2	16.8	22.3	27.9	33.5	44.7	56	84	112	279
	6	2.2	3.3	4.3	5.4	6.5	8.7	10.8	16.3	21.7	54
30	3	39.8	60	80	99	119	159	199	298	398	-
	4	13.4	20.1	26.8	33.5	40.2	54	67	101	134	335
	6	2.6	3.9	5.2	6.5	7.8	10.4	13	19.5	26	65
40	3	53.0	80	106	133	160	212	265	398	532	-
	4	17.9	26.8	35.7	44.7	54	72	89	134	179	447
	6	3.5	5.2	6.9	8.7	10.4	13.9	17.3	26	34.7	87
50	4	22.3	33.5	44.7	56	67	89	112	168	223	559
	6	4.3	6.5	8.7	10.8	13	17.3	21.7	32.5	43.3	108
	8	1.5	2.7	2.9	3.6	4.3	5.8	7.2	10.8	14.5	36.1
60	4	26.8	40.2	54	67	80	107	134	201	268	670
	6	5.2	7.8	10.4	13	16	20.8	26	39	52	130
	8	1.7	2.6	3.5	4.3	5.2	6.9	8.7	13	17.3	43.4
70	4	31.3	46.9	63	78	94	125	156	235	313	782
	6	6.1	9.1	12.1	15.2	18.4	24.3	30.3	45.5	61	152
	8	2	3	4.1	5.1	6.1	8.1	10.1	15.2	20.2	51
80	6	6.9	10.4	13.9	17.3	20.8	27.7	34.7	52	69	173
	8	2.3	3.5	4.6	5.8	6.9	9.3	11.6	17.3	23.1	58
	10	0.93	1.4	1.9	2.3	2.8	3.7	4.7	7	9.3	23.3
90	6	7.8	11.7	15.6	19.5	23.4	31.2	39	59	78	195
	8	2.6	3.9	5.2	6.5	7.8	10.4	13	19.5	26	65
	10	1.1	1.6	2.1	2.6	3.1	4.2	5.2	7.9	10.5	26.2
100	6	8.7	13	17.3	21.7	26	34.7	43.3	65	87	217
	8	2.9	4.3	5.8	7.2	8.7	11.6	14.5	21.7	28.9	72
	10	1.2	1.8	2.3	2.0	3.5	4.7	5.8	8.7	11.6	29.1

LAMINAR OR VISCOUS FLOW RANGE

Pumping Slurry

SOLIDS HANDLING CAPABILITIES, SUCTION PRESSURE LIMITATIONS

Pumping Slurry

Normally when a metal casing and a rubber diaphragm are utilized, slurry of about 30 - 40% can be pumped, though care must be taken to the size of slurry particles. When pumping slurry of a high sedimentation rate, pay attention to the following points:

1. Secure a minimum flow velocity of 1.1 Ft/Sec (20 m/min)

Please note that 1.1 Ft/Sec is a minimum velocity. A velocity of 3 Ft/Sec (55 m/min) to 7 Ft/Sec (130 m/min) may be required to keep solids in suspension, although it is ideal to keep velocities as slow as possible to minimize abrasion.

2. Always consider inlet pressure. Inversion of the diaphragm can occur if over 20 PSI (1.4 Bars) inlet pressure on rubber diaphragms and 4.3 PSI (0.3 Bars) for PTFE diaphragms.

3. When the pump is at a standstill, attempt cleaning. Don't let the slurry set up in the pump.

4. If utilizing plastic pump casing, take extra precaution when pumping highly abrasive slurry. The content shall be kept below 10Wt%.

$$\text{Weight concentration (Wt\%)} = \frac{S}{W + S} \, (X) \, 100$$

Where, W = water (kg)   S = Solid matter (kg)

5. If slurry particles are uneven, install a strainer on the suction side of the pump so large foreign matter will not enter.

Mesh Chart
COMPARATIVE PARTICLE SIZE

U.S. Mesh	Inches	Microns
10	.0787	2000
12	.0661	1680
14	.0555	1410
16	.0469	1190
18	.0394	1000
20	.0331	841
25	.0280	707
30	.0232	595
35	.0199	500
40	.0165	420
45	.0138	354
50	.0117	297
60	.0098	250
70	.0083	210
80	.0070	177
100	.0059	149
120	.0049	125
140	.0041	105
170	.0035	88
200	.0029	74
230	.0024	63
270	.0021	53
325	.0017	44
400	.0015	37

Handling Abrasives

Handling abrasive with a positive displacement pump is generally considered a tricky application. A rule of thumb is to oversize the pump and operate slower. This also applies to air-operated double diaphragm and solids handling rotary pumps. The key to handling abrasives is wear versus time, and internal fluid velocities which induce wear and accelerate erosion. With a diaphragm pump, solids; within the maximum size and percent, are handled well. However the wearing components of a pump operating at 30 strokes per minute will be considerably less than that of a smaller pump operating at 130 strokes per minute. While initial costs may be less, another good rule of thumb is (decrease speed by half, increase life by a factor of six or more).

Specific Gravity

The typical pump performance curve is based on water which has a specific gravity of 1.0. Pumping a liquid with a specific gravity other than 1.0 will affect the pump's performance. Fluids with a specific gravity higher than 1.0SG will require more energy to pump the same volume of liquid as water. Likewise, if the fluid has a lower specific gravity than 1.0SG, it will require less energy to move the same volume of liquid than water.

As is the case with power pumps, often the discharge conditions are given in pounds per square inch gauge (PSIG).

To convert this to feet of head, multiply PSIG by 2.31.

To illustrate specific gravity correction, we will use the pump curve on page 2 which shows a design point of 60 GPM @ 75' TDH with a specific gravity of 1.0.

Using a specific gravity of 1.85, the corrected total dynamic head would be 40.5' TDH.

However, you would still need to read the air requirements for the 75' TDH mark which is 60 PSIG @ 35 SCFM.

If on the other hand, if someone wants 60 GPM @ 75' TDH and tells you that the specific gravity is 1.85, you would multiply the 'TDH x S.G.

75' TDH x 1.85 S.G. = 138.75'

138.75' TDH would be the point on the curve you would read for your air requirements, which would be 95PSIG @ 48 SCFM.

53

Materials of Construction

Return to Index

Typical Wetted Materials of Construction

POLYPROPYLENE (PP/PPG)

Temperature range: 30° to 180°F
Good chemical resistance
Lightweight
Limited temperature / pressure capabilities
Not compatible with petroleum based solvents
Can be glass filled for added mechanical strength

KYNAR® (PVDF)

Temperature range: 0° to 212°F
Excellent chemical resistance
Good strength / higher temperature capability
Can be carbon filled for electrical conductivity (groundability)

ALUMINUM (356-T6)

Used in many non-corrosive, non-abrasive applications
Lightweight

CAST IRON (FC)

Used with a variety of non-corrosive services
Good for slurry applications

STAINLESS STEEL (316SS)

Used with more chemically active fluids
High abrasion resistance

PTFE

Temperature range: 32° to 176°F
Inert to most chemicals
100% Virgin PTFE

Plastic pumps in general are recommended for strong acids
and caustics and not recommended for high temperatures or slurries.

Metal pumps in general are good for abrasion resistance, solvents,
hydrocarbons, and high temperature applications.

We do not show the temperature limits on metal pumps because
body material temperature limits will exceed elastomer temperature limits.

Diaphragm Pressure Limits

Rubber diaphragms can handle a maximum positive inlet pressure of 20 PSIG dependent upon pump size, pump design and diaphragm material.

PTFE diaphragms are limited to 4.3 PSIG (10') positive inlet pressure due to their poor flexibility and low tolerances for mechanical stress.

Back up diaphragms may be used in connection with PTFE diaphragms to help extend teflon diaphragm life in severe applications.

Typically rubber diaphragms can operate under any amount of vacuum, however teflon diaphragms are generally limited to 16" HG.

Typical Diaphragm Materials

RUBBER COMPOUNDS

BUNA N (NBR)

Temperature range: 10°F to 180°F
Excellent for oil / petroleum based fluids
Identification: Red or pink dot / Diaphragm is black

NEOPRENE™ (CR)

Temperature range: 0°F to 180°F
Excellent elastomer for use in non-aggressive applications
Good for abrasive materials
Identification: No dot / Diaphragm is dull black

NORDEL® (EPDM)

Temperature range: -40°F to 210°F
Good for extremely cold applications
Good resistance to acids and caustics
Identification: Green dot / Diaphragm is black

VITON® (FPM)

Temperature range: -20°F to 248°F
Excellent for aggressive fluids such as aromatic or chlorinated hydrocarbons and acids
Good for high temperature applications
Identification: Blue dot / Diaphragm is black

NOTE: For estimated diaphragm cycle life, consult pump manufacturer.

THERMOPLASTIC COMPOUNDS

SANTOPRENE® (TPO)

Temperature range: -10°F to 180°F
Good for abrasive materials
Good resistance to acids and caustics
Good for high temperature applications
Identification: No dot / Diaphragm is shiny black

HYTREL™ (TPE)

Temperature range: 0°F to 248°F
Excellent general purpose / durable diaphragm
Long life in non-aggressive applications
Identification: No dot / Diaphragm is cream/tan

PTFE – PolyTetraFluoroEthylene

Temperature range: 40°F to 212°F
Excellent choice for pumping highly aggressive fluids
Can have good life if abrasives are not present
Back up rubber diaphragm may be used
Identification: No dot / Diaphragm is white

Elastomers may be available in FDA compliant material for use with food, pharmaceutical and cosmetic applications.

NOTE: For estimated diaphragm cycle life, consult pump manufacturer.

Pressure vs. Temperature
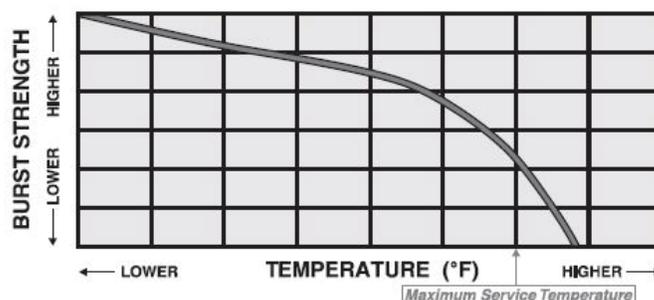
As a general rule, the working pressure of a diaphragm pump is based upon operation at room temperature (70° F).

If the temperature is too high or too low leakage problems may occur and diaphragm life may be shortened.

As the temperature increases above room temperature the pump's ability to handle pressure will decrease

As the temperature decreases below room temperature diaphragms become brittle and crack. Pump casings contract from cold temperature and leakage occurs.

All pumps work on a pressure/temperature curve. Consult your pump's manufacturer for further information.

Estimated Diaphragm Life Calculation

Formula for Calculation:

1. GPMA ÷ GPMM   =% Max Flow Rate
2. % Max Flow Rate   x   MSPM   =SPMA
3. SPMA   x   T   =SPD
4. EDL ÷ SPD   =AEL

NOTE:

GPMA	=	Gallons Per Minute Actual Output
GPMM	=	Gallons Per Minute Max. Output
MSPM	=	Maximum Strokes Per Minute
SPMA	=	Strokes Per Minute Actual
T	=	Time, in minutes, pump runs per day
SPD	=	Strokes Per Day
EDL	=	Estimated Diaphragm Life
AEL	=	Actual Estimated Life

EXAMPLE: NDP-20BST, @ 10GPM, 4 hrs. per day operation

1. 10 GPM ÷ 21   =.476
2. .476   x   195   =92.82
3. 92.82   x   240   =22,277
4. 8,000,000 ÷ 22,277   =359 Estimated life in days

NOTE: There are many variables which will affect diaphragm life and thus this calculation is just an estimation and should be regarded as such.

Effective Diaphragm Area (A$_{EFF}$)

AEFF is an approximation of the actual working area of a diaphragm. It is determined by averaging the diameнter at the outermost flex point of the diaphragm and the outside diameter of the outer diaphragm plate and calculating the area from resultant diameter.

$$A_{EFF} = \frac{\pi \left[\dfrac{(d_d + d_{DP})}{2}\right]^2}{4}$$

Displacement per stroke (D)

The volume swept by the diaphragms or bellows in one stroke.

The displacement per stroke can by approximated with the following formula:

Outer diaphragm plate

d_{DP}

d_d

Inner diaphragm plate
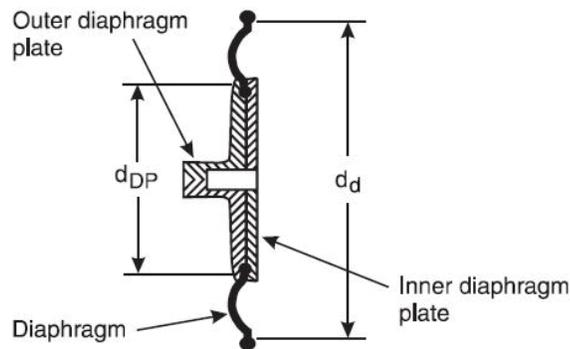
Diaphragm

—Effective diaphragm area

It should be noted that the actual displacement per stroke would vary to some degree with diaphragm construction and flow rate during operation due to the flexibility of the diaphragm.

Special Surface Finishes

Special surface finishes are becoming more common on stainless steel pumps when used in such industries as food, pharmaceutical, cosmetics, biotech and electronics. There are many different ways to measure surface finishes. The following is a cross reference of some of the methods for measuring surface finishes.

Emery Polishing Paper (CAMI)
4/0 = 800 grit
3/0 = 600 grit
2/0 = 500 grit
1/0 = 400 grit
1 = 280
2 = 220
3 = 180

Cami Micron	Grade	European New "P" Grade		Apex
	1200			
9	800	P2000		A6
15	600	P1200		A16
20	500	P1000		
30	400	P800		A30
		P600	Extra Fine	
	360	P500		
40	320	P400		A45
	280	P380		
		P320		
50	240	P280	Very Fine	A65
60		P240		A80
	220	P220		A100
80	180	P180	Fine	
100	150	P150		A130
120	120			A160
150	100	P120	Medium	
180	80	P100		
		P80		
60		P60		
50		P50	Coarse	
40		P40		
36		P36	Very Coarse	
30		P30		
24		P24		
20		P20	Extra Coarse	
16		P16		
12		P12		

*80 micron - 180 micron

Brown A/O - tougher & more wear resistance, longer life

* 9 micron - 60 micron

White A/O - finer - soft mineral, breaks down easier

Micro		
	Cuts Like	Finishes Like
15 mic.	600	much finer
30	320-400	600
40	240-320	360-400
50	220	320
80	180	280

RA Surface Finish

#10 Polish	+ 400# Grit	2L (Lapped)	
#9	320# Grit		2 RA
#8	260-280# Grit	4L (Lapped)	4 RA
#7			10 RA
	220-240# Grit	8G (Ground)	
#6			
			15 RA
#5	180-220# Grit	16G (Ground)	20 RA
			30 RA
#4	150# Grit	25ST (Sharp Turn)	
#3	120# Grit	40ST (Sharp Turn)	40 RA
	80# Grit		
	40# Grit		100 RA

RA Finish is typically used to measure surface finish on a machined part while polish and grit finishes are used to measure surface finish on mechanically polished parts.

Corrosion Resistance Guide

Return to Index

Introduction

This chapter is intended as a general guide in the selection of proper pump construction materials. This listing includes the most common liquids used in industrial and processing applications. In using this guide, please take note of the following:

1. The chart data has been compiled from many sources believed to be reliable. NO GUARANTEE IS IMPLIED OR EXPRESSLY STATED HEREIN.

2. Because of the extensive scope of this field the tabulation is not complete nor conclusive. Corrosion rates may vary widely with concentration, temperature and the presence of abrasives. Impurities or other trace elements common in industrial liquids may inhibit or accelerate the reaction of the material being pumped and the effect on pump materials.

3. Chemicals or liquids may independently be compatible with a type of pump construction, the combination of several liquids may change the chemical compatibility with a given metal/plastic and elastomer. It is important that this is remembered when selecting acceptable materials of construction for a pump.

4. In the case of uncertainty regarding corrosion resistance, testing the materials of construction under conditions as close to actual as possible is recommended.

KEY TO RATINGS:

A = Excellent

B = Good

C = Fair to Poor

X = Not Recommended

— = No Data Available

Data limited to % concentration and/or temperature (°F) shown; where not shown, temperature is 70°F.

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Kynar® is a registered trademark of Pennwalt Corporation.
Santoprene® is a registered trademark of Monsanto.
Ryton® is a registered trademark of Philips Chemical.

Halogenated Solvents Warning

WARNING!

HALOGENATED HYDROCARBON SOLVENTS, SUCH AS 1, 1, 1 TRICHLOROETHANE AND METHYLENE CHLORIDE, SHOULD NOT BE USED IN ALUMINUM EQUIPMENT. A VIOLENT EXPLOSION COULD RESULT.

- Carbon Tetrachloride

- Chloroform

- Dichlorethylene

- Methyl Chloride

- Methylene Chloride

- Trichlorethylene

WARNING:

Although materials may be chemically compatible, when pumping flammables it is important to ground the pump to prevent arcing that can be caused by a buildup of static electricity; which may ignite the volatile liquids of powders and cause an explosion and/or fire. Polypropylene is not a groundable material.

Index of Chemicals

A

Acetaldehyde
Acetamide
Acetic Acid
Acetic
Anhydride
Acetone
Acetone Cyanohydrin
Acetonitrile
Acetophenone
Acetyl
Acetone
Acetyl Chloride
Acetylene
Acetyl Salicyclic Acid
Acetylene Tetrabromide
Acrolein
Adipic Acid
Alcohols
    Allyl Alcohol
    Amyl
    Benzyl
    Butyl
    Decyl Alcohol
    Denatured Alcohol
    Diacetone
    Ethyl
    Ethyl Butyl Alcohol
    Hexyl
    Isoamyl Alcohol
    Isobutyl
    Isopropyl
    Lauryl Alcohol
    Methyl Amyl Alcohol
    Methyl
    Octyl
    Propyl
    Tridecyl Alcohol
Allyl Bromide
Allyl Chloride
Alkazene
Alum
Aluminum Acetate
Aluminum Ammonium
    Sulfate
Aluminum Bromide
Aluminum Chloride
Aluminum Fluoride
Aluminum Hydroxide
Aluminum Nitrate
Aluminum Phosphate
Aluminum Potassium
    Sulfate
Aluminum Sodium Sulfate
Aluminum Sulfate
Amines

Ammonia Anhydrous,
    Liquid
Ammonia Gas - Cold
Ammonia Gas - Hot
Ammonia Liquors
Ammonia Cupric Sulfate
Ammonium Acetate
Ammonium Bicarbonate
Ammonium Bifluoride -
    10%
Ammonium Carbonate
Ammonium Casenite
Ammonium Chloride
Ammonium Dichromate
Ammonium Fluoride
Ammonium Hydroxide
Ammonium
    Metaphosphate
Ammonium Nitrate
Ammonium Nitrite
Ammonium Oxalate
Ammonium Persulfate
Ammonium Phosphate
    Monobasic
Ammonium Phosphate, Di
    Basic
Ammonium Phosphate,
    Tri-Basic
Ammonium Sulfate
Ammonium Sulfide
Ammonium Sulfite
Ammonium Thiocyanate
Ammonium Thiosulfate
n-Amyl Amine
Amyl Borate
Amyl Chloride
Amyl Chloronaphthalene
Amyl Naphtalene
Amyl Phenol
Anilene
Anilene Dyes
Anilene Hydrochloride
Animal Gelatin
Anisole
Ansul Ether
Anthraquinone
Anti-Freeze - Alcohol Base
Anti-Freeze - Glycol Base
Antimony Pentachloride
Antimony Trichloride
Aqua Regia
Aroclor
Aromatic Hydrocarbons
Aromatic Solvents
Arsenic Acid
Arsenic Trichloride
Absorbic Acid

Askarel
Asphalt
Asphalt Topping
ASTM - Ref Motor Fuel
    A (Aliphatic)
    B (30% Aromatic)
    C (50% Aromatic)
ASTM - Ref Oil
Aviation Gasoline

B

Barbeque Sauce
Barium Carbonate
Barium Chloloride
    Dihydrate
Barium Cyanide
Barium Hydroxide
Barium Nitrate
Barium Sulfate
Barium Sulfide
Beef Extract
Beer
Beet Sugar Liquors
Benzaldehyde
Benzene
Benzene Sulfonic Acid
Benzoic Acid
Benzoyl Chloride
Benzyl Acetate
Benzyl Benzoate
Benzyl Chloride
Benzyl Dichloride
Benzol
Biphenyl
Bismuth Subcarbonate
Black Sulfate Liquor
Blast Furnace Gas
Bleach Solutions
Borax
Bordeaux Mixture
Boric Acid
Brake Fluid
Brewery Slop
Brine
Bromine - Anhydrous
Bromine Trifluoride
Bromine Water
Bromobenzene
Bromochloromethane
Bromotoluene
Bronzing Liquid
Butadiene
Butane
Butter
Buttermilk
Butyl Acetate
n-Butyl Acetate

Butyl Acetyl Ricinoleate
Butyl Acrylate
Butyl Amine
Butyl Benzoate
Butyl Butyrate
Butyl Carbitol
Butyl Cellosolve
Butyl Chloride
Butyl Ether
Butyl Oleate
Butyl Stearate
Butylene
Butyraldehyde
Butyric Acid
Butyric Anhydride
Butyronitrile

C

Calcium Acetate Hydrate
Calcium Bisulfite
Calcium Carbonate
Calcium Chlorate
Calcium Chloride
Calcium Hydrosulfide
Calcium Hydroxide
Calcium Hypochlorite 20%
Calcium Nitrate
Calcium Oxide
Calcium Silicate
Calcium Sulfate
Calcium Sulfide
Calcium Sulfite
Calgon
Cane Juice
Cane Sugar Liquors
Capryl Alcohol
Caprylic Acid
Carbamate
Carbitol
Carbolic Acid
Carbon Dioxide
Carbon Sidulfide
Carbon Monoxide
Carbon Tetrachloride
Carbonated Beverages
Carbonic Acid
Casein
Catsup
Cellosolve Cellulose
    Acetate
Cellelube Hydraulic
    Fluids
Chlorinated Lime - 35%
    Bleach
Chlorinated Water
Chlorine

Index of Chemicals (continued)

C (continued)

Chlorine Dioxide
Chlorine Trifluoride
Chloroacetic Acid
Chloroacetone
Chlorobenzene
Chlorobutadiene
Chlorobromomethane
Chloroform
1-Chloronaphthalene
Chlorosulfonic Acid
o-Chlorophenol
Chlorothene
Chlorotrifluoroethylene
Chlorox
Chocolate Syrup
Chromic Acid - to 25%
Chromic Acid - Over 25%
Cider
Citric Acid
Citrus Pectin Liquor
Cobalt Chloride
Coffee
Coke Oven Gas
Copper Acetate
Copper Chloride
Copper Cyanide
Copper Fluoroborate
Copper Nitrate
   Hexahydrate
Copper Sulfate
Copper Sulfide
Cream
Creosote, Wood-Tar
Cresylic Acid
Crotonaldehyde
Cumeme
Cyclohexane
Cyclohexanol
Cyclohexanone
Cyclopentane
Cymene

D

Decahdronaphthalene
Decanal
Decane
Detergent Solutions
Developing Fluids &
   Solutions
Dextrose
Dibenzyl Ether
Dibenzyl Sebecate
Dibutyl Amine
Dibutyl Phthalate

Dibutyl Sebecate
Dichloroacetic Acid
o-Dichlorobenzene
Dichlorobutane
Dichchloroethyl Ether
Dichloro Isopropyl Ether
Dichclohexylamine
Diethanol Amine
Diethyl Amine
Diethyl Benzene
Diethyl Carbonate
Diethyl Ether
Diethyl Phthalate
Diethyl Sebecate
Diethylene Ether
Diethylene Glycol
Diethylene Triamine
Dilsobutyl Ketone
Diisobutylene
Diisodecyl Adipate
Diisodecyl Phthalate
Diisooctyl Adipate
Diisooctyl Phthalate
Diisooctyl Sebecate
Diisopropyl Amine
Diisopropyl Benzene
Diisopropyl Ketone
N, N-Dimethylaniline
Dimethyl Ether
N, N-Dimethyl Formamide
Dimethyl Phthalate
Dimethyl Sulfate
Dimethyl Sulfide
Dinitrotoluene
Dioctyl Phtahalate
Dioctyl Sebecate
Dioxolanes
Dipentene
Diphenyl Oxides
Dipropylamine
Dipropylene Glycol
Dipropyl Ketone
Divinyl Benzene
Dodecyl Benzene
Dow Corning
Dowtherm
Dry Cleaning Fluids
Dyes

E

Epichlorohydrin
Epsom Salts
Ethane
Ethanolamine
Ethyl Acetate
Ethyl Acetoacetate

Ethyl Acrylate
Ethyl Aluminum
   Dichloride
Ethyl Amine
Ethyl Benzene
Ethyl Benzoate
Ethyl Bromide
Ethyl Butyl Acetate
Ethyl Butyl Ketone
Ethyl Butyraldehyde
Ethyl Butyrate
Ethyl Caprylate
Ethyl Cellosolve
Ethyl Cellulose
Ethyl Chloride
Ethyl Chlorocarbonate
Ethyl Cyanide
Ethyl Formate
Ethylexyl Acetate
Ethylhexyl Alcohol
Ethyl Iodide
Ethyl Isobutyrate
Ethyl Mercaptan
Ethyl Oxalate
EthylPentachlorobenzene
Ethyl Propionate
Ethyl Silicate
Ethyl Sulfate
Ethylene
Ethylene Chlorohydrin
Ethylene Diamine
Ethylene Dibromide
Ethylene Glycol
EthyleneGlycolMonobutyl
   Ether
EthyleneGlycolMonobutyl
Ether Acetate
Ethylene Glycol
   Monomethyl
Ethylene Oxide
Ethylene Trichloride
Ethylidene Chloride

F

Fatty Acids
Ferric Chloride
Ferric Hydroxide
Ferric Nitrate
Ferric Sulfate
Ferrous Chloride
Ferrous Sulfate
Fluoboric Acid
Fluorine
Fluorobenzene
Fluosilicic Acid
Formaldehyde

Formamide
Formic Acid
Freon 11
Freon 12
Freon 13
Freon 13B1
Freon 14
Freon 21
Freon 22
Freon 113
Freon 114
Freon 114B2
Freon 115
Fruit Juices
Fumaric Acid
Furan
Furfuryl Alcohol

G

Gallic Acid
Gasoline - unleaded
Gasoline - Petrol
Gelatin
Glauber's Salt
Gluconic Acid
Glucose
Glue
Glycerol
Glycolic Acid
Glycols
Gold Monocyanide
Grape Juice
Grease
Green Sulfate Liquor

H

Halowax
Heptanal
Heptane
Hexanal
Hexalin
n-Hexane
n-Hexane 1
Hexylene Glycol
Honey
Hydrazine
Hydrobromic Acid
Hydrochloric Acid
Hydrocyanic Acid
Hydrofluoric Acid
Hydrogen Fluoride
Hydrogen Peroxide
Hydrogen Sulfide (Wet)
Hydroquinone
Hydroxyacetic Acid -
   10%

Index of Chemicals (continued)

H (continued)

Hypochlorous Acid

I

Ink
Iodine
Idoform
Isoamyl Acetate
Isoamyl Butyrate
Isoamyl Chloride
Isobutyl Acetate
Isobutyl Amine
Isobutyl Chloride
Isobutyric Acid
Isododecane
Isooctane
Isopentane
Isophorone
Isopropyl Acetate
Isopropyl Amine
Isopropyl Chloride
Isopropyl Ether

J-K-L

Jet Fuels
Kerosine
Lacquers
Lacquer Solvents
Lactic Acid
Lactol
Latex
Lead Acetate
Lead Chloride
Lead Nitrate
Lead Sulfamate
Ligroin (Ligroine
Lignin Liquor
Lime Bleach
Lime Slurries
Lime, Soda
Lime Sulfur
Limonene
Linoleic Acid
Lindol
Lithium Bromide
Lye

M

Magnesium Carbonate
Magnesium Chloride
Magnesium Hydroxide
Magnesium Nitrate
Magnesium Oxide
Magnesium Sulfate

Maleic Acid
Maleix Anydride
Malic Acid
Maple Sugar Liquors
Mayonnaise
Mercuric Chloride
Mercuric Cyanide
Mercurous Nitrate
Mercury
Mesityl Oxide
Methane
Methyl Acetate
Methyl Acetoacetate
Methyl Acrylate
Methyl Acrylic Acid
Methyl Amine
Methyl Amyl Acetate
Methyl Aniline
Methyl Bromide
Methyl Butyl Ketone
Methyl Butyrate
Methyl Cellosolve
Methyl Chloride
Methyl Cyclopentane
Methyl Dichloride
Methyl Ethyl Ketone
Methyl Formate
Methyl Hexane
Methyl Iodide
Methyl Isobutyl Ketone
Methyl Isopropyl Ketone
Methyl Methacrylate
Methyl Oleate
Methyl Propyl Ketone
Methyacrylic Acid
Methylamine
Methyl Bromide
Methylene Chloride
Milk
Mine Water
Mixed Acids
Molasses
Monochlorobenzene
N-Methyl Aniline
Monoethanolamine
Monomethylether
Monovinyl Acetylene
Mustard

N

Naptha
Naphtha Coal Tar
Naphthalene
Naphthoic Acid
Neohexane
Neosol

Neville Acid
Nickel Acetate
Nickel Chloride
Nickel Nitrate
Nickel Sulfate
Nitrana
Nitric Acid
Nitrobenzene
Nitroethane
Nitrogen Tetroxide
Nitromethane
1-Nitropropane

O

Octadecane
n-Octane
Octyl Acetate
Octachlorotoulene
Oils: A through D
    Almond Oil
    Amyl Acetate
    Animal Fats & Oil
    Bunker Oil
    Castor Oil
    Cinnamon Oil
    Citric Oils
    Clove Oil
    Coconut Oil
    Cod Liver Oil
    Corn Oil
    Cotton Seed Oil
    Creosote, Coal-Tar
    Cutting Oil
    Cutting Oil
    Diesel Oil
    Diester Synthetic Oils
    Dispersing Oil #10
Oils: E through H
    Ethylene Dichloride
    Fish Oil
    Fluorolube
    Fuel Oils
    Furfual
    Fusel Oil
    Ginger Oil
    Grapefruit Oil
    Halowax Oil
    Hydraulic Oil
Oils: L through N
    Lard
    Lavender Oil
    Lemon Oil
    Linseed Oil
    Lubricating Oils
    Methyl Salicylate
    Mineral Oil

    Neatsfoot Oil
Oils: O through Q
    Oleic Acid
    Olive Oil
    Palm Oil
    Peanut Oil
    Peppermint Oil
    Petroleum
Oils: R through S
    Rape-Seed Oil
    Rose Oil
    Rosin Oil
Oils: R through S
    Sesame Seed Oil
    Silicone Oils
    Soybean Oil
    Sperm Oil
Oils: T through Z
    Transformer Oil
    Tung Oil
    Vegetable Oils
    Walnut Oil
    White Oil
Oleum
Olein
0-Dicholobenzene
Oxalic Acid
Ozone

P

Paints & Solvents
Paint Thinner, DUCO
Palmitic Acid
Paraffins
Paraformaldehyde
Paraldehyde
Pentachlorethane
Pentachlorophenol
Pentane
Perchloric Acid
Perchloroethylene
Phenethyl Alcohol
Phenol
Phenol Sulfonic Acid
Phenyl Acetate
Phenylbenzene
Phenyl Ethyl Ether
Phenyl Hydrazine
Phorone
Phosphoric Acid
Phosphorus Oxychloride
Phosphorus Trichloride
Photographic Developer
Pickling Solution
Picric Acid
Pinene

Index of Chemicals (continued)

P (continued)

Piperidine
Plating Solution
 Cadmium
 Chrome
 Lead
 Others
PolyvinylAcetateEmulsion
Potassium Acetate
Potassium Bicarbonate
Potassium Bisulfate
Potassium Bisulfite
Potassium Bromide
Potassium Carbonate
Potassium Chlorate
Potassium Chloride
Potassium Chromate
PotassiumCopperCyanide
Potassium Cyanide
Potassium Dichromate
Potassium Hydroxide
Potassium Iodide
Potassium Nitrate
Potassium Nitrite
Potassium Permanganate
Potassium Phosphate
Potassium Silicate
Potassium Sulfate
Potassium Sulfide
Potassium Sulfite
Propane
Propionaldehyde
Propionic Acid
n-Proply Acetate
Propyl Alcohol
n-Propyl Nitrate
Propylene
Propylene Dichloride
Propylene Glycol
Propylene Oxide
Pydraul
Pyranol
Pyridine
Pyroligneous Acid
Pyrrole

Q-R-S

Quaternary Ammonium
 Salts
Rosin
Rotenone
Rubber Latex Emulsions
Rubber Solvents
Rum
Rust Inhibitors

Salad Dressing
Sal Ammonian
Sal Soda
Salicyclic Acid
Salt Water
Sea Water
Sewage
Silicate Esters
Silver Cyanide
Silver Nitrate
Skydrol Hydraulic Fluid
Soap Solutions
Soda Ash
Sodium Acetate
Sodium Aluminate
Sodium Bicarbonate
Sodium Bisulfite
Sodium Bisulfate
Sodium Borate
Sodium Bromide
Sodium Chlorate
Sodium Chloride
Sodium Chromate
Sodium Cyanide
Sodium Dichromate
Sodium Fluoride
Sodium Hexametaphosphate
Sodium Hydroxide
Sodium Hypochlorite
Sodium Metaphosphate
Sodium Metasilicate
Sodium Nitrate
Sodium Nitrite
Sodium Perborate
Sodium Peroxide
Sodium Phosphate
Sodium Silicates
Sodium Sulfate
Sodium Sulfide
Sodium Sulfite
Sodium Tetraborate
Sodium Thiosulfate
Sorgum
Soy Sauce
Stannic Chloride
Stannous Chloride
Starch
Stearic Acid
Stoddard Solvent
Styrene
Sucrose Solution
Sulfamic Acid
Sulfite Liquors
Sulfur
Sulfur Chloride
Sulfur Dioxide

Sulfur Hexafluoride
Sulfur Trioxide
Sulfuric Acid
Sulfurous Acid

T

Tall Oil
Tallow
Tannic Acid
Tanning Liquors
Tar, Bituminous
Tartaric Acid
Terpenes
Terpineol
Teritary Butyl Alcohol
Teritary Butyl Catechol
Teritary Butyl Mercaptan
Tetra Bromomethane
Tetrabutyl Titanate
Tetrachloroethylene
Tetrachlorodifluoroethane
Tetrachloroethane
Tetraethyl Lead
Tetraethylene Glycol
Tetrahdrofuran
Tetrahydronaphthalene
Thionyl Chloride
Thiopene
Titanium Tetrachloride
Toluene
Toluene Diisocyanate
Toluidine
Tomato Pulp & Juice
Toothpaste
Transmission Fluid
Triacetin
Triallyl Phosphate
Triaryl Phosphate
TributoxylEthylPhosphate
Tributyl Phosphate
Tributyl Mercaptan
Trichloracetic Acid
Trichlorobenzences
Tricloroethane
Trichloroethylene
Trichloropropane
Tricesyl Phosphate
Triethanol Amine
Trethyl Aluminum
Triethyl Amine
Triethyl Borane
Triethylene Glycol
Trimethylene Glycol
Trinitrotoluene
Trioctyl Phosphate
Turpentine

U-V-W-X-Z

Unsymmetrical Dimethyl
 Hydrazine
Urea
Urine
Valeric Acid
Vanilla Extract
Varnish
Vegetable Juices
Vinegar
Vinyl Acetate
Vinyl Chloride
Water
 Distilled
 Fresh
Waxes
Weed Killers
Whiskey
White Sulfate Liquor
Wines
Wort, Distillery
Xylene
Xylidines
Zeolite
Zinc Acetate
Zinc Carbonate
Zinc Chloride
Zinc Hydrosulfite
Zinc Sulfate

Chemical/Formula	Elastomers							Metal			Plastic				
Rating Key: **(A)** Excellent; **(B)** Good; **(C)** Fair to Poor, data limited to % concentration and/or temperature; **(X)** Not Recommended; **(—)** No Data Available 0°F shown. Where not shown, termeperature is 70°F ambient.	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
Acetaldehyde (Ethanal) CH3CHO	X	A	B	X	A	B	X	A	C	A	C	A	A/150°	A	A
Acetamide (Acetic Acid Amide) CH3COHN2	B	A	-	B	A	B	B	A	B	X	A	-	A/140°	A	A
Acetate Solvents CH3COOR	X	A	-	X	A	B	X	A	X	A	X	A	A	A	A
Acetic Acid - 20%	C	A	X	B	A	A	C	B	X	A	A	A	A	A	-
Acetic Acid - 30%	C	A	X	B	A	A	X	C	X	A	A	B	B	A	-
Acetic Acid - 50% CH3COOH	C	A	-	C	A	A	C	X	X	A	B	B	B	A	-
Acetic Acid - Glacial CH3COOH	C	B	X	X	A	A	X	X	X	A	C	B	A/120°	A	A
Acetic Andydride (CH3CO)2O (Acetic Oxide)	C	B	C	B	A	A	X	B	B/212° 90%	A	X	X	B/70°	A	A
Acetone (Dimethylketone) CH3COHO3	X	A	C	X	A	A	X	B	A	B	A	B	B	A	A
Acetone Cyanohydrin (CH3)2C(OH)CH	X	X	-	B	A	A	X	A	C	A	-	-	-	A	-
Acetonitrile (Methyl Cyanide) CH3CN	C	A	-	A	A	B	X	A	A	B	B/100°	A	A	A	-
Acetophenone (Phenyl Methyl Ketone) CH6H5COCH3	X	A	-	X	A	B	X	B	B	A	A/70°	-	A	A	A
Acetyl Acetone (2,4-Pentanedione) CH3COCH2COH2	X	A	-	X	A	B	X	B	X	B	-	-	-	A	-
Acetyl Chloride CH3COCI	X	C	X	X	A	B	B	X	X	B	X	-	A	A	A
Acetylene (Ethyne) HC = CH	A	A	A	C	A	C	A	A	A	A	X	A	A	A	A
Acetyl Salicyclic Acid (Aspirin) (CH3OCO) CH64COOH	-	B	-	X	A	A	-	A	X	B	-	-	-	A	-
Acetylene Tetrabromide (Tetra Bro-moethane) (CHBr2)2	X	-	-	X	A	X	A	X	X	A	-	-	-	A	-
Acrolein (Acrylaldehyde) H2C=CHCHO	B	-	-	-	A	A	A	A	B	B	-	-	-	A	-
Acrylonitrile (Vinyl Cyanide) CH2=CHCN	X	X	-	X	A	A	X	A	B	A	B	-	A	A	-
Adipic Acid H00C(CH2)4 (1,4-Butanedicarboxylic Acid) COOH	B	-	-	X	A	B	B	B	B	B	A	A	A	A	-
ALCOHOLS															
Allyl Alcohol (2-Propen-1-ol) R-OH	A	A	-	A	A	-	A	C	A	A	A	B	A	A	-
Amyl (1-Penatol) C4H9CH2O	A	A	A	A	A	A	A	B	-	A	A	A	A	A	-
Benzyl (Phenylcarbinol) C6H5CH2OH	X	B	C	C	A	X	A	A	C	A	A	A	A	A	-
Butyl (Butanol) C3H7CH2OH	A	A	B	A	A	B	A	A	C	A	A	A	A	A	-
Decyl Alcohol (Decanol)	-	-	-	-	-	-	-	A	A	A	A	A	B	A	-
Denatured Alcohol	A	A	-	A	A	-	A	-	-	-	A	A	A	A	-

Unless otherwise specified (in F deg), all fluid data established at 70°F.

Chemical/Formula	Elastomers							Metal			Plastic				
Rating Key: **(A)** Excellent; **(B)** Good; **(C)** Fair to Poor, data limited to % concentration and/or temperature; **(X)** Not Recommended; **(—)** No Data Available 0°F shown. Where not shown, termeperature is 70°F ambient.	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
Diacetone (Tyranton) (CH3)2C(OH)CH2COCH3	X	B	C	X	A	B	X	A	A	A	X	A	A	A	-
Ethyl (Ethanol) CH3CH2OH	A	A	A	A	A	A	-	B	B	A	A	A	A	A	-
Ethyl Butyl Alcohol	A	B	-	B	A	B	B	A	A	A	A/70°	A	A	A	-
Hexyl (1-Hexanol) C5H11CH2OH	A	A	-	B	A	B	A	A	A	A	A	A	A	A	-
Isoamyl Alcohol	B	A	-	A	A	A	A	B	B	A	-	-	A	A	-
Isobutyl (Isobutanol)	B	A	-	B	A	A	B	B	B	A	A	-	A/150°	A	-
Isopropyl (Isopropanol)	A	A	A	B	A	A	A	A	A	A	A	-	A	A	-
Lauryl Alcohol (n-Dodecanol)	A	-	-	-	A	A	B	A	A	A	-	-	-	A	-
Methyl Amyl Alcohol	A	A	-	A	A	B	A	B	B	A	A/120°	-	A	A	-
Methyl (Methanol)	A	A	A	B	A	A	B	A	A	A	A	-	A	A	-
Octyl (Caprylic Alcohol)	B	A	A	B	A	B	A	A	A	A	A	-	A/120°	A	-
Propyl (Propanol) C2H5CH2OH	A	A	-	-	A	-	B	A	A	A	A	-	A	A	-
Tridecyl Alcohol	B	-	-	X	A	-	B	X	X	-	-	-	-	A	-
Allyl Bromide (3-Bromopropene) H2C=CHCH2Br	X	X	-	X	A	-	B	X	X	B	A/70°	-	A	A	-
Allyl Chloride (3-Chloropropene) CH2=CHCH2Cl	X	-	-	X	A	X	A	X	-	B	A/70°	A	-	A	-
Alkazene (Chlorethyl or Polyisopropyl benzenes)	X	-	-	X	A	B	-	-	-	-	-	-	-	A	-
Alum (Aluminum Potassium Sulfate (Dodecahydrate) KAI(SO4)2 * 12H20	A	A	-	A	A	A	X	-	-	B	A	-	A	A	-
Aluminum Acetate (Burow's Solution)	C	A	-	C	A	A	X	B	C	A	A/100°	A	A	A	-
Aluminum Ammonium Sulfate AINH4(SO4)2 (Alum)	B	-	-	B	A	A	A	-	-	-	A	-	A	A	-
Aluminum Bromide AIBr3	B	A	-	A	A	-	-	-	-	-	-	-	A	A	-
Aluminum Chloride AICl3	A	A	B	A	A	A	A	X	C	B	A	B	A	A	-
Aluminum Fluoride AIF3	A	B	-	A	A	A	A	A/50%	C	C	A	X	A	A	-
Aluminum Hydroxide AI(OH)3 (Alumina Trihydrate)	B	A	-	A	A	A	C	B/10%	B/30%	B	A	-	A	A	-
Aluminum Nitrate AI(NO3)3 * 9H20	A	A	-	A	A	A	A	X	-	A/10%	A	-	A	A	-
Aluminum Phosphate AIPO4	A	A	-	A	A	A	A	-	-	-	-	-	A	A	A
Aluminum Potassium Sulfate (Potash Alum) KAI(SO4)2	A	A	-	A	A	A	A	A/10%	X	A	A	A	A	A	-

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Aluminum Sodium Sulfate (Soda Alum) NaAl(SO4)2	A	A	-	A	A	A	A	-	-	A	-	-	-	A	A
Aluminum Sulfate (Cake Alum) Al2(SO4)3	A	A	B	A	A	A	A	B/30%	X	A 167° 50%	A	B	A	A	-
Amines R-NH2	X	A	A/70%	B	A	A	X	A	-	A	B	C	X	A	-
Ammonia Anhydrous, Liquid NH3	B	A	X	B	A	A	X	A	A	A	A	X	A	A	-
Ammonia Gas - Cold	A	-	-	A	A	A	A	-	-	-	-	-	-	A	-
Ammonia Gas - Hot	C	-	-	B	A	A	X	-	-	-	-	-	-	A	A
Ammonia Liquors	-	-	-	A	A	A	X	A	A	A	-	-	-	A	-
Ammonia Cupric Sulfate (NH4)2Cu(SO4)2	A	-	-	-	A	-	A	-	-	-	-	B	-	A	-
Ammonium Acetate CH3CO2NH4	-	-	-	A	A	A	A	A	B/50%	A/50%	-	-	-	A	-
Ammonium Bicarbonate NH4HCO	A	A	-	A	A	B	A	B	B	B/90%	-	-	-	A	-
Ammonium Bifluoride - 10% NH4HF2	B	A	-	X	A	A	A	C	X	B	A	-	A	A	-
Ammonium Carbonate (NH4)2CO3	X	A	-	B	A	A	A	B	B	B 212° 70%	A	-	A	A	A
Ammonium Casenite	-	-	-	A	-	A	-	-	-	B	-	-	-	-	-
Ammonium Chloride NH4Cl (Sal Ammoniac)	A	A	A	A	A	A	A	X	X	A/30%	A	-	A	A	-
Ammonium Dichromate (NH4)2Cr2O7	A	A	A	A	A	A	-	A	A	B	-	X	-	A	-
Ammonium Fluoride NF4F	B	A	-	B	A	-	A/20%	B/10%	B/20%	A/50%	B	-	A	A	-
Ammonium Hydroxide (Aqua Ammonia) NH4OH	B	A	-	B	A	A	B	B/30%	B/30%	B	A	-	A	A	-
Ammonium Metaphosphate	A	A	-	A	A	-	A	B/90%	B	A	A	B	A	A	A
Ammonium Nitrate	A	A	-	A	A	A	A	B	A	-	A	-	A	A	-
Ammonium Nitrite NH4NO2	A	-	-	A	A	A	-	-	-	A	A/70%	A	A	A	A
Ammonium Oxalate (NH4OOC)2	A	-	-	A	-	A	-	-	-	-	B	-	B	A	-
Ammonium Persulfate (NH4)2S2O8	B	A	-	A	A	A	A	C	X	A	A	-	A	A	-
Ammonium Phosphate, (NH4)H2PO4 Monobasic	A	A	B	A	A	A	A	X	X	B	A	A	A	A	-
Ammonium Phosphate, Di Basic (NH4)2HPO4	A	-	-	A	A	A	A	B	-	A	A	B	A	A	A
Ammonium Phosphate, Tri-Basic (NH4)2PO4 * 3H20	A	-	-	A	A	A	A	X	-	B	A	-	A	A	-
Ammonium Sulfate (NH4)2SO4	A	A	C	A	A	A	A	X	B	A/212° 80%	A	B	A	A	A
Ammonium Sulfide (NH4)2S	A	-	A	A	-	A	B	C	B	B	A	-	A	A	-

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Ammonium Sulfite (NH4)2SO * 3H2O	A	-	-	-	A	-	A	C	X	B	A	X	A	A	-
Ammonium Thiocyanate NH4SCN	A	A	-	A	A	-	A	C	C	A/50%	B	-	A	-	A
Ammonium Thiosulfate (NH4)2S2O3	A	A	-	A	A	A	A	A/40%	X	A/10%	-	-	B	A	-
n-Amyl Amine (1-Aminopentane) CH3CO2C3H11	C	X	-	X	A	-	X	-	-	-	-	-	-	A	-
Amyl Borate C5H11BO3	A	X	-	B	A	B	A	-	-	-	-	-	-	A	-
Amyl Chloride (Chloropentane) CH3(CH2)4CI	C	X	-	X	A	C	A	X	A	A	X	A	A	A	-
Amyl Chloronaphthalene	X	-	-	X	A	C	A	-	-	-	-	-	-	A	-
Amyl Naphtalene C15H18	X	X	-	X	A	C	A	-	-	-	-	-	-	A	-
Amyl Phenol C6H4(OH)C5H11	X	-	-	-	A	-	A	A	A	A	-	A	-	A	-
Anilene (Anilene Oil) (Amino Benzene) C6H5NH2	X	C	X	X	A	A	B	B	A	A	A	B	A	A	A
Anilene Dyes	X	C	-	X	A	B	B	B	C	B	A	-	A	A	-
Anilene Hydrochloride C3H5NH2 * HCl	C	-	-	X	A	A	B	X	X	X	X	-	A	A	-
Animal Gelatin	A	A	-	A	A	A	A	-	-	A	A	-	A	A	-
Anisole (Methylphenyl Ether) C6H5OCH3	C	-	-	X	A	-	X	B	B	B	-	B	-	A	-
Ansul Ether	C	-	-	X	A	X	X	-	-	-	-	-	-	A	-
Anthraquinone C14H8O2	A	-	-	-	A	-	-	B	B	B	-	A	-	A	-
Anti-Freeze - Alcohol Base	A	A	A	A	A	A	A	A	A	A	A	A	A	A	-
Anti-Freeze - Glycol Base	A	A	A	B	A	A	A	A	A	A	A	A	A	A	-
Antimony Pentachloride SbCI3	X	-	-	-	A	-	-	A	A	A	-	A	-	A	-
Antimony Trichloride SbCI5	B	A	-	-	A	-	A	B	A	A	A	B	A	A	-
Aqua Regia (Nitric & Hydrochloric Acid)	X	X	-	X	A	X	B	X	X	X	C	C	A	A	X
Aroclor PCB Mixtures	C	X	-	X	A	-	A	A	B	A	-	-	-	A	-
Aromatic Hydrocarbons C6H5R	X	X	C	X	A	C	A	A	A	A	X	-	A	A	-
Aromatic Solvents (Benzene, etc.)	C	X	X	X	A	-	A	A	B	A	B	-	A	A	-
Arsenic Acid AsH3O4	B	A	-	A	A	A	A	A	X	B	A	B	A	A	A
Arsenic Trichloride (Arsenic Butter) AsCI3	C	X	-	A	A	B	X	B	B	X	-	-	-	A	-
Absorbic Acid C6H8O6	-	-	-	-	A	-	A	A	X	A	-	-	-	A	-
Askarel (Pyranol) PCB Mixtures	B	X	-	X	A	X	C	-	-	A	-	-	-	A	-
Asphalt Hydrocarbons	B	X	-	C	A	B	A	A	B	A	A	-	A	A	-
Asphalt Topping	B	-	-	A	A	-	B	-	A	A	-	B	A	A	-
ASTM - Ref Motor Fuel A (Aliphatic)	A	X	A/158°	B	A	C	A	A	A	A	-	-	-	A	-

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ASTM - Ref Motor Fuel B (30% Aromatic)	A	X	A/158°	X	A	X	A	A	A	A	-	-	-	A	-
ASTM - Ref Motor Fuel C (50% Aromatic)	B	X	C	X	A	X	A	A	A	A	-	-	-	A	-
ASTM - Ref Oil #1 (High Anilene)	A	X	A/212°	B	A	B	A	A	A	A	-	-	-	A	-
ASTM - Ref Oil #2 (Medium Anilene)	A	X	A	B	A	-	A	A	A	A	-	-	-	A	-
ASTM - Ref Oil #3 (Low Anilene)	A	X	A/212°	C	A	-	A	A	A	A	-	-	-	A	-
ASTM - Ref Oil #4 (High Anilene)	B	X	-	X	A	-	A	A	A	A	-	-	-	A	-
Aviation Gasoline	A	X	-	C	A	X	A	A	A	A	-	-	-	A	-
Barbeque Sauce Water, oils, spices	A	-	-	A	A	B	-	-	X	A	A	-	A	A	-
Barium Carbonate BaCO5	A	A	-	A	A	A	A	X	B	B	A	-	A	A	A
Barium Chloloride Dihydrate BaCl2 * 2H2O	A	A	-	A	A	-	A	B/50%	B	B/212°	A	A	A	A	A
Barium Cyanide Ba(CN)2	C	-	X	A	-	A	A	-	-	A	X	-	-	A	-
Barium Hydroxide (Barium Hydrate) Ba(OH)2	A	A	B	A	A	A	A	X	B	B	A	A	A	A	-
Barium Nitrate Ba(NO3)2	A	-	-	A	A	A	-	B	A	A	A	B	A	A	A
Barium Sulfate (Blanc Fixed) BaSO4	A	A	X	A	A	A	A	B	B	B	A	B	A	A	A
Barium Sulfide BaS	A	A	-	A	A	A	A	X	-	B	A	-	A	A	-
Beef Extract	A	-	-	A	A	-	A	-	X	A	-	-	-	A	-
Beer Water, Carbonate	C	A	B	A	A	A	A	A	X	A	A/75°	A	A/175°	A	A
Beet Sugar Liquors (Sucrose)	A	A	-	A	A	A	A	A	B	A	A	B	A	A	-
Benzaldehyde C6H5CHO	X	B	B	X	A	B	X	A	A	A	X	-	A	A	A
Benzene (Benzol) C6H6	X	X	C/70°	X	A	C	B	B	B	A/167°	X	A	B	A	A
Benzene Sulfonic Acid C6H5DO3H	X	C	-	A	A	-	A	C	A	A	X	-	B/100°	A	A
Benzoic Acid (Benzene Carboxylic Acid) C6H5COOH	X	B	-	B	A	A	A	B	X	B	X	B	A	A	A
Benzoyl Chloride C6H2COCl	X	X	-	X	A	A	X	X	X	B	A	A	A	A	A
Benzyl Acetate CH3CO2 CH2C6H5	X	-	-	-	A	A	X	A	A	A	-	-	-	A	-
Benzyl Benzoate C6H5CO2CH2C6H5	X	B	-	X	A	C	A	A	B	B	-	-	-	A	-
Benzyl Chloride (Chlorotoluene) C6H5CH2Cl	X	X	-	X	A	C	A	X	A	B	X	-	A	A	-
Benzyl Dichloride (Benzal Chloride) C6H5CHCl	X	X	-	X	A	-	A	X	B	A	B	-	A	A	-
Benzol (Benzene) C6H6	X	X	C/70°	X	A	B	B	B	B	-	X	A	B	A	A
Biphenyl (Diphenyl) C6H5C8H5	X	X	-	X	A	-	A	A	A	-	-	-	-	A	-
Bismuth Subcarbonate (Bismuth Carbonate) (Bi0)2CO3	A	A	-	A	A	-	A	-	-	B/10%	B	-	A	A	-

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Black Sulfate Liquor	B	A	B	A	A	B	A	C	B	A	-	-	-	A	-
Blast Furnace Gas CO,H2,CH4,CO2,N2	C	-	B	A	A	-	A	-	-	-	-	-	-	A	-
Bleach Solutions Water, chlorine, oxygen	X	A	X	X	A	B	B	X	-	B	B/3%	-	A	A	-
Borax (Sodium Borate) B4Na2O2	B	A	A	A	A	A	A	B	B	A	A	B	A	A	A
Bordeaux Mixture Copper sulfate salts	A	A	B	A	A	A	-	-	-	A	-	-	-	A	-
Boric Acid (Boracic Acid) H3BO3	A	A	A	A	A	A	A	A	X	A/30%	A	C	A	A	A
Brake Fluid (non-petroleum base) Silcones or glycols	X	A	-	A	A	A	-	A	A	A	X	-	-	A	-
Brewery Slop	A	-	-	A	A	A	A	-	A	A	-	-	-	A	-
Brine (Sodium Chloride) Salt Water	A	A	B	A	A	A	A	-	X	A	A	-	A	A	-
Bromine - Anhydrous Br2	X	C	X	X	A	C	A	B	C	X	X	-	A/150°	A	-
Bromine Trifluoride BrF3	X	X	-	X	A	C	X	A	-	B	X	-	-	A	-
Bromine Water	X	X	-	B	A	B	B	X	-	X	C	-	A	A	-
Bromobenzene C65H5Br	X	X	-	X	A	X	B	X	X	A	X	-	-	A	-
Bromochloromethane BrCH2Cl	X	B	-	X	A	-	C	X	B	B	-	-	-	A	-
Bromotoluene C6H4BrCH3	X	-	-	-	A	-	B	X	B	A	-	-	-	A	-
Bronzing Liquid	X	B	-	X	A	A	X	-	-	A	-	-	-	A	-
Butadiene C4H6	X	C	-	C	A	A	C	A	-	A	X	-	A	A	A
Butane (LPG) (Buty Hydride) C4H10	A	X	A	B	A	C	A	A	A	A	X	B	A	A	A
Butter Fats	A	A	B	C	A	A	A	A	X	A	A	-	-	A	-
Buttermilk Fats, water	A	-	-	A	-	A	A	A	X	A	A	-	A/100°	A	-
Butyl Acetate CH3CO2(CH2)3CH3	X	B	-	X	A	C	X	A	A	A	X	-	B	A	-
n-Butyl Acetate CH3CO2(CH2)3CH3	X	B	-	X	A	B	X	A	A	A	-	-	-	A	-
Butyl Acetyl Ricinoleate C24H4405	C	C	-	X	A	B	B	-	A	-	-	-	-	A	-
Butyl Acrylate CH2CHCO2C4H9	X	X	-	X	A	C	X	-	-	-	-	-	C	A	-
Butyl Amine (Aminobutane) CH3(CH2)CH2NH2	B	X	-	X	A	A	X	A	A	A	X	C	B/70°	A	A
Butyl Benzoate C6H5COO (CH2)3CH3	-	B	X	X	A	C	A	B	B	B	-	-	-	A	-
Butyl Butyrate CH3(CH2)2 CH2CO2C4H2	X	-	-	-	A	-	X	A	A	A	-	-	-	A	-
Butyl Carbitol CH3(CH2)3OCH CH2OCH2CH2OH	A	A	-	B	A	B	A	-	-	-	-	-	-	A	-
Butyl Cellosolve HOCH2CH2OC4H9	B	A	-	C	A	A	C	A	A	A	A	A	B	A	-
Butyl Chloride (Chlorobutane) CH3(CH2)3CL	X	-	-	-	A	-	A	X	B	B	X	-	A	A	-
Butyl Ether (Dibutyl Ether) (CH3(CH2)3CL	A	-	-	B	A	-	C	A	B	A	X	-	A/100°	A	A

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Butyl Oleate C22H4202	-	C	-	X	A	C	A	-	-	-	-	-	-	A	-
Butyl Stearate CH3(CH2)16 CO2(CH2)3CH3	A	C	-	X	A	C	B	B	B	B	-	-	A	A	-
Butylene (Butene) C4H8	B	X	-	X	A	X	B	A	-	A	X	-	A	A	A
Butyraldehyde CH3(CH2)2CH0	X	C	-	X	A	C	X	A	A	A	-	-	B	A	-
Butyric Acid CH3(CH2)C02H	C	C	B	X	A	C	X	A	A	A	A	-	A	A	-
Butyric Anhydride (CH3CH2CH2CO)2O	C	C	B	X	A	A	C	A	X	B	-	X	A	A	A
Butyronitrile CH3CH2CH2CN	C	A	-	-	A	-	-	A	-	A	-	A	-	-	A
Calcium Acetate Hydrate Ca(CH3COO)2 * H20	X	A	X	C	X	A	X	C	-	B	-	-	-	-	A
Calcium Bisulfite Ca(HSO3)2	B	A	-	C	A	-	X	C	C	B	-	-	-	A	-
Calcium Carbonate (Chalk) CaCO3	A	A	-	A	A	-	A	C	B	A/90°	A	X	A	A	A
Calcium Chlorate Ca(ClO3)2	A	A	-	A	A	A	A	C	B	B	A	A	A	A	-
Calcium Chloride (Brine) CaCl2 * 6H20	A	A	-	A	A	-	A	B/30%	B	A/30%	A	-	A	A	-
Calcium Hydrosulfide (Calcium Sulfhydrate) Ca(HS)2 * 6H20	A	A	-	A	A	A	A	-	A	A	A	X	A	A	A
Calcium Hydroxide (Slaked Lime) Ca(OH)02	A	A	-	A	A	A	A	X	B	B	A	-	A	A	-
Calcium Hypochlorite 20% (Calcium Oxichloride) Ca(ClO)2	C	B	X	X	A	A	A	X	X	B	A	A	A	A	A
Calcium Nitrate Ca(NO3)2	A	A	-	A	A	A	A	B/212° 40%	B/212° 30%	B/212° 40%	A	X	A	A	A
Calcium Oxide (Unslaked Lime) CaO	A	A	B	A	A	B	A	A	A	A	B	-	A	A	-
Calcium Silicate Ca2SiO4	A	-	-	-	A	-	A	A	B	A	-	-	-	A	-
Calcium Sulfate (Gypsum) CaSO4	A	A	-	A	A	A	A	C	B/10%	A/10%	A	X	A	A	A
Calcium Sulfide CaS	A	A	-	B	A	A	A	A/20%	B	B	A/120°	-	A	A	-
Calcium Sulfite CaSO3 * 2H2O	A	A	-	A	A	A	A	B/10%	B	A/10%	B/70°	-	B/70°	A	-
Calgon (NaPO3)6	A	-	-	A	-	A	-	-	X	A	A	-	-	A	-
Cane Juice Sucrose, water	A	-	-	A	-	A	A	B	A	A	X	-	-	A	-
Cane Sugar Liquors	A	A	B	A	A	A	B	A	A	A	A	-	A	A	-
Capryl Alcohol (Octanol) CH3(CH2)6CH2OH	A	C	-	B	A	-	B	A	A	A	-	-	-	A	-
Caprylic Acid (Octanoic Acid) CH3(CH2)6 COOH	C	-	-	-	A	-	-	A	-	A	-	-	A	A	-
Carbamate H2NCO2R	C	C	-	C	A	A	A	-	-	-	-	-	-	A	-

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Chemical/Formula	Elastomers							Metal			Plastic				
Rating Key: **(A)** Excellent; **(B)** Good; **(C)** Fair to Poor, data limited to % concentration and/or temperature; **(X)** Not Recommended; **(—)** No Data Available 0°F shown. Where not shown, termeperature is 70°F ambient.	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
Carbitol CH3CH2OCH2CH2 OCH2CH2OH	B	C	-	C	A	B	C	A	A	A	-	-	-	A	-
Carbolic Acid (see Phenol) C6H5OH	X	C	X	C	A	C	A	B	A	B	C	X	A/150°	A	-
Carbon Dioxide (Carbonic Acid Gas) CO2	A	B	A	A	A	B	A	A	A	A	A	A	A	A	A
Carbon Disulfide (Carbon Bisulfide) CS2	X	X	C	X	A	X	A	A	B	A/90°	X	B	A	A	A
Carbon Monoxide CO	C	C	A	A	A	A	C	A	A	A	A	B	A	A	-
Carbon Tetrachloride R10 (Tetrachloro-methane) CCL4	C	X	X	X	A	X	A	X	C	B	X	B	A	A	A
Carbonated Beverages C02/H20	B	B	A/50%	X	A	A	A	X	X	A	A	A	A	A	A
Carbonic Acid (liquid) H2CO3	B	-	C	A	A	A	A	A	X	B	A	A	A	A	A
Casein a phosphoprotein	A	A	-	A	A	-	A	B	-	B	-	-	-	A	-
Catsup (Ketchup)	A	A	-	C	A	A	A	B	X	A	A	-	-	A	-
Cellosolve (Glycol Ethers) HOCH2CH2OR	C	C	X	C	A	C	B	A	-	A	A/100°	A	A	A	A
Cellulose Acetate C8H12O5	B	-	-	B	A	-	C	B	B	A	C	-	A	A	-
Cellelube Hydraulic Fluids (Phosphate Esters)	X	A	C	X	A	X	B	A	A	A	-	-	-	A	-
Chlorinated Lime - 35% Bleach CA(CIO)2	C	A	X	X	A	X	A	-	X	A	-	-	-	A	-
Chlorinated Water	C	-	X	C	A	-	A	X	X	B	B	X	A	A	-
Chlorine - Dry CL2	C	-	X	C	A	-	A	X	-	B	X	-	A	A	-
Chlorine - Wet CI2/H20	C	X	X	X	A	C	A	B	C	A	X	X	A	A	X
Chlorine - Anhydrous Liquid CI2	X	-	-	X	A	C	A	X	X	X	-	A	A	-	-
Chlorine Dioxide CIO2	X	C	-	X	A	X	B	B	-	X	X	-	A	A	-
Chlorine Trifluoride CIF3	X	X	-	X	B	X	B	A	-	A	X	-	-	-	-
Chloroacetic Acid (Monochloroacetic Acid) CICH2COOH	X	B	X	C	A	-	C	X	X	X	A	X	A	A	A
Chloroacetone (Monochloroacetone) CICH2COCH3	X	A	-	C	A	C	C	X	B	B	X	-	-	A	-
Chlorobenzene (Monchlorobenzene) C6H-5CI	X	X	X	X	A	C	A	X	B	B	X	A	A/150°	A	A
Chlorobutadiene (Chloroprene) C4H5CL	X	X	-	X	A	C	A	X	B	B	X	-	-	A	-
Chlorobromomethane CICH2Br	X	-	-	X	A	X	A	X	B	B	X	-	-	A	-
Chloroform CHCI3	X	X	X	X	A	X	A	X	A	A	X	A	A	A	A
1-Chloronaphthalene C10H7CI	X	X	-	X	A	X	C	X	B	B	X	-	-	A	-
Chlorosulfonic Acid HSO3CL	X	X	X	X	A	X	X	B	B	B	X	-	X	A	X
o-Chlorophenol C6H5CIO	X	X	-	X	A	-	B	B	B	B	-	B	A	A	A

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Chapter 6: Corrosion Resistance Guide

Chemical/Formula	Elastomers							Metal			Plastic				
Rating Key: **(A)** Excellent; **(B)** Good; **(C)** Fair to Poor, data limited to % concentration and/or temperature; **(X)** Not Recommended; **(—)** No Data Available 0°F shown. Where not shown, termemperature is 70°F ambient.	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
Chlorothene (Chlorinated Solvents) CH3CCL3	X	-	-	X	A	-	C	X	X	A	-	-	-	A	-
Chlorotrifluoroethylene C2H2ClF	X	-	-	-	A	-	-	B	B	B	-	-	-	A	-
Chlorox	C	A	X	B	A	B	A	-	X	A	B	-	A	A	-
Chocolate Syrup Corn Syrup, water, sugar	A	-	-	A	A	A	-	-	X	A	A	-	-	A	-
Chromic Acid - to 25% H2CrO	X	A	X	X	A	A	A	X	X	X	C	X	A/120%	A	A
Chromic Acid - Over 25% H2CrO4	X	C	X	X	A	A	A	X	X	X	C	X	A/120%	A	A
Cider (Apple Juice) Sucrose, water	A	B	B	A	A	A	A	B	X	A	-	-	-	A	-
Citric Acid C6H8O7 * H20	B	A	A	A	A	A	A	C	X	A/30%	A	B	A	A	A
Citrus Pectin Liquor	A	-	-	A	A	-	A	-	-	A	A	-	-	A	-
Cobalt Chloride CoCl2 * 6H20	A	C	-	A	A	A	A	X	-	-	A	-	-	A	-
Coffee Fatty oils, acids. cellulose, water	A	-	-	A	A	A	-	A	-	A	A	-	-	A	-
Coke Oven Gas H2(53%),CH4(26%) N2(11%),CO(7%)&hydrocarbons (3%)	C	-	-	C	A	B	A	-	-	-	-	-	A	A	-
Copper Acetate Cu(C2H2O2)2 * CuO * 6H20	B	A	-	C	A	A	A	X	A/90%	B/10%	A	-	A	A	-
Copper Chloride CuCl2 * 2H2O	A	A	A	A	A	A	A	X	X	X	A	-	A	A	-
Copper Cyanide CuCN	A	A	-	A	A	A	A	X	A	A/10%	A	-	A	A	A
Copper Fluoroborate	B	-	-	A	-	A	A	X	X	X	-	-	A	A	-
Copper Nitrate Hexahydrate Cu(NO3)2 * 6H20	A	A	-	A	A	A	A	X	X	A	A	A	A	A	A
Copper Sulfate (Blue Copperas) CuSO4 * 5H20	A	A	A	A	A	A	A	X	X	A/10%	A	A	A	A	A
Copper Sulfide CuS	A	-	-	-	A	-	A	-	-	-	-	-	-	A	-
Cream	A	-	-	C	A	A	A	-	X	A	A	-	-	A	-
Creosote, Wood-Tar Mixture of phenols	A	X	X	B	A	B	A	B	B	A	X	X	-	A	-
Cresylic Acid (cresol) C8H10O2	C	X	-	X	A	B	A	B	C	A	X	X	A/150°	A	-
Crotonaldehyde CH3CHCHCHO	X	-	-	A	A	-	A	A	A	A	-	-	-	A	-
Cumeme (Isopropylbenzene) C6H-5CH(CH3)2	X	X	-	X	A	-	A	B	B	B	-	-	-	A	-
Cyclohexane C6H12	B	X	A	X	A	C	A	B	B	B	X	A	A	A	A
Cyclohexanol C6H11OH	B	X	-	A	A	B	A	C	B	A	B	A	A/150°	A	A
Cyclohexanone C6H100	X	C	-	X	A	C	X	B	B	B	X	A	A	A	A
Cyclopentane C5H10	B	X	-	A	A	-	A	B	B	B	-	-	-	A	-

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Cymene (Isopropyltoluene) C10H14	C	X	-	X	A	-	A	-	-	-	-	-	-	A	-
Decahdronaphthalene (Decalin) C10H18	X	X	-	X	A	-	A	-	-	-	-	-	-	A	-
Decanal CH3(CH2)8CHO	X	X	-	-	A	-	X	-	-	-	-	-	-	A	-
Decane CH3(CH2)8CH3	B	C	-	X	A	C	A	-	-	-	A/70%	-	A	A	-
Detergent Solutions	A	A	B	A	A	A	A	B	-	A	A	A	-	A	A
Developing Fluids & Solutions	A	C	X	A	A	B	A	-	X	A	-	-	-	A	-
Dextrose C6H12O6	B	A	B/140%	B	A	B	A	A	X	A	A	-	A	A	-
Dibenzyl Ether (C6H5CH2)2O	X	C	-	X	A	C	C	B	B	B	-	-	C	A	-
Dibenzyl Sebecate C24H304	X	C	A	X	A	C	B	-	-	-	-	-	-	A	-
Dibutyl Amine (C4H9)2NH	C	C	X	-	X	A	C	X	-	A	A	X	B/70%	A	-
Dibutyl Phthalate (DBP) C6H4(CO2C4H9)2	X	A	A	A	X	A	A	B	A	B	B	X	-	X	A
Dibutyl Sebecate (DBS) C18H34O4	X	C	-	X	A	B	C	-	A	A	C	-	-	A	-
Dichloroacetic Acid CI2CHCOOH	X	-	-	X	A	B	X	-	-	-	-	-	-	A	-
o-Dichlorobenzene C6H4CI2	X	X	X	X	A	X	A	X	B	B	B	-	A/150%	A	-
Dichlorobutane C4H8CI2	X	-	-	-	A	-	A	X	B	B	-	-	-	A	-
Dichchloroethyl Ether [CICH2CH2]2O	X	-	-	-	A	-	-	B	-	-	-	-	-	A	-
Dichloro Isopropyl Ether C6H12OCI2	X	X	-	X	A	X	X	-	-	-	X	-	-	A	-
Dichclohexylamine (C6H11)2NH	X	X	-	X	A	B	B	-	-	-	-	-	-	A	-
Diethanol Amine (HOCH2CH2)2NH	B	-	-	A	A	-	-	-	A	A	A	-	-	A	-
Diethyl Amine (CH3CH2)2NH	C	C	-	C	A	-	X	B	B	A	A	-	A	A	-
Diethyl Benzene C6H4(C2H5)2	X	X	-	X	A	C	A	-	-	-	-	-	-	A	-
Diethyl Carbonate (C2H5O)2CO	X	-	-	X	A	-	-	-	A	-	-	-	-	A	-
Diethyl Ether (Ether) (CH3CH2)2O	B	X	C	C	A	A	X	B	A	A	X	A	A	A	A
Diethyl Phthalate (DEP) C6H4(CO2C2H5)2	X	-	-	-	-	-	C	A	A	A	-	-	-	-	-
Diethyl Sebecate C14H2604	X	C	A	X	A	B	B	A	A	A	A/120°	-	A/120°	A	-
Diethylene Ether (Dioxane) C4H8O2	X	A	-	X	A	B	X	A	A	A	-	-	-	A	-
Diethylene Glycol (DEG) HOCH2CH2OCH2	A	A	A	A	A	A	A	A	A	A	A	-	-	A	-
Diethylene Triamine (NH2C2H4)2NH	B	-	-	-	A	-	-	A	A	A	-	-	-	A	-
Dilsobutyl Ketone C4H9COC4H9	X	B	-	X	A	-	X	A	A	A	B	-	-	A	-
Diisobutylene [HC=C(CH2)2]	B	-	-	C	A	C	C	-	-	-	A	-	A	A	A
Diisodecyl Adipate (DIDA) C26H50O4	X	-	-	-	A	-	C	-	-	-	-	-	-	A	-
Diisodecyl Phthalate (DIDP) C28H47O4	X	A	-	X	A	-	C	-	-	-	-	-	-	A	-
Diisooctyl Adipate (DIOA) C22H42O4	X	-	-	-	A	-	C	A	A	A	-	-	-	A	-
Diisooctyl Phthalate (DIOP) C24H39O4	X	-	-	-	A	-	C	-	-	-	-	-	-	A	-

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Diisooctyl Sebecate (DIOS) C26H46O4	-	B	-	-	A	-	A	-	-	-	-	-	-	A	-
Diisopropyl Amine [(CH3)2CH]2NH	B	-	-	-	A	-	-	-	-	-	-	-	-	A	-
Diisopropyl Benzene C6H4 * [CH(CH3)2]2	X	X	-	X	A	C	A	-	-	-	-	-	-	A	-
Diisopropyl Ketone [(CH3)2CH]2CO	X	A	-	X	A	C	X	-	-	A	-	-	-	A	-
N, N-Dimethylaniline C6H5N(CH3)2	X	C	-	X	A	B	X	B	B	-	X	-	A	A	A
Dimethyl Ether CH3OCH3	A	-	-	B	A	-	A	B	B	B	-	-	-	A	-
N,N-Dimethyl Formamide (DMF) HCON(CH3)2	C	B	C	X	A	A	X	A	-	A	A/120°	B	A/120°	A	A
Dimethyl Phthalate C6H4(CO2CH3)2	X	B	B	X	A	A	B	A	-	A	X	-	A/70°	A	A
Dimethyl Sulfate (CH3)2SO4	X	-	-	-	A	-	X	-	A	-	-	-	-	A	-
Dimethyl Sulfide (CH3)2S	X	-	-	-	A	-	-	A	A	A	-	-	-	A	-
Dinitrotoluene (DNT) CH3C6H3(NO2)2	X	X	-	X	A	B	C	-	-	A	-	-	-	A	-
Dioctyl Phtahalate (DOP) C24H38O4	X	B	A	X	A	B	B	A	A	A	-	-	-	A	-
Dioctyl Sebecate C26H50O4	X	C	-	X	A	C	C	A	A	A	-	-	-	A	-
Dioxolanes (Dioxolans) Glycol ethers	X	B	-	X	A	C	C	-	-	-	-	-	-	A	-
Dipentene (Limonene) C10H16	B	X	-	X	A	C	A	A	A	A	-	-	-	A	-
Diphenyl Oxides (Phenyl Ether) C6H5OC6H5	X	C	-	X	A	C	A	B	A	A	-	-	A	A	-
Dipropylamine (CH3CH2CH2)2 NH	B	-	-	-	A	-	-	-	-	-	-	-	-	A	-
Dipropylene Glycol (C3H6OH)2O	A	-	-	-	A	A	A	-	-	-	A	-	A	A	-
Dipropyl Ketone (Butyrone) (C3H7)2CO	X	-	-	-	A	-	-	-	-	-	-	-	-	A	-
Divinyl Benzene (DVB) C6H4(CH=CH2)2	X	-	-	-	A	-	A	-	-	-	-	-	-	A	-
Dodecyl Benzene (Alkane) C6H5(CH2011CH3	X	-	-	-	A	-	A	A	A	A	-	-	-	A	-
Dow Corning (Silicones) [(CH3)2SiO]2	A	-	-	A	A	A	A	A	-	A	-	-	-	A	-
Dowtherm (Biphenyl & Phenyl Ether) (C6H5)2 AND (C6H5)2O	X	X	-	X	A	X	A	A	B	A	-	-	-	A	-
Dry Cleaning Fluids Chlorinated hydrocarbons	C	-	-	X	A	X	A	X	A	A	X	-	-	A	-
Dyes	-	-	-	C	-	B	A	B	-	A	-	-	-	A	-
Epichlorohydrin C3H5CIO	X	B	X	X	A	B	X	A	A	A	A	A	X	A	A
Epsom Salts (Magnesium Sulfate) MgSO4 * 7H20	A	A	-	A	A	A	A	A	-	A	A	-	A	A	-
Ethane C2H6	A	X	-	C	A	C	A	A	A	A	C	A	-	A	-

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Ethanolamine (Aminoethanol) H2NCH2 CH2OH	B	B	-	C	A	A	X	B	A	A	X	X	C	A	A
Ethyl Acetate CH3COOC H2CH3	X	B	C	X	A	A	X	A	A	A	B	A	A	A	-
Ethyl Acetoacetate CH3COCH2 (Acetoacetic Ester) COOCH2CH3	X	C	-	X	A	C	X	A	A	A	-	-	A/70°	A	-
Ethyl Acrylate CH2CHCO CH2CH3	X	C	-	X	A	C	X	A	A	A	B	-	B/70°	A	-
Ethyl Aluminum Dichloride CH3CH2AlCl2	X	-	-	-	A	-	B	-	-	-	-	-	-	A	-
Ethyl Amine (Monoethylamine) CH3CH2NH	X	A	-	C	A	-	X	B	B	A	-	-	-	A	-
Ethyl Benzene CH3CH2C6H5	X	X	-	X	A	X	A	B	B	B	X	A	A	A	-
Ethyl Benzoate C6H5CO2CH2CH3	X	C	-	X	A	C	A	A	A	A	B	-	-	A	-
Ethyl Bromide (Bromoethane) CH3CH2Br	X	B	-	B	A	X	-	X	A	A	-	-	-	A	-
Ethyl Butyl Acetate CH3CO2CH2 CH(2H5)2	X	-	-	-	A	-	X	-	-	-	-	-	-	A	-
Ethyl Butyl Ketone CH3CH2COC4H9	X	-	-	-	A	-	X	-	-	-	-	-	-	A	-
Ethyl Butyraldehyde C6H12O	X	-	-	-	A	-	X	-	-	-	-	-	-	A	-
Ethyl Butyrate CH3CH2CH2 CO2C2H5	X	X	-	X	A	-	C	B	A	A	B	-	-	A	A
Ethyl Caprylate CH3(CH2)5 CO2C2H5	X	X	-	X	A	-	-	-	-	-	-	-	-	A	-
Ethyl Cellosolve C2H5O(CH2)2OH	C	B	-	C	A	B	X	-	-	-	-	-	-	A	-
Ethyl Cellulose (Ethocel)	B	B	B	B	A	A	C	B	A	B	C	-	-	A	B
Ethyl Chloride (Chloroethane) C2H5Cl	A	A	X	C	A	X	A	X	B	A	X	A	A	A	A
Ethyl Chlorocarbonate (Ethyl Chloroformate) ClCO2C2H5	-	-	-	C	A	A	A	-	-	-	-	-	-	A	-
Ethyl Cyanide (Propionitrile) C2H5CN	X	A	-	B	A	-	X	-	-	-	-	-	-	A	-
Ethyl Formate HCOOCH2 CH3	X	C	-	B	A	B	A	B	A	B	-	-	-	A	-
Ethylexyl Acetate CH3CO2CH2 CH(C2H5) C4H9	X	-	-	-	A	-	X	A	-	A	A	-	A/70°	A	-
Ethylhexyl Alcohol (Ethylhexanol) C8H17OH	A	-	-	-	A	-	B	A	A	A	-	-	-	A	-
Ethyl Iodide CH3CH2I	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-
Ethyl Isobutyrate (CH3)2	X	X	-	X	A	-	-	-	-	-	-	-	-	A	-
Ethyl Mercaptan (Ethanethiol) CH3CH2SH	X	X	-	C	A	C	B	B	A	B	-	-	-	A	-
Ethyl Oxalate C2H5O2C CO2C2H5	X	A	-	X	A	B	B	-	-	-	-	-	-	A	-
Ethyl Pentachlorobenzene C2H5C6Cl5	X	-	-	X	A	X	A	X	-	-	X	-	-	A	-
Ethyl Propionate CH3CH2 COOCH2CH3	X	X	-	X	A	-	-	A	A	A	-	-	-	A	-
Ethyl Silicate Si(OCH2CH3)4	A	A	-	A	A	B	A	B	A	A	-	-	-	A	-

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Chemical/Formula	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
			Elastomers						Metal				Plastic		
Ethyl Sulfate C2H5OSO2OH	A	-	-	-	A	B	A	-	-	X	-	-	-	A	-
Ethylene (Ethene) C2H4	B	C	-	A	A	C	A	A	A	A	-	-	-	A	-
Ethylene Chlorohydrin CICH2CH2OH	X	A	X	B	A	C	B	-	B	A	X	-	A/70°	A	-
Ethylene Diamine (CH2)2(NH2)2	B	A	-	A	A	A	X	C	A	A	A	A	B	A	A
Ethylene Dibromide (Ethylene Bromide) Br(CH2)Br	X	C	-	X	A	-	B	X	X	B	X	-	A	A	-
Ethylene Glycol (Ethylene Alcohol (Glycol) CI(CH2)2CI	A	A	B	A	A	A	A/70°	A	A	A	A/120°	A	A	A	A
Ethylene Glycol Monobutyl Ether (Butyl Cellosolve) C4H9OCH2CH2OH	B	B	-	X	A	A	C	A	A	A	B	B	A	A	-
Ethylene Glycol Monobutyl Ether Acetate (Cellosolve Acetate) C2H50(CH2)2 O2CCH3	C	B	-	X	A	-	C	A	A	A	-	A	-	A	-
Ethylene Glycol Monomethyl Ether (Methyl Cellosolve) CH3O(CH2)2OH	C	B	-	C	A	B	X	B	B	A	-	-	-	A	-
Ethylene Oxide (CH2)2O	X	B	A	X	A	A	C	A	B	A	C	-	A	A	X
Ethylene Trichloride (Triclorothene) CICHCCI2	X	X	-	X	A	X	A	X	A	A	X	-	-	A	-
Ethylidene Chloride CH3CHCl2	X	X	-	X	A	-	-	X	B	A	-	-	-	A	-
Fatty Acids C8H20+1COOH	B	X	B	C	A	B	A	A/90°	X	A	B	A	A	A	-
Ferric Chloride FeCI3	A	A	B	A	A	A	A	X	X	X	A	A	A	A	A
Ferric Hydroxide FeHO2	B	A	-	-	A	-	C	-	-	A	-	A	-	A	-
Ferric Nitrate Fe(NO3)3	A	A	-	A	A	A	A	X	X	B	A	A	A	A	A
Ferric Sulfate Fe2(SO4)3	A	A	-	A	A	A	A	C	X	B	A	A	A	A	A
Ferrous Chloride FeCI2	A	A	X	A	A	A	A	X	X	B/20%	A	A	A	A	A
Ferrous Sulfate FeSO4	A	A	A	A	A	A	A	A/10%	C	B	A	A	A	A	A
Fluoboric Acid (Flouroboric Acid) HBF4	A	A	X	B	A	A	C	X	X	A/30%	A	A	A	A	A
Fluorine (Liquid) F2	X	C	X	C	A	X	B	A	-	A	X	A	A/70°	A	-
Fluorobenzene FC6H5	X	X	-	X	A	C	A	-	-	-	X	A	-	A	-
Fluosilicic Acid (Sand Acid) H2SiF6	B	B	-	A	A	A	A	X	X	A/212°	A	A	A	A	A
Formaldehyde (Formalin) HCHO	B	A	C/40°	C	A	A	A	A	C	A/90%	A	A	A/120°	A	A
Formamide HCONH2	A	A	-	A	A	-	X	A	B	B	-	A	-	A	-
Formic Acid HCOOH	C	B	C	B	A	A	C	X	X	C	A/70%	A	A	A	A
Freon 11 (Trichlorofluoromethane) CCI3F	C	X	A	C	A	C	B	B	A	A	B	A	A	A	A

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Chemical/Formula	Elastomers							Metal			Plastic				
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Freon 12 (Dichlorofluoromethane) CI2CF4	B	B	B	B	A	X	B	A	A	A	-	A	A	A	-
Freon 13 (Chlororfluoromethane) CICF3	A	A	C	A	A	X	A	A	A	A	-	A	-	A	-
Freon 13B1 (Bromotrifloromethane) BrCF3	A	A	-	A	A	-	A	-	-	-	-	A	-	A	-
Freon 14 (Tetrafluoromethane) CF4	X	B	-	X	A	-	-	-	-	-	-	A	-	A	-
Freon 21 (Dichlorofluoromethane) FCHCI2	X	X	-	B	A	X	X	A	-	-	-	A	A	A	-
Freon 22 (Chlorofluoromethane) HCCIF2	X	C	X	B	A	X	X	A	A	A	-	A	A	A	-
Freon 113 (Trichlorotetrafluoroethane) CI3CCF3	B	X	A/130°	A	A	X	B	B	-	A	-	A	A	A	-
Freon 114 (Dichlorotetrafluoroethane) C2CI2F4	A	C	A	A	A	X	A	B	-	A	-	A	A	A	-
Freon 114B2 (Dibromotetrafluoroethane) C2Br2F4	B	X	-	A	A	X	B	-	-	-	-	A	-	A	-
Freon 115 (Chloropentafluoroethane) C2CIF5	A	A	-	A	A	X	B	A	-	-	-	A	-	A	-
Fruit Juices Water, sucrose	A	A	B	A	A	A	A	A/10%	X	A	A	A	A	A	A
Fumaric Acid (Boletic Acid) Hydrocarbons	C	-	-	B	A	A	A	-	-	-	-	A	-	A	-
Furan (Furfuran) C4H40	X	X	X	X	A	B	C	-	-	-	C	A	X	A	A
Furfuryl Alcohol C5H602	X	B	B	-	A	A	X	A	A	A	-	A	B/100%	A	-
Gallic Acid C6H2(OH)3 COOH	B	B	X	C	A	B	A	A/20%	X	B	A/700	A	A/70%	A	A
Gasoline (unleaded) C4 to C12 hydrocarbons	X	X	A/120°	X	A	X	A	A	A	A	C	A	A	A	A
Gasoline (Petrol) Hydrocarbons	A	X	A	C	A	X	A	A	A	A	C	A	A	A	A
Gelatin Water solube proteins	A	A	B	A	A	A	B	A	A	A	A	B	A	A	-
Glauber's Salt (Sodium Sulfate Decahydrate) Na2so4 * 10H20	A	B	B	A	A	-	A	-	-	-	-	-	-	A	-
Gluconic Acid C6H12O7	C	A	-	-	A	-	A	B	C	A/50%	A	-	-	A	-
Glucose (Corn Syrup) C6H12O6	A	A	B	A	A	A	A	A	A	A	A	A	A	A	-
Glue	A	B	B	A	A	A	A	A	A	B	A	B	-	A	-
Glycerol (Glycerine) C3H8O3	A	A	A	A	A	A	A	A	B	A	A	A	A	A	A
Glycolic Acid HOCH2COOH	A	A	-	A	-	A	A	-	-	-	A	-	A	A	A
Glycols	A	A	A	A	A	A	A	A	B	A	A	A	A	A	A
Gold Monocyanide AuCN	A	-	-	A	-	A	A	-	-	X	-	-	-	A	-
Grape Juice Water, sucrose	C	-	-	X	A	A	A	-	X	A	A	-	A	A	-
Grease	A	-	A	X	A	B	A	A	-	A	-	-	A	A	-

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Chemical/Formula	Elastomers							Metal			Plastic				
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Green Sulfate Liquor	B	A	X	B	A	A	A	B	C	A	A	-	-	A	-
Halowax Chlorinated naphthalenes	X	X	X	-	-	X	A	X	-	-	-	-	-	-	-
Heptanal CH3(CH2)5CHO	A	-	-	-	-	-	A	A	A	A	A	C	-	A	A
Heptane C7H16	A	X	B	C	A	X	A	A	A	A	C/140°	A	A	A	A
Hexanal CH3(CH2)4CHO	B	B	-	B	A	-	C	A	B	A	-	-	-	A	-
Hexalin (Cyclohexanol) C6H11OH	B	C	-	A	A	-	A	-	-	-	-	-	-	A	-
n-Hexane C6H14	A	X	A	B	A	B	A	A	A	A	C/140°	A	A	A	A
n-Hexane 1 (Hexylene) H2CCH(CH2)2CH3	A	X	-	B	A	X	A	-	-	-	X	A	A	A	-
Hexylene Glycol (Brake fluid) C6H12(OH)2	X	C	-	A	A	-	A	A	A	A	-	-	-	A	-
Honey	-	-	-	A	A	A	-	A	A	A	A	-	-	A	-
Hydrazine (Diamine) H2NNH2	C	A	X	C	A	A	X	A	X	A	X	B	X	A	-
Hydrobromic Acid HBr	X	A	-	C	A	A	A	X	X	X	B	X	A	A	A
Hydrochloric Acid 10% HCl	B	A	-	B	A	A	A	X	C	X	A	X	A	A	A
Hydrochloric Acid 20% HCl	C	A	X	B	A	A	A	X	C	X	A	X	A	A	A
Hydrochloric Acid 37% (Conc.) HCl	C	A	X	C	A	A	B	X	X	X	A	X	A	A	A
Hydrocyanic Acid (Formonitrile) HCN	B	A	X	C	A	A	A	A/10%	X	A	A	X	A	A	-
Hydrofluoric Acid (Conc.) Cold HF 49%	X	B	X	X	A	X	B	X	X	X	X	X	A	A	A
Hydrogen Fluoride (Anhydrous) HF	X	C	X	C	A	-	A	X	X	X	A	-	A	A	-
Hydrogen Peroxide 3% H2O2	B	A	X	B	A	A	A	A	-	-	A	-	A/120°	A	X
Hydrogen Peroxide 10% H2O2	C	A	X	C	A	A	A	A	B	A	A	-	A/120°	A	X
Hydrogen Peroxide 30% H2O2	C	A	X	X	A	A	A	A	X	B	A	-	A/120°	A	X
Hydrogen Peroxide 90% H2O2	X	B	X	B	A	X	A	A	X	A	-	-	A/120°	A	X
Hydrogen Sulfide (Wet) H2S	X	A	A	C	A	A	X	A/90%	X	A/167°	A	C	A	A	A
Hydroquinone C6H4(OH)2	C	-	-	X	A	A	C	A/90%	B	A/10%	-	-	A	A	-
Hydroxyacetic Acid - 10% HOCH2COOH	X	A	-	X	A	A	-	B	-	B	-	-	-	A	-
Hypochlorous Acid HClO	X	B	-	X	A	A	A	X	X	X	A	-	A	A	-
Ink	A	-	-	A	A	A	A	C	X	A	B	-	A	A	-
Iodine I2	B	B	B	B	A	A	A	A	X	X	A	-	A/150%	A	X
Idoform CHI3	-	A	-	-	A	B	-	A	A	A	-	-	A	A	-
Isoamyl Acetate CH3CO2CH2CH2CH (CH3)2	X	B	-	X	A	-	X	A	A	A	-	-	-	A	-
Isoamyl Butyrate C9H18O2	X	-	-	-	A	-	X	A	A	A	-	-	-	A	-
Isoamyl Chloride (CH3)2 CHCH2CH2Cl	X	X	-	X	A	-	A	X	-	-	-	-	-	A	-
Isobutyl Acetate CH3CO2CH2 CH(CH)	X	C	-	X	A	-	X	A	A	A	-	-	-	A	-

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Isobutyl Amine (CH3)2 CHCOOH	X	-	-	-	A	-	X	-	-	-	-	-	-	A	-
Isobutyl Chloride (CH3)2 CHCH2CI	X	-	-	-	A	-	B	X	B	B	-	-	-	A	-
Isobutyric Acid (CH3)2 CHCOOH	X	A	-	B	A	-	-	A	-	-	-	-	-	A	-
Isododecane (CH3)2 CH(CH2)8CH3	B	X	-	A	A	-	A	B	B	B	-	-	-	A	-
Isooctane (Trimethylpentane) C8H18	A	X	A	B	A	C	A	A	A	A	A	-	A	A	A
Isopentane (CH3)2 CHCH2CH3	A	-	-	-	A	-	A	-	-	-	-	-	-	A	-
Isophorone C9H140	X	C	-	X	A	B	X	A	A	A	-	-	-	A	-
Isopropyl Acetate CH3COOCH (CH3)2	X	B	-	X	A	B	X	A	A	A	B	-	-	A	-
Isopropyl Amine C3H7NH2	X	-	-	-	A	-	X	-	A	A	-	-	-	A	-
Isopropyl Chloride (CH3)2CHCI	X	X	-	X	A	C	B	X	A	A	X	-	-	A	-
Isopropyl Ether (CH3)2CHOCH	C	X	-	C	A	B	C	B	-	A	X	-	A/70%	A	-
Jet Fuels (JP1 to JP6) (ASTM-A, A1 & B)	A	X	X	C	A	X	A	A	A	A	X	A	A	A	A
Kerosine (Kerosene) Hydrocarbons	A	X	A	C	A	X	A	A	A	A	X	A	A	A	-
Lacquers	X	X	X	X	A	C	X	A	B	A	-	B	-	A	-
Lacquer Solvents	X	X	C	X	A	C	X	A	B	A	C	B	X	A	-
Lactic Acid CH3CHOH COOH	B	A	X	B	A	A	A	A	X	A	A	C	A	A	A
Lactol (Aliphatic Naptha Solvent) CH3CHOH CO3C10H7	C	-	-	X	A	-	A	A	A	A	-	-	-	A	-
Latex Rubber emulsion	A	A	A	A	A	A	A	A	-	A	A	B	-	A	-
Lead Acetate (Sugar of Lead) Pb(CH3CO2)2	B	A	-	A	A	A	X	X	-	B	A	-	A	A	A
Lead Chloride PbCI2	-	-	-	B	A	-	-	X	-	B	A	-	A	A	-
Lead Nitrate Pb(NO3)2	B	A	-	A	A	-	A	X	B	B	A	A	A	A	-
Lead Sulfamate	B	-	-	A	A	A	A	-	-	-	A	-	-	A	-
Ligroin (Ligroine (Benzene) Petroleum fraction	A	X	-	B	A	B	A	-	A	A	X	-	-	A	-
Lignin Liquor Blend of natural aromatic oils	A	-	-	A	A	-	A	-	-	A	-	-	-	A	-
Lime Bleach	A	A	-	C	A	A	A	X	-	-	B	-	-	A	-
Lime Slurries	B	-	C	A	A	B	B	B	-	B	-	-	-	A	-
Lime, Soda (Slaked lime & soda ash) CaO	B	A	-	B	A	A	B	-	-	-	-	-	-	A	-
Lime Sulfur CaS + CaSO4	A	A	-	A	A	B	A	X	-	A	A	-	-	A	-
d-Limonene C10H16	C	X	-	X	A	-	A	A	-	A	-	-	A	A	-
Linoleic Acid C18H3202	B	X	-	X	A	B	B	A	-	A	A	-	A	A	-
Lindol (Tritolyl Phosphate) C21H21O4P4	X	-	-	C	A	A	B	-	-	-	-	-	-	A	-
Lithum Bromide LiBrH20	A	-	-	X	A	-	A	-	A	-	-	A	A	A	A

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Lye (Potassium Hydroxide) KOH	C	A	X	B	A	A	B	-	-	A	A	X	A/150°	A	A
Magnesium Carbonate MgCO3	A	C	A	A	A	A	A	A	B	B	A	A	A	A	-
Magnesium Chloride MgCO2O	A	A	A	A	A	A	A	A/20%	B/30%	B/40%	A	B	A	A	A
Magnesium Hydroxide (Milk of Magnesia) Mg(OH)2	B	A	C	B	A	A	A	A/10%	A	A	A	A	A	A	A
Magnesium Nitrate Mg(NO3)2 * 6H20	A	A	-	A	A	A	A	B/50%	B	A	A	-	A	A	A
Magnesium Oxide MgO	A	-	-	A	A	A	B	A/10%	A	A	-	-	-	A	-
Magnesium Sulfate (Epsom Salts) MgSO4 * 7H2O	A	A	B	A	A	A	A	A/70%	A	A/40%	A	A	A	A	A
Maleic Acid (CHCOOH)2	X	X	-	A	A	A	A	A/20%	B/60%	B	A	-	A	A	-
Maleix Anydride C4H2O3	-	X	-	-	A	-	A	A/20%	B	A	-	-	-	A	-
Malic Acid (Apple acid) C4H6O5	B	X	-	C	A	A	A	B	-	A	-	-	-	A	-
Maple Sugar Liquors (Sucrose) Water, sucrose	A	A	-	A	A	B	A	-	-	A	-	-	-	A	-
Mayonnaise Water, fats, oils	A	-	-	A	A	A	-	X	X	A	A	-	-	A	-
Mercuric Chloride HgCl2	A	A	-	B	A	A	A	X	X	X	A	B	A	A	-
Mercuric Cyanide Hg(CN)2	B	A	-	B	A	A	A	X	B	B	A	-	A	A	-
Mercurous Nitrate Hg2(NO3)2 * 2H2O	B	A	-	B	A	-	A	X	B	B/212°	A	-	A	A	-
Mercury Hg	A	A	A	A	A	A	A	X	A	A	X	X	X	X	-
Mesityl Oxide (CH3)2c = CHCOCH3	X	B	-	X	A	C	X	A	A	A	-	-	-	A	-
Methane CH4	A	X	B	B	A	X	A	A	A	A	B	A	A	A	-
Methyl Acetate	X	C	C	C	A	B	X	A	A	A	C	B	-	A	-
Methyl Acetoacetate CH3COCH2 COOCH3	X	-	-	-	A	-	X	-	A	A	-	-	-	A	-
Methyl Acrylate CH2CHCO2CH3	-	C	-	C	A	B	X	-	A	A	-	-	A/70°	A	-
Methyl Acrylic Acid (Crotonic Acid) CH3(CH)2COOH	-	C	-	C	A	-	X	-	-	-	-	-	-	A	-
Methyl Amine (Monomethylamine) CH3NH2	B	A	-	A	A	B	A/90%	B	B	A	X	-	C	A	-
Methyl Amyl Acetate C8H16O2	A	-	-	-	A	-	X	A	A	A	-	-	-	A	-
Methyl Aniline C6H5NH(CH3)	A	A	-	A	A	-	-	-	-	-	-	-	-	A	-
Methyl Bromide (Bromo Methane) CH3Br	C	A	X	X	A	X	A	X	A	A	X	-	A	A	-
Methyl Butyl Ketone (2-hexanone) CH3COC4H9	X	B	-	X	A	C	X	-	-	A	X	-	-	A	-
Methyl Butyrate CH3(CH2)2 CO2CH3	X	X	-	X	A	-	-	A	A	A	-	-	-	A	-
Methyl Cellosolve CH3OCH2 CH2O	X	-	-	X	A	A/70°	X	A	-	-	A	-	A	A	-

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Methyl Chloride CH3Cl	X	C	X	X	A	X	B	X	A	A	X	B	A	A	A
Methyl Cyclopentane C6H12	B	X	-	X	A	C	A	-	-	A	-	-	-	A	-
Methyl Dichloride CH2Cl2	X	-	-	X	-	X	A	X	-	-	X	-	-	A	-
Methyl Ethyl Ketone (Butanone) CH3C0 * CH2CH3	X	A	C	X	A	A	X	A	A	A	A	B	X	A	A
Methyl Formate HCOOCH3	X	C	-	B	A	B	X	A	A	A	-	-	-	A	-
Methyl Hexane C7H16	A	X	-	A	A	-	A	-	-	-	-	-	-	A	-
Methyl Iodide CH3I	X	A	-	X	A	A/70%	-	X	A	A	-	-	-	A	-
Methyl Isobutyl Ketone (Hexone) CH3COCH2CH (CH3)2	X	B	X	X	A	C	X	A	B	B	C/70%	A	A/70%	A	A
Methyl Isopropyl Ketone CH3COCH(CH3)2	X	C	X	X	A	C	X	-	-	A	C	-	A/70%	A	-
Methyl Methacrylate CH2C(CH3) CO2CH3	X	X	-	X	A	B	C	B	-	A	A	-	A/70%	A	-
Methyl Oleate C19H36O2	X	C	-	X	A	C	B	-	-	-	-	-	-	A	-
Methyl Propyl Ketone CH3CH2 CH2COCH3	X	B	-	X	A	-	X	-	-	-	-	-	-	A	-
Methyacrylic Acid CH3CHCHCO2H	-	-	-	B	A	A	B	-	-	-	-	-	-	A	-
Methylamine CH3NH2	B	A	-	A	A	A	A/90%	B	B	A	A	-	-	A	-
Methyl Bromide CH2Br2	X	-	-	X	A	-	B	X	A	A	-	-	A	A	-
Methylene Chloride CH2Cl2	X	X	X	X	A	X	B	X	B	A/90%	X	-	B/100°	A	A
Milk	B	A	B	A	A	A	A	A	X	A	A	A	A	A	-
Mine Water	A	-	-	-	A	B	-	B	-	B	-	-	-	A	-
Mixed Acids (Sulfuric & Nitric) H2SO4, HNO3	X	B	-	X	A	-	A	X	X	B	X	A	A	A	-
Molasses	A	A	B	A	A	A	A	A	A	A	A	-	A	A	A
Monochlorobenzene C6H5Cl	X	-	C	X	A	X	A	X	A	A	X	B	A/100%	A	A
N-Methyl Aniline C6H5NHCH3	X	-	-	X	A	-	C	-	-	-	C	A	-	A	-
Monoethanolamine NH2C2H4OH	B	-	-	C	A	A	C	B	A	A	A	-	X	A	A
Monomethylether	A	-	-	B	A	-	A	-	-	-	-	X	-	A	-
Monovinyl Acetylene	A	-	-	B	A	-	A	-	-	-	-	-	-	A	-
Mustard	C	-	B	A	A	A	X	B	X	A	A	A	-	A	-
Naptha (Petroleum spirits) (Thinner) Petroleum fractions	A	X	A	X	A	X	A	A	B	A	X	A	A	A	A
Naphtha Coal Tar (Benzol) Hydrocarbons	X	X	-	X	A	-	A	A	B	A	-	-	-	A	-
Naphthalene (Tar Camphor) C10H8	X	X	C	X	A	C	A	B	A	A	A	A	A	A	A
Naphthoic Acid C11H8O2	B	X	-	-	A	-	A	B	B	A	-	-	-	A	-

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Chemical/Formula	Elastomers							Metal			Plastic				
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Neohexane (2, 2-dimethylbuane) C6H14	A	-	-	-	A	-	A	-	-	-	-	-	-	A	-
Neosol	A	B	-	A	A	-	C	B	B	A	-	-	-	A	-
Neville Acid	C	C	-	C	A	A	B	-	-	-	-	-	-	A	-
Nickel Acetate Ni(CH3CO2)2	B	A	-	B	A	A	X	B/10%	-	A	A	-	A	A	-
Nickel Chloride NiCI2	A	A	X	A	A	A	A	X	X	B	A	B	A	A	A
Nickel Nitrate Ni(NO3)2 * 6H20	A	A	-	A	A	-	A	X	-	A	A	-	A	A	A
Nickel Sulfate NiSO4	A	A	-	A	A	A	A	X	X	A/40%	A	A	A	A	A
Nitrana (Ammonia Fertilizer)	B	-	-	B	A	-	C	-	-	A	-	-	-	A	-
Nitric Acid 10% HNO3	X	B	C	B	A	A	A	A	X	A	A	-	A	A	X
Nitric Acid 25% HNO3	X	B	X	C	A	B	A	X	X	A	A	-	A	A	X
Nitric Acid 35% HNO3	X	C	X	X	A	B	A	X	X	A	A	-	A	A	X
Nitric Acid 50% HNO3	X	X	X	X	A	X	A	X	X	A	A	-	A	A	X
Nitric Acid 70% HNO3	X	X	X	X	A	X	A	-	X	A	X	-	A	A	X
Nitric Acid Concentrated HNO3	X	X	X	X	A	X	B	A	X	A	X	-	A/120°	A	X
Nitric Acid Red Fuming	X	X	X	X	A	X	B	A	X	A	X	-	C	A	-
Nitrobenzene C6H5NO2	X	X	X	X	A	A	B	A	A	A	B	B	A/70°	A	-
Nitroethane C2H5NO2	X	C	-	C	A	A	X	A	A	A	C	-	A/70%	A	-
Nitrogen Tetroxide N2O4	X	X	B/50%	X	A	-	C	A	B	A	X	-	C	A	-
Nitromethane CH3N02	X	C	X	C	A	A	X	A	A	A	C	-	A/120°	A	A
1-Nitropropane CH3(CJ2)2NO2	X	A	-	C	A	-	X	A	A	A	-	-	-	A	-
Octadecane CH3(CH2)16CH3	A	X	-	B	A	B	A	-	-	-	-	-	-	A	-
n-Octane C8H18	A	X	-	-	A	B/70%	A	-	-	-	X	-	A	A	-
Octyl Acetate CH3COO (CH2)7CH3	X	-	-	-	A	-	X	A	-	A	-	-	-	A	-
Octachlorotoulene C7CI8	X	-	-	X	A	-	A	X	-	-	X	-	-	A	-
OILS (A thru D)															
Almond Oil (artificial)	X	B	-	X	A	X	X	-	-	-	-	-	-	A	-
Amyl Acetate (Banana Oil)	X	A	C	X	A	B	X	A	B	A	B	X	A/120°	A	A
Animal Fats & Oil	A	B	B	X	A	C	A	A	B	A	-	-	A	A	-
Bunker Oil (fuel #5, #6, #7)	A	X	-	B	A	B	A	A	A	A	-	-	-	A	-
Castor Oil	A	B	B	A	B	A	A	A	B	A	-	-	-	A	-
Cinnamon Oil	-	-	-	X	A	C	-	-	X	A	-	-	-	A	-
Citric Oils	C	B	-	X	A	A	A	-	X	A	A	-	-	A	-
Clove Oil (eugenol)	-	-	-	B	A	-	-	-	X	A	-	-	-	A	-
Coconut Oil (Coconut Butter)	B	A	-	B	A	B	A	B	A	A	-	-	-	A	-

Unless otherwise specified (in F deg), all fluid data established at 70°F.

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Chemical/Formula	Elastomers							Metal			Plastic				
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Cod Liver Oil (Fish Oil)	B	A	-	X	A	C	A	A	X	A	-	-	-	A	-
Corn Oil (Maize Oil)	A	C	A	X	A	A	A	B	C	B	A	-	A	A	-
Cotton Seed Oil	A	A	A	X	A	B	A	A	C	A	A	B	A	A	A
Creosote, Coal-Tar (Tar Oil)	A	X	X	X	A	X	A	B	B	B	X	X	-	A	-
Cutting Oil (water soluble)	B	-	-	X	A	B	A	A	A	A	-	-	-	A	-
Cutting Oil (Sulfer Base)	A	-	-	C	A	B	-	A	A	A	-	-	-	A	-
Diesel Oil (Fuel ASTM #2)	A	X	A	X	A	B	A	A	A	A	B	-	A	A	-
Diester Synthetic Oils	B	X	-	X	A	-	A	A	A	A	-	-	-	A	-
Dispersing Oil # 10	X	X	-	X	A	-	C	A	A	A	-	-	-	A	-
OILS (E thru H)															
Ethylene Dichloride (Dutch Oil)	X	X	X	X	A	X	B	X	B	B	X	B	A	A	A
Fish Oil	A	-	-	-	A	B	A	-	C	A	A	B	-	A	Fish
Fluorolube (Flourocarbon Oils)	C	A	-	A	A	X	B	A	A	A	X	-	-	A	A
Fuel Oils (ASTM #1 thru #9)	A	X	B	C	A	B	A	A	A	A	C	C	A	A	A
Furfual (Ant Oil)	X	B	-	B	A	C	C	A	B	A/20%	X	B	B/120°	A	A
Fusel Oil (Grain Oil)	A	A	-	A	A	-	A	-	-	-	-	-	-	A	-
Ginger Oil	-	-	-	A	A	C	A	-	X	A	-	-	-	A	-
Grapefruit Oil	X	-	-	X	A	-	-	-	X	A	-	-	-	A	-
Halowax Oil	X	X	-	X	A	X	A	X	-	-	-	-	-	A	-
Hydraulic Oil (Petroleum Base)	A	X	X	B	A	X	A	A	A	A	X	C	-	A	-
OILS (L thru N)															
Lard (lard Oil)	A	X	B	C	A	B	A	A	A	B	A	B	A	A	A
Lavender Oil	B	X	-	X	A	B	B	-	-	-	-	-	-	A	-
Lemon Oil (Cedro Oil)	-	-	-	C	A	C	A	A	-	A	-	-	-	A	-
Linseed Oil (Flaxseed Oil)	A	C	B	A	A	B	A	A	A	A	A	A	A	A	A
Lubricating Oils (petroleum)	A	X	A	B/150°	A	B	A	A	A	A	A	A	A	A	A
Methyl Salicylate (Betula Oil)	X	C	-	X	A	B	B	A	A	-	-	-	-	A	-
Mineral Oil (petroleum)	A	X	A	B	A	B	A	A	A	A	B	A	A	A	A
Neatsfoot Oil	A	C	-	-	A	B	A	-	-	A	-	-	-	A	-
OILS (O thru Q)															
Oleicf Acid (Red Oil)	C	C	A	X	A	-	B	A	C	B	B	B	A	A	A
Olive Oil	A	C	-	C	A	B	A	A	A	A	A	A	A	A	A
Palm Oil	A	-	-	C	A	B	A	-	A	A	-	-	-	A	A
Peanut Oil	A	X	-	B	A	B	A	-	A	A	A/70°	-	A	A	-

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Peppermint Oil	X	-	-	X	A	C	A	-	-	A	-	-	-	A	-
Petroleum (Crude Oil) (Sour)	B	X	C	C	A	X	A	B	B	A	X	A	A	A	-
OILS (R thru S)															
Rape Seed Oil (Colza Oil)	B	A	-	C	A	B	A	-	A	A	-	-	-	A	-
Rose Oil	-	-	-	C	A	A	A	-	-	A	-	-	-	A	-
Rosin Oil (Rosinol)	A	-	-	A	A	-	A	-	-	-	-	-	-	A	-
Sesame Seed Oil	A	-	-	C	A	B	A	-	A	A	-	-	-	A	-
Silicone Oils (Versilube, etc.)	A	X	A	C	A	C	A	B	B	A	A	-	A	A	A
Soybean Oil	A	C	A	A	A	B	A	A	A	A	B	B	-	A	A
Sperm Oil (Whale Oil)	A	-	-	X	A	B	A	-	A	A	-	-	-	A	-
OILS (T thru Z)															
Transformer Oil (Petroleum)	B	X	-	C	A	X	A	A	A	A	B	C	-	A	-
Tung Oil (Wood Oil)	A	X	B	C	A	B	A	A	-	A	A	-	-	A	-
Vegetable Oils	B	C	A	C	A	A	A	A	B	A	X	-	-	A	A
Walnut Oil	A	-	-	B	A	-	A	-	-	-	-	-	-	A	-
White Oil (Mineral) (Petroleum)	A	X	-	C	A	C	A	-	-	A	-	-	-	A	-
Oleum (Fuming sulfuric acid) H_2SO_4/SO_3	C	-	X	X	A	X	A	X	X	A	X	-	X	A	-
Olein (Triolene) $C_{57}H_{104}O_6$	B	-	-	C	A	X	-	-	-	-	-	-	-	A	-
0-Dicholobenzene $C_6H_4CI_2$	X	-	-	X	A	X	A	X	A	A	X	-	-	A	-
Oxalic Acid $(COOH)_2$	C	A	X	B	A	A	C	B	X	B/90%	A	B	A/120°	A	A
Ozone O_3	X	A	C	B	A	X	A	A/10%	A/10%	A	X	A	A	A	-
Paints & Solvents	X	-	-	X	A	-	-	A	-	A	-	A	-	A	-
Paint Thinner, DUCO Hydrocarbons	A	X	-	C	A	C	B	A	-	A	X	A	-	A	-
Palmitic Acid $CH_3(CH_2)_4 COOH$	B	B	A	C	A	A	B	B	B	A	A	-	A	A	-
Paraffins (Paraffin Oil) Hydrocarbons	A	-	-	-	A	A	-	A	-	A	A	A	-	A	-
Paraformaldehyde $(CH_2O)_8$	B	-	-	B	A	-	C	A/10%	A	A	-	A	-	A	-
Paraldehyde $C_6H_{12}O_3$	C	A	-	B	A	-	X	A	A	A	-	A	-	A	-
Pentachlorethane (Pentalin) $CI_2 CHCCI_3$	X	-	-	X	A	-	A	X	A	A	-	A	-	A	-
Pentachlorophenol (PCP) C_6CI_5OH	X	X	-	X	A	-	A	A	A	A	-	A	-	A	-
Pentane (Amyl Hydride) C_5H_{12}	A	X	B	B	A	B	A	A	B	B	-	-	-	A	-
Perchloric Acid $HCIO_4$	X	B	X	B	A/70%	X	A	X	X	B	-	C	A	A	A
Perchloroethylene (Tetrachloroethylene) C_2CI_4	X	X	X	X	A	X	A	X	B	A/90%	X	A	A	A	A
Phenethyl Alcohol (Benzyl Carbinol) $C_6H_5(CH_2)OH$	X	B	-	X	A	-	X	A	A	A	-	-	-	A	-

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Phenol (Carbolic Acid) C6H5OH	X	C	X	C	A	C	A	B	A	B	C	X	A/100%	A	A
Phenol Sulfonic Acid C6H4(OH)SO3H	X	-	-	-	A	-	X	B	B	B	-	-	-	A	-
Phenyl Acetate CH3COOC6H5	X	B	-	X	A	-	X	-	-	-	-	-	-	A	-
Phenylbenzene C6H5	X	-	-	X	A	C	A	-	-	-	-	-	-	A	-
Phenyl Ethyl Ether (Phenetole) C6H5OC2H5	X	X	-	X	A	C	C	-	-	-	-	-	-	A	-
Phenyl Hydrazine C6H5NHNH2	X	X	-	X	A	B	A	A	X	-	X	-	A/120°	A	-
Phorone (Diisopropylidene Acetone) C9H14O	X	C	-	X	A	B	A	-	-	-	-	-	-	A	-
Phosphoric Acid 10% H3PO4	A	A	-	B	A	A	A	X	X	A	A/120°	-	A	A	A
Phosphoric Acid 20% H3PO4	C	A	-	B	A	A	A	X	X	A/212°	A/120°	-	A	A	A
Phosphoric Acid 50% H3PO4	X	A	-	B	A	A	A	X	X	A	A/120°	-	A	A	A
Phosphoric Concentrated H3PO4	X	B	X	C	A	C	A	X	X	A/212°	A/120°	-	A	A	A
Phosphorus Oxychloride POCl3	-	-	-	X	A	-	-	B	B	B	-	-	-	A	-
Phosphorus Trichloride PCl3	X	A	-	X	A	A	A	C	B	A	X	-	A	A	A
Photographic Developer	A	-	X	A	-	A	A	C	X	A	A	C	A	A	A
Pickling Solution	-	X	X	X	A	A	B	-	-	-	-	-	-	A	-
Picric Acid (Carbazotic Acid) (NO2)3 C6H2OH	B	B	X	B	A	X	A	A	C	A	B	-	A	A	-
Pinene C10H16	B	X	-	X	A	C	A	-	-	-	-	-	-	A	-
Piperidine C5H11N	X	X	-	X	A	B	X	-	-	-	-	-	-	A	-
PLATING SOLUTIONS															
Cadmium	B	-	-	B	A	A	-	-	-	A	X	-	B	A	-
Chrome	X	C	-	X	A	A	A	-	-	-	X	X	B	A	X
Lead	B	-	-	B	A	A	-	-	-	-	A	A	B	A	X
Others	A	A	-	C	A	A	B	-	-	A	-	-	-	A	-
Polyol	X	A	X	X	A	X	A	A	A	A	-	-	-	-	-
Polyvinyl Acetate Emulsion PVac = H20	-	A	-	C	A	A	-	-	B	B	A	-	A	A	-
Potassium Acetate CH3CO2K	B	A	-	B	A	A	X	B/10%	A	B	A	-	A	A	-
Potassium Bicarbonate KHCO3	A	-	-	A	A	A	A	B	B/40%	A/30%	A	-	A	A	A
Potassium Bisulfate KHSO4	A	-	-	A	A	-	A	A/10%	X	A/10%	A	-	A	A	-
Potassium Bisulfite KHSO3	A	-	-	A	A	-	A	B/10%	-	B/10%	-	-	-	A	-
Potassium Bromide KBr	A	A	-	A	A	A	A	A	B/80% 212°	B/90% 212°	A	-	A	A	A
Potassium Carbonate (Potash) K2CO3	A	A	-	A	A	A	A	X	B	B	A	B	A	A	A

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Potassium Chlorate KClO3	A	A	-	A	A	A	A	X	B	A/60%	A	B	A	A	A
Potassium Chloride KCl	A	A	-	A	A	A	A	X	B	A	A	B	A	A	A
Potassium Chromate K2CrO4	A	-	-	A	A/40%	A	A	A	A	A	A	-	A	A	-
Potassium Copper Cyanide K3[Cu(CN)4]	A	A	-	A	A	-	A	-	-	-	A	-	-	A	-
Potassium Cyanide KCN	A	A	-	A	A	A	A	C	B	B/90% 212°	A	C	A	A	A
Potassium Dichromate K2Cr2O	A	A	-	A	A	A	A	A	A	A	A	C	A	A	A
Potassium Hydroxide (Caustic Potash) (Lye) KOH	B	A	X	B	A	A	B	X	B	A	A	C	A/150%	A	A
Potassium Iodide KI	A	A	-	A	A	A	A	B/10%	-	B	A	-	A	A	-
Potassium Nitrate (Saltpeter) KNO3	A	A	-	A	A	A	A	A/80%	B	B/80% 212°	A	B	A	A	A
Potassium Nitrite KNO2	A	A	B	A	A	A	A	B	B	B	A/70°	-	-	A	-
Potassium Permanganate (Purple Salt) KMnO4	C	A	X	C	A	A	B	A/10%	B	B/30% 212°	B	A	A	A	A
Potassium Phosphate KH2PO4	A	A	-	A	A	-	A	X	X	B/30%	-	-	-	A	-
Potassium Silicate K2Sii2O5	A	A	-	A	A	-	A	B	B	B	A	-	-	A	-
Potassium Sulfate K2SO4	A	A	B	A	A	-	A	B	B	A	A	B	A	A	A
Potassium Sulfide K2S	A	A	-	A	A	-	A	X	B	B	A	-	A	A	A
Potassium Sulfite K2SO32H2O	A	A	-	A	A	-	A	A	X	B/50%	A	-	A	A	-
Propane (LPG) C3H8	A	X	B	B	A	X	A	A	A	A	X	A	A	A	-
Propionaldehyde (Propanal) C2H5CHO	X	-	-	-	A	-	X	A	A	A	-	-	-	A	-
Propionic Acid (Methylacetic Acid) CH3CH2CO2H	X	A	-	X	A	A	X	A	X	B	B	-	-	A	-
n-Proply Acetate CH3COO (CH2)2CH3	X	A	-	X	A	B	X	A	-	A	C	-	A	A	-
Propyl Alcohol (1-Propanol) CH3CH2CH2OH	B	A	-	B	A	A	A	A	A	A	A	A	A	A	A
n-Propyl Nitrate (NPN) CH3(CH2)2NO3	A	B	-	-	A	B	C	A	X	-	-	-	-	A	-
Propylene C3H6	X	X	-	X	A	B	A	A	A	A	-	-	-	A	-
Propylene Dichloride CH3CH(CI)CH2CI	X	X	-	X	A	-	B	X	A	A	-	-	-	A	-
Propylene Glycol (Methyl Glycol) C3H6(OH)2	A	A	A	C	A	A	A	A	A	A	A	A	A	A	A
Propylene Oxide C3H6O	-	C	-	X	A	A	X	B	B	A	X	-	X	A	-
Pydraul (Phosphate Ester Base Fluid)	X	B	A	X	A	B	A	-	A	A	-	-	-	A	-
Pyranol	A	-	-	X	A	-	A	-	-	-	-	-	-	A	-

Unless otherwise specified (in F deg), all fluid data established at 70°F.

Chemical/Formula	Elastomers							Metal			Plastic				
Rating Key: **(A)** Excellent; **(B)** Good; **(C)** Fair to Poor, data limited to % concentration and/or temperature; **(X)** Not Recommended; **(—)** No Data Available 0°F shown. Where not shown, termeperature is 70°F ambient.	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
Pyridine N(CH)4CH	X	C	X	X	A	A	X	A	B	A	C	X	X	A	A
Pyroligneous Acid (Wood Vinegar)	C	C	-	C	A	-	A	B	X	A/10%	A	-	A	A	-
Pyrrole (Azole)	X	X	-	X	A	B	C	B	-	-	-	-	-	A	-
Quaternary Ammonium Salts	A	-	-	A	A	-	A	-	X	A	-	-	-	A	-
Rosin C20H302	A	-	-	C	A	A	-	A	-	A	A	-	-	A	-
Rotenone C23H220	A	A	-	A	A	-	A	-	-	-	-	-	-	A	-
Rubber Latex Emulsions (C5H8)n/H20	-	-	-	-	A	-	A	A	-	A	-	-	-	A	-
Rubber Solvents (Petroleum Distillate) Hydrocarbons	X	-	-	C	A	-	X	A	-	A	-	-	-	A	-
Rum Alcoholic liquor from molasses	A	A	-	A	A	A	B	-	-	A	-	-	-	A	-
Rust Inhibitors	A	-	-	C	-	B	A	-	-	A	A	-	-	A	-
Salad Dressing Fats, oils, water	A	-	-	-	-	A	A	B	X	A	A	-	-	A	-
Sal Ammonian (Ammonium Chloride) NH4CI	A	-	A	A	A	A	A	X	X	A	-	X	-	A	A
Sal Soda (Sodium Carbonate) NaCO3	A	A	-	A	A	B	A	X	A	A	-	-	-	A	-
Salicyclic Acid HOC6 H4COOH	B	A	-	B	A	-	B	A	X	B	A	-	A	A	-
Salt Water (Brine) NaCI/H20	A	A	A	B	A	A	A	B	X	A	A	-	A	A	-
Sea Water (Brine)	A	A	A	B	A	A	A	A	C	A	A	A	A	A	-
Sewage	A	C	B	B	A	A	A	B	B	A	A	-	A	A	-
Silicate Esters Si(OR)4	B	X	C	A	A	B	A	-	-	-	-	-	-	A	-
Silver Cyanide AgCN	-	-	-	A	A	-	-	X	A	A	A	-	A	A	-
Silver Nitrate AgNO3	B	A	-	A	A	A	A	X	X	A/60%	A	A	A	A	A
Skydrol Hydraulic Fluid (Phosphate Ester Base)	X	A	A	X	A	A	C	A	A	A	-	-	-	A	-
Soap Solutions Salt of fatty acid in H2O	A	A	A	B	A	A	A	C	X	A	A	A	A	A	A
Soda Ash (Sodium Carbonate) Na 2CO3	A	A	B	A	A	A	A	X	A	A	A	-	-	A	-
Sodium Acetate CH 3COONa	C	A	-	C	A	A	X	A	A	A	A	A	A	A	A
Sodium Aluminate Na 2AL2O4	A	-	-	A	A	A	A	-	A/40%	A/40%	A	-	A	A	-
Sodium Bicarbonate (Baking Soda) NaHCO 3	A	A	B	A	A	A	A	B	C	A/20%	A	X	A	A	A
Sodium Bisulfite (Niter Cake) NaHSO 4	A	A	B	A	A	A	A	B/50%	C	B/50%	A	C	A	A	A
Sodium Bisulfate NaHSO3	C	A	B	A	A	A	A	B	B/20%	A/50%	A	X	A	A	-
Sodium Borate Na 2B4O7	A	A	B	A	A	A	A	B	-	A	A/140%	C	A	A	A
Sodium Bromide NaBr	-	B	-	B	A	-	A	C	C	B/30%	A	-	A	A	-

Unless otherwise specified (in F deg), all fluid data established at 70°F.

Chemical/Formula	Elastomers							Metal			Plastic				
Rating Key: **(A)** Excellent; **(B)** Good; **(C)** Fair to Poor, data limited to % concentration and/or temperature; **(X)** Not Recommended; **(—)** No Data Available 0°F shown. Where not shown, termeperature is 70°F ambient.	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
Sodium Chlorate NaClO 3	A	A	-	B	A	A	A	B/70% 212°	B	B	A	B	A	A	A
Sodium Chloride (Table Salt) NaCl	A	A	A	A	A	A	A	B	B/30%	A	A	A	A	A	A
Sodium Chromate Na 2CrO4	A	-	A	A	A	A	A	A/80% 212°	A/60%	A/60%	A	-	A	A	-
Sodium Cyanide NaCN	A	A	A	A	A	A	A	X	A	A	A	C	A	A	A
Sodium Dichromate (Sodium Bichromate) Na 2Cr2O7 * 2H2O	-	A	X	B	A	-	A	-	-	-	A	-	A	A	A
Sodium Fluoride NaF	A	A	-	A	A	-	A	B/30%	-	B/10%	A	-	A	A	-
Sodium Hexametaphosphate (Calgon) (NaPO 3)	B	B	-	B	A	-	A	C	B	B	A	-	A	A	-
Sodium Hydroxide (Caustic Soda) (Lye) NaOH	B	A	X	B	A	A	X	X	B/50%	A/50%	A	X	C	A	X
Sodium Hypochlorite NaOCL	X	B	X	B	A	A	B	X	X	X	X	X	A	A	X
Sodium Metaphosphate (Kurrol's Salt) Na(PO3)H	B	A	-	C	A	A	A	X	-	B	A/70%	B	-	A	-
Sodium Metasilicate Na2SiO3	A	A	-	A	-	A	A	B	-	A	A	B	A	A	-
Sodium Nitrate (Chile Saltpeter) NaNO3	C	A	B	B	A	A	A	A/90%	A/90%	A/90%	A	A	A	A	A
Sodium Nitrite NaN02	A	-	-	X	A	-	A	A	A	A	A	-	A	A	-
Sodium Perborate NaBO3	C	A	B	B	A	A	A	X	B/10%	A	A	B	A	A	-
Sodium Peroxide (Sodium Dioxide) Na2O2	B	B	B	B	A	B	A	B/10%	A/90%	B/10%	B	X	A	A	-
Sodium Phosphate (Tribasic (TSP) Na3PO4	B	A	B	B	A	A	A	X	B/167%	B	A	-	A	A	-
Sodium Silicates (Water Glass) Na2O * SiO2	A	A	A	A	A	A	A	A	A	A	A	-	A	A	A
Sodium Sulfate (Salt Cake) (Thenardite) Na3SO4	A	A	A	B	A	A	A	B/30%	B	A	A	-	A	A	A
Sodium Sulfide (Pentahydrate) Na2S * 5H2O	A	A	A	A	A	A	A	A/30% 212°	B	A/30% 167°	A	A	A	A	A
Sodium Sulfite Na2SO3	A	A	A	A	A	-	A	A/30%	X	A/30%	A	A	A	A	Ryton
Sodium Tetraborate Na2B4O710H2O	A	-	B	-	A	A	A	-	-	A	C	-	A	A	-
Sodium Thiosulfate (Antichlor) Na2s2O3	A	A	-	A	A	-	A	A	C	A/1220	A	B	A	A	A
Sorgum	A	-	-	A	A	A	-	-	A	A	-	-	-	A	-
Soy Sauce Fermented soya bean/wheat	A	-	-	A	A	A	-	-	X	A	-	-	-	A	-
Stannic Chloride (Tin Chloride) SnCl4	A	B	B	B	A	A	A	X	C	A/10%	A	-	A	A	-
Stannous Chloride (Tin Salt) SnCl4	A	B	B/15%	A	A	-	A	X	B	A/10%	A	-	A	A	A

Chapter 6: Corrosion Resistance Guide

Unless otherwise specified (in F deg), all fluid data established at 70°F.

Chemical/Formula	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
Starch C6H10O5	A	B	B	A	A	A	C	A	C	A	A	B	-	A	A
Stearic Acid CH3(CH2)16 CO2H	B	B	B	B/158°	A	A	A	C	C	A	A	C	A	A	-
Stoddard Solvent Petroleum distillate	A	X	A	C	A	X	-	A	A	A	A	A	X	A	-
Styrene (Vinylbenzene) C6H5CHCH2	X	X	X	X	A	C	A	A	A	A	-	-	A	A	-
Sucrose Solution (Sugar) C12H22O11/H20	A	A	A	A	A	A	A	A	A	A	-	-	-	A	-
Sulfamic Acid H2NSO3H	B	-	A	A	A	-	-	A/10%	X	X	A	-	B	A	-
Sulfite Liquors	A	C	B	B	A	A	A	-	-	-	-	-	-	A	-
Sulfur S	X	A	A	B	A	A	A	A	A	A	A	A	A	A	A
Sulfur Chloride S2Cl2	C	X	C	X	A	X	A	B	X	B	X	-	A	A	-
Sulfur Dioxide SO2	X	B	X	A	A	A	A	A	B	A/10%	A	B	A	A	A
Sulfur Hexafluoride SF6	B	A	A	A	A	B	A	-	-	-	-	-	-	A	-
Sulfur Trioxide SO3	C	C	X	C	A	C	A	B	B	B	X	-	X	A	-
SULFURIC ACID															
10% H2SO4	B	A	X	A	A	A	A	X	X	A	A	-	A	A	10-
25% H2SO4	C	B	X	B	A	A	A	X	X	B	A	-	A/150°	A	X
50% H2SO4	X	B	X	B	A	A	A	X	X	X	A	-	A/150°	A	X
60% H2SO4	X	B	X	C	A	A	A	X	X	X	A	-	A/150°	A	X
75% H2SO4	X	C	X	X	A	A	A	X	C	C	A	-	A/150°	A	X
95% H2SO4	X	C	X	X	A	A	A	X	B	A	X	-	A/120°	A	X
Concentrated H2SO4	X	C	X	X	A	B	A	X	B	B	X	-	A/120°	A	-
Fuming H2SO4/YSO3	X	X	X	X	A	-	B	C	X	B	X	-	X	A	-
Sulfurous Acid H2SO3	B	A	C	X	A	A	A	B	X	B	A	X	A	A	A
Tall Oil (Liquid Rosin) Rosin acids	A	X	-	B	A	A	A	X	B/212°	B	A	-	A	A	-
Tallow Fat from cattle, sheep	A	-	-	-	A	B	A	A	-	A	B	C	-	A	-
Tannic Acid C76H52O46	C	C	A/10%	B	A	A	A	A	A	A	A	X	A	A	A
Tanning Liquors Tannic acid	A	-	-	B	A	A	-	A	-	A	A	X	-	A	-
Tar, Bituminous Mixture of aromatic (Coal Tar) (Pitch) & phenolic hydrocarbons	B	X	B	C	A	B	A	A	-	A	A	A	-	A	-
Tartaric Acid C4H6O6	B	B	B	A	A	A	A	A/20%	X	A	A	X	A	A	A
Terpenes C10 hydrocarbons	C	X	-	X	A	-	A	A	X	-	-	-	-	A	-
Terpineol (Terpilenol) C10H18O	C	C	-	X	A	B	A	A	A	A	X	-	B/120°	A	-
Teritary Butyl Alcohol (CH3)3COH	A	A	-	A	A	B	B	A	-	-	B	-	-	A	-
Teritary Butyl Catechol C9H14O2	X	A	-	B	A	B	A	C	B	B	-	-	-	A	-
Teritary Butyl Mercaptan C4H10S	X	-	-	X	A	B	A	B	-	-	-	-	-	A	-

Rating Key: **(A)** Excellent; **(B)** Good; **(C)** Fair to Poor, data limited to % concentration and/or temperature; **(X)** Not Recommended; **(—)** No Data Available 0°F shown. Where not shown, termeperature is 70°F ambient.

Unless otherwise specified (in F deg), all fluid data established at 70°F.

Chemical/Formula	Elastomers							Metal			Plastic				
Rating Key: **(A)** Excellent; **(B)** Good; **(C)** Fair to Poor, data limited to % concentration and/or temperature; **(X)** Not Recommended; **(—)** No Data Available 0°F shown. Where not shown, termeperature is 70°F ambient.	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
Tetra Bromomethane CBr4	X	-	-	X	A	X	A	X	-	-	X	-	-	A	-
Tetrabutyl Titanate Ti(C4H9)	B	B	-	A	A	B	A	-	-	-	-	-	-	A	-
Tetrachloroethylene Cl2C = CCl2	-	-	-	-	A	X	A	B	-	A	X	-	A	A	-
Tetrachlorodifluoroethane (Cl2FC)2	X	-	-	X	A	-	-	-	-	-	-	-	-	A	-
Tetrachloroethane (Acetylene Tetrachloride) (Cl2HC)2	X	X	-	X	A	X	A	X	A	C	X	A	A	A	-
Tetraethyl Lead Pb(C2H5)4	B	X	-	X	A	C	B	B	A	A	A	-	A	A	-
Tetraethylene Glycol (TEG) HOCH2 (CH2OCH2)3CH2OH	A	-	X	-	A	-	A	-	-	-	-	-	-	A	-
Tetrahdrofuran (THF) C4H8O	X	C	C	X	A	X	X	-	-	A	C/100°	A	B/70°	A	A
Tetrahydronaphthalene (Tetralin) C10H12	X	X	-	X	A	-	A	A	A	A	C	-	-	A	A
Thionyl Chloride SOCl2	X	X	-	X	A	B	B	X	X	X	B	B	X	A	-
Thiopene C4H4S	X	X	-	X	A	-	C	-	-	-	-	-	-	-	-
Titanium Tetrachloride TiCl4	C	X	-	X	A	X	A	X	A	B	B	-	B	A	-
Toluene (Toluol) C7H8	C	X	C	X	A	X	B	A	A	A	X	B	A	A	A
Toluene Diisocyanate CH3C6H3 (NCO)2	-	A	B	X	A	B	A	A	-	-	-	-	-	A	-
Toluidine CH3C6 H4NH2	X	-	-	-	A	-	B	A	A	A	-	-	-	A	-
Tomato Pulp & Juice	A	-	-	-	A	A	-	B	-	A	A	-	A	A	A
Toothpaste	A	A	-	C	A	-	A	-	X	A	A	-	-	A	-
Transmission Fluid (Type A)	A	X	B	C	A	C	A	A	A	A	-	-	-	A	-
Triacetin C3H5 (OCOCH3)3	A	A	-	B	A	A	X	B	-	-	-	-	-	A	-
Triallyl Phosphate P(OC3H5)3	X	A	-	C	A	-	A	-	-	-	B	-	A	A	-
Triaryl Phosphate (C6H50)3PO	X	-	-	C	A	-	A	-	-	-	-	-	-	A	-
Tributoxyl Ethyl Phosphate (C4H9O)3P(C2H5)	X	A	-	X	A	B	B	-	-	-	-	-	-	A	-
Tributyl Phosphate (TBP) (C4H9)3PO4	X	C	C	X	A	B	X	A	A	A	B/100°	-	A/100°	A	-
Tributyl Mercaptan (C4H9)2S	X	-	-	X	A	-	A	-	-	-	-	-	-	A	-
Trichloracetic Acid (TCA) CCl3COOH	C	C	X	B	A	B	B	X	X	X	B	-	B	A	A
Trichlorobenzences C6H3Cl3	X	-	-	X	A	-	B	X	A	A	-	-	-	A	-
Tricloroethane C2H3Cl3	X	X	-	X	A	X	B	X	A	A	X	-	A	A	A
Trichloroethylene (Ex-Tri) (Hi-Tri) C2HCl3	X	X	X	X	A	X	C	X	B	A/90% 167°	X	B	A	A	A
Trichloropropane CH2CICH CICH2CI	X	-	-	X	A	X	B	X	X	A	X	-	-	A	-
Tricesyl Phosphate (Lindol) (TCP) (CH3C6H4O)3 PO	X	A	C	C	A	B	C	-	A	B	B	-	X	A	-

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Chemical/Formula	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
			Elastomers						**Metal**			**Plastic**			
Triethanol Amine (TEA) C12H25 CH2OH	X	B	X	A	A	A	C	A	A	A	A	B	X	A	A
Trethyl Aluminum (ATE) N(C2H4OH)3	X	-	-	X	A	B	B	-	-	-	-	-	-	A	-
Triethyl Amine (CH3CH2)3N	A	-	-	B	A	-	-	-	A	A	C	-	A/120°	A	-
Triethyl Borane (C2h5)3B	X	-	-	X	A	B	A	-	-	-	-	-	-	A	-
Triethylene Glycol (TEG) (CH2OCH-2CHOH)2	A	-	X	-	A	-	A	A	-	A	A	-	-	A	-
Trimethylene Glycol HO(CH2)3OH	A	A	-	-	A	-	A	A	-	A	-	-	-	A	-
Trinitrotoluene (TNT) CH3C6H2(NO2)3	X	X	-	B	A	A	B	-	-	-	-	-	-	A	-
Trioctyl Phosphate (C8H17O)3PO	X	A	-	X	A	B	B	-	-	-	-	-	-	A	-
Turpentine C10H16	A	X	B	X	A	X	A	A	A	A	X	A	A	A	A
Unsymmetrical Dimethyl Hydrazine (UDMH) H2NN(CH3)2	C	A	-	C	A	B	X	-	-	-	-	A	A	A	-
Urea (Carbamide) CO(NH2)2	B	A	B	B	A	A	A	B	-	B/50%	A	-	A	A	A
Urine	A	-	-	X	A	A	A	A	A	A	A	A	A	A	-
Valeric Acid CH3(CH2)COOH	X	A	-	X	A	-	-	A	-	-	-	-	-	A	-
Vanilla Extract (Vanillin) C6H3(CH0)(OCH3)(OH)	A	-	-	X	A	-	X	-	-	A	-	-	-	A	-
Varnish Oil,gum resins, oil of turpentine	B	X	-	C	A	-	A	A	-	A	A	A	A	A	-
Vegetable Juices	A	-	-	C	A	A	-	C	-	A	A	-	-	A	-
Vinegar Dilute acetic acid	C	A	C	B	A	A	A	C	X	A	A	A	A	A	A
Vinyl Acetate CH2C00C HCH2	X	A	-	B	A	-	X	B	A	A	B	-	A	A	-
Vinyl Chloride (Chlorethylene) CH2CHCl	X	C	-	X	A	X	A	X	A	A	X	-	B	A	-
Water Distilled H2O	A	A	A	B	A	A	A/70°	A	C	A	A	A	A	A	A
Water Fresh H2O	A	A	A	B	A	A	A/70°	A	A	A	A	A	A	A	A
Waxes Hydrocarbons	A	X	-	A	A	-	-	A	-	A	-	A	-	A	-
Weed Killers	B	-	-	C	-	B	A	X	-	A	-	-	-	A	-
Whiskey Ethanol, esters, acids	B	A	B	A	A	A	A	A	X	A	A	B	A	A	-
White Sulfate Liquor	B	A	-	A	A	-	B	B	C	A	A	-	A	A	-
Wines	A	A	A	A	A	A	B	C	X	A	A	-	A	A	-
Wort, Distillery Sugar solution from malt	-	-	-	A	A	-	A	A	A	A	A	B	B	A	-
Xylene (Xylol) C6H4(CH3)2	X	X	C	X	A	X	A	A	B	B	X	-	A	A	A
Xylidines (Xylidin) (CH3)2C6H3NH2	-	X	-	X	A	C	X	B	B	-	-	-	-	A	-
Zeolite Hydrated alkali aluminum silciates	C	A	-	C	A	A	A	-	-	A	-	-	-	A	-
Zinc Acetate Zn(C2H3O)2	C	A	-	B	A	A	X	C	-	-	A	-	A	A	-

Rating Key: **(A)** Excellent; **(B)** Good; **(C)** Fair to Poor, data limited to % concentration and/or temperature; **(X)** Not Recommended; **(—)** No Data Available 0°F shown. Where not shown, termeperature is 70°F ambient.

Unless otherwise specified (in F deg), all fluid data established at 70°F.

Chemical/Formula	Elastomers							Metal			Plastic				
Rating Key: **(A)** Excellent; **(B)** Good; **(C)** Fair to Poor, data limited to % concentration and/or temperature; **(X)** Not Recommended; **(—)** No Data Available 0°F shown. Where not shown, termeperature is 70°F ambient.	Buna N NBR	Nordel® EPDM	Hytrel® TPE	Neoprene CR	PTFE	Santoprene® TPO	Viton® FPM	Aluminum T356	Cast Iron FC	Stainless Steel 316	Polypropylene PPG	Delrin (Acetal)	Kynar® PVDF	PTFE	Ryton
Zinc Carbonate ZnCO3	A	-	-	-	A	-	A	B	B	B	-	-	-	A	-
Zinc Chloride ZnCl2	B	A	A	B	A	A	A	A/10%	B	A/10%	A	B	A	A	A
Zinc Hydrosulfite ZnHSO3	A	-	-	A	A	A	A	X	-	A	-	-	-	A	-
Zinc Sulfate ZnSO4	A	A	X	A	A	A	B	B/20%	X	B	A	B	A	A	A

Rating Key: **(A)** Excellent **(B)** Good **(C)** Fair to Poor, data limited to % concentration and/or temperature **(X)** Not Recommended **(-)** No Data Available 0°F shown. Where not shown, temperature is 70°F ambient.

Unless otherwise specified (in F deg), all fluid data established at 70°F.

Chemical Synonyms / Alternate Listings

SYNONYM	LISTED AS: / ALSO SEE:
Acetec Acid Amide	Acetmide
Acetic Acid Ethenyl Ester	Vinyl Acetate
Acetic Acid Ethyl Ester	Ethyl Acetate
Acetic Acid + Methanol	Pyroligineous Acid
Acetic Acid Methyl Ester	Methyl Acetate
Acetic Acid Nitrile	Acetonitrile
Acetic Aldehyde	Acetaldehyde
Acetic Ester	Ethyl Acetate
Acetol	Alcohol Diacetone
Acetyl Benzene	Acetophenone
Acetylene Tetrachloride	Tetrachloroethane
Acryimide	Acetamide
Acrylic Acid	Propionic Acid
Alcohol, 2 Aminoethanol	Ethanolamine
Alum Potash	Potassium Hydroxide
Aluminum Hydrate	Aluminum Hydroxide
Amber Acid	Maleic Acid
Amino Benzene	Aniline
Aminoethane	Ethyl Amine
2-Amino Ethanol	Ethanolamine
Aminomethane	Methyl Amine
2-Amino 2-Methyl Propanol	Butyl Amine
Ammonia Liquors	Ammonium Hydroxide Water
Amyl Hydride	Pentane
Amylurn	Starch
Animal Fat	Butter
Animal Fat	Tallow
Ant Oil	Furan
Apple Acid	Malic Acid
Aragonite	Calcium Carbonate
ASTM Reference Fuel A	Isooctane 100%
ASTM Reference Fuel B	70% Isooctane+30% Toluene
ASTM Reference Fuel C	50% Isooctane+50% Toluene
Azine	Pyridine
Azotic Acid	Nitric Acid
Baking Soda	Sodium Bicarbonate
Benzene	Benzol
Benzene Carbonal	Benzaldehyde
Benzene Carboxylic Acid	Benzonic Acid
Benzine	Ligroin
Benzoic Acid Chloride	Benzoyl Chloride
Benzol	Benzene
Benzyl Ether	Dibenzyl Ether
Biscofite	Magnesium Chloride
Bitumen	Asphalt
Bituminous/Coal Tar	Creosote
Blank Fixe	Barium Sulfate
Bleaching Powder Solutions	Calcium Hypochlorite
Blue Copperas	Copper Sulfate
Blue Verdigris	Copper Acetate
Blue Vitriol	Copper Sulfate
Boletic Acid	Fumaric Acid
Boehmite	Aluminum Hydroxide
Boracid Acid	Boric Acid
Bromomethane	Methyl Bromide
Brucite	Magnesium Hydroxide
Butanoic Acid	Butyric Acid
Butanol	Butyl Alcohol
2-Butanone	Methyl Ethyl Ketone

SYNONYM	LISTED AS: / ALSO SEE:
Butenal	Butyraldehyde
1-Butene	Butylene
2-Butene	Butylene
cis-Butenedioic Acid	Maleic Acid
Buthylene	n-Butane
2-Butoxyethanol	Butyl Cellosolve
Butyl Citrate	n-Hexane-1
Butyl Phthalate	Dibutyl Phthalate
Butylene Glycol	1,3 Butanediol
Caliche Liquors	Potassium Nitrate
Carbamide	Urea
Carbinol	Methanol
Carbolic Acid	Phenol
Carbon Bisulfide	Carbon Disulfide
Carbonyl Diamide	Urea
Caustic Baryta	Barium Hydroxide
Caustic Lime	Calcium Hydroxide
Caustic Potash	Potassium Hydroxide
Caustic Soda	Sodium Hydroxide
Cellosolve Acetate	Ethylene Glycol Monoethyl Ether Acetate
Cellosolve Butyl	Ethylene Glycol Monobutyl Ether
Chile Nitrate	Sodium Nitrate
Chile Saltpeter	Sodium Nitrate
Chinawood Oil	Tung Oil
Chlorinated Lime	Calcium Hypochlorite
2 Chloro-1, 3 Epoxypropane	Epichlorohydrin
2 Chloro-1, 3-Butadiene	Allyl Chloride
Chloroazotic Acid	Aqua Regia
Chlorobenzol	Chlorobenzene
Chlorobutane	Butyl Chloride
Chlorodifluoromethane	Freon 22
Chloroethane	Ethyl Chloride
Chloroethanoic Acid	Chloroacetic Acid
2-Chloroethanol	Chloroethyl Alcohol
Chloroethene	Vinyl Chloride, Monomer
Chloroethylene	Vinyl Chloride
Chloromethane	Methyl Chloride
Chloronitic Acid	Aqua Regia
Chloropentafluoroethane	R1 15 (see Freons Misc.)
Chloropentate	Amyl Chloride
3-Chloropropene	Allyl Chloride
Chlorotoluene	Benzyl Chloride
Chlorotrifluoromethane	Freon 13
Coal Tar	Creosote
Copperas	Ferrous Sulfate
DBT	Dibutyl Phthalate (DBP)
DEA	Diethanolamine
Denatured Alcohol	(Ethyl Alcohol) Ethanol
1,2 Diaminoethane	1,2-Ethylene Diamine
Dibenzofuran	Diphenyl Oxide
1,2 Dibromoethane	Ethylene Dibromide
Dibromotetrafluoroethane	R 114132 (see Freons Misc.)
Dibutyl Ether	Butyl Ether
Dichlorodifluoro Methane	Freon 12
Dichloromethane	Methylene Chloride
Dichloro Monofluoromethane	Freon 21
Dichloropropane	Propylene Dichloride
Dichlorotetrafluoroethane	Freon 114

Chemical Synonyms/Alternate Listings

SYNONYM	LISTED AS: / ALSO SEE:
Diethyl-2, 2-Dihydroxyamine	Diethanolamine
Di-2-Ethylhexylphthalate	Dioctylphthalate
Diethyl Sulfate	Ethyl Sulfate
Diethylene Glycol Mono Ethyl Ether	Carbitol
Diethylene Glycol Monobutyl Ether	Butyl Carbitol
m Digallic Acid	Tannic Acid
Dihydrogen Dioxide	Hydrogen Peroxide
Dihydroxyamine	Diethanolamine
Dihydroxybenzene	Hydroquinone
Dihydroxybutanedioic Acid	Tartaric Acid
Dihydroxydiethyl Ether	Diethylene Glycol
Dihydroxyethane	Ethylene Glycol
Diisopropyl Ether	Isopropyl Ether
Dimethylbenzene	Xylene
2.6-Dimethyl 4 Heptane	Diisobutyl Ketone
Dimethyl Ketone	Acetone
Dimethyl Methane	Propane
Dimethyle	Ethane
Dioxysuccinic Acid	Tartaric Acid
Diphenyl Ether	Diphenyl Oxide
Dipropyl	Hexane
DMF	Dimethylformamide
DMP	Dimethyl Phthalate
DOP	Dioctyl Phthalate
EMK	Methyl Ethyl Ketone
1,2-Epoxyethane	Ethylene Oxide
Epoxypropane	Propylene Oxide
Ehtanal	Acetaldehyde
Ethanediamine	Ethylene Diamine
1,2-Ethanediol	Ethylene Glycol
Ethaneodionic Acid	Oxalic Acid
Ethanoic Acid	Acetic Acid
Ethanoic Anhydride	Acetic Anhydride
Ethanol	Alcohol, Ethyl
Ethanolamine	Monoethanolamine
Ethanonitrile	Acetonitrile
Ethanoyl Chloride	Acetyl Chloride
Ethene	Ethylene
Ethenyl Benzene	Styrene
Ether	Diethyl Ether
2-Ethoxy Ethanol	Cellosolve
2-Ethoxy Ethanol	Ethyl Cellosolve
2,2-Ethoxy Ethoxy Ethanol	Carbitol
Ethoxy Ethyl Ester Acetic Acid	Cellosolve Acetate
Ethoxyethyl Acetate	Cellosolve Acetate
Ethyl Butanoate	Ethyl Butyrate
Ethyl Chloroacetate	Chloroacetic Acid
Ethyl Ethanoate	Ethyl Acetate
1-Ethyl-4 Ethyl Benzene	Ethyl Benzene
Ethyl Ethylene	n-Butane
Ethyl Methyl Ketone	Methyl Ethyl Ketone
Ethyl Perchlorate	Perchloric Acid
Ethyle	Acetylene
Ethylene	Ethane
Ethylene Bromide	Ethylene Dibromide
Ethylene Dichloride	Dutch Oil
Ethylene Glycol Monobutyl Ether	Butyl Cellosolve

SYNONYM	LISTED AS: / ALSO SEE:
Ethylene Glycol Monoethyl Ether	Methyl Cellosolve
Ethylene Glycol Monoethyl Ehter Acetate	Cellosolve Acetate
Ethylene Trichloride	Trichloroethylene
Ethylic Acid	Acetic Acid
Ethyrene	Butadiene
ETO	Ethylene Oxide
Flaxseed Oil	Oil, Linseed
Formylamine	Formamide
Formylic Acid	Formic Acid
Fructose	Sucrose
Furfuran	Furan
2-Furyl Methanol	Furfural Alcohol
Galotannic Acid	Tannic Acid
Glaubers Salt	Sodium Sulfate
Glycerin	Glycerol
Glycol	Ethylene Glycol
Glycol Ethers	Diethylene Glycol
Glycol Ethylene	Ethylene Glycol
Glycol Mono Ethyl Ether	Ethyl Cellosolve
Glycolic Acid	Hydroxyacetic Acid
Glycoloic Methyl Chlorophenoxy Acetic Acid	Hydroxyacetic Acid
Gypsum	Calcium Sulfate
HCL	Hydrochloric Acid
Heptanone	Diisobutylketone
Hexadecanoic Acid	Palmetic Acid
Hexadiene	Diisobutylene
Hexahydrobenzene	Cyclohexane
Hexamethylene	Cyclohexane
Hexanedioic Acid	Adipic Acid
Hexanol	Alcohol Hexyl
2-Hexanone	Methyl Butyl Ketone
Hexone	Methyl Isobutyl Ketone
Hi-Tri	Trichloroethylene
Hydrated Lime	Calcium Hydroxide
Hydrocyanic Acid	Prussic Acid
Hydrogluosilicic Acid	Fluosilicic Acid
Hydrogen Chloride	Hydrochloric Acid
Hydrogen Cyanide	Hydrocyanic Acid
Hydrogen Dioxide	Hydrogen Peroxide
Hydrogen Fluoride	Hydrofluoric Acid
Hydrogen Oxide	Water
Hydroxyacetic Acid	Glycolic Acid
2-Hydroxy-Benzene Sulfonic Acid	Phenol Sulfonic Acid
2-Hydroxybenzoic Acid	Salicylic Acid
4-Hydroxy-Methyl-2 Pentone	Diacetone Alcohol
2-Hydroxy-1,2,3-Propane Tricarboxylic Acid	Citric Acid
Hydroxy Propanoic Acid	Lactic Acid
Hydroxysuccinic Acid	Malic Acid
Hydroxy Toluenen	Alcohol Benzyl
Hypo Photographic Solution	Sodium Thiosulfate
Iodine	Iodum
IPA	Alcohol, Isopropyl
Isobutanol	Alcohol, Iso Butyl
Isocyanate	Toluene Diisocyanate (TDI)
Isooctane	ASTM Reference Fuel A

Chemical Synonyms/Alternate Listings

SYNONYM	LISTED AS: / ALSO SEE:
Isopropanol	Alcohol Isopropyl
Isopropyl Benzene	Cumene
Isovalerone	Diisobutyl Ketone
Ketchup	Catsup
Ketohexamethylene	Cyclohexanone
Ketone	Isophorone
Lard	Butter
Lard Oil	Animal Gelatin
Levulose	Sucrose
Lime	Calcium Oxide
Lime Sulfur	Calcium Sulfide
Limewater	Calcium Carbonate
Lineoleic Acid	Stearic Acid
LPG	Propane
Lye	Sodium Hydroxide
Lye	Calcium Hydroxide
Lye	Potassium Hydroxide
Magnesium Sulfate	Epsom Salts
Marsh Gas	Methane
Mazola	Oil, Corn
MEA	Monoethanolamine
MEK	Methyl Ethyl Ketone
Methanal	Formaldehyde
Methanoic Acid	Formic Acid
Methanol	Alcohol Methyl
Methyl Benzene	Toluene
Methyl Benzoic Acid	Cresylic Acid
Methyl Butanol	Alcohol Amyl
Methyl Chloroform	Trichloroethane
Methyl Cyanide	Acetonitrile
Methyl Ether	Dimethyl Ether
Methl Isobutyl Carbinol	Alcohol Methyl Amyl
4-Methyl-2 Pentanone	Methyl Isobutyl Ketone
m Methyl Phenyl Ketone	Acetophenone
2-Methyl Propenoic Acid Methyl Ester	Methyl Methacrylate
Methyl Polysiloxanes	Oil Silicone
2-Methyl Propanol	Alcohol t-Butyl
MIBK	Methyl Isobutyl Ketone
MIL-S-313613 type I	ASTM Fuel A, Isooctane
MIL-S-313613 type III	ASTM Fuel B
MIL-H-5606	Red Oil & FHA & J43
MIL-J-5624	Jet Fuel JP3, JP4 & JP5
Milk Acid	Lactic Acid
Milk of Lime	Calcium Carbonate (Lime Water)
Milk of Magnesia	Magnesium Hydroxide
Monobrometrifluoromethane	Freon 13B1 (see Freons Misc.)
Monochlorobenzene	Chlorobenzene
Monochlorodifluoromethane	Freon 22
Monochlorotrifluoromethane	Freon 13
Monochloropentafluoroethane	Freon 115 (see Freons Misc.)
Monoethylamine	Ethylamine
Monofluorotrichloromethane	Freon 11
Muriatic Acid	Hydrochloric Acid
Natual Gas	75-99% Methane, 0.3-18% Nitrogen, 0.2-14% Ethane, 0-26% Carbon Dioxide, 0.1-12% Higher Hydrocarbons

SYNONYM	LISTED AS: / ALSO SEE:
Neu-Tri	Trichloroethylene
Niter	Potassium Nitrate
Niter	Sodium Nitrate
Niter Cake	Sodium Bisulfate
Nitrobenzine	Ligroin
Nitrobenzol	Nitrobenzene
Nitrochloric Acid	Aqua Regia
Nitrohydrochloric Acid	Aqua Regia
Octadecanoic Acid	Stearic Acid
Octanoic Acid	Caprylic Acid
1-Octanol	Alcohol Octyl
Octoic Acid	Caprylic Acid
Oil of Mirbane	Nitrobenzene
Oil of Turpentine	Turpentine
Oil of Bitriol	Sulfuric Acid, Concentrated
Oleum	Sulfuric Acid, Fuming
Orthoboric Acid	Boric Acid
Orthodichlorobenzene	o-Dichlorobenzene
Oxirane	Ethylene Oxide
Pearl Ash	Potassium Carbonate Pentachloroethane
Pentalin	Alcohol Amyl
Pentanol	Methyl Propyl Ketone
2-Pentanone Perchloroethylene	Tetrachloroethylene
Petroleum Ether	Ligroin
Phene	Benzene
Phenol	Carbolic Acid
Phenyl Amine	Aniline
Phenyl Chloride	Chlorobenzene
Phenyl Ethane	Ethyl Benzene
Phenyl Ether	Diphenyl Oxides
Phenyl Ethylene	Styrene
Phenol Sulfonic Acid	Benzene Sulfonic Acid
Phosphoric Acid Triphenyl Ester	Tricesy Phosphate
Photographic Emulsion	Silver Notrate
Photographic Hypo Fixing Bath	Sodium Thiousulfate
Picric Acid	Trinitrophenol
Pimlic Ketone	Cyclohexanone
Potash	Potassium Carbonate
Potash Caustic	Potassium Hydroxide
Potassuim Bichromate	Potassium Dichromate
Potassium Nitrate	Niter
Propane	LPG
Propane	Dimethyl Methane
1,2-Propanediol	Propylene Glycol
Propanoic Acid 2-Hydroxy	Lactic Acid
Propanoic Acid Nitrile	Acetophenone
2-Propanone	Acetone
Propanol	Propyl Alcohol
Propene	Propylene
Propenoic Acid Methyl Ester	Methyl Acetate
Propenoic Acid Notrile	Acrylonitrile
Propenyl Alcohol	Allyl Alcohol
Propionic Acid	Acrylic Acid
Propionic Acid Ethyl Ester	Ethyl Acrylate
Propylene Glycol	1,2-Propanediol
Prussic Acid	Hydrocyanic Acid
Quicklime	Calcium Carbonate
RP1	Jet Fuel JP1
Sal Ammonia	Ammonium Chloride

Chemical Synonyms/Alternate Listings

SYNONYM	LISTED AS: / ALSO SEE:
Sal Ammonian	Ammonium Chloride
SalSoda	Sodium Carbonate
Salicylic Acid	2 Hydroxy Benzoic Acid
Salt	Sodium Chloride
Salt Brine	Brine
Salt Cake	Sodium Sulfate
Saltpeter	Potassium Notrate
Saltpeter	Sodium Notrate
Sand Acid	Fluorosilicic Acid
Silicate Ester Oils	OS45 type III & IV
Silicate of Soda	Sodium Silcate
Skydrol 500, 500B & 500B4	Isooctyl Diphenyl Phosphate Hydraulic Fluids
Sludge Acid	Sewage
Soda Ash	Sodium Carbonate
Soda, Caustic	Sodium Hydroxide
Soda Niter	Aqueous Sodium Nitrate
Sodium Hexametaphosphate	Calgon
Sodium Metaborate Peroxyhy-drate	Sodium Perborate
Sodium Niter	Sodium Nitrate
Sodium Thiosulfate	Developing Fluid
Soluble Glass	Sodium Silicate
Soya Oil	Oil Soy
Succinic Acid	Maleic Acid
Sulfuric Acid Diethyl Ester	Ethyl Sulfate
Sulfuric Chlorohydrin	Chlorosulfonic Acid
Super Phosphoric Acid	100-115% Phosphoric Acid
Synthetic Natural Rubber	Latex
Table Salt	Sodium Chloride
Tannin	Tannic Acid
Tar Camphor	Naphthalene
TEA	Triethanolamine

SYNONYM	LISTED AS: / ALSO SEE:
Tetrachloroethylene	Perch loroethylene
Tetrachloromethane	Carbon Tetrachloride
Tetrafluoromethane	Freon 14 (see Freons Misc.)
Tetramethylene Oxide	Tetrahydrofuran
Tin (11) Chloride	Stannous Chloride
Tin Dichloride	Stannous Chloride
Tin Tetrachloride	Stannic Chloride
Titanic Chloride	Titanium Tetrachloride
TNT	Trinitrotoluene
Trans-Butenedoic Acid	Fumaric Acid
Traid	Trichloroethylene
Trichlorofluoromethane	Freon 113
Trichloromethane	Chloroform
Trifluoromonobromomethane	Freon 13131 (see Freon Misc.)
3,4,5-Trihydroxy Benzoic Acid	Gallic Acid
2,2,4-Trimethyl Pentane	Isooctane 100%
2,2,4-Trimethyl Pentane	Diisobutylene
2,4,6-Trinitrophenol	Picric Acid
Turps	Turpentine
Type I Fuel MIL-S-3136	ASTM Reference Fuel A
Type III Fuel MIL-S-3136	ASTM Reference Fuel B
UDMH	Unsymetrical Dimethyl Hydrazine
Vanillin	Vanilla Extract
Varsol	Mineral Oil
Vinyl Cyanide	Acrylonitrile
Vitriol, Blue	Copper Sulfate
Vitriol, Oil of	Concentrated Sulfuric Acid
Water Glass	Sodium Silicate
Whale Oil	Oil Sperm
White Vitriol	Zinc Sulfate
Wood Alcohol	Alcohol Methyl
Wood Tar	Creosote-Wood Tar
Zeolitic	Zeolite

Manufacturer / Product Reference

NAME	MANUFACTURER	PRODUCT
Actron 1		Refrigerant
Aero Lubriplate	Fish Brothers	Lubricant
Aerosafe 2300 & 2300W	Stauffer	
Aeroshell IIAC & 750	Shell Oil Co.	
Aeroshell 7A & 17	Shell Oil Co.	Grease
Airshow W		Deicing Fluid
Alk-Tri		Trichloroethylene
Ambrex 33 & 830	Mobil Oil Co.	Lubricating Oil
Anderol L-774, 826 & 829	Tenneco Chemicals	Diester Base Oil
ANG-25	Texaco	Diester Base & Glycerol Ester
Ansul Ether 161 & 181	Fire Engineers Inc.	
AN-0-3 Grade M	GAF Corp.	E.P. Grease
AN-0-6	GAF Corp.	Oil No. 6
AN-0-366	GAF Corp.	Oil
Arklone P		Trichlorotrifluoroethylene
Aro-Tox		Spray
Arochlor 1248, 1254 & 1260	Monsanto	F.R. Chlorinated Hyraulic Fluid
Askarel	Monsanto	Chlorinated Transformer Oil
Astral Oil	D.A. Stewart Oil Co.	Lubricating Oil
Atlantic Utro Gear		E.P. Lubricant
Atlantic Dominion F		
Aurex: 903R	Mobil Oil	
Bardol B	Bardahl Manufacturing Co.	Oil Additives Bayol D & 35
Blackpoint 77		
Bonderite		Parkerizing Solutions
Borax	Borax Corp.	Sodium Tetraborate
Bray GG-130	Bray Oil Co.	
Brayco 7119-R, 885 & 910	Bray Oil Co.	
Bret 710		
Brom-1 13 & 114		
Bunker C		6000 Second Fluid Oil
Calgon		Sodium Hexametaphosphate
Cellosolves	Union Carbide	Alcohols
Celluguard		
Cellulube	Celanese Corp.	Phosphate Ester Oils
Cellulube A60	Celanese Corp.	Triaryl Phosphate Ester
Cellulube 90, 100, 200, 220, 300, 500 & 1000	Celanese Corp.	Phosphate Ester Lubricants
Cellutherm 2505A	Celanese Corp.	Trimethylol Propane Ester
Chlorextol	Allis-Chalmers	Transformer Oil
Chlordane		
Chlorox	Clorox Co.	Sodium Hypochlorite
Chlorowax	Diamond Shamrock	Liquid Chlorinated Parafin
Circo Light Processing Oil	Sunmark Industries	
City Service Kool Motor		A.P. Gear Oil
City Service Pacemaker No. 2		Glycol FR 15, 20 & 25
City Service 65, 120 & 250		
Convelex 10		
Coolanol 25 & 45	Monsanto Co.	Dielectric Heat Transfer Fluid
Cryolite		
Cryscoat FH. Rinse, L.T. & S.W.	Oakite Products	Phosphate Coatings
Cryscoat 42, 87, 89 & 89M	Oakite Products	Phosphate Coatings
DC-200, 500 & 710	Dow Corning	Silicone Fluids
Delco Brake Fluid	General Motors	Hydraulic Fluid
Dextron	General Motors	Automatic Transmission Fluid
Diazon		Insecticide
Dow Chemical 50-4, ET588 & ET378	Dow Chemical	
Dow Corning Oil 3, 4 & 11	Dow Corning Corp.	Silicone Fluids
Dow Corning 5, 33, 44, 55, 220, 510, 550 704 & 705	Dow Corning Corp.	Silicone Fluids
Dow Corning 1265	Dow Corning Corp.	Fluorosilicone Fluids

Manufacturer / Product Reference

NAME	MANUFACTURER	PRODUCT
Dow Corning 1208, 4050, 6620, F-60 & XF-60	Dow Corning Corp.	Chlorinated Silicone Fluid
Dow Corning F-61	Dow Corning Corp.	
Dow General Weed Killer	Dow Chemical	Phenol & Water Base Weed Killer
Dow Gage Fluid R-200	Pressure Gage Fluid	
Dow Per	Dow Chemical Co.	Dry Cleaning Fluid
Dow Purifloc C-31	Dow Chemical Co.	
Dowanols	Dow Chemical Co.	Glycol Ethers
Dowtherm A	Dow Chemical Co.	Heat Transfer Fluid 26.5% Diphenyl, 73.5% Diphenyl Oxid
Dowtherm B	Dow Chemical Co.	
Dowtherm E & 209	Dow Chemical Co.	Heat Transfer Fluid
Dowtherm S.R. I	Dow Chemical Co.	Heat Transfer Fluid
Drinox	Morton Chemical Co.	
DTE 23-26 & 950	Mobil Oil	Light, Medium & Heavy Hydraulic Oils
DTE Light Oil	Mobil Oil	Lubricating Oil
Duco, Paint Thinner	Dupont Co.	Paint Thinner
Elco 28	Detrex Chemical Industries	E.P. Lubricant
Esso Fuel 208	Exxon Corp.	
Esso Golden Gasoline	Exxon Corp.	Gasoline
Esso Transmission Fluid	Exxon Corp.	Automatic Transmission Fluid
Esso WS2812	Exxon Corp.	MIL-L-7808A
Esso XP90	Exxon Corp.	E.P. Lubricant
Esso Turbo Oil	Exxon Corp.	Turbine Oil Esstic 42 & 43
Ex-Tri	Exxon Corp.	Ethylene Trichloride
Exxon 2380 Turbo Oil	Dow Corning	Turbine Oil F-60 & 61
FC-43		Heptacosoflourotributylamine
FC75	3M Co.	Fluorocarbon
Fluorolube	Hooker Chemical Co.	
Freon	E.I. Du Pont Co.	Fluorocarbon Refrigerants
Fyrquel 90, 100, 150, 220, 300, 500, 550 & A60	Stauffer Chemical	F.R. Hydraulic Fluids
Genesolve D	Allied Signal	Trichlorotrifluoroethane
Genesolve 2000	Allied Signal	Solvent HCFC 141 B
Genklene	Icl	Chlorinated (1,1,1-Trichloroethane)
Girling Brake Fluid	Lucas Service	Brake Fluid
Gulf Endurance Oils	Gulf Refining	Lubricating Oil
Gulf FR Fluids	Gulf Refining	F.R. Fluids
Gulf FR G-Fluids G100, 150, 200 & 250	Gulf Refining	F.R. Fluids
Gulf FIR P-Fluids P37, 40, 43, 45 & 47	Gulf Refining	F.R. Fluids
Gulf Harmony Oils	Gulf Refining	Oils
Gulf High Temeprature Grease	Gulf Refining	H.T. Grease
Gulf Legion Oils	Gulf Refining	Oils
Gulf Paramont Oils	Gulf Refining	Oils
Gulf Security Oils	Gulf Refining	Oils
Gulfcrown Grease	Gulf Refining	Grease
Hannifin Lube A	Paker Hannifin	
Hi-Lo MS No. 1		
Hi-Tri	Ethylene Trichloride	
Hollingshead H-2	E.F. Houghton & Co.	Water & Ethylene Glycol
Houghto-Safe 271 & 600	E.F. Houghton & Co.	MIL-H-27072 Water & Glycol Base
Houghto-Safe 271 & 600	E.F. Houghton & Co.	Water & Glycol Based MIL-H-27072
Houghto-Safe 416 & 500	E.F. Houghton & Co.	
Houghto-Safe 1010, 1120	E.F. Houghton & Co.	MIL-H-19547 Phosphate Ester Base
Houghto-Safe 5040	E.F. Houghton & Co.	Water & Oil Emulsion
Houghto-Safe 5040	E.F. Houghton & Co.	Petroleum Base
Hydro-Drive MIH50 & MIH10	E.F. Houghton & Co.	Petroleum Base
Hydrolube		Water & Ethylene Glycol
Hypoid Lubes		Hypoid Gear E.P. Lubes
Hy Kil No. 6		
Hyjet	Chevron	Phosphate Ester
Igepal	Gaf	Surfactant

Manufacturer / Product Reference

NAME	MANUFACTURER	PRODUCT
Irus 902		
Isopar G	Exxon Corp.	Solvent
Karo	CPC International	Syrup
Kel-F Liquids	3M Co.	Fluorocarbon Liquids
Kester No. 1544		Soldering Flux
Keystone No. 87HX	United Refining Co.	Grease
Klenzade		Sanitizer
Lestoil	Lestol	Detergent
Lehigh X1 169 & X1 170	Lehigh	
Lindoil		Phosphate Ester Hydraulic Fluid
Lindol	Stauffer Chemical Co.	FR. Plasticizer
Liqui-Moly	Lockney Co.	Oils & Greases
Lubrite		Parkerizing Solutions
Ludox		
Lysol	National Laboratories	Cleanser Master Kill
Mazola		Corn Oil
MCS 312, 352 & 463	Monsanto	Jet Lubricant
MIL-L-210413		Motor Oil SAE 10W
MIL-L-7808	Exxon P15A	Diester No. 15 Turbine Oil
MIL-S-3136B Type I		ASTM Reference Fuel A
MIL-S-313613 Type11		ASTM Reference Fuel B
MIL-H-5606		High Energy Fuel A & J-43
MIL-J-5624F		JP4 & JPS Jet Fuel
MIL-L-7808C		Dibasic Ester
MIL-L-7808E	Braco 880D	
MIL-L-7808E	Stauffer Jet I	
MIL-L-7808G		Ester Blend Oil
MIL-C-8188C		Diester Fluid
MIL-H-844613		MLO-8515 Silicone Fluid
MIL-L-1410713		Silicate Ester Oil
MIL-L-17672B		Turbine Oil
MIL-L-11945713		F.R. Fluid, Phosphate Ester
MIL-L-23699		Neopentyl Ester Oil
MIL-G-25013D		Silicone Grease
MIL-F-25558		RJ1 Ram Jet Fuel Petroleum Based
MIL-F-2555813		R.11 Ram Jet Fuel Petroleum Based
MIL-F-25576C		RP1 Rocket Fuel Petroleum Based
MIL-F-25656		JP6 Jet Fuel
MIL-L-46000A		Diester Oil
MIL-S-81087A		Chlorinated Phenyl Silicone Fluid
Mineguard FIR		F.R. Hydraulic Fluid
MLO-7277 & MLO-7557		Hydraulic Fluid
MLO-8200		Silicone Fluid
MLO-8515		MIL-H-8446B Silicone Fluid
Mobil Delvac 1100, 1110, 1120 & 1130	Mobil Co.	
Mobil HF	Mobil Co.	
Mobil Nyvac 20 & 30	Mobil Co.	
Mobil Therm 600	Mobil Co.	
Mobil Velocite C	Mobil Co.	
Mobil XRM 206A	Mobil Co.	
Mobil24DTE	Mobil Co.	
Mobilgas WA200 ATF	Mobil Co.	Automatic Transmission Fluid
Mobiloil SAE20	Mobil Co.	SAE 20W Oil
Mobilux		
Mopar	Chrysler Corp.	Hydraulic Fluid
Navee	Deicing Fluid	
Nitrana 2 & 3		
Noryl	General Electric Co.	Thermoplastic
Oakite Solutions	Oakite Product	Fluids (Cleansers/Strippers Typ.)
Oronite 8200	Chevron Chemical	Disiloxane Hyraulic Fluid
Oronite 8515	Chevron Chemical	Hydraulic Fluid 85% Disiloxane 15% Diester

Manufacturer / Product Reference

NAME	MANUFACTURER	PRODUCT
OS45 & OS70	Monsanto	Silicate Ester Base
Par-Al-Ketone (Paralketone)	Black Bear Co. & Emco Chemical Co.	
Paraplex G62	Rohm & Haas Co.	
Parapoid 10-C	Exxon Chemical Co.	Hypoid Gear Oil
Parker O-Lube	Parker Hannifin	Grease
Parker Super O-Lube	Parker Hannifin	Silicone Grease
Penda Oil		Dibasic Ester Oil
Perclene		Perchloroethylene
Perklone		Perchloroethylene
Permachlor		Degreasing Solution
Polyol Ester		Hyddraulic Fluid
Prestone	Union Carbide	Antifreeze
PRL	Rohm & Haas Co.	High Temperature Hydraulic Oil
PRL & PRL3161	Rohm & Haas Co.	High Temperature Oil
Pydraul 29E-LT, 30E, 50E, 65E & 90E	Monsanto	Phosphate Ester Oils
Pydraul 115	Monsanto	Phosphate Ester Oils
Pydraul 230C, 300, 312, 540C & MC	Monsanto	Phosphate Ester Oils
Pydraul F9 & 150	Monsanto	Aryl Phosphate Ester Hydraulic Fluid
Pyranol	General Electric	Chlorinated Transformer Oil
Pyrex	Corning Glass Works	High Temperature & Low Expansion Glass
Pyroguard	Mobil Oil	F.R. Oils
Pyrolube	Kano Laboratories	High Temperature Lubes
Red Line 100	Union Oil Co. of California	Oil
Richfield A & B	Richfield Oil Co.	Weed Killer
RJ-1 (MIL-F-25558)		Ram Jet Fuel Petroleum Based
RP-1 (MIL-F-25576A)		Rocket Fuel Petroleum Based
Sanitzer 160	Monsanto	F.R. Additive
Santosafe 300	Monsanto	
Separan NP-10	Dow Chemical	Flocculant
SF 96, SF 1147, SF 1153, SF 1154	General Electric	Silicone Fluid
Shell Alvania Grease No. 2	Shell Oil Co.	Grease
Shell Camea 19 & 29	Shell Oil Co.	
Shell DD	Shell Oil Co.	
Shell Diala	Shell Oil Co.	
Shell Irus 902 & 905	Shell Oil Co.	F.R. Hydraulic Fluid
Shell LO Hydrax 27 & 29	Shell Oil Co.	
Shell Macome 72	Shell Oil Co.	
Shell Tellus 22 & 23	Shell Oil Co.	F.R. Hydraulic Fluid Petroleum Based
Shell Turbine Oil 307	Shell Oil Co.	Turbine Oil
Shell LIMF	Shell Oil Co.	
Shell 3XF Mine Fluid	Shell Oil Co.	F.R. Hydraulic Fluid
Skelly Solvent B, C & E	Getty Refining	Solvent
Skydrol 500, 500B & 500134	Monsanto	Isooctyl Diphenyl Phosphate Hyd. Fluid
Skydrol 7000	Monsanto	Hydraulic Fluid
Skydrol LD-4	Monsanto	
Socony Mobil Type A	Mobil Oil Co.	Transmission Fluid
Socony Vacuum AMV AC781	Mobil Oil	Grease
Socony PD959B	Mobil Oil	
Solvasol 1, 2, 3, 73 & 74		
Spry		Shortening
Standard Oil Mobilube GX90-EP	Mobil Oil	Gear Lube
Stauffer 7700	Stauffer Chemical Co.	
Sunoco All Purpose Grease	Sunmark Industries	A.P. Grease
Sunoco SAE 10	Sunmark Industries	
Sunoco 3661	Sunamrk Industries	
Sunoco XS-820	Sunmark Industries	E.P. Lubricant
Sunsafe	Sun Refining	F.R. Hydraulic Fluid
Supershell Gas	Shell Oil Co.	Gasoline
Swan Finch E.P. Lube	Swan Finch	E.F. Lubricant
Swan Finch Hypoid 90	Swan Finch	Hypoid Gear E.P. Lubricant
Tellus	Shell Oil Co.	F.R. Hydraulic Fluid

Manufacturer / Product Reference

NAME	MANUFACTURER	PRODUCT
Texaco Capell A & AA	Texaco	
Texaco Meropa 220 No Lead	Texaco	Gasoline
Texaco Regal B	Texaco	
Texaco Uni-Temp Grease	Texaco	Grease
Texaco 3450	Texaco	Rear Axel Oil
Texamatic A	Texaco	Automatic Transmission Fluid
Texamatic 1581, 3401, 3525 & 3528	Texaco	Transmission Fluid Texas 1500 Oil
Therminol 44, 45, 60, 66 & VP-1		H.D. Concentrate
Thiokol TP-90B & TP-95		
Tidewater Multigear 140		E.P. Lubricant
Tidewater Oil, Beedol		Oil
Triad		Trichloroethylene
Triklone		Tricholorethylene
Turbine Oil No. 15	Exxon Corp.	Turbo Oil 15
Ucon Hydrolube J-4	Union Carbide	
Ucon Lubricant 135, 285, 300X, 625 & 1145	Union Carbide	
Ucon Lubricant 50-HB55, H13100, H13260, HB660	Union Carbide	
Ucon Oil LB65, LB385 & 40OX	Union Carbide	
Ucon Oil 50-HB28OX	Union Carbide	Polyacrylon Glycol Derivative
Univis 40 Hydraulic Fluid	Exxon Corp.	Hydraulic Fluid
Univis J43	Exxon Corp.	MIL-H-5605 F.R. Oil
Univolt No. 35	Exxon Corp.	Mineral Oil, Tranformer Oil
Varsol	Mineral Spirits Solvent	
Vasoline	Chesebrough-Ponds, Inc.	Petroleum Jelly
Versilube F44, F50 & F55	General Electric	Silicone Hydraulic Fluid
VV-H-910		Glycol Brake Fluid
Vythene		1,1,1-Trichloroethane Solvent
Wagner 21 B	Wagner Div. McGraw Edison	Brake Fluid
Wemco C		Transformer Oil

Choosing the Right Pump

Choosing a pump for long, trouble free service not only requires selecting the correct pump size for capacity and head conditions; but proper wetted and non-wetted components must be taken into consideration.

Pump components are subject to wear simply through everyday use. However, a majority of pump failures can be attributed to improper wetted components due to abrasive wear and chemical attack. The selection of wetted and non-wetted components requires knowing how to properly handle abrasive, non-lubricating fluids. Additional attention must be given to the correct materials of construction for corrosive handling of the product and the atmospheric conditions where the pump will be installed.

Compatibility

The use of chemical compatibility charts can help in the proper selection of components for the pump's construction. These charts are meant as a guideline and not intended as a guarantee of performance. In many cases, practical experience and past history can dictate the materials of construction.

In using chemical compatibility charts, it is best to select the material with an A or B rating. However, with fluids that are slightly aggressive, it may be advantageous, from a service life/dollar viewpoint, to choose a material that will provide compatibility (possibly a B rating) at a lower cost with satisfactory results.

As an example, a diaphragm pump customer handling Amyl-Alcohol, referring to chemical resistance chart, with select PTFE because of the "A" rating for compatibility. However, PTFE has a lower flex life compared to Neoprene, which has a "B" rating for this product. Though a "B" rating may indicate Neoprene has a "good" rating, it does imply there may be some lower flex life, or compatibility issues, also. When comparing the cost of PTFE vs. Neoprene, the Neoprene material may reach its mean flex life as that of the PTFE material. The cost replacement factor would dictate this would be a better choice. When a lesser rated material offers the same life expectancy as the "preferred" materials, it may be a viable alternative for the investment. In this case, the price of PTFE would be quadruple that of Neoprene.

Erosion and Abrasives

In selecting pump components subject to corrosive fluids at high velocities, erosion will occur faster than lower velocities. Erosion is accelerated by corrosion.

When faced with choosing a "B" rated material versus an "A", the effects of erosion, as related to specific pump components, should be taken into consideration.

A common misconception when handling abrasives and suspended solids is the sharpness, or ability to cut. When selecting diaphragm and ball valve materials, sharp particulates can have a tendency to cut the PTFE diaphragm, and embed into the PTFE ball valves. Incorporating metallic valve seats with PTFE balls, embedded solids can quickly wear valve seat and ball retainers. However, elastomeric ball valves and seats are more resilient and will permit the sharp particulates to "bounce" or reflect off the surface. This can greatly reduce wear.

The hardness of the ball valve and seat arrangement can greatly affect the pump's ability to pull a vacuum. A hard ball valve with a hard (PTFE or metallic) valve seat can be noisy and will greatly reduce the pump's ability to pull a vacuum compared to a softer elastomeric combination. The application should dictate the choice of the materials of construction. On high static lifts, location of the pump is essential to avoid cavitation.

Pump Sizing Selection

A commonly used statement with positive displacement pumps is, "oversize, operate slower". While there is some merit to this, there must be some degree of knowledge of the application and equipment being used.

There is no doubt that a larger pump operating at lower speeds (while meeting all application criteria) will provide longer service than a smaller pump running at higher speeds. However, considering the competitive marketplace, which the user and manufacturer face, it is not practical, or financially beneficial, to substitute a larger pump for smaller. But, when the service life versus investment ration becomes too high, the purchase of a larger pump can be justified. Unfortunately, due to the consideration of losing business or exceeding a budgetary plan, many pumps are specified and sold based solely on the initial investment portion of the equation.

These scenarios are typical when selecting materials of construction. But, decisions should be based on the material's estimated life expectancy, downtime, complexity of repair, and cost. Performance and longevity should not be sacrificed for economics when specifying and selecting the right pump for the application.

Air Data

Return to
Index

Horsepower Requirements

Horsepower Required To Drive an Air-Powered Diaphragm Pump

To determine HP required, consumption in CFM and air inlet pressure must first be known.

Using the example on the 1-1/2" Pump (Rubber Diaphragm) curves, a flow of 60 gpm against a head of 75' requires 35 CFM @ 60 psig air supple pressure.

From the following table, HP required is:

AIR SUPPLY PRESSURE	HORSEPOWER PER CFM
20	.071
25	.085
30	.096
35	.108
40	.118
45	.127
50	.136
55	.145
60	.153
65	.161
70	.168
75	.175
80	.182
85	.189
90	.195
95	.201
100	.207

35 CFM x .153/CFM = 5.35 HP required

The above table is good for estimating compressor horsepower requirements for rotary air compressors in good working condition.

The Gas Laws

The first three laws cover conditions where the quantity or mass of air is constant.

BOYLE'S LAW

$$P_1 V_1 = P_2 V_2$$

The basic law covers the relationship between the changes in pressure and volume when temperature remains constant. When volume (V2) increases, pressure (P2) would correspondingly decrease.

Variations:

(a) $V_2 = \dfrac{P_1 V_1}{P_2}$ 　　(b) $P_2 = \dfrac{P_1 V_1}{V_2}$ 　　(c) Free Air Calculation: $V_{fa} = V_x \dfrac{(P\ 14.7)}{14.7}$

CHARLES' LAW

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

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. When volume is constant, a decreasing temperature (T2) corresponds to a decreasing pressure (P2).

Variations:

(a) $P_2 = \dfrac{P_1(T_2)}{T_1}$ 　　(b) $V_2 = \dfrac{V_1(T_2)}{T_1}$ 　　(c) $T_2 = \dfrac{P_2(T_1)}{P_1}$ 　　(d) $T_2 = \dfrac{V_2(T_1)}{V_1}$

COMBINED GAS LAW

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

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

Variations:

(a) $P_2 = \dfrac{P_1 V_1}{T_1} \smile \dfrac{T_2}{V_2}$ 　　(b) $V_2 = \dfrac{P_1 V_1}{T_1} \smile \dfrac{T_2}{P_1}$ 　　(c) $T_2 = \dfrac{P_2 V_2}{P_1 V_1} \smile \dfrac{T_1}{}$

NOMENCLATURE

P1 = inlet absolute pressure

P2 = discharge absolute pressure

V1 = inlet volume

V2 = discharge volume

T1 = inlet absolute temperature

T2 = discharge absolute temperature

m = mass

FLOW MEASUREMENTS

The volume of air delivered by a compressor or removed by a vacuum pump is given in either cubic feet of free air per minute (cfm) or in standard cubic feet of air per minute (scfm). SCFM is under standard conditions which is used on most air operated pump curves.

FREE AIR

This is air at atmospheric pressure and ambient temperature. Free air volume (cfm) is obtained by using the gas laws to convert volume at atmospheric pressure and ambient temperature.

Compressed Air Quality and Hints on Installation

COMPRESSED AIR QUALITY TO ISO 8573.1

The new International Standard for compressed air quality introduces a simple system of classification for the three main contaminants present in any compressed air system – DIRT, WATER, and OIL.

To specify the quality class required for a particular application, simply list the class for each contaminant in turn.

For example:

Compressed air to Quality Class: 2.2.2 (Dirt: 1 micron. Water: -40°C PDP. Oil: 0.1 mg/m3)

QUALITY CLASS	DIRT Particle size in Micron	WATER Pressure Dewpoint °C (ppm. vol.) at 7 bar g	OIL (Including vapor) mg/m³
1	0.1	−70 (0.3)	0.01
2	1	−40 (16)	0.1
3	5	−20 (128)	1.0
4	40	+ 3 (940)	5
5	–	+7 (1240)	25
6	–	+10 (1500)	–

For general industrial use quality class 3.3.4 is considered acceptable. It is recommended not to use excessively dry air as this causes o-ring/seal problems in air operated pumps, such as dry or cracked o-rings or excessive o-ring/seal ring wear.

Moisture/Dewpoint
8 BAR ABSOLUTE (7 BAR G)

Dewpoint °C	°F	Moisture (g/m3)	Relative Humidity at 20°C; %	PPM volume	PPM weight	Dewpoint °C	°F	Moisture (g/m³)	Relative Humidity at 20°C; %	PPM volume	PPM weight
-70	-94	0.0002	0.011	0.327	0.203	2	36	0.6415	29.932	875.89	543.66
-68	-90	0.0003	0.015	0.439	0.272	4	39	0.7456	34.784	1018.04	631.88
-66	-87	0.0004	0.020	0.586	0.364	6	42	0.8574	39.991	1170.62	726.59
-64	-83	0.0006	0.027	0.784	0.487	8	46	0.9837	45.874	1343.05	833.62
-62	-80	0.0008	0.035	1.028	0.638	10	50	1.1260	52.501	1537.36	954.22
-60	-76	0.0010	0.046	1.350	0.838	12	54	1.2867	59.983	1756.83	1090.45
-58	-72	0.0013	0.060	1.766	1.096	14	57	1.4668	68.363	2002.75	1243.09
-56	-69	0.0017	0.079	2.298	1.426	16	60	1.6691	77.768	2278.93	1414.51
-54	-65	0.0022	0.102	2.975	1.847	18	64	1.8946	88.243	2586.67	1605.52
-52	-62	0.0028	0.131	3.834	2.380	20	68	2.1477	100.000	2932.32	1820.06
-50	-58	0.0036	0.168	4.919	3.053	22	72	2.4296	113.083	3317.22	2058.96
-48	-54	0.0046	.0215	6.283	3.900	24	75	2.7431	127.619	3745.22	2324.62
-46	-51	0.0059	0.273	7.991	4.960	26	79	3.0919	143.779	4221.50	2620.24
-44	-47	0.0074	0.346	10.121	6.282	28	82	3.4789	161.693	4749.96	2948.25
-42	-44	0.0093	0.437	12.763	7.922	30	86	3.9080	181.531	5335.82	3311.89
-40	-40	0.0117	0.549	16.038	9.954	32	90	4.3821	203.420	5983.08	3713.64
-38	-36	0.0164	0.687	20.075	12.461	34	93	4.9059	227.576	6698.32	4157.58
-36	-33	0.0204	0.856	25.026	15.533	36	97	5.4835	254.168	7486.89	5657.03
-34	-29	0.0254	1.062	31.101	19.304	38	100	6.1206	283.454	8356.76	5186.95
-32	-26	0.0313	1.316	38.489	23.890	40	104	6.8204	315.562	9312.17	5779.97
-30	-22	0.0386	1.624	47.477	29.469	42	108	7.5897	350.791	10362.53	6431.92
-28	-18	0.0473	1.996	58.366	36.227	44	111	8.4346	389.397	11516.11	7147.93
-26	-15	0.0579	2.445	71.505	44.382	46	115	9.3556	431.381	12773.61	7928.46
-24	-11	0.0706	2.986	87.320	54.199	48	118	10.3711	477.555	14160.21	8789.10
-22	-8	0.0858	3.635	106.29	65.971	50	122	11.4745	527.576	15666.66	9724.13
-20	-4	0.1039	4.412	129.02	80.079	52	126	12.6853	582.300	17319.87	10750.26
-18	0	0.1255	5.336	156.02	96.843	54	129	14.0047	641.727	19121.26	11868.37
-16	3	0.1513	6.439	188.29	116.87	56	133	15.4432	706.285	21085.42	13087.50
-14	7	0.1817	7.743	226.43	140.54	58	136	17.0120	776.400	23227.26	14416.92
-12	10	0.2176	9.286	271.57	168.56	60	140	18.7124	852.074	25548.99	15857.99
-10	14	0.2598	11.103	324.73	201.56	62	144	20.5658	934.160	28079.42	17428.60
-8	18	0.3095	12.856	376.02	233.38	64	147	22.5839	1023.087	30834.85	19138.87
-6	21	0.3678	15.498	453.33	281.38	66	151	24.7596	1118.427	33805.44	20982.69
-4	25	0.4358	18.692	546.80	339.39	68	154	27.1349	1221.890	37048.56	22995.66
-2	28	0.5152	22.116	647.04	401.61	70	158	29.7035	1333.048	40555.66	25172.48
0	32	0.6022	26.114	764.08	474.26						

Air Line Pipe Sizes

Figures in body of chart are pipe sizes on a 100 PSI air system to carry air at about a 1 PSI per 100 feet pressure loss. When measuring piping distances, to be conservative, count each pipe fitting as equal to 5 feet of pipe. At other than 100 PSI, flow capacity will be in inverse proportion to pressure [as based on PSIA (absolute) pressure levels and calculated by Boyle's Law].

SCFM FLOW	Length of Run - Feet									Compr. HP
	25	50	75	100	150	200	300	500	1000	
6	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	3/4	1
18	1/2	1/2	1/2	3/4	3/4	3/4	3/4	1	1	3
30	3/4	3/4	3/4	3/4	1	1	1	1-1/4	1-1/4	5
45	3/4	3/4	1	1	1	1	1-1/4	1-1/4	1-1/4	7-1/2
60	3/4	1	1	1	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	10
90	1	1	1-1/4	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	2	15
120	1	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	1-1/2	2	2	20
150	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	2	2	2	2-1/2	25
180	1-1/4	1-1/2	1-1/2	1-1/2	2	2	2	2-1/2	2-1/2	30
240	1-1/4	1-1/2	1-1/2	2	2	2	2-1/2	2-1/2	3	40
300	1-1/2	2	2	2	2	2-1/2	2-1/2	3	3	50
360	1-1/2	2	2	2	2-1/2	2-1/2	2-1/2	3	3	60
450	2	2	2	2-1/2	2-1/2	3	3	3	3-1/2	75
600	2	2-1/2	2-1/2	2-1/2	3	3	3	3-1/2	4	100
750	2	2-1/2	2-1/2	3	3	3	3-1/2	3-1/2	4	125

Air Pressure Loss

Figures in this table are approximate PSI compressed air pressure losses for every 100 feet of clean commercial steel pipe, Schedule 40.

NOMINAL PIPE DIAMETER

CFM FREE AIR	1/2 INCH		3/4 INCH		1 INCH		1-1/4 INCH		1-1/2 INCH	
	80 PSI	125 PSI	80 PSI	125 PSI	80 PSI	125 PSI	80 PSI	125 PSI	80 PSI	125 PSI
10	.45	.30	.11	.08	.04	.02	—	—	—	—
20	1.75	1.15	.40	.28	.15	.08	—	—	—	—
30	3.85	2.55	.90	.60	.30	.20	—	—	—	—
40	6.95	4.55	1.55	1.05	.45	.30	—	—	—	—
50	10.5	7.00	2.40	1.60	.75	.50	.18	.12	—	—
60	—	—	3.45	2.35	1.00	.70	.25	.17	—	—
70	—	—	4.75	3.15	1.35	.90	.35	.23	.16	.10
80	—	—	6.15	4.10	1.75	1.20	.45	.30	.20	.14
90	—	—	7.75	5.15	2.25	1.50	.56	.40	.25	.17
100	—	—	9.60	6.35	2.70	1.80	.65	.45	.30	.20
125	—	—	15.5	9.80	4.20	2.80	1.05	.70	.45	.32
150	—	—	23.0	14.5	5.75	4.00	1.45	1.00	.65	.45
175	—	—	—	—	8.10	5.45	2.00	1.30	.90	.60
200	—	—	—	—	10.9	7.10	2.60	1.75	1.15	.80
250	—	—	—	—	—	—	4.05	2.65	1.80	1.20
300	—	—	—	—	—	—	5.80	3.85	2.55	1.70
350	—	—	—	—	—	—	7.90	5.15	3.55	2.35
400	—	—	—	—	—	—	10.3	6.75	4.55	3.05
450	—	—	—	—	—	—	—	—	5.80	3.80
500	—	—	—	—	—	—	—	—	7.10	4.70

Estimating Air Flow Loss Through Pipes

To estimate the air pressure loss through a pipe, find the factor from the chart on the preceding page according to the pipe size and SCFM flow. Take the factor and divide it by the ratio of the compression (calculated in absolute pressure values). Compression ratio will be [gauge pressure + 14.5] ÷ 14.5 PSI. Then multiply this number by actual length of pipe, in feet, then divide by 1000. This will give pressure loss in PSI.

PRESSURE LOSS THROUGH FITTINGS

Figure in the body of this chart are air pressure flow losses through screw fittings expressed in equivalent lengths of straight pipe of the same diameter. For example, on a 1" gate valve the flow resistance would be the same as 0.57 foot of straight 1" pipe.

Pipe Size NPT	Gate Valve	Long Radius Ell or *	Medium Radius Ell or **	Standard Ell or ***	Angle Valve	Close Return Bend	Tee Thru Side	Globe Valve
1/2	0.31	0.41	0.52	0.84	1.1	1.3	1.7	2.5
3/4	0.44	0.57	0.73	1.2	1.6	1.8	2.3	3.5
1	0.57	0.77	0.98	1.6	2.1	2.3	3.1	4.7
1-1/4	0.82	1.1	1.4	2.2	2.9	3.3	4.4	6.5
1-1/2	0.98	1.3	1.6	2.6	3.5	3.9	5.2	7.8
2	1.3	1.7	2.2	3.6	4.8	5.3	7.1	10.6
2-1/2	1.6	2.2	2.8	4.4	5.9	6.6	8.7	13.1
3	2.1	2.8	3.6	5.7	7.7	8.5	11.4	17.1
4	3.0	3.9	5.0	7.9	10.7	11.8	15.8	23.7
5	3.9	5.1	6.5	10.4	13.9	15.5	20.7	31

* Or on run of standard tee
**Or on run of tee reduced in size 25%
***Or on run of standard tee reduced in size 50%

FRICTION OF AIR IN HOSE
Pressure drop per 25 feet. In proportion for longer or shorter lengths

Size	SCFM	50 PSI	60 PSI	70 PSI	80 PSI	90 PSI	100 PSI	110 PSI
1/2" ID	20	1.8	1.3	1.0	0.9	0.8	0.7	0.6
	30	5.0	4.0	3.4	2.8	2.4	2.3	2.0
	40	10.1	8.4	7.0	6.0	5.4	4.8	4.3
	50	18.1	14.8	12.4	10.8	9.5	8.4	7.6
	60	—	23.4	20.0	17.4	14.8	13.3	12.0
	70	—	—	28.4	25.2	22.0	19.3	17.6
	80	—	—	—	34.6	30.5	27.2	24.6
3/4" ID	20	0.4	0.3	0.2	0.2	0.2	0.2	0.1
	30	0.8	0.6	0.5	0.5	0.4	0.4	0.3
	40	1.5	1.2	0.9	0.8	0.7	0.6	0.5
	50	2.4	1.9	1.5	1.3	1.1	1.0	0.9
	60	3.5	2.8	2.3	1.9	1.6	1.4	1.3
	70	4.4	3.8	3.2	2.8	2.3	2.0	1.8
	80	6.5	5.2	4.2	3.6	3.1	2.7	2.4
	90	8.5	6.8	5.5	4.7	4.0	3.5	3.1
	100	11.4	8.6	7.0	5.8	5.0	4.4	3.9
	110	14.2	11.2	8.8	7.2	6.2	5.4	4.9
1" ID	30	0.2	0.2	0.1	0.1	0.1	0.1	0.1
	40	0.3	0.3	0.2	0.2	0.2	0.2	0.2
	50	0.5	0.4	0.4	0.3	0.3	0.2	0.2
	60	0.8	0.6	0.5	0.5	0.4	0.4	0.3
	70	1.1	0.8	0.7	0.7	0.6	0.5	0.4
	80	1.5	1.2	1.0	0.8	0.7	0.6	0.5
	90	2.0	1.0	1.3	1.1	0.9	0.8	0.7
	100	2.6	2.0	1.6	1.4	1.2	1.0	0.9
	110	3.5	2.6	2.0	1.7	1.4	1.2	1.1

Air Friction Loss 60–80 lb Gauge

Loss of pressure in lbs. per sq. in. inch 1000 ft. lengths of pipe.

(60 lbs. gauge)

Cu. Ft. of Free Air per Minute	Equivalent Cu. Ft. of Compressed Air per Minute	Nominal Diameter in Inches										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2
10	1.96	10.0	1.53	.43	.10	......	......	......	......	......	......	......
20	3.94	39.7	5.99	1.71	.39	.18	......	......	......	......	......	......
30	5.89	89.7	13.85	3.86	.88	.40	......	......	......	......	......	......
40	7.86	......	24.7	6.85	1.59	.71	.19	......	......	......	......	......
50	9.84	......	38.6	10.7	2.48	1.10	.30	......	......	......	......	......
60	11.81	......	55.5	15.4	3.58	1.57	.43	......	......	......	......	......
70	13.75	......	75.8	21.0	4.87	2.15	.57	.22	......	......	......	......
80	15.72	......	99.0	27.4	6.37	2.82	.75	.29	......	......	......	......
90	17.65	......	......	34.7	8.05	3.57	.95	.37	......	......	......	......
100	19.60	......	......	42.8	9.95	4.40	1.18	.46	......	......	......	......
125	24.60	......	......	67.0	15.7	6.90	1.83	.71	.14	......	......	......
150	29.45	......	......	96.4	22.4	9.90	2.64	1.02	.32	.15	......	......
175	34.44	......	......	......	30.8	13.40	3.64	1.40	.43	.20	......	......
200	39.40	......	......	......	39.7	17.60	4.71	1.83	.57	.27	......	......
250	49.20	......	......	......	62.8	27.5	7.37	2.85	.89	.42	.21	......
300	58.90	......	......	......	89.3	39.6	10.55	4.11	1.30	.60	.31	......
350	68.8	......	......	......	......	54.0	14.4	5.60	1.70	.82	.42	.23
400	78.8	......	......	......	......	79.4	18.6	7.30	2.30	1.06	.53	.30
450	88.4	......	......	......	......	89.1	23.7	9.20	2.90	1.35	.70	.38
500	98.4	......	......	......	......	......	29.7	11.4	3.60	1.67	.85	.46
600	118.1	......	......	......	......	......	42.3	16.4	5.17	2.40	1.22	.67
700	137.5	......	......	......	......	......	57.8	22.3	7.00	3.27	1.67	.91
800	157.2	......	......	......	......	......	75.2	29.2	9.16	4.26	2.18	1.20
900	176.5	......	......	......	......	......	95.5	39.0	11.6	5.40	2.76	1.51
1000	196.0	......	......	......	......	......	......	45.7	14.3	6.65	3.40	1.87

(80 lbs. gauge)

Cu. Ft. of Free Air per Minute	Equivalent Cu. Ft. of Compressed Air per Minute	Nominal Diameter in Inches										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2
10	1.55	7.90	1.21	.31	......	......	......	......	......	......	......	......
20	3.10	31.4	4.72	1.35	.31	......	......	......	......	......	......	......
30	4.65	70.8	10.9	3.05	.69	.31	......	......	......	......	......	......
40	6.20	......	19.5	5.40	1.25	.56	......	......	......	......	......	......
50	7.74	......	30.5	8.45	1.96	.87	......	......	......	......	......	......
60	9.29	......	43.8	12.16	2.82	1.24	.34	......	......	......	......	......
70	10.82	......	59.8	16.6	3.84	1.70	.45	......	......	......	......	......
80	12.40	......	78.2	21.6	5.03	2.22	.59	......	......	......	......	......
90	13.95	......	......	27.4	6.35	2.82	.75	......	......	......	......	......
100	15.5	......	......	33.8	7.85	3.47	.93	.36	......	......	......	......
125	19.4	......	......	46.2	12.4	5.45	1.44	.56	......	......	......	......
150	23.2	......	......	76.2	17.7	7.82	2.08	.81	......	......	......	......
175	27.2	......	......	......	24.8	10.6	2.87	1.10	......	......	......	......
200	31.0	......	......	......	31.4	13.9	3.72	1.44	.45	......	......	......
250	38.7	......	......	......	49.0	21.7	5.82	2.25	.70	.33	......	......
300	46.5	......	......	......	70.6	31.2	8.35	3.24	1.03	.47	......	......
350	54.2	......	......	......	96.0	42.5	11.4	4.42	1.39	.65	.33	......
400	62.0	......	......	......	......	55.5	14.7	5.76	1.82	.84	.42	......
450	69.7	......	......	......	......	70.2	18.7	7.25	2.29	1.06	.55	......
500	77.4	......	......	......	......	86.7	23.3	9.0	2.84	1.32	.67	.30
600	92.9	......	......	......	......	......	33.4	12.9	4.08	1.89	.96	.53
700	108.2	......	......	......	......	......	45.7	17.6	5.52	2.58	1.32	.72
800	124.0	......	......	......	......	......	59.3	23.1	7.15	3.36	1.72	.95
900	139.5	......	......	......	......	......	75.5	29.2	9.17	4.26	2.18	1.19
1000	155.0	......	......	......	......	......	93.2	36.1	11.3	5.27	2.68	1.48

Air Friction Loss 100–125 lb Gauge
Loss of pressure in lbs. per sq. inch in 1000 ft. lengths of pipe.
(100 lbs. gauge)

Cu. Ft. of Free Air per Minute	Equivalent Cu. Ft. of Compressed Air per Minute	Nominal Diameter in Inches										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2
10	1.28	6.50	.99	.28	......	......	......	......	......	......	......	......
20	2.56	25.9	3.90	1.11	.25	.11	......	......	......	......	......	......
30	3.84	58.5	9.01	2.51	.57	.26	......	......	......	......	......	......
40	5.12	......	16.0	4.45	1.03	.46	......	......	......	......	......	......
50	6.41	......	25.1	6.96	1.61	.71	.19	......	......	......	......	......
60	7.68	......	36.2	10.0	2.32	1.02	.28	......	......	......	......	......
70	8.96	......	49.3	13.7	3.16	1.40	.37	......	......	......	......	......
80	10.24	......	64.5	17.8	4.14	1.83	.49	.19	......	......	......	......
90	11.52	......	82.8	22.6	5.23	2.32	.62	.24	......	......	......	......
100	12.81	......	......	27.9	6.47	2.86	.77	.30	......	......	......	......
125	15.82	......	......	48.6	10.2	4.49	1.19	.46	......	......	......	......
150	19.23	......	......	62.8	14.6	6.43	1.72	.66	.21	......	......	......
175	22.40	......	......	......	19.8	8.72	2.36	.91	.28	......	......	......
200	25.62	......	......	......	25.9	11.4	3.06	1.19	.37	.17	......	......
250	31.64	......	......	......	40.4	17.9	4.78	1.85	.58	.27	......	......
300	38.44	......	......	......	58.2	25.8	6.85	2.67	.84	.39	.20	......
350	44.80	......	......	......	......	35.1	9.36	3.64	1.14	.53	.27	......
400	51.24	......	......	......	......	45.8	12.1	4.75	1.50	.69	.35	.19
450	57.65	......	......	......	......	58.0	15.4	5.98	1.89	.88	.46	.25
500	63.28	......	......	......	......	71.6	19.2	7.42	2.34	1.09	.55	.30
600	76.88	......	......	......	......	......	27.6	10.7	3.36	1.56	.79	.44
700	89.60	......	......	......	......	......	37.7	14.5	4.55	2.13	1.09	.59
800	102.5	......	......	......	......	......	49.0	19.0	5.89	2.77	1.42	.78
900	115.3	......	......	......	......	......	62.3	24.1	7.6	3.51	1.80	.99
1000	126.6	......	......	......	......	......	76.9	29.8	9.3	4.35	2.21	1.22

(125 lbs. gauge)

Cu. Ft. of Free Air per Minute	Equivalent Cu. Ft. of Compressed Air per Minute	Nominal Diameter in Inches										
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2
10	1.05	5.35	.82	.23	......	......	......	......	......	......	......	......
20	2.11	21.3	3.21	.92	.21	......	......	......	......	......	......	......
30	3.16	48.0	7.42	2.07	.47	.21	......	......	......	......	......	......
40	4.21	......	13.2	3.67	.85	.38	......	......	......	......	......	......
50	5.26	......	20.6	5.72	1.33	.59	......	......	......	......	......	......
60	6.32	......	29.7	8.25	1.86	.84	.23	......	......	......	......	......
70	7.38	......	40.5	11.2	2.61	1.15	.31	......	......	......	......	......
80	8.42	......	53.0	14.7	3.41	1.51	.40	......	......	......	......	......
90	9.47	......	68.0	18.6	4.30	1.91	.51	.20	......	......	......	......
100	10.50	......	......	22.9	5.32	2.36	.63	.25	......	......	......	......
125	13.15	......	......	39.9	8.4	3.70	.98	.38	......	......	......	......
150	15.79	......	......	51.6	12.0	5.30	1.41	.55	.17	......	......	......
175	18.41	......	......	......	16.3	7.2	1.95	.75	.24	......	......	......
200	21.05	......	......	......	21.3	9.4	2.52	.98	.31	......	......	......
250	26.30	......	......	......	33.2	14.7	3.94	1.53	.48	.22	......	......
300	31.60	......	......	......	47.3	21.2	5.62	2.20	.70	.32	......	......
350	36.80	......	......	......	......	28.8	7.7	3.00	.94	.44	.22	......
400	42.10	......	......	......	......	37.6	10.0	3.91	1.23	.57	.28	......
450	47.30	......	......	......	......	47.7	12.7	4.92	1.55	.72	.37	.20
500	52.60	......	......	......	......	58.8	15.7	6.10	1.93	.89	.46	.25
600	63.20	......	......	......	......	......	22.6	8.8	2.76	1.28	.64	.36
700	73.80	......	......	......	......	......	30.0	11.9	3.74	1.75	.89	.49
800	84.20	......	......	......	......	......	40.2	15.6	4.85	2.28	1.17	.64
900	94.70	......	......	......	......	......	51.2	19.8	6.2	2.89	1.48	.81
1000	105.1	......	......	......	......	......	63.2	24.5	7.7	3.57	1.82	1.00

Air Flow Through Orifices

Figures in this chart show theoretical SCFM air flow through sharp edged orifices. In practice, only about 2/3rds of this flow is obtained. The chart may be useful for roughly estimating travel speed of a loaded air cylinder. Assume about 75% of the line PSI is actually working on the load, with the remaining 25% consumed in flow losses in the 4-way valve and connecting lines. calculate 75% of your incoming line PSI and use this figure to enter the first column in this chart. Move across the table to the column headed by the actual port size of the 4-way valve in the circuit. Use about half the flow shown, because a 4-way valve is not a sharp edged orifice, and will usually pass only about half as much air as a sharp edged orifice.

After finding the SCFM (free air) flow, convert this to CFM (compressed air flow) at the pressure required to move the load. From this the speed of travel of the air cylinder can be estimated.

Chart shows approximate SCFM (free air) flow through sharp edged orifices.

PSI Across Orifice	Orifice Diameter, in Inches										
	1/64	1/32	1/16	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1
5	.062	.249	.993	3.97	15.9	35.7	63.5	99.3	143	195	254
6	.068	.272	1.09	4.34	17.4	39.1	69.5	109	156	213	278
7	.073	.293	1.17	4.68	18.7	42.2	75.0	117	168	230	300
9	.083	.331	1.32	5.30	21.2	47.7	84.7	132	191	260	339
12	.095	.379	1.52	6.07	24.3	54.6	97.0	152	218	297	388
15	.105	.420	1.68	6.72	26.9	60.5	108	168	242	329	430
20	.123	.491	1.96	7.86	31.4	70.7	126	196	283	385	503
25	.140	.562	2.25	8.98	35.9	80.9	144	225	323	440	575
30	.158	.633	2.53	10.1	40.5	91.1	162	253	365	496	648
35	.176	.703	2.84	11.3	45.0	101	180	281	405	551	720
40	.194	.774	3.10	12.4	49.6	112	198	310	446	607	793
45	.211	.845	3.38	13.5	54.1	122	216	338	487	662	865
50	.229	.916	3.66	14.7	58.6	132	235	366	528	718	937
60	.264	1.06	4.23	16.9	67.6	152	271	423	609	828	1082
70	.300	1.20	4.79	19.2	76.7	173	307	479	690	939	1227
80	.335	1.34	5.36	21.4	85.7	193	343	536	771	1050	1371
90	.370	1.48	5.92	23.7	94.8	213	379	592	853	1161	1516
100	.406	1.62	6.49	26.0	104	234	415	649	934	1272	1661
110	.441	1.76	7.05	28.2	113	254	452	705	1016	1383	1806
120	.476	1.91	7.62	30.5	122	274	488	762	1097	1494	1951
130	.494	1.98	7.90	31.6	126	284	506	790	1138	1549	2023

Vacuum Flow Through Orifices

This chart approximates the flow that might be expected through a practical orifice. Flows are about 2/3rds the theoretical flow obtained through a sharp edged orifice. At best, these figures are only approximate because the flow characteristic of your orifice can only be determined by actual measurement under specified conditions.

DESIGN NOTE: This chart shows that multiple-hole grippers work more efficiently at reasonably high vacuums. For example, looking at the chart for a 1/4" diameter hole, the first 6" Hg of vacuum flows 8.25 SCFM, while the increase in flow over the last 6", from 18" to 24", is only 2.2 SCFM. The more efficient design would be to use more smaller holes working at a higher vacuum.

Figures in body of chart are air flows in SCFM (standard cubic feet/minute)

Orifice Diam., Inches	Degree of Vacuum Across Orifice, Inches Mercury ("Hg)								
	2"	4"	6"	8"	10"	12"	14"	18"	24"
1/64	.018	.026	.032	.037	.041	.045	.048	.055	.063
1/32	.074	.100	.128	.148	.165	.180	.195	.220	.250
1/16	.300	.420	.517	.595	.660	.725	.780	.880	1.00
1/8	1.20	1.68	2.06	2.37	2.64	2.89	3.12	3.53	4.04
1/4	4.78	6.74	8.25	9.52	10.6	11.6	12.4	14.0	16.2
3/8	10.8	15.2	18.5	21.4	23.8	26.0	28.0	31.8	36.4
1/2	19.1	27.0	33.0	38.5	42.3	46.3	50.0	56.5	64.6
5/8	30.0	42.2	51.7	59.5	66.2	72.6	78.0	88.0	101
3/4	43.0	60.6	74.0	85.3	95.2	104	112	127	145
7/8	58.8	82.6	101	116	130	142	153	173	198
1	76.5	108	131	152	169	185	200	225	258

C$_V$ Information

The value flow co-efficient (CV) is defined as the number of gallons per minute of room temperature water which will flow through a valve with a pressure drop of 1 PSI across the valve.

When dealing with compressed gases, the volume which will flow through any given valve will be much greater than that of water because of the much lower viscosity and much lower specific gravity of that compressed gas when compared to water.

It is important to pay attention to the CV factor on air preparation equipment and valves in the air supply system because if the CV rating is too low for the pump, the pump will be starved for air and not function properly.

As a rule of thumb, 1 CV = 23 SCFM.

If a pump requires 105 SCFM to operate 105/23 = 4.57 CV. You would need an air line valve with a minimum CV of 4-57.

The formula for calculating a CV factor is:

$$C_V = \frac{1.024 \ \breve{} \ Q}{\sqrt{\triangle P \ (P2 - 14.7)}}$$

Q = SCFM

P2 = Pressure at pump air inlet

ΔP = P-P2

P = Main line pressure

Principles of Operation

Return to
Index

Diaphragm Pump Fundamentals

There are two diaphragms fixed to the center rod, one at each end. When compressed air is supplied to air chamber B (right side, see Fig. 1.1), the center rod moves to the right, the material in liquid chamber B is pushed out, and at the same material is drawn into liquid chamber A. When the center rod is moved full-stroke to the right, the air switch valve is switched, compressed air is sent to air chamber A (left side, see Fig. 1.2), and the center rod moves to the left. The material in liquid chamber A is pushed out, and at the same time material is drawn into liquid chamber

B. The reciprocating motion of the diaphragms along with the action of the check valves placed at the inlet and outlet of each liquid chamber enable the pump to move liquid in a continuous flow.

There are virtually no diaphragm pumps made that do not use check valves to direct the flow of liquid through the pump. There are several common types of check valves, each with it's own unique design for a specific type of application.

Fig.1.1

Fig.1.2
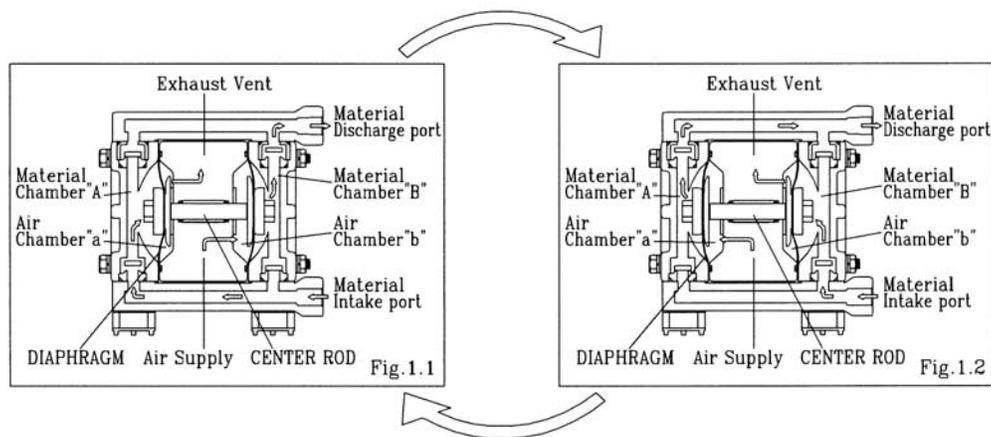
Check Valve Types

BALL TYPE CHECK VALVE

- This is the most common type of check valve, made from a wide variety of material including such materials as all common elastomers, PTFE and stainless steel
- Good for high viscosity materials
- Good for high concentrations of solids but limited on solids size
- Available in almost all size pumps
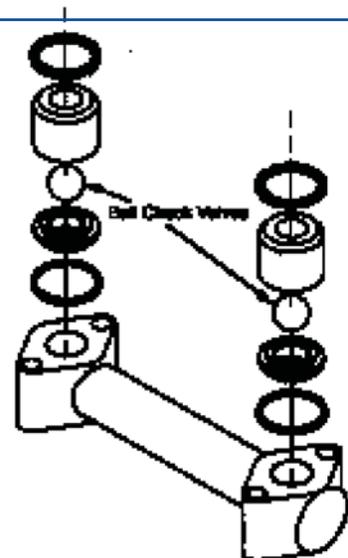
FLAT (DISC) TYPE CHECK VALVE

- Up to 15% increase in volume when compared to ball type check valve
- High suction lift capability
- Will not handle solids or high viscosity materials
- Available in PTFE or stainless steel only
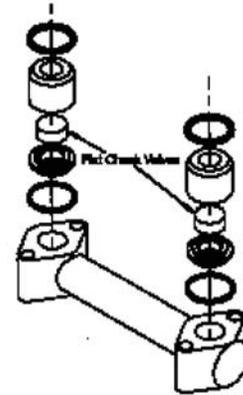
ACCORDION TYPE CHECK VALVE

- Constructed of Buna N, Neoprene and EPDM
- Good for high inlet pressure where check ball float is a problem due to excessive inlet pressure or extremely low discharge pressure
- Will allow the pump to be mounted in a laying down position
- Not good with solids
- Available in 1" and larger pumps
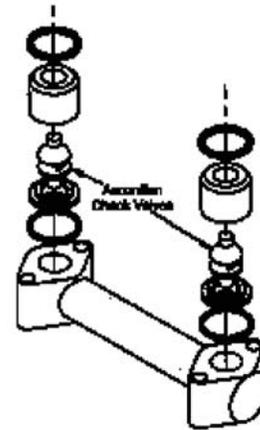
FLAPPER TYPE CHECK VALVE

- Metallic construction, sometimes in combination with an elastomeric material
- Good for pumping large/high concentrations of solids and high viscosity materials
- Poor suction lift
- Usually available in 2" and 3" pumps
- Often found with top suction/ bottom discharge
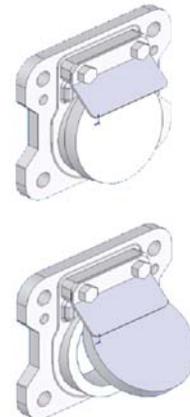
DUCKBILL TYPE CHECK VALVE

- Usually constructed of Buna N or Neoprene
- Good for solids, long fibers and high viscosity
- Usually available in smaller size pumps
- Can be top suction, bottom discharge or vice versa
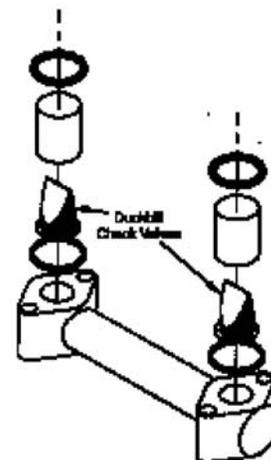
Pulsation Dampeners

Manual vs. Automatic Type

Manual

This model is designed for use on **constant pressure systems** and allows the user to fine-tune the dampener by adjusting the air pressure into the unit manually. For proper system dampening regulation, the supply air pressure requires a 10–20% lower differential pressure than the system liquid pressure going into the dampener. The self-relieving regulator will maintain approximately 90% of the system liquid pressure.

Automatic

This model is designed for **varying system pressures**, for example, a filter press application where the pressure continuously builds and than reverts back to the original pressure. A constant air supply is required to automatically compensate for additional higher pressures when required. The air supply pressure must be higher than the maximum system liquid pressure for the automatic dampener to operate within the liquid systems range.

Pulsation Dampeners–Manual
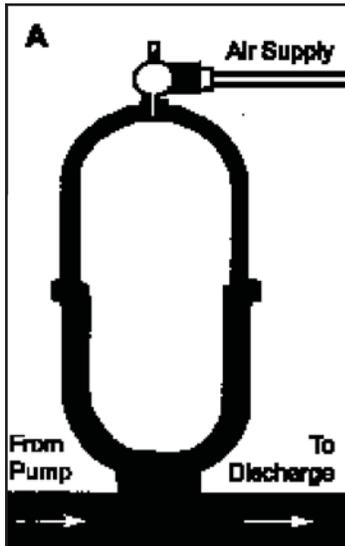
Compressed gas is used to charge the top of the dampener at a predetermined pressure (usually 80% to 90% of liquid pressure) as pumped liquid flows, it takes the line of least resistance and enters the dampener.
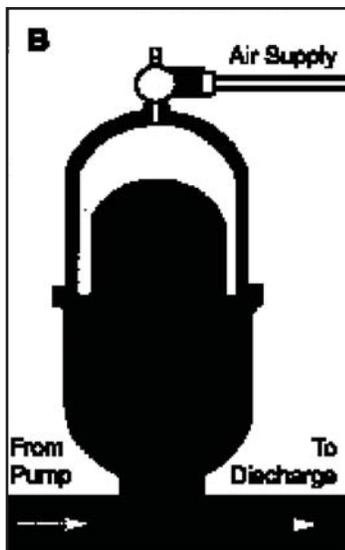
As liquid fills the dampener, the bladder compresses the gas to equal maximum liquid pressure. At the point of pump shift, liquid pressure drops below compressed gas pressure.
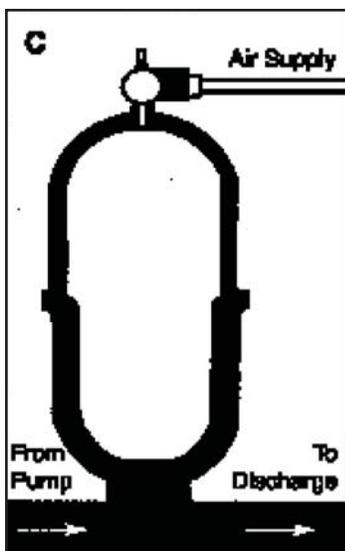
With liquid pressure now less than gas pressure the bladder is forced down discharging accumulated liquid back into the pipeline filling the void created during pump shift. The result is a continuous surge free flow of liquid.

Pulsation Dampeners–Automatic

When pulsations occur with the pump operation, it will result in the pressure in Chamber B being greater than that in Chamber A. The diaphragm will act as an air cushion and automatically adjust to this pressure change and absorb the pulsation.

This operation will shift the center rod position and allow more air into Chamber A through the air inlet, returning the diaphragm to a neutral position.

If liquid pressure decreases, air pressure in Chamber A causes diaphragm to move downward, shifting shaft location and changing valve position, releasing excess air pressure in Chamber A which returns diaphragm to a neutral position.

This action causes a reduction in surges and pulsation caused by a diaphragm pump.

A = AIR CHAMBER
B = LIQUID CHAMBER

EXHAUST — CONTROL VALVE

AIR INLET

SHAFT

A

DIAPHRAGM

B

INLET

OUTLET
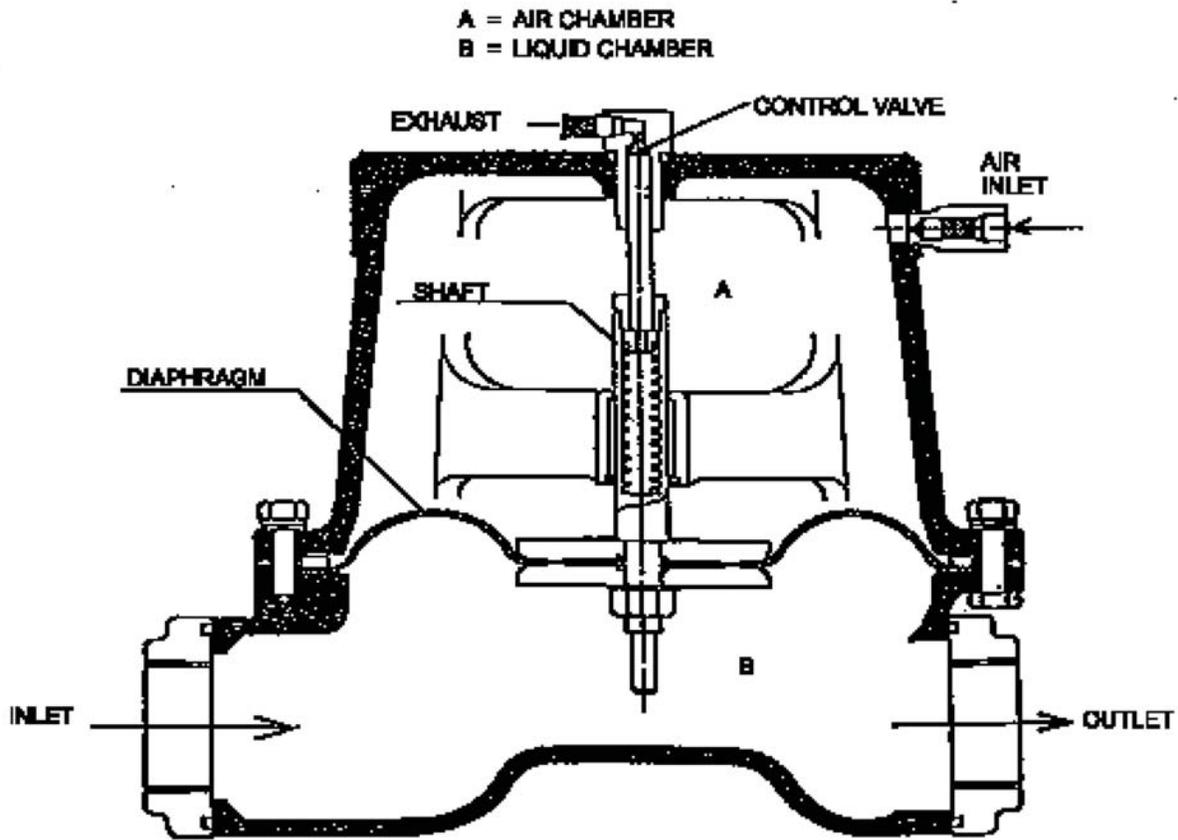
Air Pressure Regulators

Regulation of pressure is necessary because at pressures above optimum, rapid wear will take place with little or no increase in output. Air pressure that is too low or too high is uneconomical because it results in poor efficiency.

STANDARD REGULATOR

Pressure regulators have a diaphragm to balance the output pressure against an adjustable spring force.

The secondary pressure is set by the adjusting screw loading the setting spring to hold the main valve open, allowing flow from the primary pressure $p1$ inlet port to the secondary pressure $p2$ outlet port. Then the pressure in the circuit connected to the outlet rises and acts on the diaphragm, creating a lifting force against the spring load.

When consumption starts, $p2$ will initially drop and the spring, momentarily stronger than the lifting force from $p2$ on the diaphragm, opens the valve.

Fig. A - Principles of the Pressure Regulator

If the consumption rate drops, $p2$ will slightly increase, this increases the force on the diaphragm against the spring force -- diaphragm and valve will then lift until the spring force is equaled again. The airflow through the valve will be reduced until it matches the consumption rate and the output pressure is maintained.

If the consumption rate increases, $p2$ will slightly decrease. This decreases the force on the diaphragm against the spring force, diaphragm and valve drop until the spring force is equaled again. This increases the airflow through the valve to match the consumption rate.

Without air consumption the valve is closed. If the secondary pressure rises above the set value by virtue of:

• re-setting the regulator to a lower outlet pressure; or

• an external reverse thrust from an actuator, the diaphragm will lift to open the relieving seat so that excess pressure can be bled off through the vent hole in the regulator body.

Do NOT rely on this orifice as an exhaust flow path.

Fig. B - Relieving Function

With very high flow rates the valve is wide open. The spring is therefore elongated and thus weaker and the equilibrium between p2 on the diaphragm area and the spring occurs at a lower level. This problem can be corrected by creating a third chamber with a connection to the output channel. In this channel the flow velocity is high. As explained in section 3, the static pressure is then low (Bernoulli). As p3 is now at a lower static pressure, the balance against the weakened spring at high flow rates is compensated.

The effect can be improved by inserting a tube in the connection, cut at an angle with the opening oriented towards the outlet (Fig. D).

There is still a back pressure in the regulator of Fig. C: if the inlet pressure p1 increases, a higher force is acting on the bottom of the valve, trying to close it. That means that an increasing input pressure decreases the output pressure and vice versa. A valve having equal surface areas for both input and output pressure in both directions can eliminate this. This is realized in the regulator of Fig. D.

The most important parts are:

1. Adjusting Spindle

2. Setting Spring

3. Relieving Seat

4. Diaphragm

5. Flow Compensation Chamber

6. Flow Compensation Connection

7. Tube Valve

8. O-Ring for Pressure Compensation

9. Valve Spring

10. O-Ring for Flow Compensation
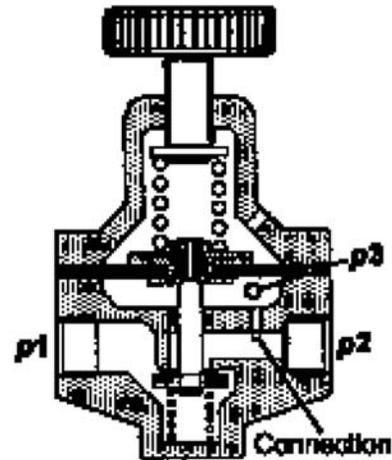
Fig. C - Principle of Flow Compensated Regulator
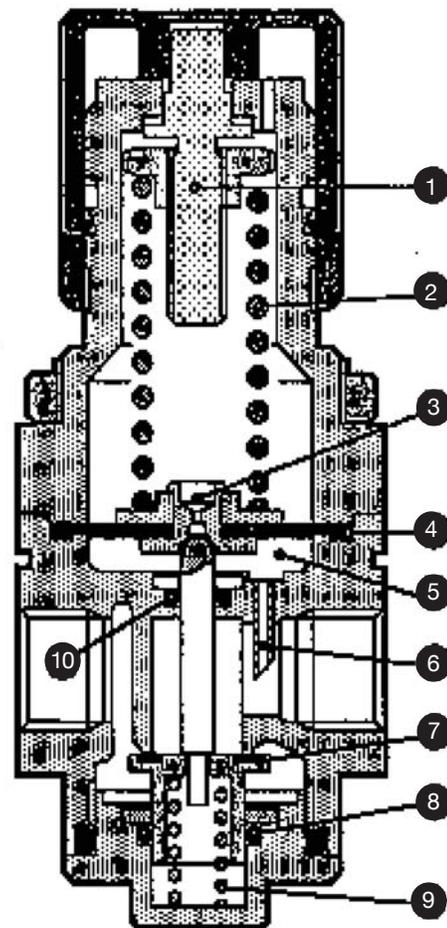
Fig. D - Fully Compensated Pressure Regulator

Installation & Troubleshooting

Pipe Tightening, Flange Loading, & Discharge Piping Procedures

NPT PIPE TIGHTENING PROCEDURE

1. Make sure pipe threads are clean and free of any foreign material.

2. Wrap TFE (PTFE) white thread tape in the direction of the threads. Overlap each wrap by one half the width of the tape.
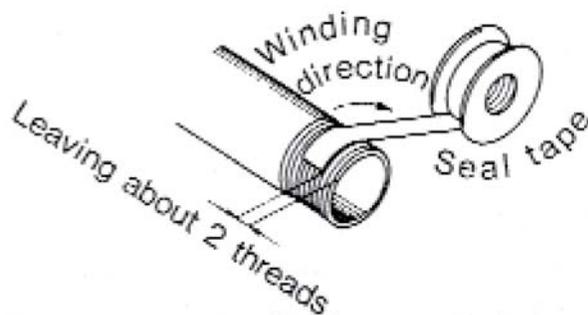
Do not use excessive amounts of PTFE tape. One or two wraps are sufficient.

Too many wraps of PTFE tape will effectively increase the O.D. of the threaded area and cause threading problems or even split a fitting.

3. Screw the pipe/fitting into the manifold and tighten by hand. Using a strap wrench further tightens the connection an additional one to two treads past hand tightness. **DO NOT OVER TORQUE;** as this may cause damage to the manifold or fitting.

FLANGE LOADING

When hard piping a diaphragm pump it is recommended that no more than a five foot run of pipe before using a pipe support. Any longer distance than this may cause undue stress on the manifold flanges or other components of the pump.

DISCHARGE PIPING

1. A valve should be installed in the liquid discharge line. The valve is required for regulation of flow capacity (an air regulator for controlling pump speed is a more preferred way of controlling flow) and for inspection and maintenance of the pump.

2. Do not attempt to self-prime when the discharge pipe is filled with liquid (this is impossible if static head is more than 20 feet (6m) water because the pump may not be able to compress the air from suction pipe sufficiently to overcome the large static volumetric head.) See page 4.

3. A manual or automatic air flow control valve should be used to control the pump flow and should be installed between pressure regulator and pump. Air should be clean, dry and filtered.

Always blow out air line before connection to the pump, to remove dirt or rust. Clean out air filter as needed.

4. In cold weather operation and if air has high humidity, the pump may "freeze up" due to moisture in air. Install in the air line a drip feed lubricator filled with monoethylene glycol antifreeze at minimum setting (1-2 drops/15-20 min) may be installed to overcome pump icing problems.

5. AIR PRESSURE: should be kept 15 PSI (1 bar) higher than the pump discharge pressure and in any case, it should never drop below 15 PSI (1 bar), otherwise erratic pump running or stalling may occur.

6. AIR FLOW: make sure that flow of compressed air is sufficient, checking that the pressure reading at the pressure regulator gauge never drops below the total dynamic head of pump. The air filter should be cleaned out regularly to avoid pump flow reduction. If you notice the pump not delivering the volume it should, check the air pressure gauge. If it has a wide fluctuation in the gauge reading greater than 20%, it is likely the pump is being starved for air.

7. EXHAUST MUFFLER: When the muffler is plugged or contaminated with pumpage due to a failed diaphragm, it must be replaced. If it is not replaced, pump stalling may occur and diaphragm life may be shortened.

Pump Flange Connections

Thermoplastics have become popular in the process industry due to their chemical resistance, weight savings and cost effectiveness. You can find pumps, piping, valves and fittings made of thermoplastics in almost any industrial plant.

The most common plastic materials used for pumps piping and valves are PP (Polypropylene), PVC, CPVC, PVDF (Kynar) and PTFE/PFA/TFE.

Care must be taken as to not damage plastic piping and fittings during installation.

A. SELECTION OF MATERIALS

• Gasket – full faced elastomeric (durometer "A: scale of 55 to 80, usually 1/8" thick). Must be resistant to chemicals flowing through the line.

• Fasteners – bolts, nuts and washers, also resistant to the chemical environment. (Threads should be well lubricated.)

• Torque Wrench – a necessity for tightening bolts in a manner that guards against excessive torque.

CAUTION
1. Do not over-torque flange bolts.
2. Use the proper bolt tightening sequence.
3. Make sure the system is in proper alignment.
4. Flanges should not be used to draw piping assemblies together.
5. Flat washers must be under every nut and bolt head.

B. FLANGE ASSEMBLY

1. Join the flange to the pipe as outlined in the solvent cementing section or in the threading section depending on the joining method desired.

2. Align the flanges and gasket by inserting all of the bolts through the matching bolt holes. Proper mating of flanges and gaskets is very important for a positive seal.

3. Using a torque wrench, tighten each bolt in a gradual sequence as outlined by the flange sketch. For final tightening of all bolts, find the recommended torque valve in the chart below.

Flange Bolt Tightening Pattern
(Tighten bolts evenly; follwing numerical sequence)

12-Bolt Pattern

8-Bolt Pattern

4-Bolt Pattern
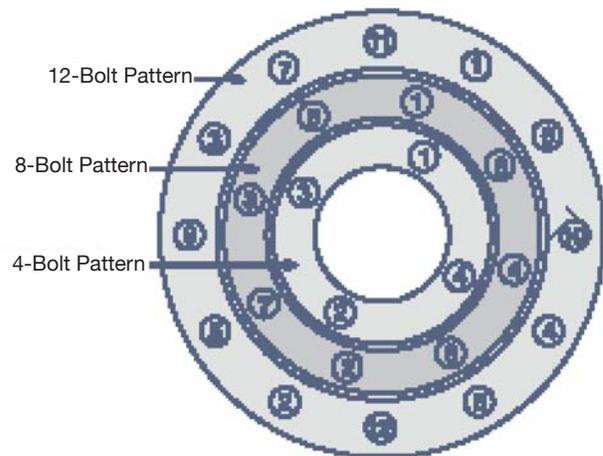
RECOMMENDED TORQUE

Pipe Size (IPS)	No. Bolt Holes	Bolt Diameter	Approx. Bolt Length* in.	Recommended Torque ft./lbs
1/2"	4	1/2"	2-1/2"	10-15
3/4"	4	1/2"	2-1/2"	10-15
1"	4	1/2"	2-1/2"	10-15
1-1/4"	4	1/2"	3"	10-15
1-1/2"	4	1/2"	3"	10-15
2"	4	5/8"	3-1/2"	20-30
2-1/2"	4	5/8"	3"	20-30
3"	4	5/8"	3-1/2"	20-30
4"	8	5/8"	4"	20-30
6"	8	3/4"	4"	33-50
8"	8	7/8"	5"	33-50

*Bolt lengths were calculated using two Eslon flanges. Additional accessories or different mating surfaces will alter these number. NOTE: Flange bolt hole pattern meets ANSI B16.5
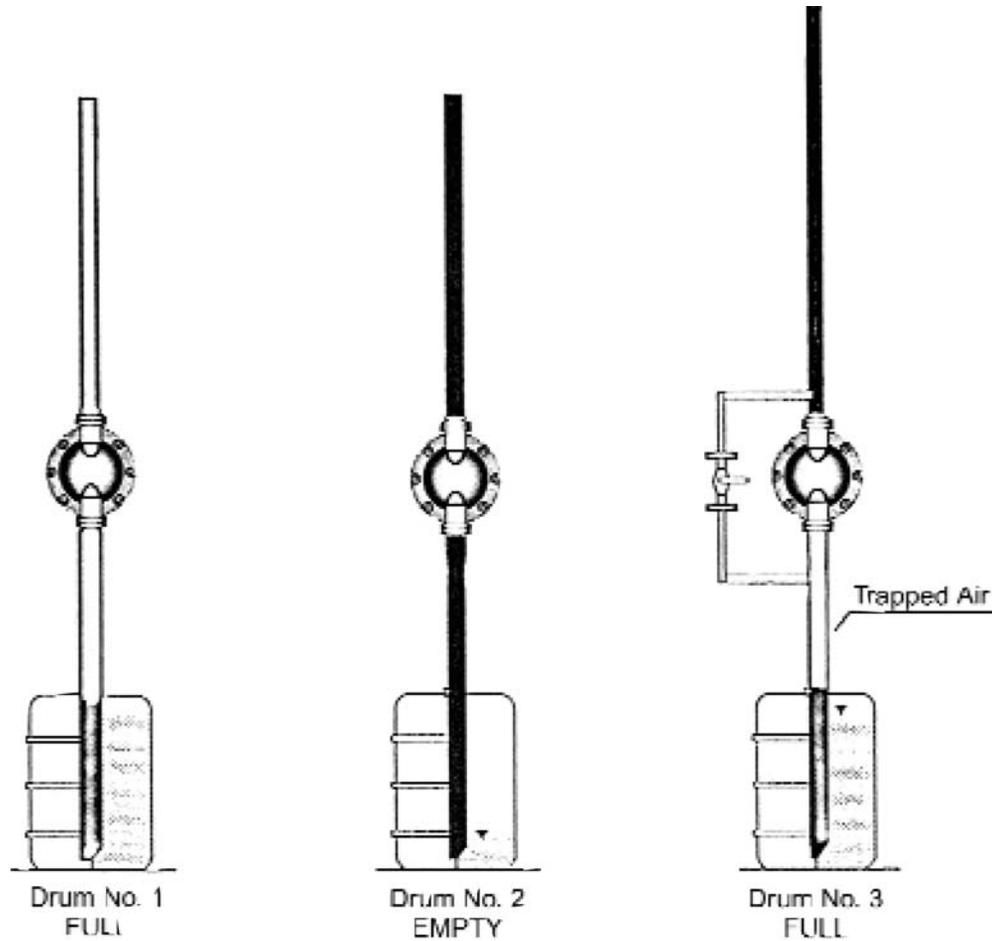
Suction Pipe Installation

CORRECT

>5%

INCORRECT

Air trapped
In Suction Line
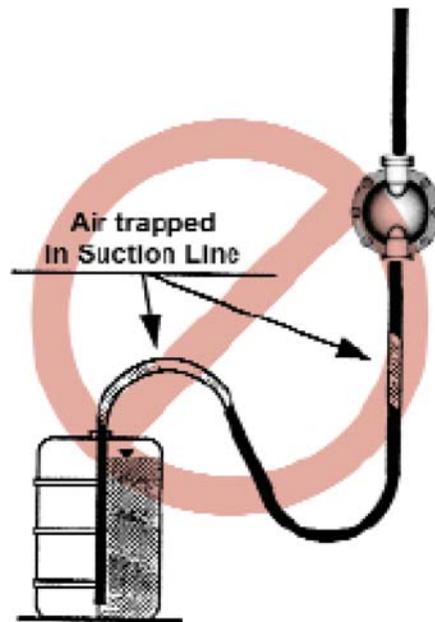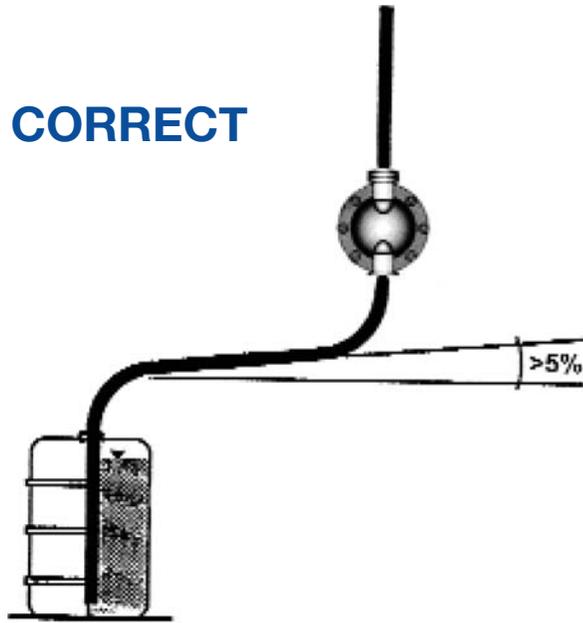
Discharge Piping

When using a pump to empty a drum or carboy and the suction line is transferred from an empty drum to a full drum and there is 20 ft. (6 m) or more of liquid in the discharge line, the pump may become air locked due to the presence of air in the suction line and pump liquid chambers.

There are several solutions to this problem:

1.   Empty the discharge line.

2.   Install a recirculation line from discharge line to suction line.

3.   Use the pump only in low head applications.

Air Supply

Make sure air supply is adequate to run the pump. The air should be clean and dry.

- Air should be filtered with a 5 micron filter

- Air should be dried to a dew point of -40°F to prevent unwanted pump icing.

When possible, control the pump flow rate by controlling the air supply as opposed to controlling the flow rate by using a valve on this pump discharge.

Controlling the air supply is the most efficient way to control an air operated pump since it requires less energy to overcome a lower discharge pressure, although a certain amount of discharge pressure is required to prevent the check valve balls from floating.

It is highly recommended that a combination Filter/Regulator be installed with each pump.

Other Pump Operation Tips

1. Do not run a pump with excessive suction pressure. This will lead to premature diaphragm failure, poor pump efficiency and a loud running pump. A good rule of thumb is to **limit the inlet pressure to a maximum of 15% of the discharge pressure.** Some of the negative effects of excess suction pressure can be over come by installation of a suction dampener.

When pumping a hazardous chemical, install the pump above the liquid (suction lift) is at all possible. This way is a diaphragm fails the content of the tank will not leak into the environment through the air motor. If you must have a flooded suction with a hazardous liquid, it is recommended that you use a diaphragm monitor in conjunction with an automated valve to secure the system in the event of a diaphragm failure.

RECOMMENDED (Fig. 1) — **NOT RECOMMENDED** (Fig. 2)
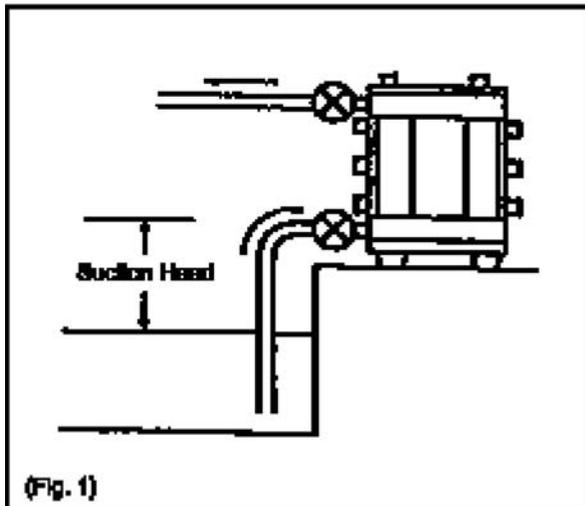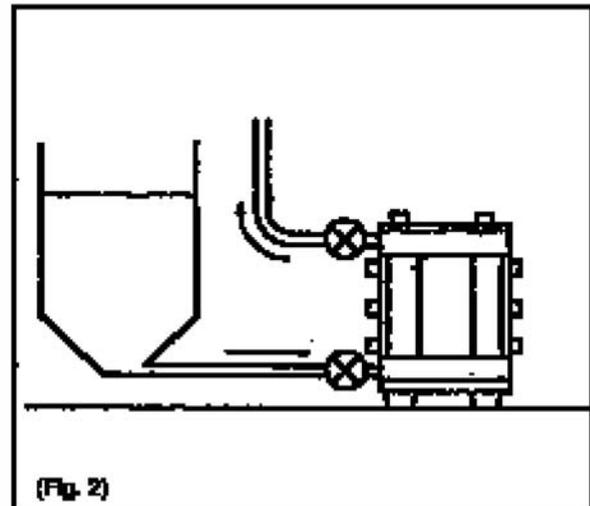
2. Do not run a pump with excessive air pressure. This will cause premature diaphragm failure.

3. When running a pump in a system with a long run of discharge pipe, use a pulsation dampener to overcome water hammer (hydraulic shock). Water hammer will damage piping, valves, flow meters, pressure gauges and also damage the pump check valves, diaphragms, and even air motors. A pulsation dampener can also act as an expansion tank when pumping liquids with high

vapor pressure. If a dampener is not used with a high vapor pressure liquid, a pressure relief valve should be used.

Finally, every pump should have a compound gauge on the pump suction and a pressure gauge on the pump discharge and air supply. This will allow you to monitor the pump/system when things are working properly, and to troubleshoot the pump/system when things are not working properly.

Recommended Installation

AIR INLET

OPTIONAL AIRLINE CONNECTION
WITH PULSATION DAMPENER

PULSATION DAMPENER
(OPTIONAL)

AIR INLET

AIR EXHAUST

FLEXIBLE CONNECTION

PIPE CONNECTION
(STYLE OPTIONAL)

GAUGE

SHUT-OFF VALVE

DISCHARGE

DRAIN PORT

SHUT-OFF VALVE

GAUGE

FLEXIBLE CONNECTION

AIR SHUT-OFF VALVE

AIR INLET

SUCTION

COMBINATION FILTER
REGULATOR

DRAIN PORT

PIPE CONNECTION
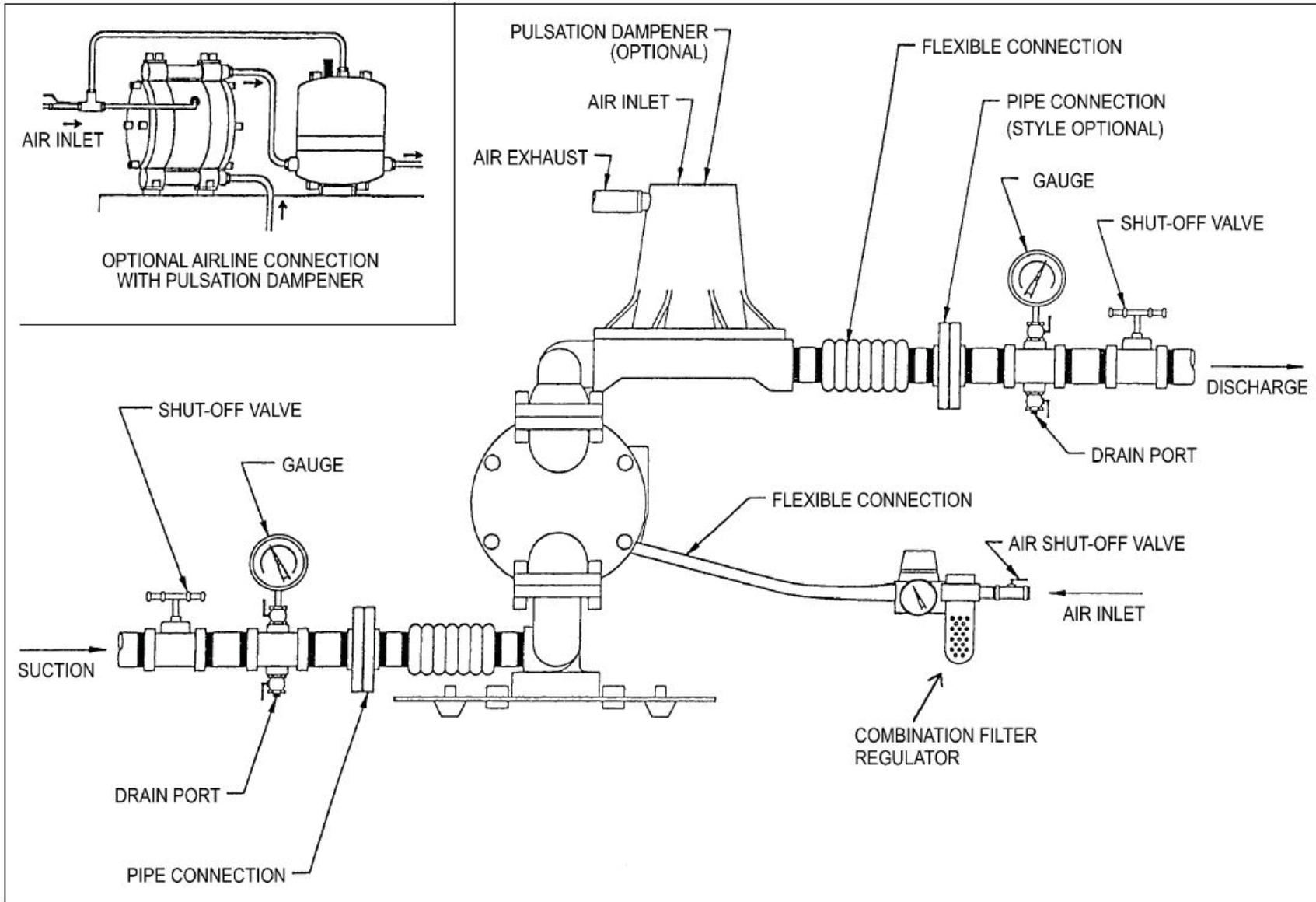
Troubleshooting Guide

PROBLEM	CAUSE

Pump will not cycle or pump cycles then stops or erratic running

Liquid End Problem
– liquid end of pump plugged from pumping slurry
– pump operating against closed discharge valve (dead head) clogged discharge line/filter causing system pressure to exceed air pressure
– pump check ball wedged in valve seat
– pump check ball guide worn
– pump check ball worn
– pump check valve improperly installed

Air Motor Problem
– air supply turned off
– air filter plugged
– air exhaust/muffler plugged
– icing
– air valve seal rings worm or defective
– shaft seal o-ring/shaft bearing worn
– shuttle valve/sleeve worn
– pilot assembly worn or defective
– blockage of internal air passageway
– defective air motor gasket
– shaft seized due to excessive heat

Pump cycles slow

– inadequate air supply
– undersized air line
– plugged air exhaust/muffler
– shaft seal o-ring worn
– air valve seal rings worn or contaminated
– air valve sleeve worn
– plugged liquid end check valve
– worn check valve guide
– excessive system discharge pressure

Pump continues to cycle with discharge valve closed

– damaged or defective check valve
– damaged or defective pilot valves/ pilot valve seat
– air leak in suction line
– damaged or defective air motor gaskets or o-rings

Troubleshooting Guide

PROBLEM	CAUSE
Premature diaphragm failure	– chemical attack (misapplied diaphragm) – excessive liquid inlet pressure – process operating outside diaphragm temperature range (too hot/too cold) – pump misassembled, incorrect center disks or center shaft – excess air pressure – extremely low discharge pressure – over torqued liquid chamber bolts
Bent or broken center shaft	– pumping slurry with excessive solids content – loose center disk – extremely long run of discharge line
Pump will cycle but delivers no liquid	– supply tank empty – closed valve on suction line – plugged suction line – excessive suction lift – air leak on liquid inlet line – bad o-rings on pump suction manifold – defective check valves – defective pilot valves causing short cycling – excessive suction lift (cavitation)
Liquid coming out air exhaust	– failed or ruptured diaphragm – loose shaft nut/center disk – bad diaphragm seal o-ring (PTFE diaphragms only) – excessive air line moisture
Air in liquid line	– failed or ruptured diaphragm – loose shaft nut/center disk – bad diaphragm seal o-ring (PTFE diaphragms only) – air leak on liquid inlet line – bad o-rings on pump suction manifold – excessive suction lift (cavitation)

Acknowledgements

When compiling the Air-Powered Double Diaphragm Pump Engineering Handbook, we used data from various sources which include:

- Hydraulic Institute Engineering Data Book

- Cameron Hydraulic Data Book, Ingersoll Rand Co.

- Hydraulic Handbook, Fairbanks Morse Pump

- Basic Pneumatics Manual, SMC Pneumatics, Inc.

- Fluid Power Data Book, Hedland Division of Racine Federated, Inc.

- Compressed Air Pocket Guide, Domnick Hunter, Ltd.

- Chemical Resistance Guide, Compass Publications

- Blacoh Fluid Control Data Book

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