PRICE PUMP CO.

Engineering Data

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NOTE: The information compiled in this manual was gathered from many sources, i.e., various manufacturers' data, engineering handbooks, practical experience and laboratory tests.
To the best of our ability, the information is accurate, although we are not responsible for any information gathered and compiled in this manual.

COMMON PUMP HEAD TERMS

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 lbs./sq. in. or feet of liquid 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 line of the pump.

SUCTION HEAD
—exists when the source of supply is above the center line of the pump.

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. Although the velocity head loss is a factor in figuring the dynamic heads, the value is usually small and in most cases negligible. See table

VELOCITY—VELOCITY HEAD

Velocity Ft./Sec.	4	5	6	7	8	9	10	11	12	13	14	15
Velocity Head-Feet	.25	.39	.56	.76	1.0	1.25	1.55	1.87	2.24	2.62	3.05	3.25

The term "head" is usually expressed in feet whereas pressure is usually expressed in pounds per square inch. Quite often the suction lift is expressed in inches of vacuum (mercury). The formula for converting these factors follows:

$$\text{lbs./sq. in. Pressure} = \frac{\text{Head (Feet)} \times \text{Specific Gravity}}{2.31}$$

$$\text{Head (Feet)} = \frac{\text{Pressure (PSI)} \times 2.31}{\text{Specific Gravity}}$$

$$\text{Vacuum inches of mercury} = \text{Dynamic suction lift (feet)} \times 0.883 \times \text{Specific Gravity}$$

DEFINITIONS AND OTHER INFORMATION

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.

NOTE: A centrifugal pump develops head, not pressure. All pressure figures should be converted to feet of head taking into consideration the sp. gr. (Ft. HD = PSI × 2.31 ÷ 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 reduces the viscosity; conversely, a temperature reduction increases the viscosity. Pipe friction loss increases as viscosity increases.

EFFECTS OF VISCOSITY

Viscous liquids tend to increase pump HP, reduce efficiency, reduce capacity and head and increase pipe friction.

VISCOSITY-CENTRIFUGAL PUMP PERCENTAGE OF WATER CHARACTERISTICS—APPROXIMATE GUIDE

Viscosity S.S.U.	Capacity	Head	Efficiency
31.5	100%	100%	100%
500	95%	98%	80%
1000	92%	97%	70%
2000	89%	94%	60%

NOTE: Viscosities higher than 500 SSU should be referred to manufacturer.

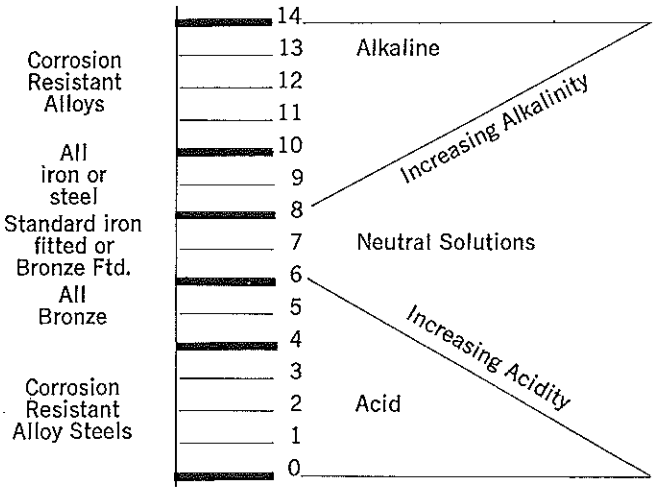
ELECTROLYSIS

Any combination of dissimilar metals should be avoided whenever practicable when the liquid being pumped is an electrolyte. Such metals tend to promote galvanic action and may deteriorate rapidly. An electrolyte solution is one similar to brackish sea water, certain acids, etc.

pH is a measure of hydrogen ion concentration. pH of 7 is neutral—below 7 acid—above 7 alkaline

General Guide—Pump Construction

pH VALUE OF SOLUTIONS—GENERAL GUIDE FOR PUMP CONSTRUCTION



NOTE: There is no substitute for experience in selecting materials for pump construction. Previous experience in handling a particular solution should be the main criterion in determining the optimal construction.

POWER REQUIRED FOR PUMPING

Water Horsepower (Theoretical H.P.) $= \frac{\text{GPM} \times \text{Feet Head} \times \text{Sp. Gr.}}{3960}$

Brake Horsepower $= \frac{\text{GPM} \times \text{Feet Head} \times \text{Sp. Gr.}}{3960 \times \text{Pump Efficiency}}$

Over-All-Horsepower (wire to water HP) $= \text{BHP} \times \text{Motor Eff.}$

Current Consumption in Kilowatt Hours (per 1000 gallons of water) $= \frac{\text{Feet Head} \times 0.00315}{\text{Pump Eff.} \times \text{Motor Eff.}}$

MOTOR SPEEDS

The syncronous speed of any alternating current (AC) motor is set by the frequency of the line voltage and the number of poles.

SYNCHRONOUS SPEED				
POLES	60 CYCLES	50 CYCLES	40 CYCLES	25 CYCLES
2	3600	3000	2400	1500
4	1800	1500	1200	750
6	1200	1000	800	500
8	900	750	600	375
10	720	600	480	300
12	600	500	400	250

Squirrel-cage or wound-rotor induction motors lose speed as the load increases. Decrease the syncronous speed about 3% to 5% to obtain the actual shaft speed.

THEORETICAL HORSEPOWER REQUIRED TO PUMP WATER

The values in the following table (slide rule calculations) are theoretical water horse-power figures. To determine the actual pump brake horse power or size of motor, divide by pump efficiency, and for liquids other than water multiply by the specific gravity of the liquid. Horse-power correction must also be made for viscosity.

U.S.	HEIGHT OR HEAD IN FEET																			
G.P.M.	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
5	.006	.013	.019	.025	.032	.038	.044	.050	.057	.063	.069	.076	.082	.088	.095	.101	.107	.114	.120	.126
10	.013	.025	.038	.051	.063	.076	.089	.102	.114	.127	.139	.152	.164	.177	.189	.202	.215	.227	.240	.253
15	.019	.038	.057	.076	.095	.114	.133	.152	.171	.190	.209	.228	.247	.266	.285	.304	.323	.342	.361	.380
20	.025	.051	.076	.101	.126	.152	.177	.202	.227	.253	.278	.303	.328	.354	.379	.404	.429	.455	.479	.505
25	.032	.063	.095	.126	.158	.189	.221	.253	.284	.316	.347	.379	.410	.442	.474	.505	.537	.569	.599	.632
30	.038	.076	.114	.152	.189	.228	.265	.303	.341	.379	.416	.454	.492	.530	.568	.606	.644	.682	.719	.757
35	.044	.089	.133	.177	.221	.265	.309	.353	.398	.442	.486	.530	.574	.618	.663	.707	.751	.795	.839	.883
40	.050	.102	.152	.202	.253	.303	.353	.403	.455	.505	.555	.606	.656	.706	.757	.808	.858	.909	.959	1.01
45	.057	.114	.171	.227	.284	.341	.398	.455	.512	.568	.625	.682	.739	.795	.852	.909	.966	1.02	1.08	1.14
50	.063	.127	.190	.253	.316	.379	.442	.505	.568	.632	.695	.758	.821	.884	.947	1.01	1.07	1.13	1.20	1.26
55	.069	.139	.209	.278	.347	.416	.486	.555	.625	.695	.764	.833	.903	.972	1.04	1.11	1.18	1.25	1.32	1.39
60	.076	.152	.228	.303	.379	.454	.530	.606	.682	.758	.833	.909	.985	1.06	1.14	1.21	1.29	1.36	1.44	1.52
65	.082	.164	.247	.328	.410	.492	.574	.656	.739	.821	.903	.985	1.07	1.15	1.23	1.31	1.40	1.48	1.56	1.64
70	.088	.177	.266	.354	.442	.530	.618	.706	.795	.884	.972	1.06	1.15	1.24	1.33	1.42	1.51	1.59	1.68	1.77
75	.095	.189	.285	.379	.474	.568	.663	.757	.852	.947	1.04	1.14	1.23	1.33	1.42	1.52	1.62	1.71	1.80	1.89
80	.101	.202	.304	.404	.505	.606	.707	.808	.909	1.01	1.11	1.21	1.31	1.42	1.52	1.62	1.72	1.82	1.92	2.02
85	.107	.215	.323	.429	.537	.644	.751	.858	.966	1.07	1.18	1.29	1.40	1.51	1.62	1.72	1.83	1.93	2.04	2.15
90	.114	.227	.342	.455	.569	.682	.795	.909	1.02	1.13	1.25	1.36	1.48	1.59	1.71	1.82	1.93	2.04	2.16	2.27
95	.120	.240	.361	.479	.599	.719	.839	.959	1.08	1.20	1.32	1.44	1.56	1.68	1.80	1.92	2.04	2.16	2.28	2.40
100	.126	.253	.380	.505	.631	.757	.883	1.01	1.14	1.26	1.39	1.52	1.64	1.77	1.90	2.02	2.15	2.27	2.40	2.53
105	.133	.266	.399	.530	.663	.705	.927	1.06	1.19	1.33	1.46	1.59	1.72	1.86	1.99	2.12	2.25	2.39	2.52	2.65
110	.139	.278	.418	.555	.695	.834	.973	1.11	1.25	1.39	1.53	1.67	1.81	1.94	2.09	2.22	2.36	2.50	2.64	2.78
115	.145	.291	.437	.580	.726	.872	1.02	1.16	1.31	1.45	1.60	1.74	1.89	2.03	2.18	2.32	2.47	2.61	2.76	2.90
120	.152	.303	.456	.605	.758	.910	1.06	1.21	1.37	1.52	1.67	1.82	1.97	2.12	2.27	2.42	2.58	2.73	2.88	3.03
125	.158	.316	.475	.632	.789	.947	1.11	1.26	1.42	1.58	1.74	1.89	2.05	2.21	2.37	2.53	2.68	2.84	3.00	3.16
130	.164	.328	.494	.656	.821	.985	1.15	1.31	1.48	1.64	1.81	1.97	2.13	2.30	2.46	2.63	2.79	2.96	3.12	3.28
135	.170	.341	.513	.681	.853	1.02	1.19	1.36	1.54	1.71	1.88	2.05	2.22	2.39	2.56	2.73	2.90	3.07	3.24	3.41
140	.177	.354	.532	.707	.885	1.06	1.24	1.41	1.59	1.77	1.95	2.12	2.30	2.48	2.66	2.83	3.01	3.18	3.36	3.54
145	.183	.366	.551	.733	.916	1.10	1.28	1.47	1.65	1.83	2.02	2.20	2.38	2.56	2.75	2.93	3.11	3.30	3.48	3.66
150	.189	.379	.570	.758	.948	1.14	1.33	1.52	1.71	1.90	2.09	2.27	2.46	2.65	2.84	3.03	3.22	3.41	3.60	3.80
155	.196	.392	.589	.783	.980	1.18	1.37	1.57	1.76	1.96	2.15	2.35	2.54	2.74	2.94	3.13	3.33	3.52	3.72	3.91
160	.202	.404	.608	.809	1.01	1.21	1.42	1.62	1.82	2.02	2.22	2.43	2.63	2.83	3.03	3.24	3.44	3.64	3.84	4.04
165	.208	.417	.627	.834	1.04	1.25	1.46	1.67	1.88	2.09	2.29	2.50	2.71	2.92	3.13	3.34	3.54	3.75	3.96	4.17
170	.214	.429	.646	.860	1.07	1.29	1.50	1.72	1.93	2.15	2.36	2.58	2.79	3.01	3.22	3.44	3.65	3.86	4.08	4.29
175	.221	.442	.665	.885	1.11	1.33	1.55	1.77	1.99	2.21	2.43	2.65	2.87	3.09	3.32	3.54	3.76	3.99	4.20	4.42
190	.240	.480	.722	.960	1.20	1.44	1.68	1.92	2.16	2.40	2.64	2.88	3.12	3.36	3.60	3.84	4.08	4.32	4.56	4.80
200	.253	.505	.760	1.01	1.26	1.52	1.77	2.02	2.27	2.53	2.78	3.03	3.28	3.54	3.79	4.04	4.29	4.55	4.80	5.05
225	.284	.568	.852	1.14	1.42	1.70	1.99	2.27	2.56	2.84	3.13	3.42	3.70	3.98	4.26	4.55	4.83	5.11	5.40	5.68
250	.316	.632	.948	1.26	1.58	1.90	2.21	2.53	2.84	3.16	3.47	3.79	4.10	4.42	4.74	5.05	5.37	5.69	5.99	6.32
275	.347	.694	1.04	1.38	1.74	2.08	2.43	2.78	3.13	3.48	3.82	4.10	4.51	4.86	5.21	5.56	5.90	6.25	6.60	6.94
300	.378	.758	1.14	1.52	1.90	2.27	2.65	3.03	3.41	3.79	4.16	4.55	4.92	5.31	5.68	6.06	6.44	6.82	7.19	7.58
350	.442	.884	1.33	1.77	2.21	2.65	3.09	3.54	3.98	4.42	4.86	5.30	5.74	6.19	6.63	7.08	7.51	7.95	8.39	8.84
400	.505	1.01	1.52	2.02	2.53	3.03	3.53	4.04	4.55	5.05	5.55	6.06	6.56	7.08	7.57	8.09	8.58	9.09	9.59	10.1
450	.568	1.14	1.71	2.27	2.84	3.41	3.98	4.55	5.12	5.68	6.25	6.82	7.39	7.95	8.52	9.09	9.66	10.2	10.8	11.4
500	.632	1.26	1.90	2.53	3.16	3.79	4.42	5.05	5.68	6.32	6.95	7.58	8.21	8.84	9.47	10.1	10.7	11.3	12.0	12.6
550	.695	1.39	2.09	2.78	3.47	4.16	4.86	5.55	6.25	6.95	7.64	8.33	9.03	9.72	10.4	11.1	11.8	12.5	13.2	13.9
600	.757	1.52	2.27	3.03	3.79	4.55	5.30	6.06	6.82	7.58	8.33	9.10	9.85	10.6	11.4	12.1	12.9	13.6	14.4	15.2
650	.821	1.64	2.47	3.28	4.10	4.92	5.74	6.56	7.39	8.21	9.03	9.85	10.7	11.5	12.3	13.1	14.0	14.8	15.6	16.4
700	.885	1.77	2.66	3.54	4.42	5.30	6.18	7.06	7.95	8.84	9.72	10.6	11.5	12.4	13.3	14.2	15.1	15.9	16.8	17.7
750	.948	1.89	2.85	3.79	4.74	5.68	6.63	7.57	8.52	9.47	10.4	11.4	12.3	13.3	14.2	15.2	16.2	17.1	18.0	18.9
800	1.01	2.02	3.03	4.04	5.05	6.06	7.07	8.08	9.09	10.1	11.1	12.1	13.1	14.2	15.2	16.2	17.2	18.2	19.2	20.2
850	1.07	2.15	3.23	4.29	5.37	6.44	7.51	8.58	9.66	10.7	11.8	12.9	14.0	15.1	16.2	17.2	18.3	19.3	20.4	21.5
900	1.14	2.27	3.42	4.55	5.69	6.82	7.95	9.09	10.2	11.3	12.5	13.6	14.8	15.9	17.1	18.2	19.3	20.4	21.6	22.7
950	1.20	2.40	3.61	4.79	5.99	7.19	8.39	9.59	10.8	12.0	13.2	14.4	15.6	16.8	18.0	19.2	20.4	21.6	22.8	24.0
1,000	1.26	2.53	3.79	5.05	6.32	7.58	8.84	10.1	11.4	12.6	13.9	15.2	16.4	17.7	19.0	20.2	21.5	22.7	24.0	25.3
1,100	1.39	2.78	4.18	5.55	6.95	8.34	9.73	11.1	12.5	13.9	15.3	16.7	18.1	19.4	20.9	22.2	23.6	25.0	26.4	27.8
1,200	1.52	3.03	4.56	6.05	7.58	9.10	10.6	12.1	13.7	15.2	16.7	18.2	19.7	21.2	22.7	24.3	25.8	27.3	28.8	30.3
1,300	1.64	3.28	4.94	6.56	8.21	9.85	11.5	13.1	14.8	16.4	18.1	19.7	21.3	23.0	24.6	26.3	27.9	29.6	31.2	32.8
1,400	1.77	3.54	5.32	7.07	8.85	10.6	12.4	14.1	15.9	17.7	19.5	21.2	23.0	24.8	26.6	28.3	30.1	31.8	33.6	35.4
1,500	1.89	3.79	5.69	7.58	9.48	11.4	13.3	15.2	17.1	19.0	20.9	22.7	24.6	26.5	28.4	30.3	32.2	34.1	36.0	37.9
1,600	2.02	4.04	6.08	8.09	10.1	12.1	14.2	16.2	18.2	20.2	22.2	24.3	26.3	28.3	30.3	32.4	34.4	36.4	38.4	40.4
1,700	2.14	4.29	6.46	8.60	10.7	12.9	15.0	17.2	19.3	21.5	23.6	25.8	27.9	30.1	32.2	34.4	36.5	38.6	40.8	42.9
1,800	2.27	4.55	6.82	9.10	11.4	13.7	15.9	18.4	20.5	22.7	25.0	27.3	29.5	31.8	34.2	36.4	38.7	40.9	43.2	45.5
1,900	2.40	4.80	7.22	9.60	12.0	14.4	16.8	19.2	21.6	24.0	26.4	28.8	31.2	33.6	36.0	38.4	40.8	43.2	45.6	48.0
2,000	2.53	5.05	7.58	10.1	12.6	15.2	17.7	20.2	22.7	25.3	27.8	30.3	32.8	35.4	37.9	40.4	42.9	45.5	48.0	50.5
2,500	3.16	6.32	9.48	12.6	15.8	19.0	22.1	25.3	28.4	31.6	34.7	37.9	41.0	44.2	47.4	50.5	53.7	56.9	59.9	63.2

GENERAL INFORMATION ON PUMP INSTALLATION

Care must be exercised in the layout and installation of pumping systems for handling industrial and petroleum liquids, especially systems handling volatile liquids.

The suction piping should be as short and direct as possible. It should be the full size called for by the pump, and if the line is long, the size should be increased. All horizontal runs should slope up to the pump so as to avoid air pockets in the suction line.

Many pumps are installed as replacements where it is necessary to utilize existing suction lines. In such places, the lift and friction of the piping should be carefully analyzed so that the pump selected will be one that does not exceed the pipe capacity.

On installations involving suction lifts a good foot valve or line check, located at the beginning of the suction lift or an angle check valve at ground level will help insure flow as soon as the pump is started. Careful consideration should be given to the friction loss through the valve under consideration.

Fittings should be provided to permit the installation of vacuum and pressure gauges on each side of the pump if provision has not already been made in the pump for these gauges.

Quick-closing valves or nozzles should not be used on the discharge lines.

A check-valve should be installed in the discharge line as close as possible to the pump when the static discharge head exceeds 25 feet.

INFORMATION NEEDED FOR SELECTING PUMP

GPM — (Flow)

DISCHARGE HEAD — (Push) PSI or Ft.

SUCTION LIFT — (Pull)

FRICTION — (Resistance)

TEMPERATURE — (How hot)

VISCOSITY — (How thick)

LIQUID — (What liquid)

NATURE OF LIQUID — (Clear—with solids)

SERVICE FACTOR — (Continuous or intermittent)

SP. GR. — (Weight)

TYPE OF DRIVE — (Motor—Engine, Etc.)

NOTE: *If the Total Dynamic Suction Lift (or head) and Total Dynamic Discharge Head have not been figured—list separately for suction and discharge the length and size of piping including list of all fittings, static elevation, and pressure required at discharge nozzle, if any.*

COMPUTING SUCTION AND DISCHARGE CONDITIONS

PROBLEM An oil company wishes to pump 200 GPM of kerosene from a 12 ft. tank buried three feet under the ground to a loading rack assembly. The spout is sixteen feet above the same ground level and approximately 200 ft. from the tank. The suction line consists of 25′ of 3″ pipe and a 3″ angle check valve. The discharge line consists of 200′ of 3″ pipe with three 90° elbows; 3″ strainer, meter and air eliminator; and 3″ loading arm assembly.

DYNAMIC SUCTION LIFT

1. Static Suction Lift (Maximum) (12′ Tank + 3′ below ground level)			15 Ft.
Suction Pipe Length	25′		
Equivalent Length of Angle Check Valve (See Page 26)	18′		
Total Equivalent Pipe	43′		
2. Friction Loss 200 GPM — 3″ pipe Ft. loss per 100′ Pipe (See Page 23)	12.2′ × .43	=	5.2 Ft.
3. Velocity Head — 9.08 Ft/sec Velocity		=	1.25 Ft.
Dynamic Suction Lift			21.45 Ft.

DYNAMIC DISCHARGE HEAD

	Pipe Length	Head Loss		
1. Static Discharge Head				16.0 Ft.
Discharge Pipe Length	200′			
Equivalent Pipe Length:				
Meter (See Page 28)		7	Ft. Loss	
Air Eliminator (See Page 27)		3	Ft. Loss	
Strainer (See Page 27)		4	Ft. Loss	
Loading Arm (See Page 28)		9.2	Ft. Loss	
Three 90° Ells (See Page 26)	33′			
Total Equivalent Pipe Lgth.	233			
2. Head Loss of Accessories		23.2	Ft. Loss	= 23.2 Ft.
3. Friction Loss 200 GPM—3′ Pipe based on 233′ pipe Ft. Loss per 100′ Pipe (See Page 23) 12.2 × 2.33				= 28.4 Ft.
Dynamic Discharge Head				67.6 Ft.

Total Dynamic Head 21.45 + 67.6 = 89 Ft.

A pump to handle 200 GPM against a Total Dynamic Head of 89 Ft. (including 21′ suction) can now be selected from the Head-capacity charts or curves on the individual pump models. In the selection, the dynamic suction lift must be considered to make sure that the pump is capable of this lift at the flow rate of 200 GPM. If not, the suction must be reduced or a larger pump selected.

NOTE

The Dynamic Suction Lift calculated in this problem represents the maximum condition (empty tank). The average condition would be a tank half full in which case the static lift would be 9′ and the Dynamic Suction Lift 15.45 ft. The Total Dynamic Head would then be 83 ft. This average condition is often used in pump selection.

SUCTION LIMITATIONS

(ANY PUMP)

The importance of keeping within the suction limitations of any pump (centrifugal, rotary, piston) cannot be emphasized too greatly. A pump, by creating a vacuum at the suction (impeller eye on a centrifugal) utilizes atmospheric pressure (14.7# at sea level) to push the liquid into the pump. Because of this, the suction lift is limited theoretically to 33.9 ft. of water maximum (14.7# $\times$ 2.31 $\div$ SG (1.0) = 33.9′ water). Internal pump losses reduce this limitation even more. The dynamic suction lift should be calculated carefully at the required capacity to make sure that it is within the pump's capabilities. Even systems taking suction from a source above the pump can cause trouble when friction losses are too great. *Always keep the pump as close to the liquid source as possible.* Many pump performance curves will show the maximum practical dynamic suction lifts for a given pump or for given capacities from that same pump. Since the limitation is based on internal pump losses also, it can be seen that in any given pump the recommended suction lift is reduced as flow increases.

VAPOR PRESSURE

Another factor that can limit the suction lift is the vapor pressure of the liquid being handled. Vapor pressure denotes the lowest absolute pressure witnessed with a given liquid at a given temperature. If the pressure in a pump system is not equal to or greater than the vapor pressure of the liquid, the liquid will flash into a gas. It is for this same reason that we must have pressure available on the suction side of a pump when handling hot water or volatile liquids such as gasoline. Without sufficient pressure, the liquid will flash into a gas and become, of course, unpumpable.

Many process applications use pressurized vessels on the suction side to overcome vapor pressure of some liquids. The amount of pressure needed depends on the liquid and liquid temperature. The higher the temperature, the higher the vapor pressure. On applications involving an above ground or underground vented tank or a sump, care must be taken when handling volatile liquids to keep within the atmospheric pressure limitations.

Consider, for example a ball of liquid that has a VP of 6# absolute. This means that at least 6# pressure is needed to maintain the liquid state. Since atmospheric pressure is only 14.7# pressure (sea level) we have only 8.7# left to cover suction static lift and friction besides internal pump losses.

NOTE: *Water boils at 212° F. at sea level because its vapor pressure is 14.7# at that temperature. Since atmospheric pressure does not exceed 14.7#, there is no extra pressure to maintain a liquid state.*

NOTE: *V.P. is measured in pounds absolute. Absolute pressure is pressure above a perfect vacuum.*

NET POSITIVE SUCTION HEAD

(NPSH)

NPSH combines all of 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 *Required NPSH* and *Available NPSH.*

Required NPSH — this refers to internal pump losses and is determined by laboratory test. It varies with each pump and with each pump capacity and speed change. The greater the capacity, the greater the required NPSH. *Required NPSH must always be given by the manufacturer.*

Available NPSH — this is a characteristic of the suction system. It can be calculated, or on an existing installation, it can be determined by field vacuum gauge readings. By definition, it is the net positive suction head above the vapor pressure available at the suction flange of the pump to maintain a liquid state. Since there are also internal pump losses (required NPSH) the available NPSH in a system must exceed the pump required NPSH — otherwise, reduction in capacity, loss of efficiency, noise, vibration and cavitation will result.

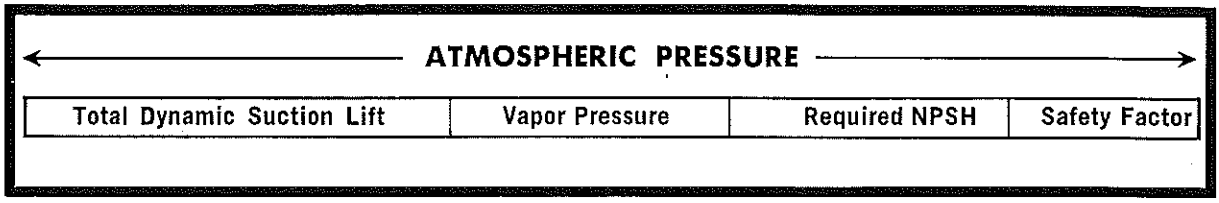
AVAILABLE NPSH IN A SYSTEM

Available NPSH = Positive factors (less) negative factors

Positive Factors		Negative Factors
Static Suction Head (if any)		Vapor Pressure—PSIA
Atmospheric Pressure (if open or vented tank or sump)		*All Friction Losses (including velocity head) Total Dynamic Suction Lift
Positive Pressure (if closed pressurized tank)		*Static Suction Lift (if any)
This side	(less)	This Side = Balance or Available NPSH

Note: Always convert all terms to feet taking into consideration the Sp. Gr. of the liquid being handled.

An ideal suction condition pumping from a vented tank would be:



NPSH FORMULAS

PROPOSED INSTALLATION — EXISTING INSTALLATION

To determine the N.P.S.H. available in a proposed application, the following formula is recommended:

$$Hsv = Hp \pm Hz - Hf - Hvp$$

Hsv = Available N.P.S.H. expressed in feet of fluid.

Hp = Absolute pressure on the surface of the liquid where the pump takes suction, expressed in "feet". This could be atmospheric pressure or vessel pressure (pressurized tank).

Hz = Static elevation of the liquid above or below the centerline of the impeller, expressed in feet.

Hf = Friction and velocity head loss in the piping, also expressed in feet.

Hvp = Absolute vapor pressure of the fluid at the pumping temperature, expressed in feet of fluid.

To determine the N.P.S.H. available in an *existing installation,* the preceding formula can be used or the following can be employed in which case it is not necessary to figure elevations and friction losses because the suction gauge reading accounts for these factors.

$$Hsv = Pa \pm Ps - \frac{Vs2}{2g} - Hvp$$

Hsv = N.P.S.H. expressed in feet of fluid.

Pa = Atmospheric pressure for the elevation of the installation, expressed in feet.

Ps = Gauge pressure or vacuum at the suction flange of the pump corrected to the pump centerline and expressed in feet. (+ if pressure or— if vacuum).

$\frac{Vs2}{2g}$ = Velocity head at the point of measurement of Ps.

Hvp = Absolute vapor pressure, expressed in feet.

MISCELLANEOUS DATA ON STANDARD PIPE

Nominal Diameter, Inches	Actual Outside Diameter, Inches	Actual Inside Diameter, Inches	Inside Area, Square Inches	Weight per Foot, Pounds	Length in Feet Containing One U. S. Gallon	Length in Feet Containing One Cubic Foot	U. S. Gallons in One Lineal Foot	Pounds of Water in One Lineal Foot
½	0.840	0.622	0.304	0.846	63.322	473.910	0.0158	0.1316
¾	1.050	0.824	0.533	1.119	36.116	270.030	0.0277	0.2309
1	1.315	1.049	0.864	1.660	22.280	166.620	0.0449	0.3742
1¼	1.660	1.380	1.496	2.244	12.867	96.275	0.0777	0.6477
1½	1.900	1.610	2.036	2.684	9.454	70.733	0.1058	0.8816
2	2.375	2.067	3.356	3.609	5.736	42.913	0.1743	1.4530
2½	2.875	2.469	4.788	5.725	4.020	30.077	0.2487	2.0732
3	3.500	3.068	7.393	7.486	2.593	19.479	0.3840	3.2012
3½	4.000	3.548	9.887	9.001	1.947	14.565	0.5136	4.2812
4	4.500	4.026	12.730	10.665	1.512	11.312	0.6613	5.5125
4½	5.000	4.506	15.947	12.392	1.207	9.030	0.8284	6.9053
5	5.563	5.047	20.006	14.448	0.962	7.198	1.0398	8.6629
6	6.625	6.065	28.890	18.755	0.666	4.984	1.5008	12.5101
7	7.625	7.023	38.738	23.271	0.497	3.717	2.0124	16.7743
8	8.625	7.981	50.027	28.221	0.384	2.878	2.5988	21.6627

PRESSURE EQUIVALENTS

PSI	Feet of Water	Inches of Water	Meters of Water	Inches of Mercury	MM of Mercury	Kilograms per Sq. CM
1.0	2.306	27.68	.704	2.036	51.712	.0703
.433	1.0	12.0	.305	.8826	22.418	.0305
.0361	.0833	1.0	.0254	.0736	1.868	.00254
1.421	3.28	39.37	1.0	2.89	—	.1
.4912	1.133	13.596	.0346	1.0	25.4	.0345
.01934	.0446	.5354	.0136	.03937	1.0	.001360
14.223	32.81	393.7	10.0	28.96	735.51	1.0

DECIMAL EQUIVALENTS

1/64	.015625	17/64	.265625	33/64	.515625	49/64	.765625
1/32	.03125	9/32	.28125	17/32	.53125	25/32	.78125
3/64	.046875	19/64	.296875	35/64	.546875	51/64	.796875
1/16	.0625	5/16	.3125	9/16	.5625	13/16	.8125
5/64	.078125	21/64	.328125	37/64	.578125	53/64	.828125
3/32	.09375	11/32	.34375	19/32	.59375	27/32	.84375
7/64	.109375	23/64	.359375	39/64	.609375	55/64	.859375
1/8	.125	3/8	.375	5/8	.625	7/8	.875
9/64	.140625	25/64	.390625	41/64	.640625	57/64	.890625
5/32	.15625	13/32	.40625	21/32	.65625	29/32	.90625
11/64	.171875	27/64	.421875	43/64	.671875	59/64	.921875
3/16	.1875	7/16	.4375	11/16	.6875	15/16	.9375
13/64	.203125	29/64	.453125	45/64	.703125	61/64	.953125
7/32	.21875	15/32	.46875	23/32	.71875	31/64	.96875
15/64	.234375	31/64	.484375	47/64	.734375	63/64	.984375
1/4	.25	1/2	.50	3/4	.75	1	1.

SPECIFIC GRAVITY CONVERSION TABLES

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

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

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

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

CONVERSION TABLE BAUME

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	9.08	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

A. P. I.	Specific Gravity	Wght. per Gal.	A. P. I.	Specific Gravity	Wght. per Gal.	A. P. I.	Specific Gravity	Wght. per Gal.	A. P. I.	Specific Gravity	Wght. per Gal.	A. P. I.	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	.636	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	0.6634	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	0.6481	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	....	.....	.....	.....	.....	.....

ATMOSPHERIC PRESSURE CONDITIONS—

ELEVATIONS ABOVE SEA LEVEL

Altitude Above Sea Level	Atmospheric Pressure Pounds/sq. in.	Barometer Reading Inches of Mercury	Equivalent Head or Water Feet	Reduction to Max. Practical Dyn. Suction Lift
0	14.7	29.929	33.95	0 Ft.
1000	14.2	28.8	32.7	1.2 "
2000	13.6	27.7	31.6	2.3 "
3000	13.1	26.7	30.2	3.7 "
4000	12.6	25.7	29.1	4.8 "
5000	12.1	24.7	27.9	6 "
6000	11.7	23.8	27.	6.9 "
7000	11.2	22.9	25.9	8 "
8000	10.8	22.1	24.9	9 "

MAXIMUM PRACTICAL DYNAMIC SUCTION LIFT AND VAPOR PRESSURE

WATER CHARACTERISTICS

Temp. of	Vapor Pressure PSI Abs	Vapor Pressure Feet	Specific Gravity	Approx. Maximum Theoretical Suction Lift — Feet	Maximum Practical Dyn. Suction Lift — Feet
40	.1217	0.281	1.0000	33.7	25
50	.1781	0.4115	.9997	33.5	25
60	.2563	0.592	.9990	33.4	25
70	.3631	0.815	.9980	33.1	25
80	.5069	1.17	.9966	32.7	24
90	.6982	1.612	.9950	32.3	24
100	.9492	2.191	.9931	31.4	23
110	1.275	2.942	.9906	31	22
120	1.692	3.91	.9888	30	21
130	2.223	5.145	.9857	288	20
140	2.889	6.675	.9833	27.2	18
150	3.718	8.56	.9803	25.3	16
160	4.741	10.945	.9773	23	14
170	5.992	13.84	.9738	20	11
180	7.510	17.35	.9702	16.5	7
190	9.339	21.55	.9667	12.4	3
200	11.53	26.65	.9632	7.2	2′ Positive
210	14.12	32.6	.9592	1.3	8′ Positive
220	17.19	39.7	.9552	0	15′ Positive

MAXIMUM PRACTICAL DYNAMIC SUCTION LIFTS

GASOLINES • JET FUEL • KEROSENE • SEA LEVEL ATMOSPHERE CONDITIONS

TEMPERATURE	MOTOR GASOLINE					AVIATION GAS	JET FUEL AND KEROSENE
	Winter Gas		Summer Gas				
	Reid Vapor Pressure	14#	12#	10#	8#		
50° F.		15	18	21	23	25	25′
60° F.		11	15	18′	21	23	25′
70° F.		6′	11	15′	18′	20	25′
80° F.		—	5	11	15	18	24′
90° F.		—	—	6	11	14	23′
110° F.		—	—	—	6	10	22′

NOTE: Average temperature of gasoline in underground storage tank is 55° F., not ambient.

APPROX. VAPOR PRESSURE — *PSI Absolute*

FUEL CHARACTERISTICS

TEMPERATURE	MOTOR GASOLINE				AVIATION GAS	JET FUEL AND KEROSENE
	Winter Gas		Summer Gas			
	14 Reid	12 Reid	10 Reid	8 Reid		
40	4.8	4.0	3.4	2.8	2.2	.9
50	5.9	4.9	4.1	3.4	2.8	1.0
60	7.4	6.0	5.0	4.1	3.5	1.0
70	8.9	7.4	6.0	5.0	4.2	1.2
80	10.7	9.0	7.1	5.9	5.1	1.4
90	12.8	10.6	8.6	7.0	6.2	1.7
100	14	12	10	8	7.4	2.0

EFFECTS OF ALTITUDE ON INTERNAL COMBUSTION ENGINES

There is a power loss of approximately 3 per cent for every 1000 of elevation above sea level; also a power loss of 1 per cent for every 10° F. over 60° F. This will result in a loss of speed, flow and pressure on the pump. The following table gives the percentage of sea level performance that can be expected at various elevations.

Altitude	Flow	Head	Altitude	Flow	Head
Sea Level	100%	100%	6000 Ft.	93%	87%
2000 Ft.	97%	95%	8000 Ft.	91%	83%
4000 Ft.	95%	91%	10000 Ft.	88%	78%

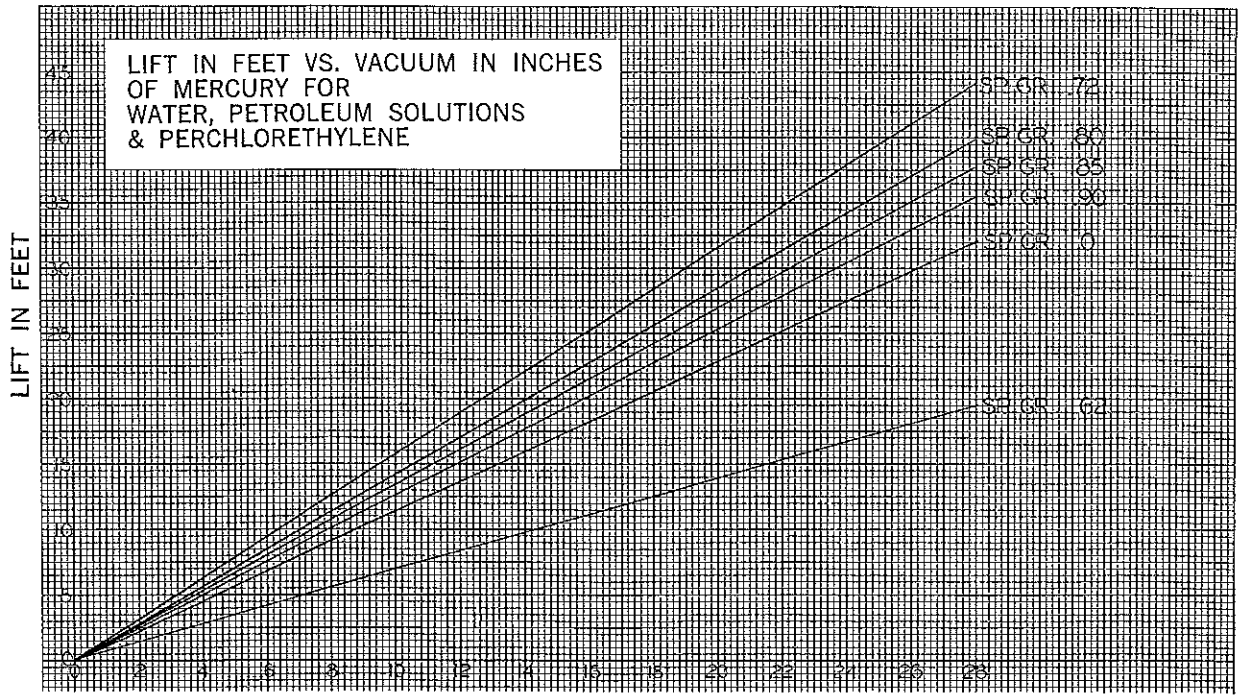
Approx. Characteristics

NATURAL GAS OR BUTANE

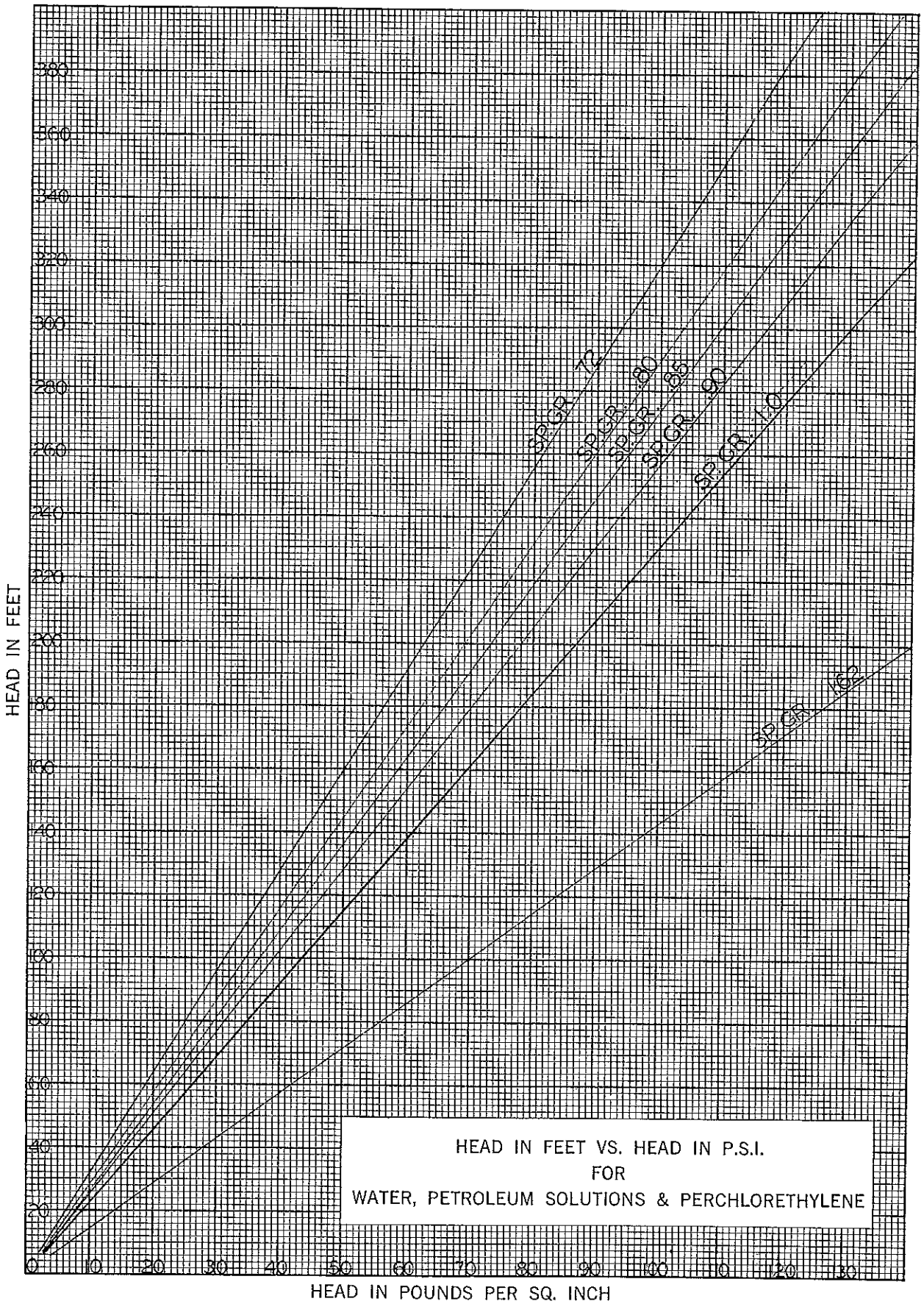
a. Air cooled engines — (Wisconsin).
Engines built at the factory with high compression heads, special carburetor, manifold, and gas valve and regulator will develop the same power as the engines when using gasoline. The BTU content of the gas should be above 1000. Reductions in BTU content will reduce the power.

b. Water Cooled Engines.
Converted at the factory with higher compression ratios and other equipment, there will be no power loss from the gasoline fuel performance. Field conversions without change of head (compression ratio) or manifolds will result in a 10 - 15% power loss.

CONVERSION CHART LIFT IN FEET VS. VACUUM IN INCHES OF MERCURY



CONVERSION CHART HEAD IN FEET VS. HEAD IN P.S.I.



THEORETICAL DISCHARGE OF NOZZLES IN U. S. GALLONS PER MINUTE

HEAD		Velocity of Discharge Feet Per Second	DIAMETER OF NOZZLE IN INCHES								
Pounds	Feet		1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16
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
25	57.7	61.0	0.58	2.34	5.25	9.34	21.0	37.3	58.3	84.0	114
30	69.3	66.85	0.64	2.56	5.75	10.2	23.0	40.9	63.9	92.0	125
35	80.8	72.2	0.69	2.77	6.21	11.1	24.8	44.2	69.0	99.5	135
40	92.4	77.2	0.74	2.96	6.64	11.8	26.6	47.3	73.8	106	145
45	103.9	81.8	0.78	3.13	7.03	12.5	28.2	50.1	78.2	113	153
50	115.5	86.25	0.83	3.30	7.41	13.2	29.7	52.8	82.5	119	162
55	127.0	90.4	0.87	3.46	7.77	13.8	31.1	55.3	86.4	125	169
60	138.6	94.5	0.90	3.62	8.12	14.5	32.5	57.8	90.4	130	177
65	150.1	98.3	0.94	3.77	8.45	15.1	33.8	60.2	94.0	136	184
70	161.7	102.1	0.98	3.91	8.78	15.7	35.2	62.5	97.7	141	191
75	173.2	105.7	1.01	4.05	9.08	16.2	36.4	64.7	101	146	198
80	184.8	109.1	1.05	4.18	9.39	16.7	37.6	66.8	104	150	205
85	196.3	112.5	1.08	4.31	9.67	17.3	38.8	68.9	108	155	211
90	207.9	115.8	1.11	4.43	9.95	17.7	39.9	70.8	111	160	217
95	219.4	119.0	1.14	4.56	10.2	18.2	41.0	72.8	114	164	223
100	230.9	122.0	1.17	4.67	10.5	18.7	42.1	74.7	117	168	229
105	242.4	125.0	1.20	4.79	10.8	19.2	43.1	76.5	120	172	234
110	254.0	128.0	1.23	4.90	11.0	19.6	44.1	78.4	122	176	240
115	265.5	130.9	1.25	5.01	11.2	20.0	45.1	80.1	125	180	245
120	277.1	133.7	1.28	5.12	11.5	20.5	46.0	81.8	128	184	251
125	288.6	136.4	1.31	5.22	11.7	20.9	47.0	83.5	130	188	256
130	300.2	139.1	1.33	5.33	12.0	21.3	48.0	85.2	133	192	261
135	311.7	141.8	1.36	5.43	12.2	21.7	48.9	86.7	136	195	266
140	323.3	144.3	1.38	5.53	12.4	22.1	49.8	88.4	138	199	271
145	334.8	146.9	1.41	5.62	12.6	22.5	50.6	89.9	140	202	275
150	346.4	149.5	1.43	5.72	12.9	22.9	51.5	91.5	143	206	280
175	404.1	161.4	1.55	6.18	13.9	24.7	55.6	98.8	154	222	302
200	461.9	172.6	1.65	6.61	14.8	26.4	59.5	106	165	238	323

HEAD		Velocity of Discharge Feet Per Second	DIAMETER OF NOZZLE IN INCHES								
Pounds	Feet		1	1 1/8	1 1/4	1 3/8	1 1/2	1 3/4	2	2 1/4	2 1/2
10	23.1	38.6	94.5	120	148	179	213	289	378	479	591
15	34.6	47.25	116	147	181	219	260	354	463	585	723
20	46.2	54.55	134	169	209	253	301	409	535	676	835
25	57.7	61.0	149	189	234	283	336	458	598	756	934
30	69.3	66.85	164	207	256	309	368	501	655	828	1023
35	80.8	72.2	177	224	277	334	398	541	708	895	1106
40	92.4	77.2	188	239	296	357	425	578	756	957	1182
45	103.9	81.8	200	253	313	379	451	613	801	1015	1252
50	115.5	86.25	211	267	330	399	475	647	845	1070	1320
55	127.0	90.4	221	280	346	418	498	678	886	1121	1385
60	138.6	94.5	231	293	362	438	521	708	926	1172	1447
65	150.1	98.3	241	305	376	455	542	737	964	1220	1506
70	161.7	102.1	250	317	391	473	563	765	1001	1267	1565
75	173.2	105.7	259	327	404	489	582	792	1037	1310	1619
80	184.8	109.1	267	338	418	505	602	818	1070	1354	1672
85	196.3	112.5	276	349	431	521	620	844	1103	1395	1723
90	207.9	115.8	284	359	443	536	638	868	1136	1436	1773
95	219.4	119.0	292	369	456	551	656	892	1168	1476	1824
100	230.9	122.0	299	378	467	565	672	915	1196	1512	1870
105	242.4	125.0	306	388	479	579	689	937	1226	1550	1916
110	254.0	128.0	314	397	490	593	705	960	1255	1588	1961
115	265.5	130.9	320	406	501	606	720	980	1282	1621	2005
120	277.1	133.7	327	414	512	619	736	1002	1310	1659	2050
125	288.6	136.4	334	423	522	632	751	1022	1338	1690	2090
130	300.2	139.1	341	432	533	645	767	1043	1365	1726	2132
135	311.7	141.8	347	439	543	656	780	1063	1390	1759	2173
140	323.3	144.3	354	448	553	668	795	1082	1415	1790	2212
145	334.8	146.9	360	455	562	680	809	1100	1440	1820	2250
150	346.4	149.5	366	463	572	692	824	1120	1466	1853	2290
175	404.1	161.4	395	500	618	747	890	1210	1582	2000	2473
200	461.9	172.6	423	535	660	790	950	1294	1691	2140	2645

NOTE: The actual quantities will vary from these figures, the amount of variation depending upon the shape of nozzle and size of pipe at the point where the pressure is determined. With smooth taper nozzles the actual discharge is about 94 per cent. of the figures given in the tables.

VOLUME AND CAPACITY EQUIVALENTS

U. S. Gallons	Imperial Gallons	Cubic Inches	Cubic Feet	Cubic Meters	Liters
1.	0.8327	231.0	0.1337	0.003785	3.785
1.201	1.	277.4	0.1605	0.004545	4.546
0.004329	0.003604	1.	0.0005787	0.00001639	0.01639
7.481	6.229	1728.	1.	0.02832	28.32
264.2	220.0	61023.	35.31	1.	1000.
0.2642	0.2200	61.02	0.03531	0.001000	1.

VISCOSITY CONVERSION TABLE

SSU Seconds Saybolt Universal	SSF Seconds Saybolt Furol	Kinematic Viscosity Centistokes (Centi-poises)	Seconds Redwood (Standard)
31	.....	1.00	29
35	.....	2.56	32.1
40	.....	4.30	36.2
50	.....	7.40	44.3
60	.....	10.20	52.3
70	12.95	12.83	60.9
80	13.70	15.35	69.2
90	14.44	17.80	77.6
100	15.24	20.20	85.6
150	19.30	31.80	128
200	23.5	43.10	170
250	28.0	54.30	212
300	32.5	65.40	254
400	41.9	87.60	338
500	51.6	110.0	423
600	61.4	132	508
700	71.1	154	592
800	81.0	176	677
900	91.0	198	762
1000	100.7	220	896
1500	150	330	1270
2000	200	440	1690
2500	250	550	2120
3000	300	660	2540
4000	400	880	3380
5000	500	1100	4230
6000	600	1320	5080
7000	700	1540	5920
8000	800	1760	6770
9000	900	1980	7620
10000	1000	2200	8460
15000	1500	3300	13700
20000	2000	4400	18400

$$\text{Kinematic Viscosity (Stokes)} = \frac{\text{Absolute Visc. (Poises)}}{\text{Specific Gravity}}$$

$$1 \text{ Centistoke} = \frac{\text{Stoke}}{100}$$

$$1 \text{ Centipoise} = \frac{\text{Poise}}{100}$$

1 Stoke = 100 Centistokes

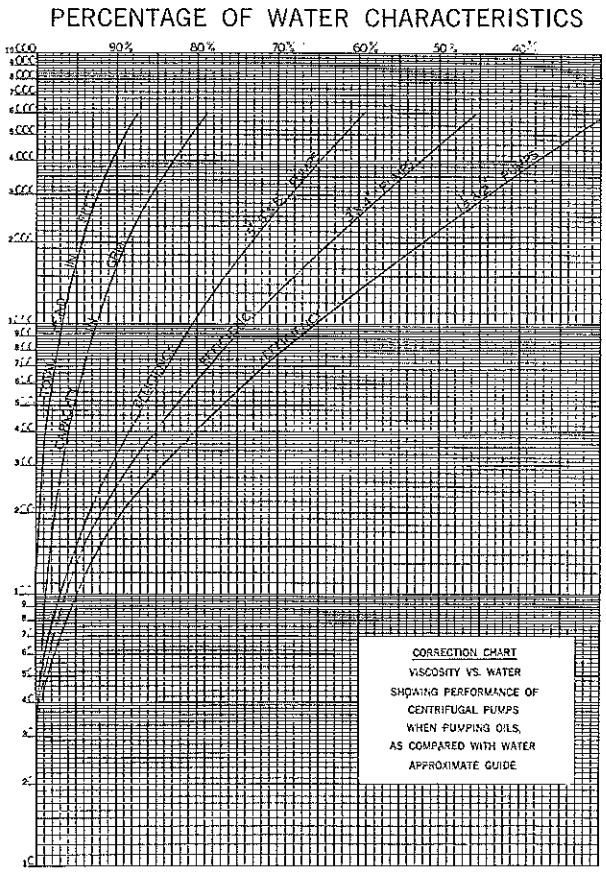
1 Poise = 100 Centipoises

*Centipoises

The term "Centipoises" is referred to commonly as a measure of **Kinematic Viscosity.** Convert centipoises to centistokes by dividing by the Specific Gravity of the solution at the operating temperature.

NOTE: Plotting Viscosity = If viscosity is known at any two temperatures, the viscosity at other temperatures can be obtained by plotting the viscosity against temperature in degrees fahrenheit on log paper. The points lie in a straight line.

VISCOSITY IN SECONDS SAYBOLT UNIVERSAL



VISCOSITY AND SPECIFIC

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 Oil 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	90000	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	200-280
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

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.
Transmission Oils — Automobile Transmission Gear Lubricants								
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
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	100	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

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)	—	—	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 212° F.		—
Tars				
Coke Oven—Tar	1.12+	3000- 8000	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	—	—
Silicate of Soda	—	—	365-640	—
Sulfuric Acid (100%)	1.83	75	—	—

FRICTION SECTION

The size of pipe and pipe fittings for any installation should be large enough to keep friction losses reasonably low. The velocity should be kept within 10 ft./sec. for good practical results. There are, however, many other factors to consider such as the length and cost of pipe vs cost of pump power. The cost factor can be especially important on installations involving long pipe runs and numerous valves and fittings.

PIPE & FITTINGS

All charts are based on friction losses for clean steel pipe on schedule 40 and show average values for new pipe including adjustment of 15% for commercial installation.

To obtain approximate values for other types of pipe use multiplier correction factor of 0.9 for smooth pipe, — for 15 year old pipe use 1.43. At best, these are rough estimates.

FRICTION LOSS FOR WATER IN FEET PER 100 FT. PIPE

Schedule 40

SIZES ½" THRU 1¼" — CLEAN STEEL PIPE

Flow US GPM	Size ½" Velocity Ft./Sec.	Friction Head in Ft.	Size ¾" Vel.	Size ¾" Frict.	Size 1" Vel.	Size 1" Frict.	Size 1¼" Vel.	Size 1¼" Frict.
2	2.43	5.50	—	—	—	—	—	—
3	3.65	11.50	—	—	—	—	—	—
4	4.85	19.67	2.77	4.84	—	—	—	—
5	6.07	29.67	3.46	7.27	—	—	—	—
6	7.29	41.98	4.15	10.20	2.56	3.08	—	—
8	9.72	72.11	5.52	17.25	3.42	5.22	—	—
10	12.14	110.29	6.92	26.45	4.27	7.98	—	—
12	14.61	156.40	8.30	37.99	5.12	11.06	2.96	2.85
14	17.02	210.45	9.68	50.02	5.98	14.72	3.45	3.77
16	19.44	270.35	11.07	64.75	6.83	18.98	3.94	4.83
18	—	—	12.42	80.85	7.68	23.69	4.44	6.00
20	—	—	13.80	99.01	8.53	23.69	4.93	7.29
22	—	—	15.18	119.60	9.40	34.73	5.43	8.72
24	—	—	16.56	140.30	10.25	40.94	5.92	10.26
26	—	—	17.94	164.45	11.10	47.84	6.42	11.93
28	—	—	19.32	188.60	11.95	55.09	6.91	13.69
30	—	—	—	—	12.77	62.79	7.41	15.64
35	—	—	—	—	14.95	89.30	8.64	20.93
40	—	—	—	—	17.02	109.25	9.87	27.02
45	—	—	—	—	19.21	136.85	11.10	33.70
50	—	—	—	—	21.39	167.90	12.31	41.40
55	—	—	—	—	—	—	13.57	49.68
60	—	—	—	—	—	—	13.90	38.65
65	—	—	—	—	—	—	15.99	80.04
70	—	—	—	—	—	—	17.25	79.12
75	—	—	—	—	—	—	18.52	90.51
80	—	—	—	—	—	—	19.78	102.58

FRICTION LOSS IN FEET OF LIQUID PER

SIZES 1½" – 2½"

PIPE SIZE	VELOCITY FT/SEC	U.S. GPM	VISCOSITY S.S.U. 31.5	35	40	50	60	80	100	150	200	300	500
1½"	.94	6	.3	.5	.6	.5	.7	1.0	1.4	2.1	2.9	4.3	7.0
	1.26	8	.7	.8	.9	1.0	.9	1.4	1.8	2.8	3.8	5.6	9.3
	1.57	10	.9	1.2	1.4	1.5	1.2	1.7	2.2	3.5	4.8	7.0	11.7
	1.89	12	1.4	1.6	1.8	2.1	2.3	2.1	2.6	4.1	5.8	8.4	14.0
	2.36	15	2.1	2.4	2.6	3.1	3.3	2.4	3.3	5.2	7.1	10.6	17.5
	3.15	20	3.3	4.0	4.4	5.1	5.5	6.2	4.5	6.9	9.5	14.0	23.3
	3.80	25	5.2	6.0	6.7	7.5	8.1	9.1	9.8	8.6	11.8	17.5	29.2
	4.72	30	7.2	8.3	9.1	10.2	11.2	12.5	13.5	10.4	14.3	21.0	35.0
	6.30	40	12.4	14.0	15.2	17.3	18.4	20.5	22.0	24.8	19.1	28.1	46.7
	7.87	50	18.9	21.0	22.8	25.5	27.3	30.2	32.3	36.5	39.3	35.0	58.3
	9.44	60	26.7	29.8	32.1	35.2	38.0	41.6	44.6				
	11.02	70	35.9	39.4	42.4	46.2	50.1	54.9	58.4				
	12.59	80	46.3	50.6	54.1	59.3	63.4	69.2	73.9				
	14.71	90	58.5	63.3	67.3	72.9	78.3	85.8	91.1				
	15.74	100	71.5	77.1	82.1	89.0	94.3	103.3	109.1				
2"	2.55	25	1.5	1.8	2.0	2.3	2.5	2.8	2.1	3.2	4.3	6.4	10.8
	3.06	30	2.1	2.5	2.8	3.1	3.5	3.8	4.1	3.8	5.2	7.7	12.9
	3.57	35	2.8	3.2	3.6	4.1	4.5	5.1	5.4	4.5	6.0	9.1	15.1
	4.08	40	3.6	4.1	4.6	5.2	5.6	6.2	7.0	5.1	6.9	10.4	17.3
	5.11	50	5.4	6.2	6.8	7.7	8.3	9.1	9.9	11.2	8.6	12.9	21.5
	6.13	60	7.6	8.5	9.4	10.6	11.4	12.8	13.7	15.4	16.8	15.5	25.9
	7.15	70	10.2	11.5	12.4	13.8	15.0	16.7	17.9	20.2	21.7	18.1	30.1
	8.17	80	13.1	14.6	15.9	17.7	19.1	20.9	22.4	25.2	27.4	20.7	34.5
	9.19	90	16.3	18.2	19.7	22.1	23.5	25.9	27.5	31.1	33.7	37.6	38.8
	10.21	100	20.0	22.2	23.9	26.5	28.1	30.9	33.2	37.0	40.5	44.6	43.0
	11.23	110	24.3	26.6	28.3	31.6	33.4	36.7	38.5	43.6	47.4	53.5	47.4
	12.25	120	28.6	31.4	33.4	36.9	39.2	43.1	45.5	51.2	53.2	61.8	51.6
	13.28	130	33.4	36.3	38.5	42.8	45.1	49.7	52.8	58.7	63.1	71.1	56.0
	14.30	140	39.9	41.9	44.0	48.8	51.6	56.5	59.9	66.7	72.1	80.8	60.3
	15.32	150	43.9	47.7	50.3	55.1	58.7	63.6	67.4	75.3	81.1	91.1	104.5
	16.34	160	49.5	53.9	56.8	61.6	65.8	71.4	75.8	84.8	91.1	102.0	
	17.36	170	55.8	60.0	63.6	69.1	73.5	79.8	83.8	92.9	101.4		
	18.38	180	62.4	67.0	71.2	76.5	82.1	88.2	92.5	100.2	110.6		
	19.40	190	69.2	74.6	79.1	84.3	91.1	97.3	101.7	113.4			
	20.42	200	76.6	82.3	86.9	92.9	97.9	106.6	112.4				
2½"	1.96	30	.9	1.0	1.2	1.4	1.5	1.6	1.3	1.8	2.5	3.8	6.3
	2.29	35	1.2	1.4	1.5	1.7	2.0	2.2	2.3	2.2	3.0	4.5	7.5
	2.61	40	1.5	1.7	2.0	2.2	2.4	2.6	2.9	2.5	3.3	5.1	8.5
	2.94	45	1.8	2.2	2.4	2.8	3.0	3.3	3.6	2.9	3.8	5.8	9.5
	3.27	50	2.2	2.6	2.9	3.2	3.6	3.9	4.3	3.1	4.3	6.3	10.6
	3.92	60	3.1	3.6	3.9	4.5	4.8	5.4	5.9	6.6	5.1	7.6	12.7
	4.58	70	4.1	4.8	5.2	6.0	6.4	7.1	7.6	8.5	5.9	8.9	14.8
	5.23	80	5.4	6.1	6.6	7.5	8.1	9.0	9.5	10.8	11.6	10.1	16.9
	5.88	90	6.8	7.6	8.2	9.2	10.0	10.9	11.8	13.2	14.4	11.4	19.1
	6.54	100	8.3	9.2	9.9	11.0	12.0	13.2	14.1	15.8	17.0	12.7	21.2
	7.18	110	9.9	10.9	11.8	13.0	13.9	15.5	16.8	18.9	20.2	22.3	23.2
	7.84	120	11.7	12.9	13.9	15.3	16.4	18.2	19.4	21.6	23.6	26.0	25.4
	8.48	130	13.6	15.0	16.0	17.8	19.1	20.8	22.3	24.8	26.7	30.2	27.5
	9.15	140	15.6	17.3	18.4	20.2	21.6	24.0	25.4	28.4	30.7	34.4	29.6
	9.81	150	17.8	19.6	20.8	22.8	24.4	26.9	28.8	32.1	35.1	38.3	31.7
	10.46	160	20.1	22.0	23.3	25.8	27.4	30.1	32.3	35.9	38.9	43.0	33.8
	11.11	170	22.5	24.6	26.0	28.5	30.7	33.4	35.9	39.7	42.9	47.7	35.9
	11.76	180	25.2	27.5	29.1	31.9	34.2	37.0	39.7	44.2	47.4	53.0	61.0
	12.42	190	27.9	30.5	32.2	35.2	37.7	40.9	43.5	48.3	52.2	59.1	67.5
	13.07	200	30.9	33.6	35.4	38.4	41.1	45.0	48.0	52.6	56.7	63.3	72.2
	14.38	220	37.0	40.4	42.4	46.0	49.1	53.0	55.9	62.1	67.4	75.7	86.5
	15.69	240	43.8	47.8	50.1	53.9	56.8	62.0	65.9	72.8	78.4	87.4	99.6
	16.99	260	51.2	55.4	60.4	62.4	6.61	71.4	75.9	84.2	89.9	99.7	
	18.30	280	59.0	63.9	66.7	72.5	75.6	81.7	87.2				
	19.61	300	67.4	72.7	75.8	81.1	86.0	92.3	97.6				

Values to the right of the solid line are for any pipe (laminar flow). Values to the left apply only to clean steel pipe (turbulent flow).

Chart friction loss shows average value for clean steel pipe

100′ STEEL PIPE

SIZES 3″ — 6″ — VISCOSITY S.S.U.

VELOCITY FT/SEC	U.S. GPM	31.5	35	40	50	60	80	100	150	200	300	500	SIZE PIPE
2.27	50	.8	.9	1.0	1.2	1.3	1.4	1.5	1.4	1.7	2.6	4.5	
2.72	60	1.0	1.3	1.4	1.6	1.7	2.0	2.1	1.6	2.2	3.2	5.3	
3.18	70	1.5	1.7	1.8	2.1	2.3	2.5	2.8	3.1	2.5	3.7	6.2	
3.63	80	1.8	2.2	2.3	2.6	2.9	3.2	3.5	3.9	2.9	4.3	7.1	
4.09	90	2.4	2.6	2.9	3.2	3.6	3.9	4.1	4.7	5.2	4.8	7.9	
4.54	100	2.8	3.2	3.5	3.9	4.3	4.7	5.1	5.8	6.1	5.3	8.9	
5.45	120	3.9	4.5	4.8	5.4	5.9	6.6	6.9	7.8	8.4	6.4	10.7	
6.35	140	5.3	5.9	6.4	7.6	7.8	8.4	9.1	10.2	10.9	12.4	12.4	
7.26	160	6.7	7.6	8.2	9.1	9.7	10.6	11.3	12.8	13.8	15.5	14.1	
8.17	180	8.4	9.4	10.0	11.2	12.0	13.1	14.0	15.8	17.0	18.9	16.0	
9.08	200	10.2	11.5	12.2	13.5	14.4	15.8	16.8	18.7	20.6	22.8	17.7	
10.22	225	12.9	14.3	15.2	16.7	17.8	19.4	20.7	23.5	25.6	27.8	32.1	
11.36	250	15.8	17.4	18.4	20.1	21.6	23.5	25.1	27.8	30.0	33.5	38.2	3″
12.50	275	18.9	20.7	22.0	23.9	26.0	27.9	29.7	32.8	35.8	39.4	45.5	
13.64	300	22.2	24.4	25.9	28.1	30.0	32.3	34.3	38.1	41.5	45.8	52.4	
14.78	325	25.9	28.4	30.0	32.5	34.5	37.4	39.7	43.8	47.8	52.7	60.6	
15.92	350	29.9	32.5	34.5	37.3	39.6	42.9	45.5	50.1	53.7	60.1	68.2	
17.06	375	34.3	37.0	39.2	42.2	44.6	48.8	51.5	56.7	60.7	67.4	77.3	
18.20	400	39.0	41.7	44.3	47.6	50.1	54.7	57.3	63.3	68.1	75.4	86.4	
19.34	425	43.8	46.8	49.7	53.2	56.1	60.8	63.3	70.4	75.4	83.7	95.9	
20.48	450	49.1	52.3	55.2	59.2	62.4	67.5	71.2	77.6	83.7	92.2	106.7	
21.62	475	54.4	58.0	61.2	65.7	68.9	74.3	78.4	85.6	92.1	102.2		
22.76	500	60.3	63.8	67.5	72.1	75.7	81.3	86.3					
23.90	525	66.0	70.0	74.1	79.1	82.8	88.6	94.4					
25.04	550	72.1	76.5	80.8	86.0	90.0	96.4	102.4					
1.53	60	.3	.3	.3	.5	.5	6	.6	.6	.7	1.0	1.8	
1.79	70	.3	.5	.5	.6	.6	.7	.8	.6	.8	1.3	2.1	
2.04	80	.5	.6	.7	.7	.8	.9	.9	.7	.9	1.5	2.4	
2.30	90	.6	.7	.8	.9	.9	1.0	1.2	1.3	1.0	1.6	2.8	
2.55	100	.7	.8	.9	1.0	1.2	1.3	1.4	1.6	1.3	1.8	3.0	
3.06	120	1.0	1.2	1.3	1.5	1.6	1.7	2.0	2.2	2.3	2.2	3.6	
3.57	140	1.4	1.6	1.7	2.0	2.1	2.3	2.5	2.8	3.1	2.5	4.3	
4.08	160	1.7	2.0	2.2	2.4	2.6	2.9	3.1	3.5	3.8	2.9	4.8	
4.60	180	2.2	2.5	2.6	3.0	3.2	3.6	3.8	4.4	4.7	5.3	5.4	
5.11	200	2.6	3.0	3.2	3.7	3.9	4.3	4.6	5.2	5.6	6.3	6.0	
5.62	220	3.1	3.6	3.8	4.3	4.6	5.1	5.4	6.1	6.6	7.5	6.6	
6.13	240	3.7	4.1	4.5	5.1	5.4	6.0	6.3	7.1	7.5	8.6	7.2	
6.64	260	4.3	4.8	5.2	5.8	6.2	6.8	7.2	8.2	8.9	9.9	7.8	
7.15	280	4.9	5.5	6.0	6.7	7.1	7.8	8.2	9.3	10.0	11.2	8.4	4″
7.66	300	5.6	6.3	6.8	7.5	8.1	8.7	9.3	10.5	11.4	12.7	14.6	
8.94	350	7.6	8.4	9.0	9.9	10.5	11.6	12.3	13.6	14.7	16.4	19.1	
10.21	400	9.8	10.8	11.5	12.5	13.3	14.6	15.5	17.1	18.6	20.7	23.9	
11.49	450	12.2	13.5	14.3	15.5	16.6	18.1	19.2	21.2	22.8	25.5	29.2	
12.77	500	15.0	16.3	17.4	18.9	20.0	21.7	23.1	25.4	27.3	30.5	35.1	
14.04	550	18.1	19.6	20.7	22.4	23.7	25.8	27.5	30.2	32.2	36.0	41.4	
15.32	600	21.3	23.0	24.4	26.3	27.8	30.2	32.0	35.1	37.7	41.9	48.0	
16.59	650	24.8	26.6	28.3	30.6	32.2	34.8	36.7	40.6	43.5	48.2	55.2	
17.87	700	28.6	30.7	32.5	35.2	37.0	39.8	42.0	46.2	49.8	54.5	62.8	
19.15	750	32.8	35.1	36.9	40.0	42.1	45.0	47.6	52.3	56.1	61.3	70.8	
20.42	800	37.3	39.7	41.6	45.1	47.3	50.5	53.5	58.7	62.8	65.6	79.0	
3.11	275	.7	.7	.8	.9	.9	1.0	1.2	1.3	1.4	1.6	1.6	
3.40	300	.7	.8	.9	1.0	1.2	1.3	1.4	1.5	1.6	1.8	1.7	
3.96	350	1.0	1.2	1.3	1.4	1.5	1.6	1.7	2.0	2.1	2.4	2.1	
4.55	400	1.3	1.5	1.6	1.7	1.8	2.1	2.2	2.4	2.6	3.0	2.3	
5.11	450	1.6	1.8	2.0	2.2	2.3	2.5	2.8	3.0	3.3	3.7	4.3	
5.68	500	2.0	2.2	2.4	2.6	2.8	3.1	3.3	3.6	3.9	4.4	5.1	
6.25	550	2.3	2.5	2.8	3.1	3.3	3.6	3.9	4.3	4.6	5.2	6.0	
6.81	600	2.6	3.0	3.3	3.6	3.8	4.1	4.5	4.9	5.4	6.0	6.8	
7.38	650	3.1	3.6	3.8	4.1	4.5	4.8	5.2	5.8	6.2	6.9	8.1	
7.85	700	3.6	4.0	4.4	4.7	5.1	5.5	5.9	6.6	7.0	7.9	9.1	
8.50	750	4.1	4.6	4.9	5.4	5.8	6.2	6.6	7.5	7.9	8.9	10.2	6″
9.08	800	4.7	5.2	5.5	6.1	6.4	7.0	7.4	8.3	8.9	9.9	11.3	
10.00	900	5.9	6.4	6.8	7.6	7.9	8.6	9.2	10.2	10.9	12.1	13.8	
11.34	1000	7.1	7.8	8.4	9.1	9.7	10.5	11.0	12.2	13.2	14.5	16.6	
12.48	1100	8.6	9.3	10.0	10.9	11.5	12.5	13.1	14.4	15.6	17.0	19.7	
13.61	1200	10.1	11.0	11.7	12.8	13.5	14.5	15.3	16.8	18.2	19.9	23.0	
15.90	1400	13.6	14.7	15.5	16.8	17.8	19.2	20.4	22.2	23.7	26.5	29.7	
18.10	1600	17.6	18.9	19.9	21.5	22.9	24.5	25.8	28.1	29.9	33.1	37.1	
20.41	1800	22.2	23.7	24.8	26.7	28.3	30.4	32.0	34.4	37.0	40.3	45.9	
22.69	2000	27.3	29.1	30.4	32.7	34.0	36.8	38.4	41.9	44.5	48.9	55.3	

including adjustment of 15% for commercial installations.

SIZE 8" – 12"

PIPE SIZE	VELOCITY FT/SEC	U.S. GPM	VISCOSITY S.S.U. 31.5	35	40	50	60	80	100	150	200	300	500
8"	3.19	500	.5	.6	.6	.7	.8	.8	.9	1.0	1.0	1.3	1.0
	3.84	600	.7	.8	.9	.9	1.0	1.2	1.3	1.4	1.5	1.6	2.0
	4.46	700	.9	1.0	1.2	1.3	1.4	1.5	1.6	1.8	2.0	2.2	2.5
	5.10	800	1.2	1.4	1.5	1.6	1.7	2.0	2.1	2.3	2.4	2.8	3.1
	5.75	900	1.5	1.7	1.8	2.0	2.2	2.3	2.5	2.8	3.0	3.3	3.8
	6.38	1000	1.8	2.1	2.2	2.4	2.5	2.9	3.0	3.3	3.6	4.0	4.6
	7.66	1200	2.5	2.9	3.1	3.3	3.6	3.9	4.1	4.6	4.9	5.4	6.2
	8.95	1400	3.5	3.8	4.1	4.4	4.7	5.1	5.5	6.0	6.4	7.1	8.2
	10.21	1600	4.5	4.8	5.2	5.6	6.0	6.4	6.8	7.6	8.2	9.0	10.2
	11.50	1800	5.5	6.0	6.4	7.0	7.5	8.1	8.5	9.3	10.0	11.0	12.7
	12.78	2000	6.8	7.4	7.7	8.5	9.0	9.7	10.2	11.3	12.1	13.3	15.2
	14.05	2200	8.1	8.7	9.3	10.1	10.6	11.5	12.1	13.3	14.3	15.8	17.8
	15.32	2400	9.5	10.4	10.9	11.8	12.4	13.5	14.1	15.5	16.7	18.3	20.8
	16.59	2600	11.3	12.1	12.7	13.7	14.4	15.5	16.3	17.8	19.3	21.0	23.9
	17.86	2800	12.9	13.9	14.6	15.6	16.6	17.8	18.7	20.5	22.0	24.2	27.1
10"	3.67	900	.5	.6	.6	.7	.7	.8	.8	.9	1.0	1.2	1.4
	4.08	1000	.6	.7	.7	.8	.8	.9	1.0	1.2	1.3	1.4	1.6
	4.49	1100	.7	.8	.8	.9	1.0	1.2	1.2	1.4	1.4	1.6	1.8
	4.90	1200	.8	.9	1.0	1.2	1.2	1.3	1.4	1.6	1.7	1.8	2.2
	5.31	1300	.9	1.0	1.2	1.3	1.4	1.5	1.6	1.8	2.0	2.2	2.4
	5.71	1400	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.1	2.2	2.4	2.8
	6.12	1500	1.3	1.4	1.5	1.6	1.7	2.0	2.1	2.3	2.4	2.8	3.1
	6.53	1600	1.4	1.6	1.7	1.8	2.0	2.2	2.3	2.5	2.8	3.0	3.6
	7.35	1800	1.7	2.0	2.1	2.3	2.4	2.6	2.8	3.1	3.3	3.7	4.3
	8.16	2000	2.2	2.4	2.5	2.8	3.0	3.2	3.5	3.8	4.0	4.5	5.2
	8.98	2200	2.5	2.9	3.0	3.3	3.5	3.8	4.0	4.5	4.7	5.3	6.0
	9.80	2400	3.0	3.3	3.6	3.9	4.1	4.5	4.7	5.2	5.5	6.2	7.0
	10.61	2600	3.6	3.9	4.1	4.5	4.7	5.2	5.4	6.0	6.4	7.1	8.1
	11.41	2800	4.0	4.5	4.7	5.2	5.4	5.9	6.2	6.8	7.4	8.1	9.2
	12.24	3000	4.6	5.1	5.4	5.9	6.1	6.7	7.0	7.7	8.3	9.1	10.4
12"	2.27	800	.1	.2	.2	.2	.2	.2	.3	.3	.3	.5	.3
	2.56	900	.2	.2	.2	.3	.3	.3	.3	.5	.5	.5	.6
	2.84	1000	.2	.2	.3	.3	.3	.5	.5	.5	.6	.6	.7
	3.41	1200	.3	.3	.5	.5	.5	.6	.6	.7	.7	.8	.9
	3.98	1400	.5	.5	.6	.6	.7	.7	.8	.8	.9	1.0	1.2
	4.55	1600	.6	.7	.7	.8	.8	.9	.9	1.0	1.2	1.3	1.5
	5.11	1800	.7	.8	.9	.9	1.0	1.2	1.3	1.4	1.5	1.6	1.8
	5.68	2000	.9	1.0	1.0	1.2	1.3	1.4	1.5	1.6	1.7	2.0	2.2
	7.00	2500	1.4	1.5	1.6	1.7	1.8	2.1	2.2	2.4	2.5	2.8	3.2
	8.52	3000	2.0	2.1	2.2	2.3	2.5	2.9	3.0	3.3	3.5	3.9	4.4

FRICTION LOSS IN FEET HEAD
PER 100 FEET OF SMOOTH BORE RUBBER HOSE

U. S. Gal. Per Min.	ACTUAL INSIDE DIAMETER IN INCHES ¾	1	1¼	½	2	2½	3	4
15	70	23	5.8	2.5	.9	.2		
20	122	32	10	4.2	1.6	.5		
25	182	51	15	6.7	2.3	.7		
30	259	72	21.2	9.3	3.2	.9	.2	
40		122	35	15.5	5.5	1.4	.7	
50		185	55	23	8.3	2.3	1.2	
60		233	81	32	11.8	3.2	1.4	
70			104	44	15.2	4.2	1.8	
80			134	55	19.8	5.3	2.5	
90			164	70	25	7	3.5	.7
100			203	85	29	8.1	4	.9
125			305	127	46	12.2	5.8	1.4
150			422	180	62	17.3	8.1	1.6
175				230	85	23.1	10.6	2.5
200				308	106	30	13.6	3.2
250					162	44	21	4.9
300					219	62	28	6.7
350					292	83	39	9.3
400						106	49	11.8
500						163	74	17.1
600						242	106	23
700						344	143	30
800						440	182	40
900							224	51
1000							270	63
1250							394	100
1500	Chart losses based on 31.5 SSU Liquid Viscosity. For other liquids, multiply these losses by friction factor for other viscosities shown in chart on page 26 of this manual.						525	141
1750								185
2000								230

LOSS OF HEAD IN FEET PER 100 FEET OF ALUMINUM PIPE

Table based on Scobey's Formula

(KS = .34 for 2" pipe,
K– = .33 for 3" pipe,
KS = .32) for other sizes

1 cubic ft. per sec. (sec. ft.) = 7.48 gal. per second
= 448.8 gal. per minute (commonly used as 450 gpm)
= 646,272 gal. per day (24 hours)

G.P.M.	C.F.S.	2" O.D. .05" Wall	3" O.D. .05" Wall	4" O.D. .063" Wall	5" O.D. .063" Wall	6" O.D. .063" Wall	7" O.D. .078" Wall	8" O.D. .094" Wall
5	.01	.07						
10	.02	.32	.04					
20	.04	1.20	.15	.04				
30	.07	2.58	.32	.08				
40	.09	4.49	.56	.13	.04			
50	.11	6.85	.85	.20	.07	.03		
60	.13	9.67	1.21	.28	.09	.04		
70	.16	12.95	1.61	.38	.12	.05		
80	.18	16.70	2.06	.49	.16	.06	.03	
90	.20	20.80	2.58	.60	.20	.08	.04	
100	.22	25.40	3.18	.74	.24	.10	.05	.03
120	.27		4.51	1.06	.34	.14	.07	.04
140	.31		6.00	1.41	.46	.19	.09	.05
160	.36		7.76	1.82	.59	.24	.11	.06
180	.40		9.67	2.27	.73	.30	.14	.07
200	.45		11.83	2.78	.89	.36	.17	.09
220	.49		14.12	3.31	1.07	.44	.20	.11
240	.54		16.72	3.91	1.27	.52	.24	.13
260	.58		19.42	4.56	1.47	.60	.28	.15
280	.62		22.40	5.26	1.71	.69	.33	.17
300	.67		25.45	5.98	1.93	.79	.37	.19
350	.78			8.03	2.59	1.05	.50	.26
400	.89			10.36	3.33	1.35	.64	.33
450	1.00			12.90	4.15	1.69	.80	.41
500	1.12			15.73	5.07	2.06	.97	.50
550	1.23			19.12	6.16	2.50	1.18	.62
600	1.34			22.46	7.24	2.94	1.38	.72
650	1.45			26.10	8.42	3.41	1.62	.84
700	1.56				9.68	3.92	1.86	.97
750	1.67				11.05	4.46	2.11	1.10
800	1.79				12.48	5.03	2.38	1.24
850	1.90				13.95	5.64	2.67	1.39
900	2.01				15.65	6.35	2.98	1.56
950	2.12				17.35	7.02	3.32	1.73
1000	2.23				19.10	7.72	3.64	1.90
1100	2.46				22.85	9.22	4.37	2.27
1200	2.68				26.95	10.88	5.16	2.68
1300	2.90					12.62	5.96	3.10
1400	3.12					14.65	6.90	3.60
1500	3.34					16.67	7.87	4.07
1600	3.57					18.80	8.89	4.62
1700	3.79					20.95	9.95	5.16
1800	4.01					23.60	11.15	5.79
1900	4.24						12.35	6.42
2000	4.46						13.65	7.10

(Above table computed for Aluminum Pipe with Coupler)

PLASTIC PIPE – FRICTION LOSS

HEAD LOSS IN FEET PER 100 FEET

GPM	SIZE PLASTIC PIPE									
	½"	¾"	1"	1¼"	1½"	2"	3"	4"	6"	GPM
5	24	5	15	0.5	—	—	—	—	—	5
10	—	19	5	1.5	1	—	—	—	—	10
15	—	30	10	3.5	1.5	—	—	—	—	15
20	—	—	17	5.5	2.5	1	—	—	—	20
25	—	—	26	8	4	1.5	—	—	—	25
30	—	—	—	11	5.5	2	—	—	—	30
35	—	—	—	14	7	2.5	—	—	—	35
40	—	—	—	18	8.5	3	—	—	—	40
45	—	—	—	21	10.5	3.5	—	—	—	45
50	—	—	—	25	13	4	1	—	—	50
75	—	—	—	—	27	8	1.5	—	—	75
100	—	—	—	—	—	15	2	—	—	100
125	—	—	—	—	—	22	3.5	—	—	125
150	—	—	—	—	—	30	5	—	—	150
200	—	—	—	—	—	—	8	2	—	200
250	—	—	—	—	—	—	12	3	—	250
300	—	—	—	—	—	—	16	4	1	300
350	—	—	—	—	—	—	21	6	1.5	350
400	—	—	—	—	—	—	26	8	1.5	400
500	—	—	—	—	—	—	—	12	2	500
600	—	—	—	—	—	—	—	17	2	600
700	—	—	—	—	—	—	—	—	3	700
900	—	—	—	—	—	—	—	—	5	900

FRICTION LOSS IN STEEL VALVES AND FITTINGS
EQUIVALENT LENGTH OF STRAIGHT PIPE

TURBULENT FLOW

Size in Inches		1"	1½"	2"	2½"	3"	4"	6"	8"	10"	12"
Elbow 45°	Screwed	1.3	2.1	2.7	3.2	4.0	5.5	—	—	—	—
	Flanged	0.81	1.3	1.7	2.0	2.6	3.5	5.6	77	9.0	11
Elbow 90°	Screwed	5.2	7.4	8.5	9.3	11	13	—	—	—	—
	Flanged	1.6	2.4	3.1	3.6	4.4	5.9	8.9	12	14	17
Elbow 90° Long Radius	Screwed	2.7	3.4	3.6	3.6	4.0	4.6	—	—	—	—
	Flanged	1.6	2.3	2.7	2.9	3.4	4.2	5.7	7	8	9
Tee — Run Thru	Screwed	3.2	5.6	7.7	9.3	12	17	—	—	—	—
	Flanged	1.0	1.5	1.8	1.9	2.2	2.8	3.8	4.7	5.2	6.0
Tee — Thru Side	Screwed	6.6	9.9	12	13	17	21	—	—	—	—
	Flanged	3.3	5.2	6.6	7.5	9.4	12	18	24	30	34
180° Return Bend	Screwed	5.2	7.4	8.5	9.3	11	13	—	—	—	—
	Flanged	1.6	2.4	3.1	3.6	4.4	5.9	8.9	12	14	17
Gate Valve	Screwed	.84	1.2	1.5	1.7	1.9	2.5	—	—	—	—
	Flanged	—	—	2.6	2.7	2.8	2.9	3.2	3.2	3.2	3.2
Globe Valve	Screwed	29	42	54	62	79	110	—	—	—	—
	Flanged	45	59	70	77	94	120	190	260	310	390
Swing Check Valve	Screwed	11	15	19	22	27	38	—	—	—	—
	Flanged	7.2	12	17	21	27	38	63	90	120	140
Angle Valve	Screwed	17	18	18	18	18	18	—	—	—	—
	Flanged	17	18	21	22	28	38	63	90	120	140
Plug Valve		—	—	6	7	8	17	65	110	150	—
Foot Valve		—	38	46	55	64	71	77	79	81	83
Enlargement	½	—	2.6	3.2	3.8	4.7	6.2	9.5	13	16	19
	¾	—	1.0	1.2	1.3	1.7	2.3	3.4	4.5	5.6	6.8
Contraction	½	—	1.5	1.8	2.2	2.8	3.6	5.6	24	9.5	11
	¾	—	1.0	1.2	1.3	1.7	2.3	3.4	4.5	5.6	6.8

VISCOSITY CORRECTION

FOR EQUIPMENT ON PAGES 27, 28, 29

MULTIPLY FRICTION LOSS BY:

31.5	SSU	1.0	150	SSU	1.7
40	SSU	1.15	200	SSU	1.8
60	SSU	1.3	300	SSU	2.1
80	SSU	1.4	400	SSU	2.5
100	SSU	1.5	500	SSU	2.8

NOZZLE LOSS (HEAD FEET)

	FUEL OIL TYPE		AVIATION TYPE		
GPM	1¼"	1½"	1½"	2"	2½"
50	19'	9'	—	—	—
75	33'	16'	—	—	—
100	—	28'	8'	5'	—
150	—	—	16'	7'	—
200	—	—	30'	12'	7'
300	—	—	—	25'	12'
400	—	—	—	—	18'
500	—	—	—	—	29'

PRESSURE DROPS (HEAD FEET)

AIR ELIMINATORS

GPM	1½"	2"	2½"	3"	4"	6"
50	3'	—	—	—	—	—
100	5'	3'	—	—	—	—
150	—	5'	3'	—	—	—
200	—	7'	5'	3'	—	—
250	—	—	10'	5'	—	—
300	—	—	—	6'	3'	—
350	—	—	—	7'	4'	—
400	—	—	—	10'	5'	3'
450	—	—	—	—	6'	3'
500	—	—	—	—	7'	4'
550	—	—	—	—	8'	4'
600	—	—	—	—	—	5'

LINE STRAINERS

	2"	2½"	3"	4"	6"
50	1'	—	—	—	—
100	4'	—	—	—	—
150	6'	3'	3'	—	—
200	—	5'	4'	—	—
250	—	7'	5'	—	—
300	—	—	6'	3'	—
350	—	—	7'	4'	—
400	—	—	10'	5'	1'
450	—	—	—	6'	1'
500	—	—	—	7'	3'
550	—	—	—	—	3'
600	—	—	—	—	4'

PRESSURE DROP IN FEET LOADING RACK EQUIPMENT

CAPACITY GPM	COMPLETE LOADING ASSEMBLY				SWING JOINT				LOADING VALVE			
	2"	2½"	3"	4"	2"	2½"	3"	4"	2"	2½"	3"	4"
100	13.8	6.9	—	—	1.1	—	—	—	6.9	3.4	1.1	—
150	27.7	12.7	4.6	—	2.3	1.1	—	—	13.8	5.7	3.4	1.1
200	41.5	20.7	9.2	—	3.4	2.3	1.1	—	23.1	9.2	4.6	2.3
250	64.6	30.0	13.8	4.6	4.6	3.4	2.3	1.1	—	16.1	6.9	3.4
300	87.7	43.8	18.4	5.7	6.9	4.6	3.4	2.3	—	—	9.2	3.4
350	—	57.7	25.4	8.0	11.5	6.9	5.7	2.3	—	—	11.5	4.6
400	—	—	33.4	10.3	13.8	9.2	6.9	3.4	—	—	13.8	4.6
450	—	—	46.2	13.8	16.1	11.5	9.2	3.4	—	—	20.7	6.9
500	—	—	57.7	16.1	20.7	16.1	11.5	4.6	—	—	25.4	9.2
550	—	—	—	18.4	—	—	16.1	4.6	—	—	—	11.5
600	—	—	—	21.9	—	—	—	6.9	—	—	—	13.8
650	—	—	—	27.7	—	—	—	8.0	—	—	—	16.1
700	—	—	—	32.3	—	—	—	8.0	—	—	—	18.4

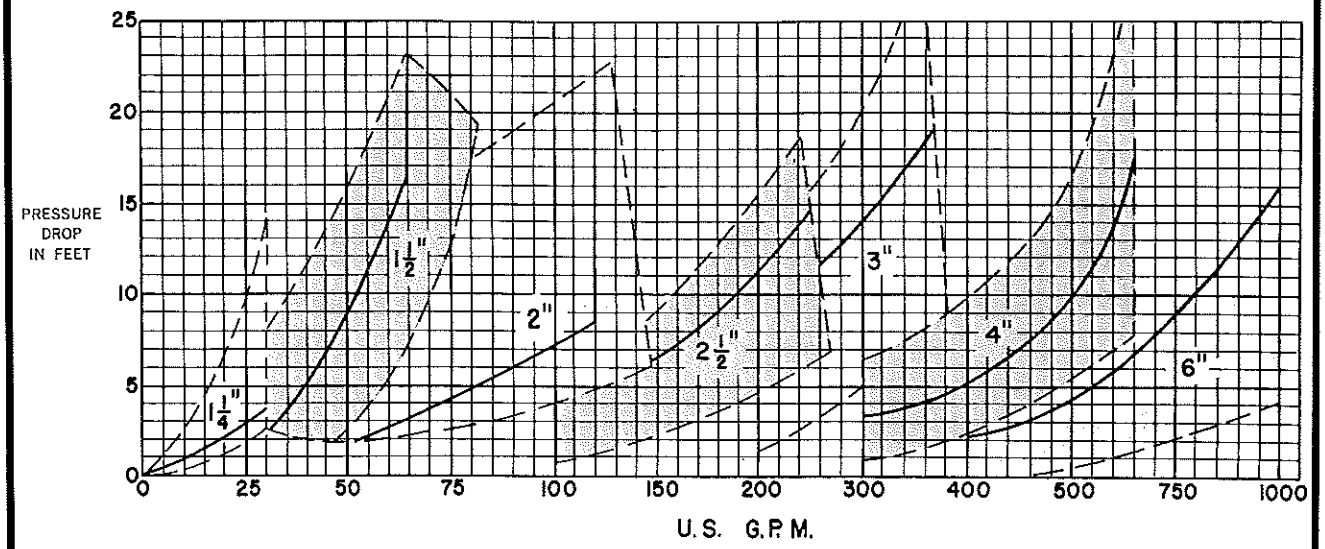
PRESSURE LOSS — METERS

THESE LOSSES REPRESENT AVERAGE FIGURES TO COVER THE MANY METER VARIATIONS AVAILABLE ON THE MARKET TODAY.

FOR METERS WITH AN AUTOMATIC STOP VALVE THE AVERAGE SHOULD BE TAKEN ABOVE THE SOLID LINE WITHIN EACH SIZE.

FOR METERS WITHOUT AN AUTOMATIC STOP THE AVERAGE CAN BE TAKEN BELOW THE SOLID LINE.

OBTAIN ACCURATE LOSS DATA FROM THE METER MANUFACTURER WHENEVER POSSIBLE.

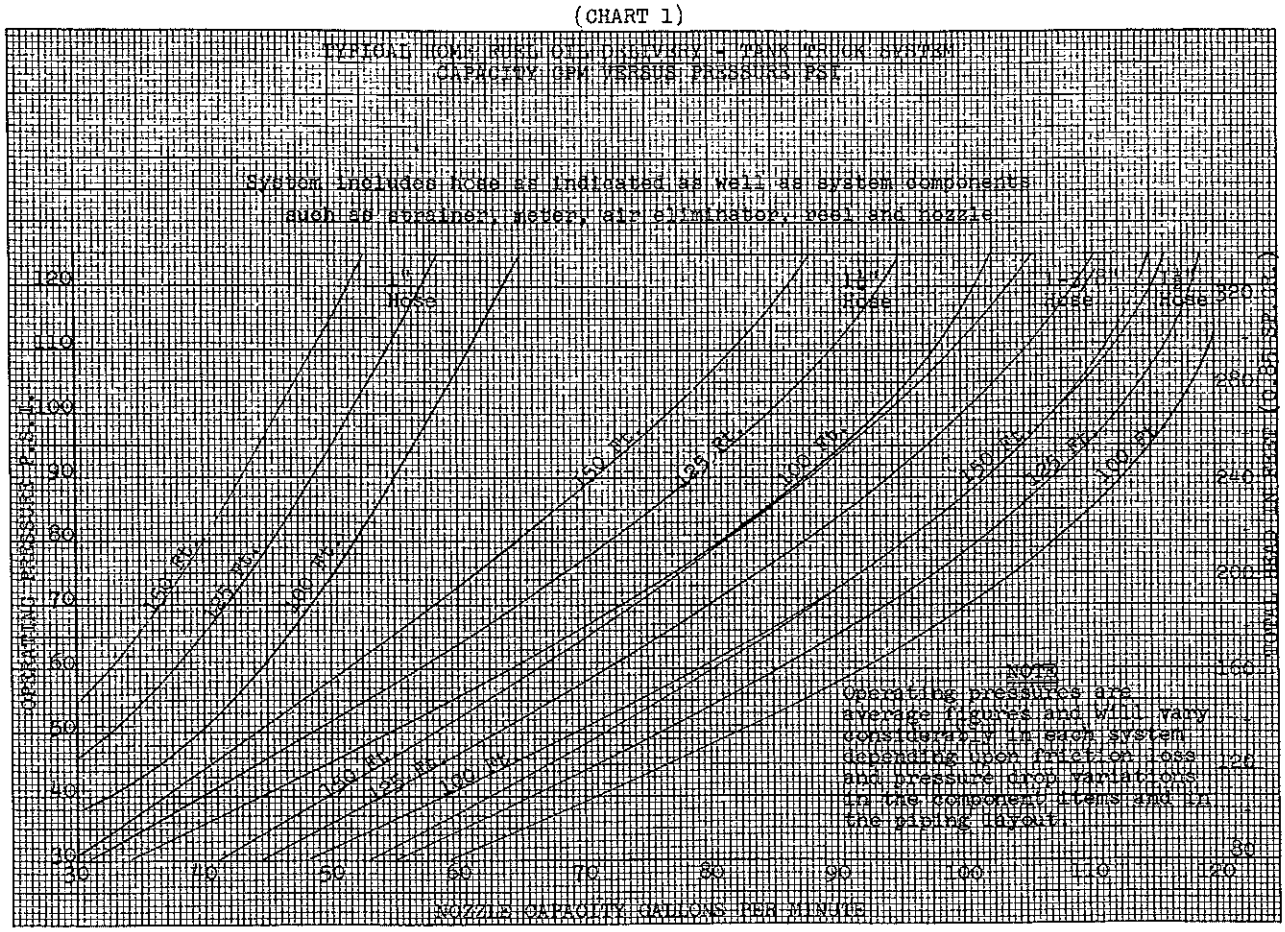


TRANSPORT UNLOADING

SUCTION HEAD LOSS IN FEET (31.5 SSU)

FLOW G.P.M.	MANIFOLD LOSSES				HOSE LOSSES (15" LENGTH)		
	2"	2½"	3"	4"	2"	2½"	3"
50	2.2′	1.1′	.5′	—	1.3′	.4′	—
100	8.0′	4.2′	1.4′	.4′	4.4′	1.2′	—
150	17.5′	8.9′	3.0′	1.1′	9.3′	2.7′	1.2′
200	30.0′	15.5′	.5.1′	1.8′	16.0′	4.5′	2.0′
250	—	24.0′	7.9′	2.8′	—	6.6′	3.2′
300	—	—	11.1′	3.9′	—	9.3′	4.3′
400	—	—	19.5′	6.8′	—	16.0′	7.4′
500	—	—	30.2′	10.5′	—	—	11.3′
600	—	—	—	15.0′	—	—	16.0′

(CHART 1)



MATERIALS RECOMMENDED FOR

Liquid	Condition	Specific Gravity	Pump Material
Acetaldehyde	Moisture Free	0.98	All Iron
Acetaldehyde	Presence of Moisture	0.78	Bronze Liquid End, 304
Acetone		0.79	All Iron, Standard Fitted
Acetate Solvents			Std. Ftd. All Bronze, All Iron
Acid, Acetic	5% Room Temp.	1.05	Bronze Liquid End, 304, 316
Acetic	20% Room Temp.		304, 316
Acetic	50% Room Temp.		304, 316
Acetic	50% Boiling		Hastelloy, 316 with Caution
Acetic	100% Room Temp.		Aluminum, 304, 316, Alum Bronze
Acetic	100% Boiling		Hastelloy, 316 with Caution
Arsenic	Room Temp.	2.0-2.5	All Iron, 304, 316
Arsenic	90% at 225°F		304 with Caution
Benzoic		1.27	304, 316, Aluminum
Boric			Bronze Liquid End, 304
Butyric	5%-100% Room Temp.	0.96	Aluminum, 304, 316
Carbolic	Concentrated	1.07	All Iron, 304, 316
Carbolic in H_2O			All Iron, Standard Fitted
Carbonic	Aqueous Solution		Bronze Liquid End, Alum., 304, 316
Chromic			All Iron, 304, 316
Chromic with H_2SO_4			304, 316
Chromic	50% Boiling		Hastelloy C
Citric			Bronze Liquid End, 304, 316
Citric	Concentrated, Boiling		316, Hastelloy (All)
Fatty (Oleic, Palmitic & Stearic)			Bronze Liquid End, 304, 316
			Alum Bronze, Monel
Formic		1.22	Bronze Liquid End, 304, 316
Fruit			Bronze Liquid End, 304, 316, Alum Bronze
Gallic	5% Room to Boiling		Aluminum, Std. Ftd. 304, 316
Hydrobromic	Boiling		Hastelloy B
Hydrochloric	5% Unaerated-Room Temp.	1.19(38%)	Hastelloy All, High Silicon
Hydrochloric	10% Unaerated-Room Temp.		Hastelloy All, Monel, Nickel High Silicon
Hydrochloric	All 100°F		Hastelloy All, High Silicon Stoneware
Hydrochloric	All 160°F		Hastelloy A & B, High Silicon
Hydrochloric	Fumes		Illium, Cupro-Nickel with Caution
Hydrocyanic		.70	All Iron, Aluminum, 304, 316
Hydrofluoric			Bronze or Monel with Caution
Hydrofluosilicic		1.30	Bronze or Monel with Caution
Lactic	Room Temp.	1.25	Bronze Liquid End, 304, Aluminum
Minewater			Bronze Liquid End, 304
Mixed			Full Range from All Iron, 304, 316, Lead, Steel Depending on Acid Conc. & Percent Water
Naphthenic			Aluminum, 304, 316
Nitric	Concentrated-Room Temp.	1.50	Aluminum, 304, 316
Nitric	95% Room Temp.		Aluminum
Nitric	65% Boiling		304, 316
Nitric	Dilute Room Temp.		304, 316
Oxalic	5%-10% Room or Hot	1.65	Bronze Liquid End, 304, 316
Oxalic	10% Boiling		Illium, Silicon, Bronze, Hastelloy
Ortho-Phosphoric	Crude	1.87	316
Phosphoric	Dilute Room Temp.		304, 316
Pickling			Depending on Conditions
Picric	Concentrated-Room Temp.	1.76	304, 316, High Silicon Iron
Pyrogallic		1.45	304, 316
Pyroligneous			Bronze Liquid End, 304, 316
Sulfuric	77%-Room Temp.	1.69-1.84	All Iron, 304, 316
Sulfuric	77%-Hot		304, 316
Sulfuric	Very Dilute-Room Temp.		304, 316
Sulfuric	Very Dilute-Boiling		Hastelloy B
Sulfuric Fuming (Oleum)		1.92-1.94	Steel
Sulfurous			Bronze, Liquid End, 316, Alum Bronze, Lead
Tannic			Bronze Liquid End, 304, 316, Monel
Tartaric	Solution		Bronze Liquid End, 304
Alcohol, Grain Ethyl			Bronze Liquid End, Std. Ftd.
Alcohol, Wood Methyl			Bronze Liquid End, Std. Ftd.
Aluminum Sulfate	Solution		High Silicon, Lead, 304, 316
Ammonium Bicarbonate	H_2O Solution		All Iron
Ammonium Chloride	H_2O Solution		All Iron, 316
Ammonium Hydroxide	H_2O Solution		All Iron
Ammonium Nitrate	H_2O Solution		All Iron, 304, 316
Ammonium Phosphate	H_2O Solution		All Iron, 304, 316
Ammonium Sulphate with H_2SO_4			Bronze Liquid End, Lead
Ammonium Sulphate	H_2O Solution		All Iron, 304, 316
Aniline		1.02	All Iron
Aniline Hydrochloride	H_2O Solution		High Silicon Iron
Asphalt	Hot	.98-1.4	All Iron
Barium Chloride	H_2O Solution	All Iron, 316	
Barium Nitrate	H_2O Solution	All Iron, 304, 316	
Beer			Bronze Liquid End, 304, 316
Beer Wort			Bronze Liquid End, 304, 316
Beet Juice			Bronze Liquid End, 304, 316
Benzene		.88	See Benzol
Benzol			All Iron, Standard Fitted

PUMPING VARIOUS LIQUIDS

Liquid	Condition	Specific Gravity	Pump Material
Benzine			See Petroleum Ether
Bichloride of Mercury			See Mercuric Chloride
Bittern			Ni Resist
Bitterwasser			Bronze Liquid End, 304
Black Liquor			All Iron, 304, 316, Ni Resist
Bleach Solutions			See Respective Hypochlorites
Blue Vitriol			See Copper Sulfate
Boiler Feed Water			All Iron, Bronze Liquid End, Standard Fitted Depending on pH
Borax			All Iron
Brine, Calcium Chloride			All Iron if pH is 8.5, otherwise Bronze Liquid End
Brine, Calcium & Magnesium			Bronze Liquid End, Ni Resist
Brine, Calcium & Sodium Chloride			Bronze Liquid End
Brine, Sodium Chloride	3% Salt	1.02-1.20	All Iron, Bronze Liquid End
Brine, Sodium Chloride	Over 3%		Bronze Liquid End, 304, 316
Brine, Sea Water		1.03	All Iron, Bronze Liquid End
Butane		.60 (32°F.)	Standard Fitted Iron Fitted
Cachaza			Standard Fitted
Cadium Plating Solution			Chrome-Nickel Iron, High Silicon, Rubber, Stone
Calcium Bisulfite		1.06	316
Calcium Chlorate			304, 316
Calcium Chlorite			See Brine
Calcium Hypochlorite			All Iron, High Silicon Iron
Cane Juice			Standard Fitted Bronze Liquid End
Carbonated Water			See Acid, Carbonic
Carbon Bisulfide		1.26	All Iron
Carbonate of Soda			See Soda Ash
Carbon Dioxide			See Acid, Carbonic
Carbon Tetrachloride	Moisture Free	1.50	All Iron
Carbon Tetrachloride	In Presence of Moisture		Bronze Liquid End
Caustic Potash			See Potassium Hydroxide
Caustic Soda			See Sodium Hydroxide
Cellulose Acetate			316, High Silicon Iron
Chlorate of Lime			See Calcium Chlorate
Chloride of Lime			See Calcium Hypochlorite
Chlorinated Solvents	Moisture Free		All Iron
Chlorinated Solvents	Presence of Moisture		Bronze Liquid End
Chlorine			Hastelloy, High Silicon
Chlorobenzene		1.1	Stoneware, Rubber
Chloroform		1.5	Standard Fitted 304
Chrome Alum	H_2O Solution		Bronze Liquid End, 304, 316, Lead
			High Silicon Iron, Chrome-Nickel Iron
Copperas Green			See Ferrous Sulfate
Copper Acetate			316
Copper Chloride	H_2O Solution		Hastelloy, High Silicon, Rubber Stoneware
Copper Nitrate			304, 316
Copper Sulfate, Blue Vitriol			304, 316, High Silicon, Lead
Clay Slip, (Paper Mill)			All Iron, (Hardened Fittings)
Condensate			Standard Fitted
Creosote		1.04-1.10	All Iron, Std. Ftd.
Cresol, Meta		1.03	All Iron
Cyanide			All Iron
Cyanogen	In H_2O		All Iron
Developing Solutions			304
Diethanolamine			All Iron
Diethylene Glycol			All Iron, Bronze Liquid End,
Diphenyl	Moisture Free	.99	Standard Fitted
Diphenyl Oxide,	Moisture Free		All Iron, Steel
Diphenyl	In Alcohol		All Iron, Steel
Distillery Wort			All Iron
			Bronze Liquid End
Enamel			All Iron
Epsom Salts			See Magnesium Sulfate
Ethyl Acetate			All Iron 316
Ethyl Alcohol (Ethanol)			See Alcohol, Ethyl
Ethylene Chloride	Cold	1.28	Lead, High Silicon, High Chrome, Nickel Iron
Ferric Chloride			Hastelloy, High Silicon, Rubber, Stoneware
Ferric Sulfate			304, High Silicon
Ferrous Chloride			Bronze Liquid End, 304
Ferrous Sulfate			Bronze Liquid End, 304, Rubber, Stoneware, Lead
Formaldehyde		1.08	Bronze Liquid End, 304
Fruit Juices			Bronze Liquid End, 304
Fuel Oil			See Oil, Fuel
Furfural		1.16	All Iron, Bronze Liquid End, Standard Fitted
Fusel Oil			Bronze Liquid End
Gasoline, Refined		.68-.75	Standard Fitted Iron Ftd.
Glaubers Salt			See Sodium Sulfate
Glue			Standard Fitted
Glue Sizing			Bronze Liquid End

MATERIALS RECOMMENDED FOR

Liquid	Condition	Specific Gravity	Pump Material
Glycerin			See Glycerol
Glycerol		1.26	Std. Fitted, Bronze Liquid End,
Green Liquor			All Iron, 304, 316
Heptane		0.69	Standard Fitted
Hydrogen Peroxide			Aluminum, 304, 316
Hydrogen Sulfide			Aluminum, 304
Hydrosulfite of Soda			See Sodium Hydrosulfite
Hyposulfite of Soda			See Sodium Thiosulfate
Kaolin Slip			Bronze Liquid End
Kerosene			Std. Fitted, Bronze Liquid End
Lacquer			Std. Fitted, All Iron, Bronze Liquid End
Lacquer Solvents			Std. Fitted, All Iron, Bronze Liquid End
Lard			Std. Fitted, All Iron
Latex			All Iron
Lead (Molten)			All Iron, Steel
Lead Acetate	H_2O Solution		304, 316, Rubber, Stoneware
Lime Water			All Iron
Lithium Chloride	H_2O Solution		All Iron, Bronze Liquid End
Lye			See Sodium Hydroxide
Magnesium Chloride			Bronze Liquid End, Lead, High Silicon
Magnesium Sulfate			Bronze Liquid End, All Iron
Magma (Thick Residue)			Bronze Liquid End, All Iron, 304
Manganese Chloride	H_2O Solution		Ni Resist
Manganous Sulfate	H_2O Solution		Bronze Liquid End, 304, 316
Mash			All Iron, Bronze Liquid End, 304, 316
			Standard Fitted, Bronze Liquid End, 304
Mercuric Chloride	Very Dilute H_2O Solution		304, High Silicon Iron
Mercuric Chloride	Comm'l Conc. H_2O Solution		Hastelloy, High Silicon, Stoneware
Mercuric Sulfate	In H_2SO_4		High Silicon Iron, Stoneware
Mercurous Sulfate	In H_2SO_4		High Silicon Iron, Stoneware
Mercury			All Iron
Methyl Acetate			316
Methyl Alcohol			See Alcohol, Wood
Methyl Chloride		0.52	All Iron
Methylene Chloride		1.34	All Iron, 304
Milk		1.03-1.04	Tinned Bronze, 304
Milk of Lime			See Lime Water
Mine Water			See Acid, Mine Water
Miscella		0.75	All Iron
Molasses			Std. Fitted, Bronze Liquid End
Mustard			Bronze Liquid End, 304
Naphtha		.78-.88	Standard Fitted
Naphtha, Crude		.92-.95	Standard Fitted
Nickel Chloride	Low pH Plating Solutions		Chrome-Nickel Iron, High Silicon
Nickel Sulfate	Low pH Plating Solutions		Chrome-Nickel Iron, High Silicon
Nicotine Sulfate			Chrome-Nickel Iron, High Silicon
Nitre			See Potassium Nitrate
Nitre Cake			See Sodium Bisulphate
Nitro-Ethane		1.04	304, 316
Nitro-Methane		1.14	304, 316
Oil, Cocoanut		.91	All Iron, Br. Ftd. All Bronze
Oil Crude (Asphalt Base)			Standard Fitted
Crude (Paraffin Base)			Standard Fitted
Fuel (Furnace)			All Iron, Standard Fitted
Fuel (Kerosene)			All Iron, Standard Fitted
Lubricating			Standard Fitted
Mineral			Standard Fitted
Mineral	U. S. P.		304
Palm		.90	All Iron, Bronze Liquid End, Monel
Quenching		.91	Standard Fitted, All Iron
Soya Bean			All Iron, Bronze Liquid End, Monel
Vegetable			All Iron, Standard Fitted
Coal Tar			All Iron, Standard Fitted
Creosote			All Iron, Standard Fitted
Turpentine		.87	All Iron, Standard Fitted
Linseed		.94	All Iron, Std. Ftd.
Rapeseed		.92	Bronze Liquid End, 304, Monel
Olive Oil		.90	All Iron, Std. Ftd.
Paraffin			Standard Fitted, All Iron
Perchlorethlene		1.62	Std. Ftd. Iron Ftd.
Petroleum			See Oil, Crude
Petroleum Solvent		0.80	Std. Ftd. Iron Ftd.
Perhydrol			See Hydrogen Peroxide
Peroxide of Hydrogen			See Hydrogen Peroxide
Petroleum Ether			All Iron, Standard Fitted
Phenol		1.07	See Acid, Carbonic
Photographic Developers			See Developing Solutions
Pickling Acids			See Acid, Pickling
Potash			See Potassium Carbonate
Potash Alum			Bronze Liquid End
Potassium Bichromate			All Iron
Potassium Carbonate			All Iron
Potassium Chloride			Bronze Liquid End
Potassium Cyanide			All Iron
Potassium Hydroxide			All Iron, 304
Potassium Nitrate			All Iron
Potassium Sulfate			All Iron
Propane		.59 (48°F.)	Std. Ftd. All Iron

PUMPING VARIOUS LIQUIDS

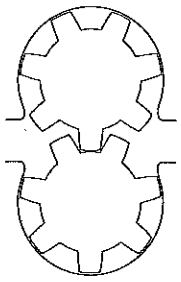
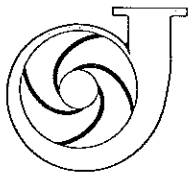
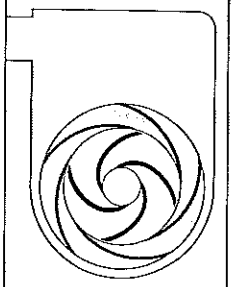
Liquid	Condition	Specific Gravity	Pump Material
Pyridine Sulfate			High Chrome-Nickel Iron, Lead
Rectifying Pump (Distillery)			Bronze Liquid End
Rhigolene (Oil Distillery)			Standard Fitted
Rosin (Colophony)			All Iron
Sal Ammoniac			See Ammonium Chloride
Salt			See Brines
Salt Cake			Bronze Liquid End
Sea Water			See Water, Sea
Sewage			Standard Fitted All Iron
Silicate of Soda			All Iron, Standard Fitted, Bronze
Silver Nitrate			Liquid End
Slop, Brewery			304, 316, High Silicon Iron
Slop, Distillery			Bronze Liquid End
Soap Liquor			Bronze Liquid End
			All Iron
Soda Ash			See Sodium Carbonate
Sodium Bicarbonate			All Iron, Bronze Liquid End
Sodium Bisulfate			High Silicon, Lead
Sodium Carbonate			All Iron
Sodium Chloride			See Brine, Sodium
Sodium Cyanide			All Iron
Sodium Hydroxide			All Iron
Sodium Hydrosulfite			304, 316, Lead
Sodium Hypochlorite			High Silicon, Stoneware, Lead
Sodium Hyposulfite			See Sodium Thiosulfate
Sodium Nitrate			All Iron, 304
Sodium Phosphate (mono)			Bronze Liquid End, 304
Sodium Phosphate (di)			Bronze Liquid End
Sodium Phosphate (tri)			All Iron
Sodium Phosphate (meto)			304
Sodium Silicate (water glass)			All Iron
Sodium Sulfate			Bronze Liquid End, All Iron
Sodium Sulfide			All Iron, 304
Sodium Sulfite			Bronze Liquid End
Sodium Tetraborate			All Iron
Sodium Thiosulfate			Bronze Liquid End, 304
Stannic Chloride			Hastelloy, High Silicon, Rubber, Stoneware
Stannous Chloride			Hastelloy, High Silicon, Rubber, Stoneware
Starch			Standard Fitted
Stock, Paper			Bronze Liquid End or Std. Fitted, Depending on pH value
Strontium Nitrate			All Iron, 304
Sugar			Bronze Liquid End
Sulfite Liquor (paper mill)			316, Bronze Liquid End
Sulfur	In Water		All Iron, Bronze Liquid End, Ni Resist
Sulfur	Molten		All Iron
Sulfur Chloride	Cold		All Iron, Lead
Syrup			Bronze Liquid End
Tallow		0.90	All Iron
Tanning Liquor			Bronze Liquid End, 304
Tar			All Iron
Tar & Ammonim	In Water		All Iron
Tetraethyl Lead		1.66	Std. Fitted, All Iron
Toluene (Toluol)		0.87	Std. Fitted, All Iron
Trichloroethylene	Moisture Free	1.47	All Iron
Trichloroethylene	Moisture Present	1.47	Bronze Liquid End
Trisodium Phosphate			See Sodium Phosphate (tri)
Turpentine			All Iron, Standard Fitted
Urine			Bronze Liquid End
Varnish			Standard Fitted
Vinegar			Bronze Liquid End, 304
Vitriol, Blue			See Copper Sulfate
Vitriol, Green			See Ferrous Sulfate
Vitriol, Oil of			See Acid, Sulfuric
Vitriol, White			See Zinc Sulfate
Water, Acid Mine			See Acid, Mine Water
Water, Distilled			Bronze Liquid End, Std. Fitted
Water, Fresh			Std. Fitted, Bronze Liquid End
Water, Salt			Bronze Liquid End, All Iron
Water, Sea			Bronze Liquid End, All Iron
Whiskey			Bronze Liquid End, 304
White Liquor			Bronze Liquid End or Std. Fitted
Wine			Depending On pH
Wood Vinegar			Bronze Liquid End, 304
Wort			See Pyroligneous Acid
Xylol (Xylene)		0.87	Standard Fitted, All Iron
Yeast			Bronze Liquid End, Std. Fitted
Zinc Chloride			316, High Silicon Iron
Zinc, Plating Solution			High Silicon Iron, Lead
Zinc Sulfate			Bronze Liquid End, 304

NOTE: **ALL IRON PUMP**—All parts of the pump coming in direct contact with the liquid pumped are to be made of Iron or ferrous metal.

STANDARD FITTED PUMP—Iron Fitted or Bronze Fitted includes cast iron casing, steel shaft, either iron or bronze impeller and usually bronze wearing rings and shaft sleeves (when used).

BRONZE LIQUID END—All parts of the pump coming in direct contact with the liquid pumped are to be made of bronze, with stainless steel fastenings.

PUMP CHARACTERISTICS—COMPARISON

CHARACTERISTICS	ROTARY PUMPS	STRAIGHT CENTRIFUGALS	SELF-PRIMING CENTRIFUGALS
Rotary Pump Advantages / Straight Centrifugal Advantages / Self-Priming Centrifugal Pump Advantages			
Use on Sucton Lifts (Self-Priming)	Excellent (when new)	Auxiliary Equipment Needed	Excellent
Pump Life	Poor on Dry Liquids	Excellent	Excellent
Quiet Operation	No	Yes	Yes
Pressure Relief	Bypass Valve Required	Unnecessary	Unnecessary
Resists Vapor Lock	Yes	No	Yes
Direct Drive Possible	No	Yes	Yes
High Capacity	No	Yes	Yes
H. P. Required	High	Low	Low
High Viscosity	Yes	No	No

ADDED SELF PRIMING CENTRIFUGAL ADVANTAGES

1. Ability to prime with suction lift.
2. Ability to handle air.
3. Ability to handle volatile and dry liquids such as gasoline.

SELF PRIMING CENTRIFUGAL PUMP APPLICATION

Because of its vapor handling and self priming abilities, the self priming centrifugal is ideally suited for applications involving suction lifts, volatile liquids or stripping requirements. These include:

Sump applications
Pumping from Underground Tanks
Stripping a compartment
De-watering applications
Tank Truck Delivery
Unloading Tank Cars
Unloading tank trucks or trailers
Dual operations — loading and unloading
Filter Application
Aviation Refueling

NOTE: *On applications such as unloading tank cars or tank trucks (trailers) a self priming pump is needed even though the source of supply is above the pump. Introduction of air into the suction system occurs frequently from vortex conditions especially when the liquid level is low. This air must be manually relieved before pumping is resumed. In addition, it is next to impossible to strip the tank no matter what air release devices are used (manual or mechanical). In explanation of this, the static head is not high enough to develop the pressure needed to push the air through the suction pipe and pump to the discharge side. The "self primer" is inherently capable of handling some air during pumping and when loss of prime occurs, it is capable to developing the vacuum needed to transfer air to the discharge side to reprime the system.*

AFFINITY LAWS

Effect on centrifugal pumps of change of speed or impeller diameter.

Capacity varies directly as the speed or impeller diameter.
Head varies as the square of the speed or impeller diameter.
BHP varies as the cube of the speed or impeller diameter.

CENTRIFUGAL PUMPS

A centrifugal pump is one that employs centrifugal force for pumping liquids. Liquid entering the eye (center) of the impeller is accelerated by the impeller vanes to a high velocity and is thrown out from the rotating vanes by centrifugal force into an annular channel or volute to the discharge. It differs from the Rotary positive displacement pump in that there is no close internal fit of rubbing or sliding parts.

The self-priming centrifugal pump combines the smooth, quiet and efficient operation of the straight centrifugal pump with the self-priming characteristics of a rotary pump. It will operate on suction lifts where straight centrifugals cannot be used and yet work equally as efficient on flooded suctions as well. For handling volatile liquids or "dry" liquids it is especially desirable. No other pump is as versatile.

STRAIGHT CENTRIFUGAL

This single stage, end suction straight centrifugal pump has an impeller rotating within the volute casing.

SELF PRIMING CENTRIFUGAL

This self-priming pump has an impeller rotating within a stationary diffuser. Air is mixed with liquid at the vane tips during the priming action. When primed, diffuser acts as several volutes.

The diffuser prime action picks up air from the impeller. The air is expelled through the diffuser passageways and escapes by bubbling to the surface of the liquid. Here it is eliminated from the pump system while the reservoir liquid is returned to the impeller tips to capture more air. This action continues very rapidly until all of the air is eliminated at which time the suction line is fully primed and pumping begins. This type of self-priming centrifugal pump retains priming efficiency since there are no recirculating priming valves or pealers to wear.

CENTRIFUGAL PUMP ADVANTAGES

1. Low initial cost
2. Low maintenance cost
3. Extremely long life
4. Reduces weight and size
5. Quietness
6. Greater performance

CONVERSION UNITS

Multiply	By	To Obtain
ACRES	160	Square rods
Acres	4840	Square yards
Acres	43.560	Square feet
ACRES INCHES	27,154	Gallons
ACRES INCH/HR	452	GPM
ATMOSPHERES (STD.) 760 MM of Mercury at 32°F	14.696	Lbs./sq. inch
ATMOSPHERES	76.0	Cms. of mercury
Atmospheres	29.92	Inches of mercury
Atmospheres	33.90	Feet of water
Atmospheres	1.0333	Kgs./sq. cm.
Atmospheres	14.70	Lbs./sq inch
Atmospheres	1.058	Tons/sq. ft.
BARRELS-OIL	42	Gallons-Oil
BARRELS (Beer)	31.5	Gallons
(Wine)	31.0	Gallons
BRIT. THERM. UNITS	0.2520	Kilogram-calories
Brit. Therm. Units	777.5	Foot-lbs.
Brit. Therm. Units	3.927×10^{-4}	Horse-power-hrs.
Brit. Therm. Units	107.5	Kilogram-meters
Brit. Therm. Units	2.928×10^{-4}	Kilowatt-hrs.
B.T.U./MIN	12.96	Foot-lbs./sec.
B.T.U./min	0.02356	Horse-power
B.T.U./min	0.01757	Kilowatts
B.T.U./min	17.57	Watts
CENTARES (CENTIARES)	1	Square meters
CENTIGRAMS	0.01	Grams
CENTILETERS	0.01	Liters
CENTIMETERS	0.3937	Inches
Centimeters	0.03280	Feet
Centimeters	0.01	Meters
Centimeters	10	Millimeters
CENTIMTRS. OF MERC	0.01316	Atmospheres
Centimtrs. of merc	0.4461	Feet of water
Centimtrs. of merc	136.0	Kgs./sq. meter
Centimtrs. of merc	27.85	Lbs./sq. ft.
Centimtrs. of merc	0.1934	Lbs./sq. inch
CENTIMTRS./SECOND	1.969	Feet/min.
Centimtrs./second	0.03281	Feet/sec.
Centimtrs./second	0.036	Kilometers/hr.
Centimtrs./second	0.6	Meters/min.
Centimtrs./second	0.02237	Miles/hr.
Centimtrs./second	3.728×10^{-4}	Miles/min.
CMS./SEC./SEC	0.03281	Feet/sec./sec.
CUBIC CENTIMETERS	3.531×10^{-5}	Cubic feet
Cubic centimeters	6.102×10^{-2}	Cubic inches
Cubic centimeters	10^{-6}	Cubic meters
Cubic centimeters	1.308×10^{-6}	Cubic yards
Cubic centimeters	2.642×10^{-4}	Gallons
Cubic centimeters	10^{-3}	Liters
Cubic centimeters	2.113×10^{-3}	Pints (liq.)
Cubic centimeters	1.057×10^{-3}	Quarts. (liq.)

Multiply	By	To Obtain
CUBIC FEET	2.832×10^{4}	Cubic cms.
Cubic feet	1728	Cubic inches
Cubic feet	0.02832	Cubic meters
Cubic feet	0.03704	Cubic yards
Cubic feet	7.48052	Gallons U.S.
Cubic feet	6.23	Imper. Gallons
Cubic feet	28.32	Liters
Cubic feet	59.84	Pints (liq.)
Cubic feet	29.92	Quarts (liq.)
CUBIC FEET/MINUTE	472.0	Cubic cms./sec.
Cubic feet/minute	0.1247	Gallons/sec.
Cubic feet/minute	0.4720	Liters/sec.
Cubic feet/minute	62.43	Lbs. of water/min.
CUBIC FEET/SECOND	0.646317	Million gals./day
Cubic feet/second	448.831	Gallons/min.
CUBIC FOOT WATER	62.4	Pounds
Cubic foot water	998.8	Ounces
Cubic foot water	28.315	Kilograms
CUBIC INCHES	16.39	Cubic centimeters
Cubic inches	5.787×10^{-4}	Cubic feet
Cubic inches	1.639×10^{-5}	Cubic meters
Cubic inches	2.143×10^{-5}	Cubic yards
Cubic inches	4.329×10^{-3}	Gallons
Cubic inches	1.639×10^{-2}	Liters
Cubic inches	0.03463	Pints (liq.)
Cubic inches	0.01732	Quarts (liq.)
CUBIC METERS	10^{6}	Cubic centimeters
Cubic meters	35.31	Cubic feet
Cubic meters	61,023	Cubic inches
Cubic meters	1.308	Cubic yards
Cubic meters	264.2	Gallons U.S.
Cubic meters	220	Imperial Gallons
Cubic meters	10^{3}	Liters
Cubic meters	2113	Pints (liq.)
Cubic meters	1057	Quarts (liq.)
CUBIC YARDS	7.646×10^{5}	Cubic centimeters
Cubic yards	27	Cubic feet
Cubic yards	46,656	Cubic inches
Cubic yards	0.7646	Cubic meters
Cubic yards	202.0	Gallons
Cubic yards	764.6	Liters
Cubic yards	1616	Pints (liq.)
Cubic yards	807.9	Quarts (liq.)
CUBIC YARDS/MIN	0.45	Cubic feet/sec.
Cubic yards/min	3.367	Gallons/sec.
Cubic yards/min	12.74	Liters/sec.
DECIGRAMS	0.1	Grams
DECILITERS	0.1	Liters
DECIMETERS	0.1	Meters
DEGREES (ANGLE)	60	Minutes
Degrees (angle)	0.01745	Radians
Degrees (angle)	3600	Seconds
DEGREES/SEC	0.01745	Radians/sec.
Degrees/sec	0.1667	Revolutions/min.
Degrees/sec	0.002778	Revolutions/sec.
DEKAGRAMS	10	Grams

CONVERSION UNITS

Multiply	By	To Obtain
DEKALITERS	10	Liters
DEKAMETERS	10	Meters
DRAMS	27.34375	Grains
Drams	0.0625	Ounces
Drams	1.771845	Grams
FATHOMS	6	Feet
FEET	30.48	Centimeters
Feet	12	Inches
Feet	0.3048	Meters
Feet	1/3	Yards
FEET OF WATER	0.02950	Atmospheres
Feet of water	0.8826	Inches of mercury
Feet of water	0.03048	Kgs./sq. cm.
Feet of water	62.43	Lbs./sq. ft.
Feet of water	0.4335	Lbs./sq. inch
FEET/MIN	0.5080	Centimeters/sec.
Feet/min	0.01667	Feet/sec.
Feet/min	0.01829	Kilometers/hr.
Feet/min	0.3048	Meters/min.
Feet/min	0.01136	Miles/hr.
FEET/SEC./SEC	30.48	Cms./sec./sec.
Feet/sec./sec	0.3048	Meters/sec./sec.
FOOT-POUNDS	1.286×10^{-3}	Br. Thermal Units
Foot-pounds	5.050×10^{-7}	Horse-power-hrs.
Foot-pounds	3.241×10^{-4}	Kilogram-calories
Foot-pounds	0.1383	Kilogram-meters
Foot-pounds	3.766×10^{-7}	Kilowatt-hrs.
FOOT-POUNDS/MIN	1.286×10^{-3}	B. T. Units/min.
Foot-pounds/min	0.01667	Foot-pounds/sec.
Foot-pounds/min	3.030×10^{-5}	Horse-power
Foot-pounds/min	3.241×10^{-4}	Kg.-calories/min.
Foot-pounds/min	2.260×10^{-5}	Kilowatts
FOOT-POUNDS/SEC	7.717×10^{-2}	B. T. Units/min.
Foot-pounds/sec	1.818×10^{-3}	Horse-power
Foot-pounds/sec	1.945×10^{-2}	Kg.-calories/min.
Foot-pounds/sec	1.356×10^{-3}	Kilowatts
GALLONS	3785	Cubic centimeters
Gallons	0.1337	Cubic feet
Gallons	231	Cubic inches
Gallons	3.785×10^{-3}	Cubic meters
Gallons	4.951×10^{-3}	Cubic yards
Gallons	128	Fluid ounces
Gallons	3.785	Liters
Gallons	8	Pints (liq.)
Gallons	4	Quarts (liq.)
GALLONS, IMPERIAL	1.20095	U.S. Gallons
Gallons, U.S.	0.83267	Imperial gallons
Gallons Imperial	277.3	Cubic inches
Gallons Imperial	0.16	Cubic foot
Gallons Imperial	4.546	Liters
Gallons Imperial	0.00454	Cubic meter
GALLONS WATER	8.3453	Pounds of water
GALS. WATER (U.S.)	3.785	Kilograms
GALS. WATER (IMP.)	10.02	Pounds
Gals. water (Imp.)	4.54	Kilograms
GALLONS/MIN	2.228×10^{-3}	Cubic feet/sec.
Gallons/min	0.06308	Liters/sec.
Gallons/min	8.0208	Cu. ft./hr.
GALLONS WATER/MIN.	6.0086	Tons water/24 hrs.
GRAINS (TROY)	1	Grains (avoir.)
Grains (troy)	0.06480	Grams
Grains (troy)	0.04167	Pennyweights (troy)
Grains (troy)	2.0833×10^{-3}	Ounces (troy)
GRAINS/U.S. GAL	17.118	Parts/million
Grains/U.S. gal	142.86	Lbs./million gal.
GRAINS/IMP. GAL	14.286	Parts/million
GRAMS	980.7	Dynes
Grams	15.43	Grains
Grams	10^{-3}	Kilograms
Grams	10^{3}	Milligrams
Grams	0.03527	Ounces
Grams	0.03215	Ounces (troy)
Grams	2.205×10^{-3}	Pounds
GRAMS/CM	5.600×10^{-3}	Pounds/inch
GRAMS/CU. CM	62.43	Pounds/cubic foot
Grams/cu. cm	0.03613	Pounds/cubic inch
GRAMS/LITER	58.417	Grains/gal.
Grams/liter	8.345	Pounds/1000 gals.
Grams/liter	0.062427	Pounds/cubic foot
Grams/liter	1000	Parts/million
HECTOGRAMS	100	Grams
HECTOLITERS	100	Liters
HECTOMETERS	100	Meters
HECTOWATTS	100	Watts
HORSE-POWER	42.44	B. T. Units/min.
Horse-power	33,000	Foot-lbs./min.
Horse-power	550	Foot-lbs./sec.
Horse-power	1.014	H-power (Metric)
Horse-power	10.70	Kg.-calories/min.
Horse-power	0.7457	Kilowatts
Horse-power	745.7	Watts
HORSE-POWER (BOILER)	33,479	B. T. U./hr.
Horse-power (boiler)	9.803	Kilowatts
HORSE-POWER-HOURS	2547	Br. Thermal Units
Horse-power-hours	1.98×10^{6}	Foot-lbs.
Horse-power-hours	641.7	Kilogram-calories
Horse-power-hours	2.737×10^{5}	Kilogram-meters
Horse-power-hours	0.7457	Kilowatt-hours
INCHES	2.540	Centimeters
Inches	25.4	Millimeters
Inches	.0254	Meters
Inches	.0833	Foot
INCHES OF MERCURY	0.03342	Atmospheres
Inches of mercury	1.133	Feet of water

CONVERSION UNITS

Multiply	By	To Obtain
Inches of mercury	0.03453	Kgs./sq. cm.
Inches of mercury	70.73	Lbs./sq. ft.
Inches of mercury	0.4912	Lbs./sq. inch
INCHES OF WATER	0.002458	Atmospheres
Inches of water	0.07355	Inches of mercury
Inches of water	0.002540	Kgs./sq. cm.
Inches of water	0.5781	Ounces/sq. inch
Inches of water	5.202	Lbs./sq. foot
Inches of water	0.03613	Lbs./sq. inch
KILOGRAMS	980,665	Dynes
Kilograms	2.205	Lbs.
Kilograms	1.102×10^{-3}	Tons (short)
Kilograms	10^{3}	Grams
KGS./METER	0.6720	Lbs./foot
KGS./SQ. CM.	0.9678	Atmospheres
Kgs./sq. cm.	32.81	Feet of water
Kgs./sq. cm.	28.96	Inches of mercury
Kgs./sq. cm.	2048	Lbs./sq. foot
Kgs./sq. cm.	14.22	Lbs./sq. inch
KGS./SQ. MILLIMETER	10^{6}	Kgs./sq. meter
KILOLITERS	10^{3}	Liters
KILOMETERS	10^{5}	Centimeters
Kilometers	3281	Feet
Kilometers	10^{3}	Meters
Kilometers	0.6214	Miles
Kilometers	1094	Yards
KILOMETERS/HR.	27.78	Centimeters/sec.
Kilometers/hr.	54.68	Feet/min.
Kilometers/hr.	0.9113	Feet/sec.
Kilometers/hr.	0.5396	Knots
Kilometers/hr.	16.67	Meters/min.
Kilometers/hr.	0.6214	Miles/hr.
KMS./HR./SEC.	27.78	Cms./sec./sec.
Kms./hr./sec.	0.9113	Ft./sec./sec.
Kms./hr./sec.	0.2778	Meters/sec./sec.
KILOWATTS	56.92	B. T. Units/min.
Kilowatts	4.425×10^{4}	Foot-lbs./min.
Kilowatts	737.6	Foot-lbs./sec.
Kilowatts	1.341	Horse-power
Kilowatts	14.34	Kg.-calories/min.
Kilowatts	10^{3}	Watts
KILOWATT-HOURS	3415	Br. Thermal Units
Kilowatt-hours	2.655×10^{6}	Foot-lbs.
Kilowatt-hours	1.341	Horse-power-hrs.
Kilowatt-hours	860.5	Kilogram-calories
Kilowatt-hours	3.671×10^{5}	Kilogram-meters
LITERS	10^{3}	Cubic centimeters
Liters	0.03531	Cubic feet
Liters	61.02	Cubic inches
Liters	10^{-2}	Cubic meters
Liters	1.308×10^{-3}	Cubic yards
Liters	0.2642	Gallons
Liters	2.113	Pints (liq.)
Liters	1.057	Quarts (liq.)
LITERS/MIN.	5.886×10^{-4}	Cubic/ft./sec.
Liters/min.	4.403×10^{-3}	Gals./sec.

Multiply	By	To Obtain
LUMBER WIDTH (IN.) X THICKNESS (IN.)	Length (ft.) / 12	Board Feet
METERS	100	Centimeters
Meters	3.281	Feet
Meters	39.37	Inches
Meters	10^{-3}	Kilometers
Meters	10^{3}	Millimeters
Meters	1.094	Yards
METERS/MIN.	1.667	Centimeters/sec.
Meters/min.	3.281	Feet/min.
Meters/min.	0.05468	Feet/sec.
Meters/min.	0.06	Kilometers/hr.
Meters/min.	0.03728	Miles/hr.
METERS/SEC.	196.8	Feet/min.
Meters/sec.	3.281	Feet/sec.
Meters/sec.	3.6	Kilometers/hr.
Meters/sec.	0.06	Kilometers/min.
Meters/sec.	2.237	Miles/hr.
Meters/sec.	0.03728	Miles/min.
METRIC TONS	2204.6	Pounds
Metric tons	1.1023	Short tons
MICRONS	10^{-6}	Meters
MILES	1.609×10^{5}	Centimeters
Miles	5280	Feet
Miles	1.609	Kilometers
Miles	1760	Yards
MILES/HR.	44.70	Centimeters/sec.
Miles/hr.	88	Feet/min.
Miles/hr.	1.467	Feet/sec.
Miles/hr.	1.609	Kilometers/hr.
Miles/hr.	0.8684	Knots
Miles/hr.	26.82	Meters/min.
MILES/MIN.	2682	Centimeters/sec.
Miles/min.	88	Feet/sec.
Miles/min.	1.609	Kilometers/min.
Miles/min.	60	Miles/hr.
MILLIERS	10^{3}	Kilograms
MILLIGRAMS	10^{-3}	Grams
MILLILITERS	10^{-3}	Liters
MILLIMETERS	0.1	Centimeters
Millimeters	0.03937	Inches
MILLIGRAMS/LITER	1	Parts/million
MILLION GALS./DAY	1.54723	Cubic ft./sec.
MINER'S INCHES	1.5	Cubic ft./min.
Miner's inches (Arizona, Cal., Mont., Nevada, Oregon)	11.25	G.P.M.

CONVERSION UNITS

Multiply	By	To Obtain
(Idaho, Kansas, Neb., N.M., N.D., S.D., Utah)	9	G.P.M.
MINUTES (ANGLE)	2.909×10^{-4}	Radians
OUNCES	16	Drams
Ounces	137.5	Grains
Ounces	0.0625	Pounds
Ounces	28.349527	Grams
Ounces	0.9115	Ounces (troy)
Ounces	2.790×10^{-5}	Tons (long)
Ounces	2.835×10^{-5}	Tons (metric)
OUNCES, TROY	480	Grains
Ounces, troy	20	Pennywghts. (troy)
Ounces, troy	0.08333	Pounds (troy)
Ounces, troy	31.103481	Grams
Ounces, troy	1.09714	Ounces, avoir.
OUNCES (FLUID)	1.805	Cubic inches
Ounces (fluid)	0.02957	Liters
OUNCES/SQ. INCH	0.0625	Lbs./sq. inch
PARTS/MILLION	0.0584	Grains/U.S. gal.
Parts/million	0.07016	Grains/Imp. gal.
Parts/million	8.345	Lbs./million gal.
PENNYWGHTS. (TROY)	24	Grains
Pennywghts. (troy)	1.55517	Grams
Pennywghts. (troy)	0.05	Ounces (troy)
Pennywghts. (troy)	4.1667×10^{-3}	Pounds (troy)
PINTS	0.4732	Liter
POUNDS (AVOIR.)	16	Ounces
Pounds (avoir.)	256	Drams
Pounds (avoir.)	7000	Grains
Pounds (avoir.)	0.0005	Tons (short)
Pounds (avoir.)	453.5924	Grams
Pounds (avoir.)	1.21528	Pounds (troy)
Pounds (avoir.)	14.5833	Ounces (troy)
Pounds (avoir.)	0.454	Kilograms
POUNDS (TROY)	5760	Grains
Pounds (troy)	240	Pennywghts. (troy)
Pounds (troy)	12	Ounces (troy)
Pounds (troy)	373.24177	Grams
Pounds (troy)	0.822857	Pounds (avoir.)
Pounds (troy)	13.1657	Ounces (avoir.)
Pounds (troy)	3.6735×10^{-4}	Tons (long)
Pounds (troy)	4.1143×10^{-4}	Tons (short)
Pounds (troy)	3.7324×10^{-4}	Tons (metric)
POUNDS OF WATER	0.01602	Cubic feet
Pounds of water	27.68	Cubic inches
Pounds of water	0.1198	Gallons
Pounds of water	0.10	Imp. gallon
LBS. OF WATER/MIN.	2.670×10^{-4}	Cubic ft./sec.
POUNDS/CUBIC FOOT	0.01602	Grams/cubic cm.
Pounds/cubic foot	16.02	Kgs./cubic meter
Pounds/cubic foot	5.787×10^{-4}	Lbs./cubic inch
POUNDS/CUBIC INCH	27.68	Grams/cubic cm.
Pounds/cubic inch	2.768×10^{4}	Kgs./cubic meter
Pounds/cubic inch	1728	Lbs./cubic foot
POUNDS/FOOT	1.488	Kgs./meter
Pounds/inch	178.6	Grams/cm.
POUNDS/SQ. FOOT	0.01602	Feet of water
Pounds/sq. foot	4.883×10^{-4}	Kgs./sq. cm.
Pounds/sq. foot	6.945×10^{-3}	Pounds/sq. inch
POUNDS/SQ. INCH	0.06804	Atmospheres
Pounds/sq. inch	2.307	Feet of water
Pounds/sq. inch	2.036	Inches of mercury
Pounds/sq. inch	0.07031	Kgs./sq. cm.
QUARTS (DRY)	67.20	Cubic inches
QUARTS (LIQ.)	57.75	Cubic inches
QUINTAL, ARGENTINE	101.28	Pounds
Quintal, Brazil	129.54	Pounds
Quint., Castile, Peru	101.43	Pounds
Quintal, Chile	101.41	Pounds
Quintal, Mexico	101.47	Pounds
Quintal, Metric	220.46	Pounds
$\frac{1}{\text{SQ. FT./GAL./MIN.}}$	8.0208	Overflow rate (ft./hr.)
TEMP. (°C.)+273	1	Abs. temp. (°C.)
Temp. (°C.)+17.78	1.8	Temp. (°F.)
Temp. (°F.)+460	1	Abs. temp. (°F.)
Temp. (°F.)−32	5/9	Temp. (°C.)
TONS (LONG)	1016	Kilograms
Tons (long)	2240	Pounds
Tons (long)	1.12000	Tons (short)
TONS (METRIC)	10^{3}	Kilograms
Tons (metric)	2205	Pounds
TONS (SHORT)	2000	Pounds
Tons (short)	32000	Ounces
Tons (short)	907.18486	Kilograms
Tons (short)	2430.56	Pounds (troy)
Tons (short)	0.89287	Tons (long)
Tons (short)	29166.66	Ounces (troy)
Tons (short)	0.90718	Tons (metric)
TONS OF WATER/24 HRS.	83.333	Pounds water/hr.
Tons of water/24 hrs.	0.16643	Gallons/min.
Tons of water/24 hrs.	1.3349	Cu. ft./hr.
WATTS	0.05692	B. T. Units/min.
Watts	44.26	Foot-pounds/min.
Watts	0.7376	Foot-pounds/sec.
Watts	1.341×10^{-3}	Horse-power
Watts	0.01434	Kg.-calories/min.
Watts	10^{-3}	Kilowatts
WATT-HOURS	3.415	Br. Thermal Units
Watt-hours	2655	Foot-pounds
Watt-hours	1.341×10^{-3}	Horse-power hrs.
Watt-hours	0.8605	Kilogram-calories
Watt-hours	367.1	Kilogram-meters
Watt-hours	10^{-3}	Kilowatt-hours

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October 2010