Blackmer®

Bulletin 33

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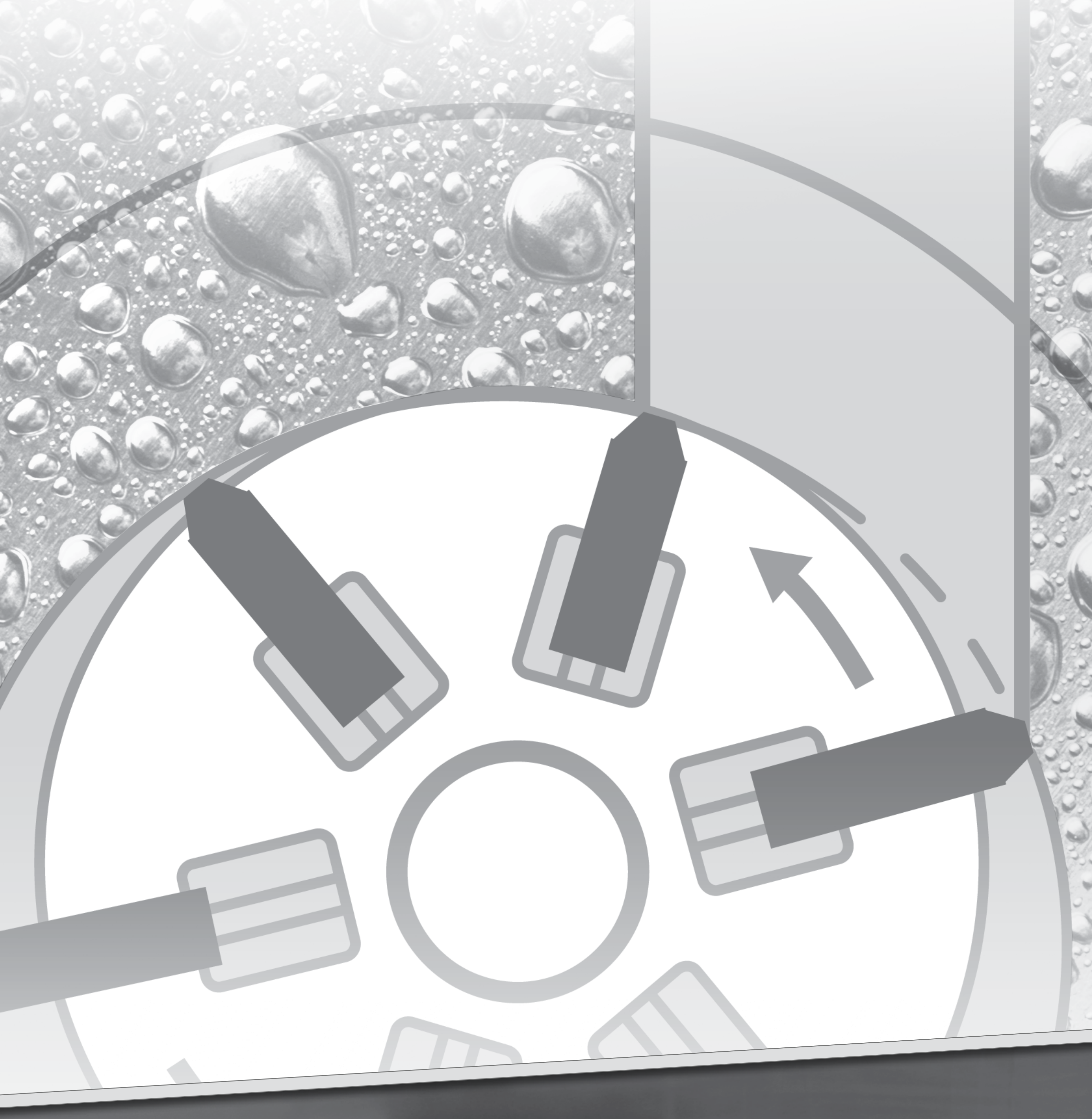
Hydraulic Data For Pump Applications

For Blackmer Positive Displacement Sliding Vane Pumps



HYDRAULIC DATA

This HYDRAULIC DATA BULLETIN was compiled by Blackmer's Engineering Department as an aid to operators, engineers, maintenance supervisors, equipment distributors, sales engineers, and Blackmer customers for planning installations of positive displacement rotary pumps. The Pipe Friction Curves were reprinted from the ENGINEERING DATA BOOK, First Edition, copyrighted 1979 by the Hydraulic Institute.

Blackmer Sales Offices, Distributors, and Application Engineers are available for assistance and recommendations in planning specific applications. Although this bulletin is not for sale, additional copies are available to all Blackmer customers.

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Planning for a satisfactory and economical pump installation involves the two basic items of (1) selecting the proper type, size and speed of pumping equipment and (2) making a careful study of the suction and discharge conditions, including all details of the piping layout.

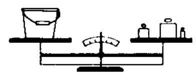
The proper selection of pumping equipment must consider all of the application conditions to include these important factors. For specific selection of Blackmer Positive Displacement Rotary Pumps, please refer to our individual Pump Characteristic Curves.

How much flow?

1.
Approximate DELIVERY required in gallons per minute (G.P.M.).

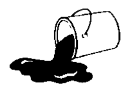
How much push?

2.
Differential PRESSURE required in pounds per square inch (psi).



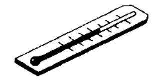
How heavy?

3.
Specific GRAVITY of the liquid.



How thick?

4.
Maximum VISCOSITY of the liquid in Seconds Saybolt Universal (SSU).



How hot?

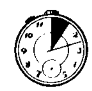
5.
Pumping TEMPERATURE of the liquid in degrees Fahrenheit.

How much pull?

6.
SUCTION conditions when pumping in inches of mercury for vacuum, or psi for pressure.

What liquid?

7.
Type of LIQUID to be handled.



How long?

8.
Type of SERVICE, i.e. intermittent duty, semi-continuous duty, or continuous duty.

DEFINITIONS of HYDRAULIC TERMS

The Hydraulic Institute has made a study of hydraulic terms in an effort to establish standardization of definitions. Their recommendations are as follows:

Head — is the hydraulic pressure and is expressed in pounds-per-square-inch (psi) gauge using atmospheric pressure as the datum. It can be determined by use of pressure gauges or can be computed by using pipe friction tables and static head measurements.

Frictional Head — is the hydraulic pressure exerted to overcome frictional resistance of a piping system to the liquid flowing through it.

Static Suction Lift — is the hydraulic pressure be low atmospheric at the intake port with the liquid at rest. It is usually expressed in or converted to inches of mercury (Hg) vacuum.

Total Suction Lift — is the total hydraulic pressure below atmospheric at the intake port with the pump in operation (the sum of the static suction lift and the friction head of the suction piping).

Flooded Suction — is a very indefinite term which has been carelessly used for so many years that its meaning is no longer clear. More often than not, it merely indicates that suction conditions have not been accurately determined. One point to remember is that a static suction head may become a suction lift when the pump goes into operation.

Total Suction Head — is the hydraulic pressure above atmospheric at the intake port with the pump in operation (the difference between the static suction head and the friction head of the suction piping).

Static Discharge Head — is the hydraulic pressure exerted at the pump discharge by the liquid at rest, commonly measured as the difference in elevation between the pump discharge port and the delivery port.

Total Discharge Head — is the total hydraulic pressure at the discharge port with the pump in operation (the sum of the static discharge head and the friction head of the discharge piping).

Total Pumping Head (or Dynamic Head) — is the sum of the total discharge head and the total suction lift; or the difference between the total discharge head and the total suction head.

Head Expressed in Feet — although the foregoing definitions refer to the "head" as expressed in psi, it is also proper to specify the total pumping head in feet of liquid or feet of water. Conversions can be made between these expressions of psi to feet (See chart on Page 6), but since there will normally be an appreciable difference between the feet of head of a particular liquid and the feet of head of water, it is extremely important to specify which term is being used.

COMPUTING SUCTION & DISCHARGE CONDITIONS

Two methods are outlined in this bulletin for computing suction and discharge conditions: (1) by using the direct-reading charts for quick preliminary computations, and (2) by using the Intake and Discharge Analysis Form (Page 12) in conjunction with the Hydraulic Institute friction loss curves (Pages 13 thru 19).

FIRST PROCEDURE (using the direct-reading charts)

Total Suction Lift

(1) Given the maximum static lift in feet, determine the static vacuum in inches of mercury (Hg) from chart at top of Page 5.

(2) Compute total equivalent length of pipe in suction line by using the chart on Page 11.

(3) Read friction loss in inches of mercury per 100 ft. of pipe from the direct reading charts (Pages 7 thru 10). Multiply this value by the total equivalent length of pipe and divide by 100.

(4) Add this friction loss to the static suction lift to obtain the total suction lift.

Total Discharge Head

(1) Follow the same procedure as in steps 1 and 2 above but refer to static discharge head chart on Page 6.

(2) Refer to the direct-reading charts as in step 3 above, but read friction loss from the psi column.

(3) Add this friction loss to the static discharge head to obtain the total discharge head.

example

DATA

Liquid to be pumped............gasoline
Gallons per minute 90
Static suction lift. ....10' liquid
Suction line..........................43' of 2½" pipe, with one 2½" elbow
Static discharge head...........40' liquid
Discharge line......................80' of 2" pipe, with 5 elbows

SUCTION

1. From static lift chart (p. 5), 10' lift=6.4 in. Hg 6.4 in. Hg
2. Total equivalent length suction pipe (from page 11) =43'+7' = 50''
3. From Table (Page 8), friction per 100' = 3.7 in. Hg
4. Frictional head of suction piping $\frac{50 \times 3.7}{100}$ = 1.9 in. Hg <u>1.9 in. Hg</u>

Total suction lift 8.3 in. Hg

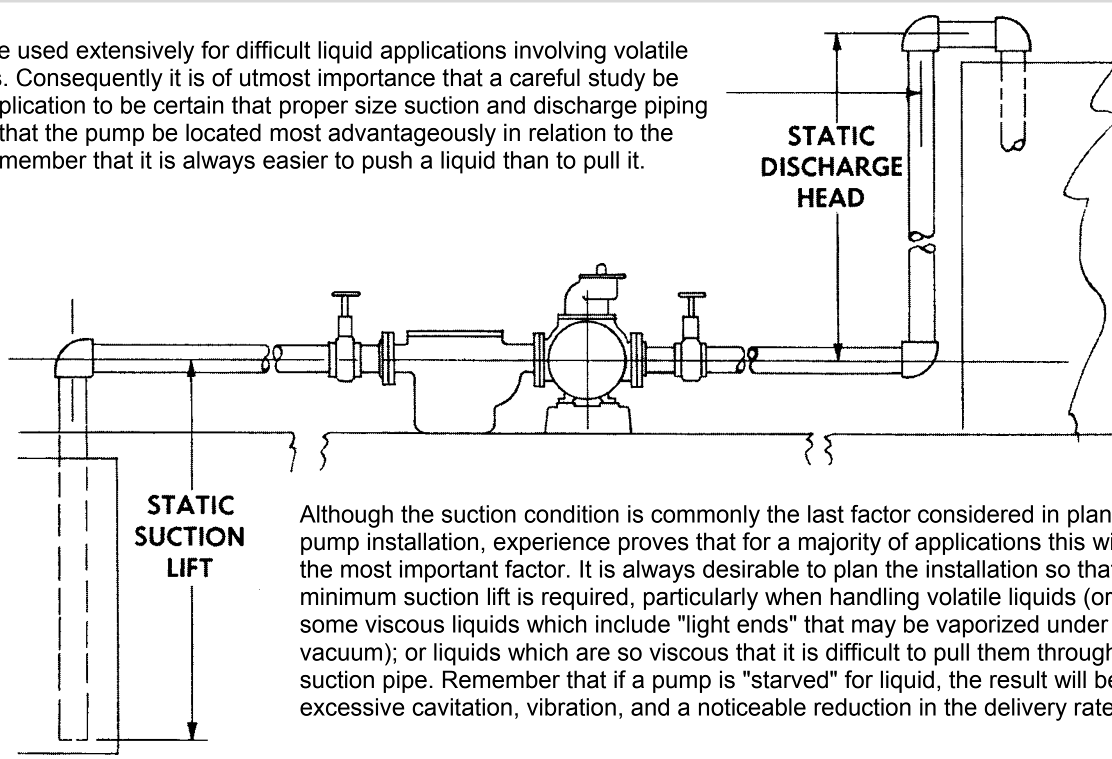
DISCHARGE

1. From static head chart (Page 6), 40' head = 12.5 psi 12.5 psi
2. Total equivalent length discharge pipe (from page 11) = 80 + (5 x 5)=105'
3. From table (Page 8), friction per 100' = 4.4 psi
4. Frictional head of discharge piping $\frac{105 \times 4.4}{100}$ = 4.6 psi 4.6 psi
5. Total discharge head 17.1 psi

NOTE: To determine the required horsepower, first convert the total suction lift from in. Hg to psi (using the pressure conversion factors on page 21). Then add this value to the total discharge head to obtain the total pumping or dynamic head, from which the required horsepower can be determined using Blackmer Characteristic Curves printed separately.

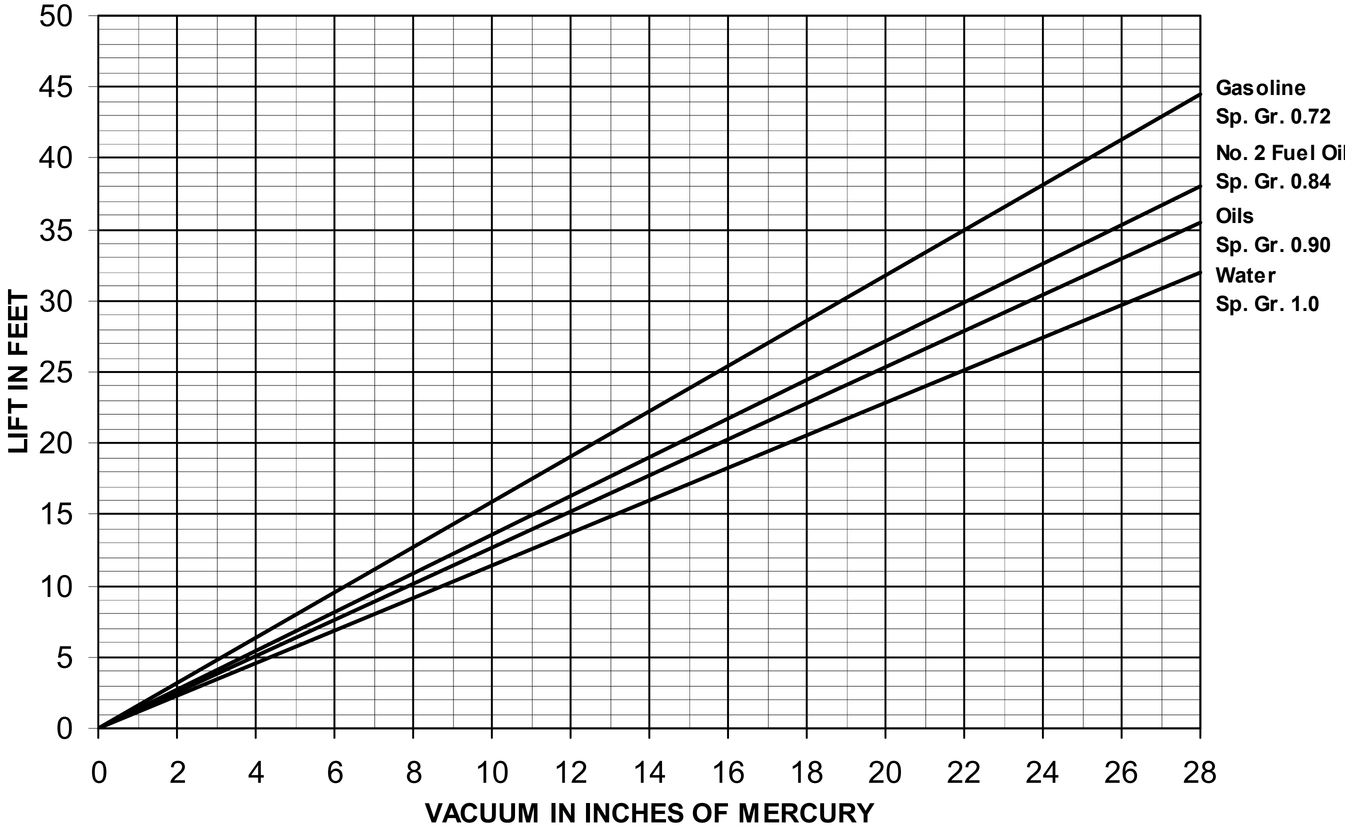
TYPICAL ROTARY PUMP INSTALLATION

Rotary pumps are used extensively for difficult liquid applications involving volatile or viscous liquids. Consequently it is of utmost importance that a careful study be made of each application to be certain that proper size suction and discharge piping will be used and that the pump be located most advantageously in relation to the liquid source. Remember that it is always easier to push a liquid than to pull it.



Although the suction condition is commonly the last factor considered in planning a pump installation, experience proves that for a majority of applications this will be the most important factor. It is always desirable to plan the installation so that a minimum suction lift is required, particularly when handling volatile liquids (or even some viscous liquids which include "light ends" that may be vaporized under vacuum); or liquids which are so viscous that it is difficult to pull them through a suction pipe. Remember that if a pump is "starved" for liquid, the result will be excessive cavitation, vibration, and a noticeable reduction in the delivery rate.

STATIC LIFT CONVERSION CHART



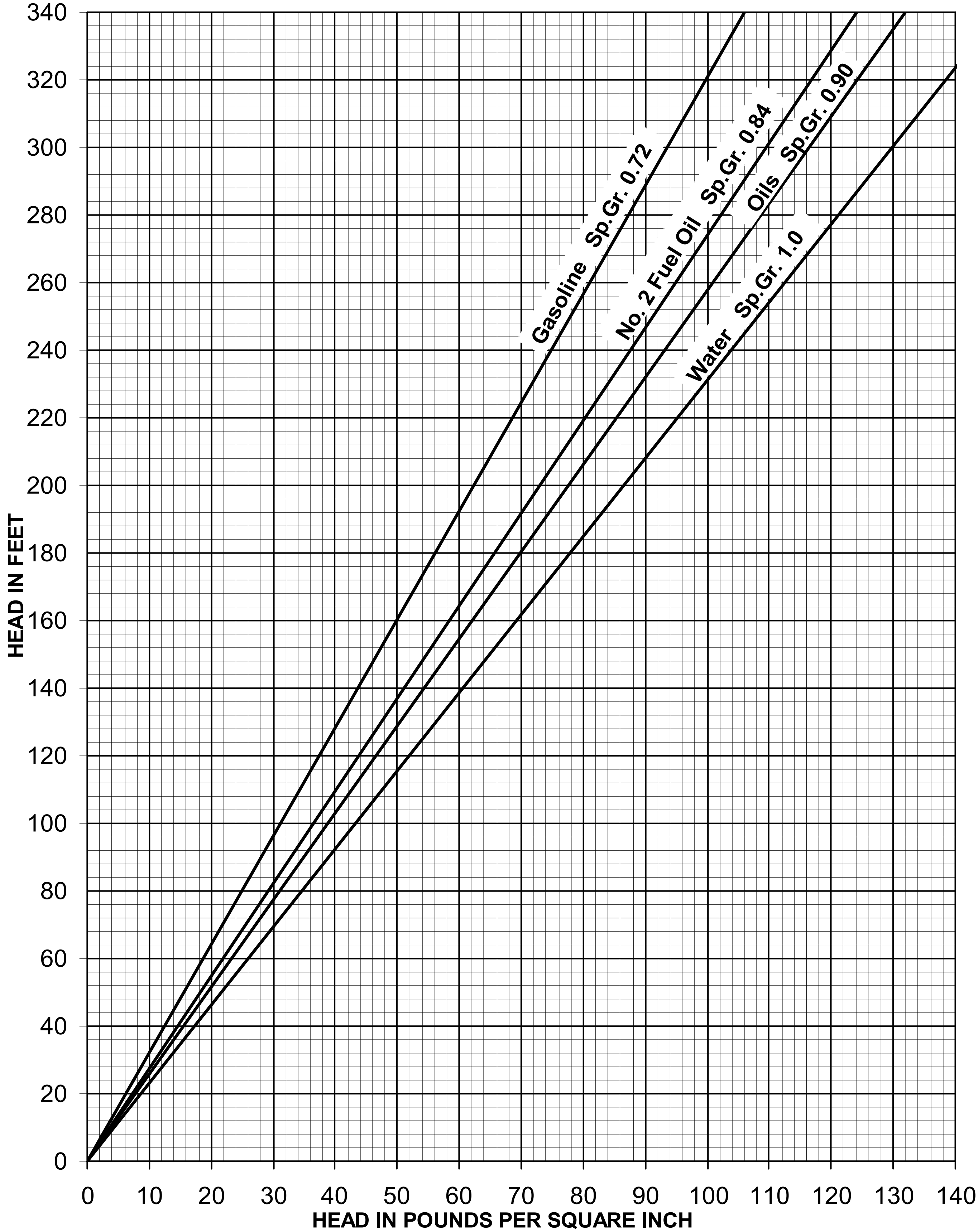
FRICTION LOSS in SMOOTH-BORE RUBBER HOSE

Values represent equivalent loss in PSI per 100 feet of hose

U.S. Gal. Per Min.	ACTUAL INSIDE DIAMETER IN INCHES							
	¾	1	1¼	1½	2	2½	3	4
15	30.0	8.9	2.5	1.1	0.4	0.1		
20	53.0	14.0	4.3	1.8	0.7	0.2		
25	79.0	22.0	6.5	2.9	1.0	0.3		
30	112.0	31.0	9.2	4.0	1.4	0.4	0.1	
40		53.0	15.0	6.7	2.4	0.6	0.3	
50		80.0	24.0	10.0	3.6	1.0	0.5	
60		101.0	35.0	14.0	5.1	1.4	0.6	
70			45.0	19.0	6.6	1.8	0.8	
80			58.0	24.0	8.6	2.3	1.1	
90			71.0	30.0	11.0	3.0	1.4	0.3
100			88.0	37.0	12.5	3.5	1.7	0.4
125			132.0	55.0	20.0	5.3	2.5	0.6
150			183.0	78.0	27.0	7.5	3.5	0.7
175				100.0	37.0	10.0	4.6	1.1
200				133.0	46.0	13.0	5.9	1.4
250					70.0	19.0	9.1	2.1
300					95.0	27.0	12.0	2.9
350					126.0	36.0	17.0	4.0
400						46.0	21.0	5.1
500						70.0	32.0	7.4
600						105.0	46.0	10.0
700						148.0	62.0	13.0
800						190.0	79.0	17.0
900							97.0	22.0
1000							116.0	27.0
1250							170.0	43.0
1500							226.0	61.0
1750								80.0
2000								100.0

Note: Data shown is for liquid having specific gravity of 1 and a viscosity of 30 SSU.

STATIC HEAD CONVERSION CHART



DIRECT-READING FRICTION TABLES

HOW TO USE THE FRICTION TABLES: These tables, based on data from the Standards of the Hydraulic Institute, show the friction loss (in PSI or inches of Mercury) for 100 feet of pipe. Values in the white area are proportional to GPM and viscosity and may be interpolated. Values in the shaded area are for new pipe only. (Multiply by 1.4 to calculate losses for 15-year-old pipe.) **IMPORTANT:** Note that sample liquids at the top of each column have different specific gravities. In all cases, be sure to divide the friction loss by the specific gravity of the sample liquid and multiply it by the specific gravity of the liquid being transferred. For example, the friction loss per hundred feet of 2-inch pipe when pumping a liquid of 2000 SSU at 100 GPM would be half way between 28.8 PSI (the loss for 1000 SSU) and 86.4 PSI (the loss for 3000 SSU) or in other words 57.6 PSI ... if the liquid had a specific gravity of .9. However, if the liquid had a specific gravity of say 1.1, then the friction loss per hundred feet would be 57.6 divided by .9 and multiplied by 1.1, or 70.4 PSI.

PIPE SIZE	GPM	GASOLINE SP. GR. .72		WATER SP. GR. 1		NO. 2 FUEL OIL SP. GR. .84 50 SSU		OIL SP. GR. .9 500 SSU		OIL SP. GR. .9 1000 SSU		OIL SP. GR. .9 3000 SSU	
		PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.
½"	2	1.3	2.7	2.1	4.3	2.3	4.7	35.5	73	71	145	213	435
	4	4.8	9.8	7.6	15.5	8.8	18.0	71.0	145	145	296	435	888
	6	10.8	22.1	16.5	33.7	18.5	37.8	107.0	219	216	442	648	1326
	8	18.5	37.8	28.0	57.2	31.0	63.5	145.0	296	280	572	840	1716
	10	28.8	58.9	42.0	85.8	46.0	94.0	175.0	358	355	725	1065	2175
¾"	5	1.8	3.7	2.8	5.7	3.4	7.0	29	59	57	117	170	348
	10	6.7	13.7	10.2	20.9	11.5	23.5	57	117	117	239	351	718
	15	15.2	31.1	22.0	45.0	25.0	51.1	87	178	170	348	510	1042
	20	26.0	53.1	39.0	80.0	42.0	86.0	117	239	230	470	690	1410
1"	5	0.6	1.2	0.8	1.6	1.0	2.0	10.8	22.0	21.6	44.0	64.8	132.3
	10	2.1	4.3	2.7	5.5	3.6	7.3	21.6	44.0	43.2	88.2	129.6	264.6
	15	4.4	9.0	6.5	13.3	7.6	15.5	32.4	66.1	64.8	132.3	194.4	396.9
	20	7.9	16.1	11.5	23.5	12.6	27.7	43.2	88.2	86.4	176.4	259.2	529.2
	25	11.9	24.3	17.3	35.3	18.9	38.6	54.0	110.2	108.0	220.5	324.0	661.5
	30	17.6	35.9	25.0	51.0	26.9	54.9	64.8	132.3	129.6	264.6	388.8	793.8
	35	23.0	47.0	33.0	67.4	35.3	72.1	75.6	154.3	151.2	308.7	453.6	926.1
	40	30.6	62.5	43.0	87.8	44.5	90.9	86.4	176.4	172.8	352.8	518.4	1058.4
1¼"	5	0.1	0.4	0.2	0.4	0.3	0.6	3.6	7.3	7.2	14.7	21.6	44.1
	10	0.5	1.0	0.8	1.6	1.0	2.0	7.2	14.7	14.4	29.4	43.2	88.2
	15	1.2	2.4	1.7	3.5	2.0	4.1	10.8	22.0	21.6	44.1	64.8	132.3
	20	2.0	4.1	2.8	5.7	3.4	6.9	14.4	29.4	28.8	58.8	86.4	176.4
	25	3.0	6.1	4.3	8.8	5.0	10.2	18.0	36.7	36.0	73.5	108.0	220.5
	30	4.2	8.6	6.0	12.2	7.1	14.5	21.6	44.1	43.2	88.2	129.6	264.6
	35	5.8	11.8	8.2	16.7	9.5	19.4	25.2	51.4	50.4	102.9	151.2	308.7
	40	7.6	15.5	11.0	22.4	11.8	24.1	28.8	58.8	57.6	117.6	172.8	352.8
	45	9.4	19.2	13.5	27.6	14.7	30.0	32.4	66.1	64.8	132.3	196.4	401.0
	50	11.5	23.5	16.3	33.2	17.6	35.9	36.0	73.5	72.0	147.0	216.0	441.0
	60	16.6	33.9	23.0	47	24.4	50	45.0	91.9	90.0	183.7	270.0	551.2
	70	22.3	45.6	31.0	63	32.0	65	54	111	101	207	303	620
	80	28.8	59	40.0	82	40	82	72	147	115	235	345	705
	90	36.0	74	50.0	102	50	102	89	182	129	264	387	790
1½"	5	0.1	0.2	0.1	0.2	0.1	0.2	2.0	4.1	4.5	8.2	12.0	24.5
	10	0.2	0.6	0.4	0.8	0.5	1.0	4.0	8.2	8.0	16.3	24.0	49.0
	15	0.5	1.0	0.8	1.6	0.9	1.8	5.9	12.2	12.0	24.0	36.0	73.5
	20	0.9	1.8	1.3	2.7	1.6	3.3	8.1	16.3	16.0	32.6	48.0	98.0
	25	1.4	2.9	2.0	4.2	2.3	4.7	10.0	20.4	20.0	40.8	60.0	122.5
	30	2.0	3.9	2.9	5.9	3.3	6.9	12.0	24.5	24.0	49.0	72.0	147.0
	35	2.6	5.2	3.7	7.5	4.2	8.6	14.0	28.6	28.0	57.2	84.0	171.5
	40	3.3	6.7	4.8	9.8	5.5	11.2	16.0	32.6	32.0	65.3	96.0	196.0
	45	4.2	8.6	6.0	12.2	6.7	13.7	18.0	36.8	36.0	73.5	108.0	225.5
	50	5.1	10.4	7.4	15.1	8.4	17.1	20.0	40.8	40.0	81.7	120.0	245.0
	60	7.6	15.5	11.0	22.4	11.8	24.0	24.0	49.0	48.0	98.0	144.0	294.0
	70	10.1	20.6	14.6	29.8	15.6	31.8	28.0	57.1	56.0	114.3	168.0	343.0
	80	13.0	26.6	18.5	37.8	20.1	41.0	32.0	65.3	64.0	130.7	192.0	392.0
	100	19.5	40	28.0	57	29	59	51	104	80	164	240	491
	120	28	57	41	84	42	86	73	149	96	196	288	589

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		PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.
2"	10	0.1	0.2	0.1	0.2	0.1	0.2	1.4	2.9	2.8	5.7	8.4	17.1
	15	0.1	0.2	0.2	0.4	0.3	0.6	2.1	4.3	4.2	8.6	12.6	25.7
	20	0.2	0.4	0.4	0.8	0.4	0.8	2.8	5.7	5.6	11.4	16.8	34.2
	25	0.4	0.8	0.6	1.2	0.7	1.4	3.6	7.3	7.2	14.7	21.6	44.0
	30	0.5	1.0	0.8	1.6	0.9	1.8	4.2	8.6	8.4	17.1	25.2	51.5
	35	0.7	1.4	1.1	2.2	1.3	2.7	4.9	10.0	9.8	20.0	29.4	60.0
	40	0.9	1.8	1.3	2.7	1.5	3.1	5.6	11.4	11.2	22.8	33.6	68.6
	45	1.2	2.4	1.7	3.5	1.9	3.9	6.3	12.9	12.6	25.7	37.8	77.2
	50	1.4	2.9	2.1	4.3	2.4	4.9	7.2	14.7	14.4	29.4	43.2	88.2
	60	2.0	4.1	3.0	6.1	3.4	6.9	8.6	17.5	17.2	35.1	51.6	105.3
	70	2.7	5.5	4.0	8.2	4,4	9.0	10.1	20.6	20.2	41.2	60.6	123.7
	80	3.4	6.9	5.0	10.2	5.6	11.4	11.5	23.5	23.0	47.0	69.0	140.9
	90	4.4	9.0	6.2	12.7	6.9	14.1	12.9	26.4	25.8	52.7	77.4	158.0
	100	5.4	11.0	7.8	16.3	8.4	17.1	14.4	29.4	28.8	58.8	86.4	176.4
	120	7.9	15.1	11.6	23.7	12.1	20.7	20.7	41.2	34.4	70.2	103.2	210.7
	140	10.1	20.6	15.0	30.7	15.5	31.7	28	57	40	82	120	245
	160	13.0	26.6	19.0	38.8	20.0	40.8	36	74	45	92	135	276
	180	17.0	34.8	23.5	48.0	25.0	51.1	46	94	51	104	153	313
	200	20.5	42.0	28.5	58.3	30.0	61.4	58	118	56	115	168	343
2½"	20	0.1	0.2	0.2	0.4	0.2	0.4	1.4	2.9	2.8	5.7	8.4	17.1
	25	0.2	0.4	0.2	0.4	0.3	0.6	1.8	3.7	3.6	7.3	10.8	22.0
	30	0.2	0.4	0.3	0.6	0.4	0.8	2.2	4.5	4.4	9.0	13.2	26.9
	35	0.3	0.6	0.4	0.8	0.5	1.0	2.5	5.1	5.0	10.2	15.0	30.6
	40	0.4	0.8	0.6	1.2	0.7	1.4	2.9	5.9	5.8	11.8	17.4	35.0
	45	0.5	1.0	0.7	1.4	0.8	1.6	3.2	6.5	6.4	13.1	19.2	39.2
	50	0.6	1.2	0.9	1.8	1.0	2.0	3.6	7.3	7.2	14.7	21.6	44.0
	60	0.9	1.8	1.2	2.4	1.4	2.9	4.3	8.8	8.6	17.5	25.8	52.5
	70	1.2	2.4	1.6	3.3	1.9	3.9	5.0	10.2	10.0	20.4	30.0	61.2
	80	1.4	2.9	2.0	4.1	2.4	4.9	5.8	11.8	11.6	23.6	34.8	71.0
	90	1.8	3.7	2.5	5.1	2.9	5.9	6.5	13.3	13.0	26.5	39.0	79.6
	100	2.2	4.5	3.0	6.1	3.6	7.3	7.2	14.7	14.4	29.4	43.2	88.2
	120	3.1	6.3	4.5	9.2	5.0	10.2	8.6	17.5	17.2	35.1	57.6	117.6
	140	4.1	8.4	6.0	12.2	6.6	13.5	11.3	23.0	20.2	41.2	60.6	123.7
	160	5.4	11.0	7.8	15.9	8.4	17.1	15.1	30.8	23.0	47.0	69.0	140.9
	180	6.9	14.1	10.0	20.4	10.5	21.4	19.8	40.5	25.9	52.9	77.7	158.6
	200	8.6	17.5	12.0	24.5	12.6	25.7	23.9	48.8	28.8	58.8	86.4	176.4
	220	9.5	19.5	13.8	28.2	14.3	29.2	26.5	54	31	64	93	190
	240	11.9	24.3	16.5	33.7	17.5	35.8	32.5	66	34	70	103	211
	260	13.7	28.0	19.3	39.4	20.5	42.0	37.0	75.5	38	78	113	231
3"	30	0.1	0.2	0.1	0.2	0.1	0.2	0.9	1.8	1.8	3.7	5.4	11.0
	35	0.1	0.2	0.1	0.2	0.2	0.4	1.1	2.2	2.1	4.3	6.3	12.9
	40	0.1	0.2	0.2	0.4	0.2	0.4	1.2	2.4	2.4	4.9	7.2	14.7
	45	0.2	0.4	0.2	0.4	0.3	0.6	1.3	2.7	2.7	5.5	8.1	16.5
	50	0.2	0.4	0.3	0.6	0.3	0.6	1.5	3.1	3.0	6.1	9.0	18.3
	60	0.3	0.6	0.4	0.8	0.5	1.0	1.8	3.7	3.6	7.3	10.8	22.0
	70	0.4	0.8	0.6	1.2	0.6	1.2	2.1	4.3	4.2	8.6	12.6	25.7
	80	0.5	1.0	0.7	1.4	0.8	1.6	2.4	4.9	4.8	9.8	14.4	29.4
	90	0.6	1.2	0.9	1.8	1.0	2.0	2.7	5.5	5.4	11.0	16.2	33.0
	100	0.7	1.4	1.1	2.2	1.2	2.4	3.0	6.1	6.0	12.2	18.0	36.7
	120	1.0	2.0	1.5	3.1	1.7	3.5	3.6	7.3	7.2	14.7	21.6	44.0

DIRECT-READING FRICTION TABLES

HOW TO USE THE FRICTION TABLES: These tables, based on data from the Standards of the Hydraulic Institute, show the friction loss (in PSI or inches of Mercury) for 100 feet of pipe. Values in the white area are proportional to GPM and viscosity and may be interpolated. Values in the shaded area are for new pipe only. (Multiply by 1.4 to calculate losses for 15-year-old pipe.) **IMPORTANT:** Note that sample liquids at the top of each column have different specific gravities. In all cases, be sure to divide the friction loss by the specific gravity of the sample liquid and multiply it by the specific gravity of the liquid being transferred. For example, the friction loss per hundred feet of 2-inch pipe when pumping a liquid of 2000 SSU at 100 GPM would be half way between 28.8 PSI (the loss for 1000 SSU) and 86.4 PSI (the loss for 3000 SSU) or in other words 57.6 PSI ... if the liquid had a specific gravity of .9. However, if the liquid had a specific gravity of say 1.1, then the friction loss per hundred feet would be 57.6 divided by .9 and multiplied by 1.1, or 70.4 PSI.

PIPE SIZE	GPM	GASOLINE SP. GR. .72		WATER SP. GR. 1		NO. 2 FUEL OIL SP. GR. .84 50 SSU		OIL SP. GR. .9 500 SSU		OIL SP. GR. .9 1000 SSU		OIL SP. GR. .9 3000 SSU	
		PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.
3"	140	1.4	2.9	2.0	4.1	2.2	4.5	4.2	8.6	8.4	17.1	25.2	51.4
	160	1.8	3.7	2.6	5.3	2.9	5.9	5.0	10.2	9.6	19.6	28.8	58.8
	180	2.3	4.7	3.3	6.7	3.6	7.3	6.3	12.9	10.8	22.0	32.4	66.1
	200	2.7	5.5	4.0	8.2	4.2	8.6	8.1	16.5	12.0	24.4	36.0	73.5
	250	4.2	8.6	6.0	12.2	6.4	13.1	12.2	24.7	15.0	30.6	45.0	91.9
	300	6.1	12.4	8.7	17.7	9.2	18.8	18.0	36.7	18.0	36.7	54.0	110.2
	350	7.9	16.2	11.5	23.5	11.8	24.1	24.3	50	24.3	50	62	127
	400	10.2	20.9	15.0	30.7	15.3	31.3	28.4	58	31.5	64	71	145
	450	12.9	26.4	18.7	38.2	19.0	38.9	35.5	73	40.5	83	80	164
4"	60	0.1	0.2	0.1	0.2	0.1	0.2	0.6	1.2	1.2	2.5	3.6	7.3
	70	0.1	0.2	0.1	0.2	0.2	0.4	0.7	1.4	1.4	2.9	4.2	8.6
	80	0.1	0.2	0.2	0.4	0.2	0.4	0.8	1.6	1.6	3.3	4.8	9.8
	90	0.2	0.4	0.2	0.4	0.3	0.6	0.9	1.8	1.8	3.7	5.4	11.0
	100	0.2	0.4	0.3	0.6	0.3	0.6	1.0	2.0	2.0	4.1	6.0	12.2
	120	0.3	0.6	0.4	0.8	0.5	1.0	1.2	2.4	2.4	4.9	7.2	14.7
	140	0.3	0.6	0.5	1.0	0.6	1.2	1.4	2.9	2.8	5.7	8.4	17.1
	160	0.4	0.8	0.7	1.4	0.8	1.6	1.6	3.3	3.2	6.5	9.6	19.6
	180	0.6	1.2	0.8	1.6	1.0	2.0	1.8	3.7	3.6	7.3	10.8	22.0
	200	0.7	1.4	1.0	2.0	1.2	2.4	2.0	4.1	4.0	8.2	12.0	24.5
	250	1.0	2.0	1.5	3.1	1.8	3.7	3.2	6.5	5.0	10.2	13.0	30.6
	300	1.5	3.1	2.2	4.5	2.4	4.9	4.5	9.2	6.0	12.2	18.0	36.7
	350	2.0	4.1	2.9	5.9	3.2	6.5	6.3	12.9	7.1	14.3	21.0	42.8
	400	2.6	5.3	3.7	7.5	4.0	8.2	8.1	16.5	8.1	16.5	24.3	49.0
	450	3.3	6.7	4.6	9.4	5.0	10.2	10.1	20.6	10.1	20.6	27.0	55.0
	500	4.0	8.2	5.8	11.8	6.1	12.4	12.4	25.3	12.4	25.3	30.2	61.2
	550	4.8	9.8	6.8	13.9	7.4	15.1	14.8	30.3	15.3	31.3	33	67.5
	600	5.7	11.7	8.1	16.6	8.7	17.8	16.3	32.3	18.0	36.8	36	73.6
	650	6.8	13.9	9.4	19.2	9.9	20.2	20.0	41.0	22.0	45.0	39	79.8
6"	100	----	----	----	----	----	----	0.2	0.4	0.4	0.8	1.2	2.4
	120	----	----	----	----	----	----	0.2	0.4	0.5	1.0	1.4	2.9
	140	----	----	----	----	----	----	0.3	0.6	0.6	1.2	1.7	3.5
	160	0.1	0.2	0.1	0.2	0.1	0.2	0.3	0.6	0.6	1.2	1.9	3.9
	180	0.1	0.2	0.1	0.2	0.1	0.2	0.4	0.8	0.7	1.4	2.1	4.3
	200	0.1	0.2	0.1	0.2	0.2	0.4	0.4	0.8	0.8	1.6	2.4	4.9
	250	0.1	0.2	0.2	0.4	0.2	0.4	0.5	1.0	1.0	2.0	3.0	6.1
	300	0.2	0.4	0.3	0.6	0.3	0.6	0.6	1.2	1.2	2.4	3.6	7.3
	350	0.3	0.6	0.4	0.8	0.4	0.8	0.8	1.6	1.4	2.9	4.2	8.6
	400	0.3	0.6	0.5	1.0	0.6	1.2	1.1	2.2	1.6	3.3	4.8	9.8
	450	0.4	0.8	0.6	1.2	0.7	1.4	1.4	2.9	1.8	3.7	5.4	11.0
	500	0.5	1.0	0.7	1.4	0.8	1.6	1.7	3.5	2.0	4.1	6.0	12.2
	600	0.7	1.4	1.1	2.2	1.2	2.4	2.4	4.9	2.4	4.9	7.2	14.7
	700	1.0	2.0	1.4	2.9	1.6	3.3	3.4	6.9	3.4	6.9	8.4	17.1
	800	1.3	2.7	1.8	3.7	1.9	3.9	4.2	8.6	4.2	8.6	9.6	19.6
	900	1.6	3.3	2.3	4.7	2.4	4.9	5.4	11.0	5.4	11.0	10.8	22.0
	1000	2.0	4.1	2.8	5.7	2.9	5.9	6.7	13.7	6.7	13.7	12.0	24.5
	1200	2.8	5.7	4.0	8.2	4.2	8.6	10.0	20.2	9.9	20.2	14.4	29.4
	1500	4.2	8.6	6.0	12.2	6.2	12.6	15.3	31.2	15.3	31.2	18.0	36.7
8"	200	----	----	----	----	----	----	0.1	0.2	0.3	0.6	0.8	1.6
	250	----	----	----	----	----	----	0.2	0.4	0.3	0.6	1.0	2.0
	300	----	----	----	----	0.1	0.2	0.2	0.4	0.4	0.8	1.2	2.4

DIRECT-READING FRICTION TABLES

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PIPE SIZE	GPM	GASOLINE SP. GR. .72		WATER SP. GR. 1		NO. 2 FUEL OIL SP. GR. .84 50 SSU		OIL SP. GR. .9 500 SSU		OIL SP. GR. .9 1000 SSU		OIL SP. GR. .9 3000 SSU	
		PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.	PSI	IN. HG.
8"	350	----	----	0,1	0.2	0.1	0.2	0.2	0.4	0.5	1.0	1.4	2.9
	400	----	----	0.1	0.2	0.1	0.2	0.3	0.6	0.5	1.0	1.6	3.3
	450	0.1	0.2	0.2	0.4	0.2	0.4	0.3	0.6	0.6	1.2	1.8	3.7
	500	0.1	0.2	0.2	0.4	0.2	0.4	0.4	0.8	0.7	1.4	2.0	4.1
	600	0.2	0.4	0.3	0.6	0.3	0.6	0.6	1.2	0.8	1.6	2.4	4.9
	700	0.2	0.4	0.4	0.8	0.4	0.8	0.8	1.6	1.0	2.0	2.8	5.7
	800	0.3	0.6	0.5	1.0	0.5	1.0	1.1	2.2	1.1	2.2	3.2	6.5
	900	0.4	0.8	0.6	1.2	0.6	1.2	1.4	2.9	1.4	2.9	3.6	7.3
	1000	0.5	1.0	0.7	1.4	0.8	1.6	1.5	3.5	1.7	3.5	4.0	8.2
	1200	0.7	1.4	1.0	2.0	1.1	2.2	2.3	4.7	2.3	4.7	4.8	9.8
	1500	1.0	2.0	1.5	3.1	1.6	3.3	3.8	7.8	3.8	7.8	6.0	12.2
	1800	1.5	3.1	2.1	4.3	2.3	4.7	4.4	9.0	5.3	10.8	7.2	14.7
	2100	2.0	4.1	2.8	5.7	3.0	6.1	6.0	12.3	7.2	14.7	8.3	17.0
10"	450	----	----	----	----	----	----	0.1	0.2	0.2	0.4	0.7	1.4
	500	----	----	----	----	0.1	0.2	0.1	0.2	0.3	0.6	0.8	1.6
	600	----	----	----	----	0.1	0.2	0.2	0.4	0.3	0.6	1.0	2.0
	700	0.1	0.2	0.1	0.2	0.1	0.4	0.3	0.6	0.4	0.8	1.1	2.2
	800	0.1	0.2	0.2	0.4	0.2	0.4	0.4	0.8	0.4	0.8	1.3	2.7
	900	0.1	0.2	0.2	0.4	0.2	0.4	0.4	0.8	0.5	1.0	1.4	2.9
	1000	0.1	0.2	0.2	0.4	0.3	0.6	0.5	1.0	0.5	1.0	1.6	3.3
	1200	0.2	0.4	0.3	0.6	0.4	0.8	0.8	1.4	0.7	1.4	1.9	3.9
	1500	0.3	0.6	0.5	1.0	0.5	1.0	1.1	2.2	1.2	2.4	2.4	4.9
	1800	.5	1.0	.7	1.4	.8	1.6	1.5	3.1	1.7	3.5	2.8	5.7
	2100	.7	1.4	.9	1.8	1.0	2.0	2.0	4.1	2.3	4.7	3.3	6.8
	2400	.8	1.6	1.1	2.3	1.3	2.7	2.5	5.1	2.8	5.7	3.7	7.6
	3000	1.3	2.7	1.8	3.6	1.9	3.9	3.7	7.6	4.2	8.6	4.7	9.6
12"	500	----	----	----	----	----	----	----	----	0.1	0.2	0.4	0.8
	600	----	----	----	----	----	----	----	----	0.2	0.4	0.5	1.0
	700	----	----	----	----	----	----	----	----	0.2	0.4	0.6	1.2
	800	----	----	----	----	----	----	0.1	0.2	0.2	0.4	0.6	1.2
	900	----	----	----	----	----	----	0.2	0.4	0.2	0.4	0.7	1.4
	1000	----	----	----	----	0.1	0.2	0.2	0.4	0.3	0.6	0.8	1.6
	1200	0.1	0.2	0.1	0.2	0.2	0.4	0.3	0.6	0.3	0.6	1.0	2.0
	1500	0.1	0.2	0.2	0.4	0.2	0.4	0.5	1.0	0.5	1.0	1.2	2.4
	1800	.2	.4	.3	.6	.4	.8	.6	1.2	.7	1.5	1.5	3.1
	2100	.3	.6	.4	.8	.4	.8	.8	1.6	1.0	2.0	1.7	3.5
	2400	.4	.8	.5	1.0	.5	1.0	1.1	2.3	1.2	2.5	1.9	3.9
	3000	.5	1.0	.7	1.5	.8	1.6	1.6	3.3	1.9	3.9	2.4	4.9
14"	1000	.036	.074	.057	.116	.070	.143	.135	.276	.17	.35	.53	1.07
	1500	.083	.170	.125	.256	.147	.301	.31	.64	.31	.63	.79	1.61
	2000	.133	.27	.22	.45	.250	.51	.49	1.00	.55	1.13	1.05	2.15
	2500	.200	.41	.32	.66	.37	.76	.70	1.43	.87	1.78	1.31	2.68
	3000	.290	.59	.45	.92	.51	1.04	1.04	2.13	1.26	2.58	1.57	3.21
	4000	.50	1.02	.79	1.62	.93	1.90	1.60	3.27	2.03	4.15	2.30	4.70
16"	1000	.018	.037	.03	.06	.035	.072	.068	.139	.106	.217	.32	.65
	2000	.069	.141	.11	.23	.126	.258	.25	.51	.27	.55	.63	1.29
	3000	.151	.31	.23	.47	.26	.53	.52	1.06	.63	1.29	.991	2.02
	4000	.26	.53	.40	.82	.44	.90	.85	1.74	1.04	2.13	.26	2.58
	5000	.40	.82	.61	1.25	.66	1.35	1.26	2.58	1.53	3.13	1.70	3.48

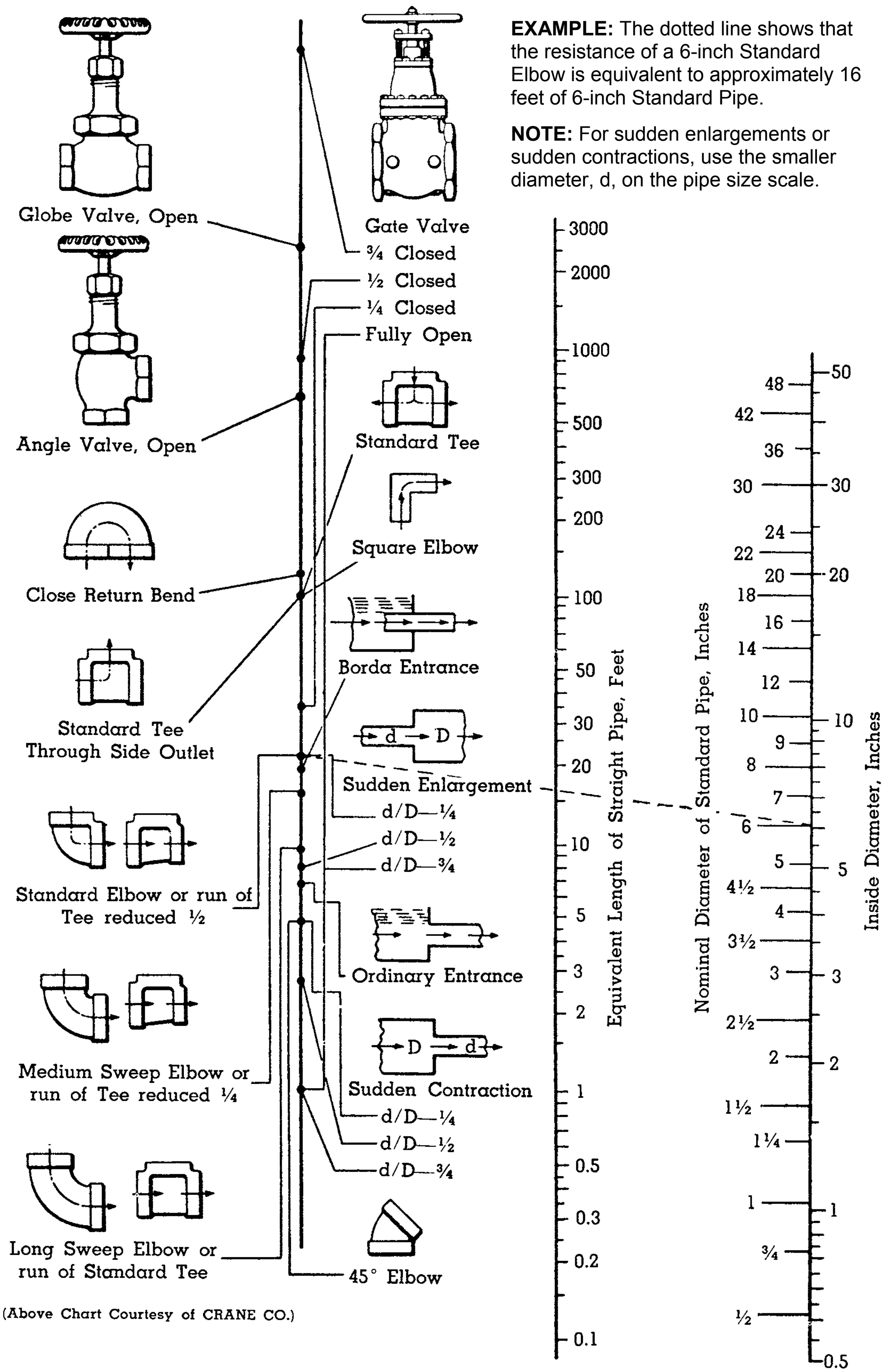
FRICTION LOSS IN VALVES and FITTINGS

RESISTANCE OF VALVES AND FITTING TO FLOW OF NON-VISCOUS LIQUIDS

(At very high liquid viscosities and relatively low flow rates, resistances may be less than shown.)

EXAMPLE: The dotted line shows that the resistance of a 6-inch Standard Elbow is equivalent to approximately 16 feet of 6-inch Standard Pipe.

NOTE: For sudden enlargements or sudden contractions, use the smaller diameter, d, on the pipe size scale.



(Above Chart Courtesy of CRANE CO.)

COMPUTING SUCTION and DISCHARGE CONDITIONS

SECOND PROCEDURE (Using the Hydraulic Institute friction loss curves)

The following form may be used for analyzing the Intake and Discharge head conditions in conjunction with the Hydraulic Institute friction loss curves on the following pages. The viscosity and the specific gravity of the liquid at lowest pumping temperature must be known to use these curves. For viscosity and specific gravity values of common liquids, refer to Pages 23 and 24.

ANALYZING THE INTAKE SYSTEM

1. Maximum Vertical Suction Lift .... ______ Ft. of Liquid
2. Suction Pipe Size Total Length = ______ Ft.
   (See Page 11 For Equivalent Length of Fittings.)
3. Number of Elbows ______ @ ______ Ft. = ______ Ft.
4. Number of Valves ______ @ ______ Ft. = ______ Ft.
5. Strainer ______ @ ______ Ft. = ______ Ft.
6. Other Fittings ______ @ ______ Ft. = ______ Ft.
7. ______ @ ______ Ft. = ______ Ft.
8. Total Equivalent Length of Pipe: ______ Ft. (Add values 2 thru 7)
9. Friction Modulus (From pages 13 thru 19) = ______
10. Friction Loss = 2.31 X (______) X (______) ÷ 100 .... ______ Ft. of Liquid
    (value8) (value 9)
11. Total Suction Lift = (value 10 + value 1) .... ______ Ft. of Liquid
    NOTE: When 1 is a lift, add 1 to 10. When 1 is a positive head, subtract 1 from 10.
12. Total Suction Lift in Ft. of Water = (______) X (______) .... ______ Ft. of Water
    (Sp. Gr.) (value 11)
13. Vacuum in inches of Hg=(______) ÷ 1.13 .... ______ In. Hg
    (value 12)

NOTE: To determine if the pump will perform satisfactorily at this vacuum, refer to the Blackmer Vapor Pressure Graphs 50/1.

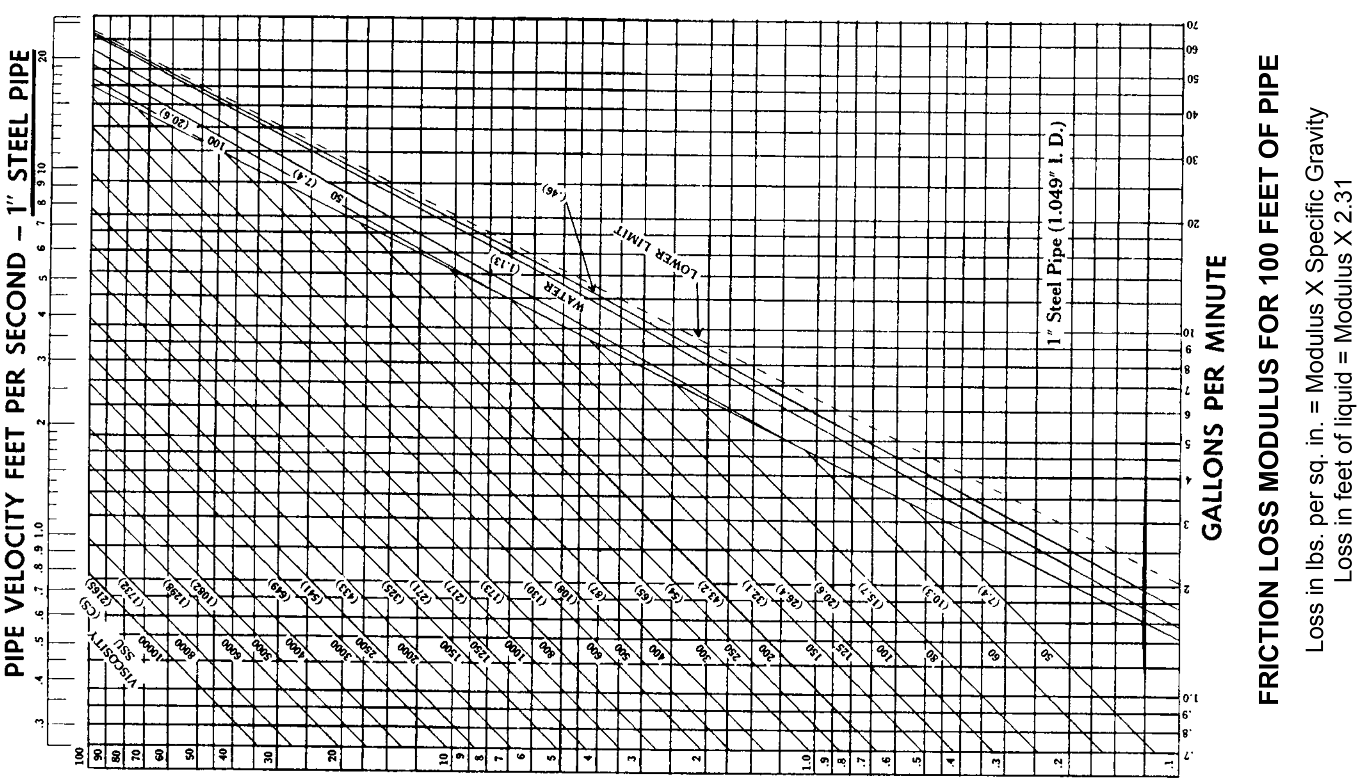
ANALYZING THE DISCHARGE SYSTEM

14. Vertical Discharge Head .... ______Ft. of Liquid
15. Discharge Pipe Size Total Length ______ Ft.
    (See Page 11 For Equivalent Length of Fittings.)
16. Number of Elbows ______ @ ______ Ft. = ______ Ft.
17. Number of Valves ______ @ ______ Ft. = ______ Ft.
18. Other Fittings ______ @ ______ Ft. = ______ Ft.
19. ______ @ ______ Ft. = ______ Ft.
20. ______ @ ______ Ft. = ______ Ft.
21. Total Equivalent Length of Pipe = ______ Ft. (Add values 15 thru 20)
22. Friction Modulus (From Pages 13 thru 19)= ______
23. Friction Loss = 2.31 X (______) X (______) ÷ 100 .... ______ Ft. of Liquid
    (value 21) (value 22)
24. Total Discharge Head = (______) + (______) .... ______ Ft. of Liquid
    (value 14) (value 23)
25. Total Discharge Head in Ft. of Water = (______) X (______) .... ______ Ft. of Water
    (Sp. Gr.) (value 24)
26. Discharge Pressure in PSI =(________) ÷ 2.31 .... ______ PSI
    (Ft. of Water)
27. Total Dynamic Head (______) + (______) = ...______Ft. of Water
    (value 25) (value 12)
28. Differential Pressure = (______) ÷ 2.31 .... ______ PSI
    (value 27)
29. Horsepower Required — (Refer to Blackmer Characteristic Curves printed separately) .... ______ HP

PIPE FRICTION CURVES — 1" STEEL PIPE

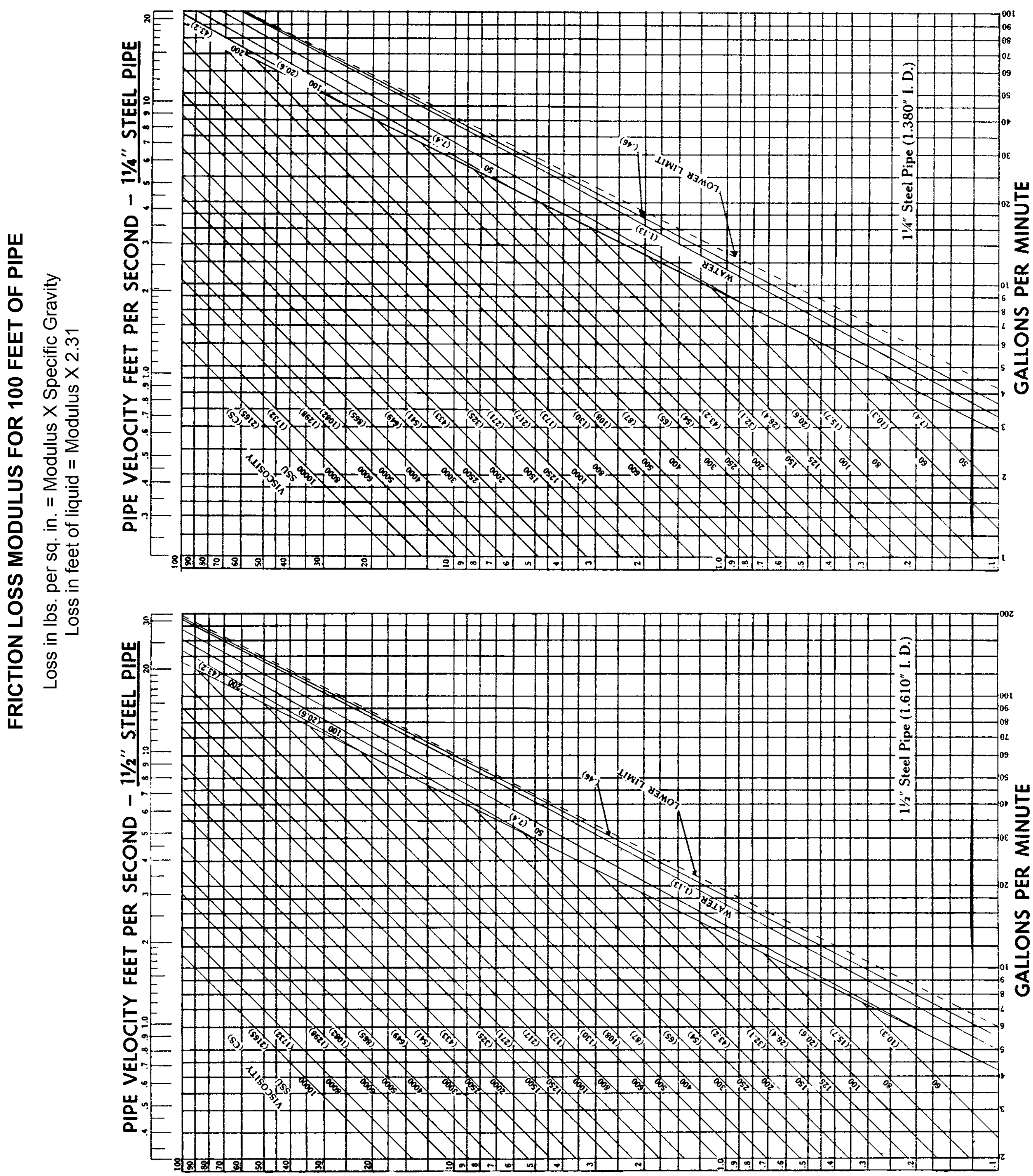
IMPORTANT: Friction values shown in the following charts are for new, clean steel or wrought iron pipes having schedule 40 wall thickness. No allowance has been made for abnormal conditions of interior surface nor for deterioration from age. Roughness of interior surfaces of pipe does not affect the friction loss in laminar flow unless the open area has been reduced. In turbulent flow, however, friction loss is very much affected by roughness. It is recommended that when using 15-year-old pipe of average roughness, friction loss values in the turbulent area as shown on the charts be multiplied by 1.4.

HOW TO USE THESE CURVES: First find the chart that pertains to the correct pipe size. Then move upward along the vertical GPM line corresponding to the proper delivery rate until it intersects the diagonal line indicating the viscosity of the liquid to be pumped. Move horizontally from this point to the left hand scale and read the modulus value for this condition. For example, pumping a 1000 SSU liquid at 10 GPM through 1-inch pipe would have a modulus of 48. The actual friction loss per 100 feet of pipe may then be determined in PSI or in feet of liquid according to the formulae below. Notice there are many conditions where the diagonal viscosity lines reach the "limit" lines before intersecting all of the vertical GPM lines (such as 100 SSU at 20 GPM on the 1-inch chart). In these cases it is necessary to continue upward along the proper limit line until it intersects the vertical. Thus in the example of 100 SSU at 20 GPM, the modulus would be 20.

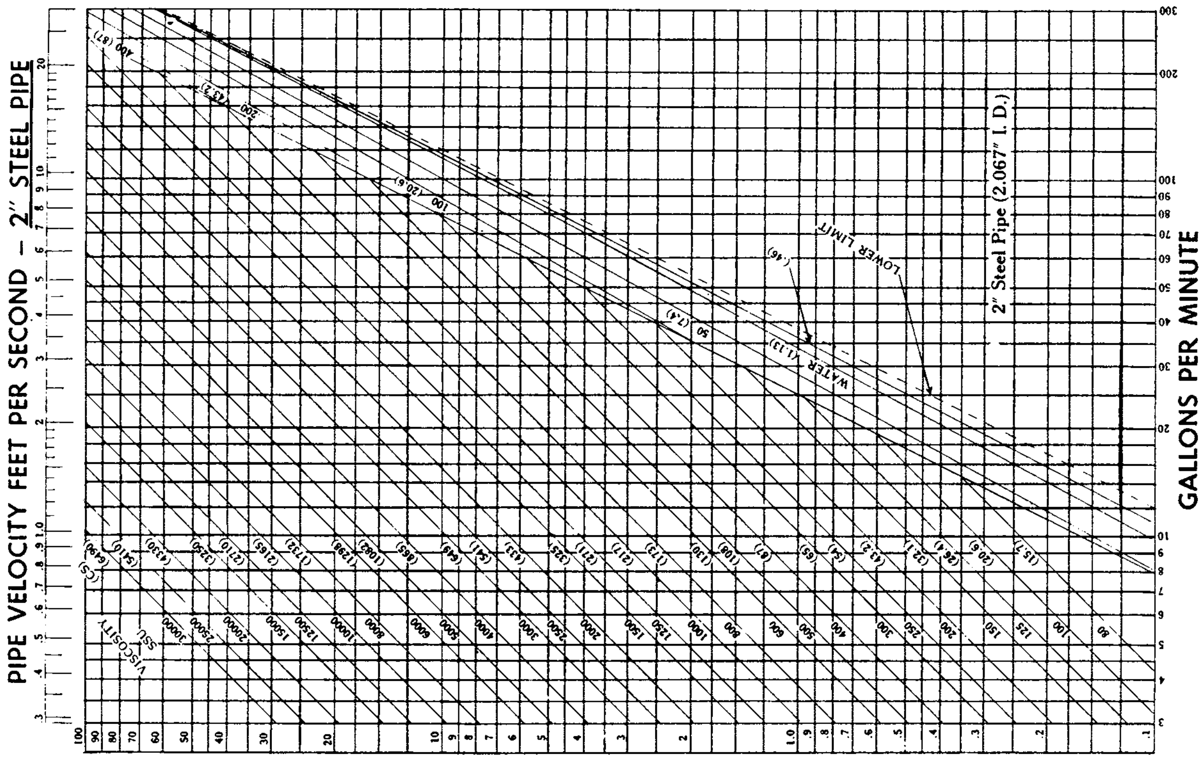


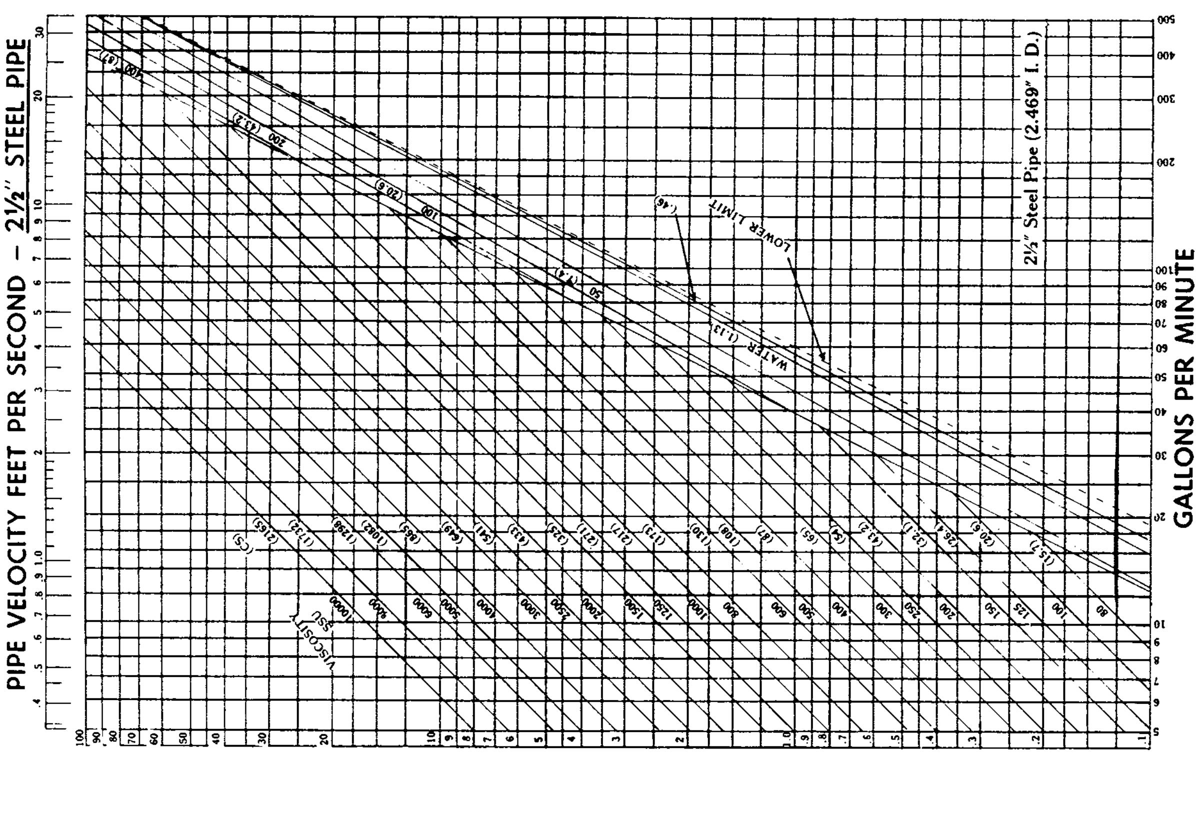
PIPE FRICTION CURVES — 1¼" and 1½" STEEL PIPE

IMPORTANT: Friction values shown in the following charts are for new, clean steel or wrought iron pipes having schedule 40 wall thickness. No allowance has been made for abnormal conditions of interior surface nor for deterioration from age. Roughness of interior surfaces of pipe does not affect the friction loss in laminar flow unless the open area has been reduced. In turbulent flow, however, friction loss is very much affected by roughness. It is recommended that when using 15-year-old pipe of average roughness, friction loss values in the turbulent area as shown on the charts be multiplied by 1.4. (For information on how to use these curves, see page 13.)



IMPORTANT: Friction values shown in the following charts are for new, clean steel or wrought iron pipes having schedule 40 wall thickness. No allowance has been made for abnormal conditions of interior surface nor for deterioration from age. Roughness of interior surfaces of pipe does not affect the friction loss in laminar flow unless the open area has been reduced. In turbulent flow, however, friction loss is very much affected by roughness. It is recommended that when using 15-year-old pipe of average roughness, friction loss values in the turbulent area as shown on the charts be multiplied by 1.4. (For information on how to use these curves, see page 13.)





FRICTION LOSS MODULUS FOR 100 FEET OF PIPE

Loss in lbs. per sq. in. = Modulus X Specific Gravity
Loss in feet of liquid = Modulus X 2.31

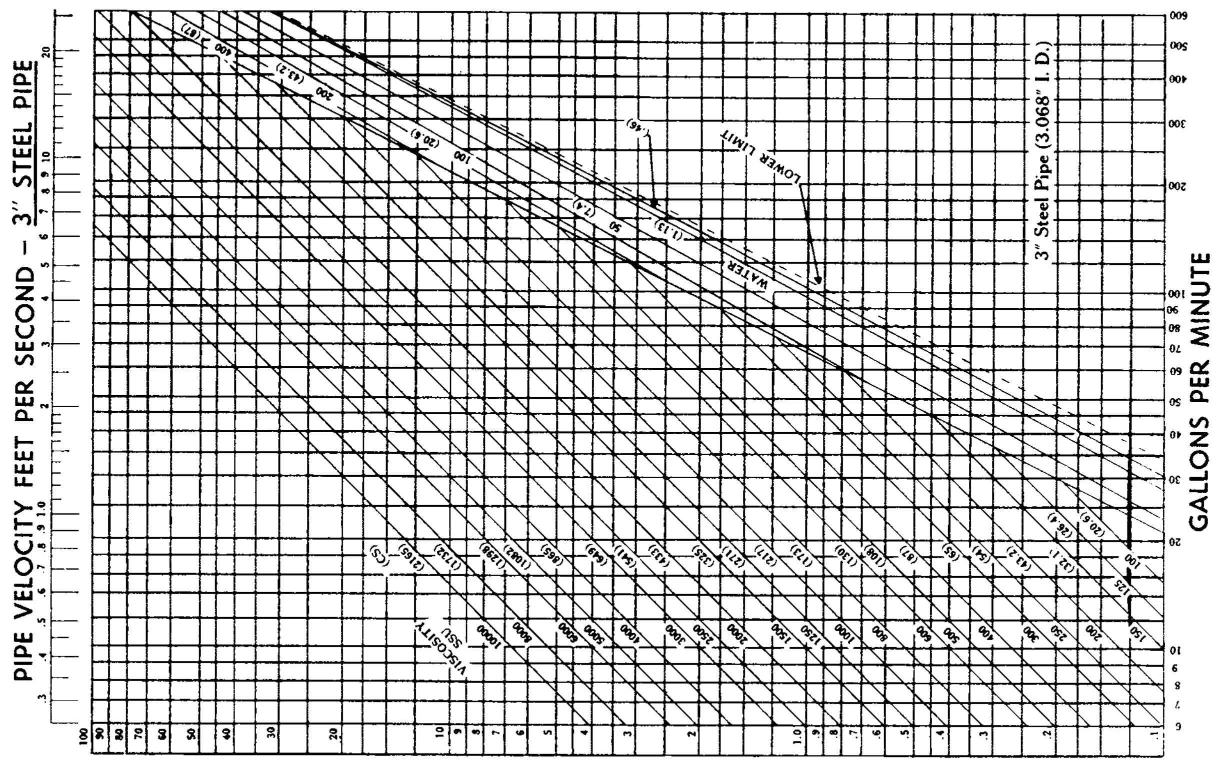
PIPE FRICTION CURVES — 3" and 4" STEEL PIPE

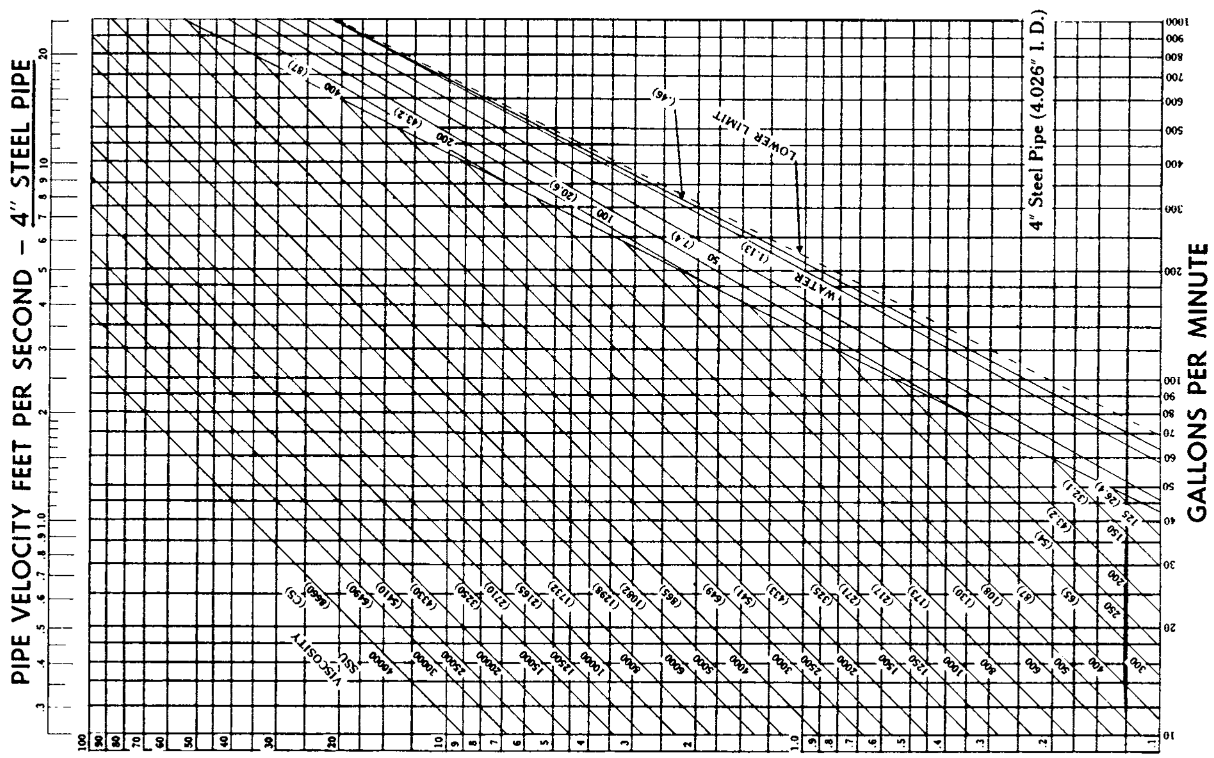
IMPORTANT: Friction values shown in the following charts are for new, clean steel or wrought iron pipes having schedule 40 wall thickness. No allowance has been made for abnormal conditions of interior surface nor for deterioration from age. Roughness of interior surfaces of pipe does not affect the friction loss in laminar flow unless the open area has been reduced. In turbulent flow, however, friction loss is very much affected by roughness. It is recommended that when using 15-year-old pipe of average roughness, friction loss values in the turbulent area as shown on the charts be multiplied by 1.4. (For information on how to use these curves, see page 13.)

FRICTION LOSS MODULUS FOR 100 FEET OF PIPE

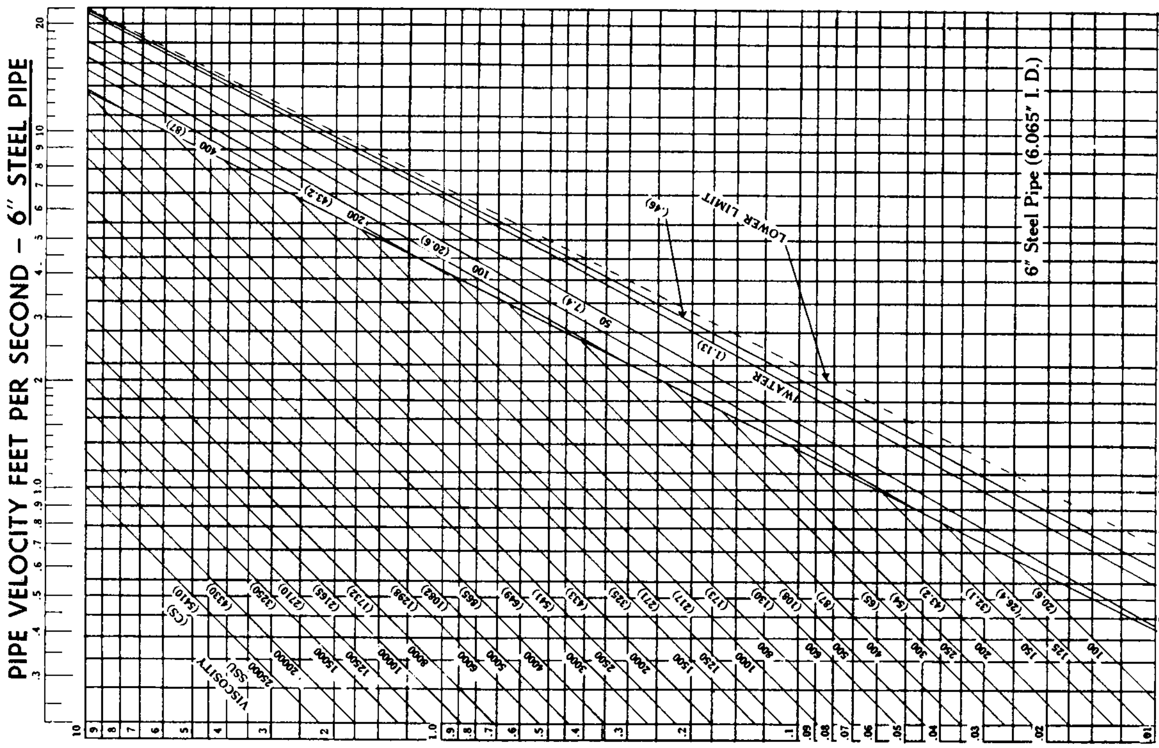
Loss in lbs. per sq. in. = Modulus X Specific Gravity

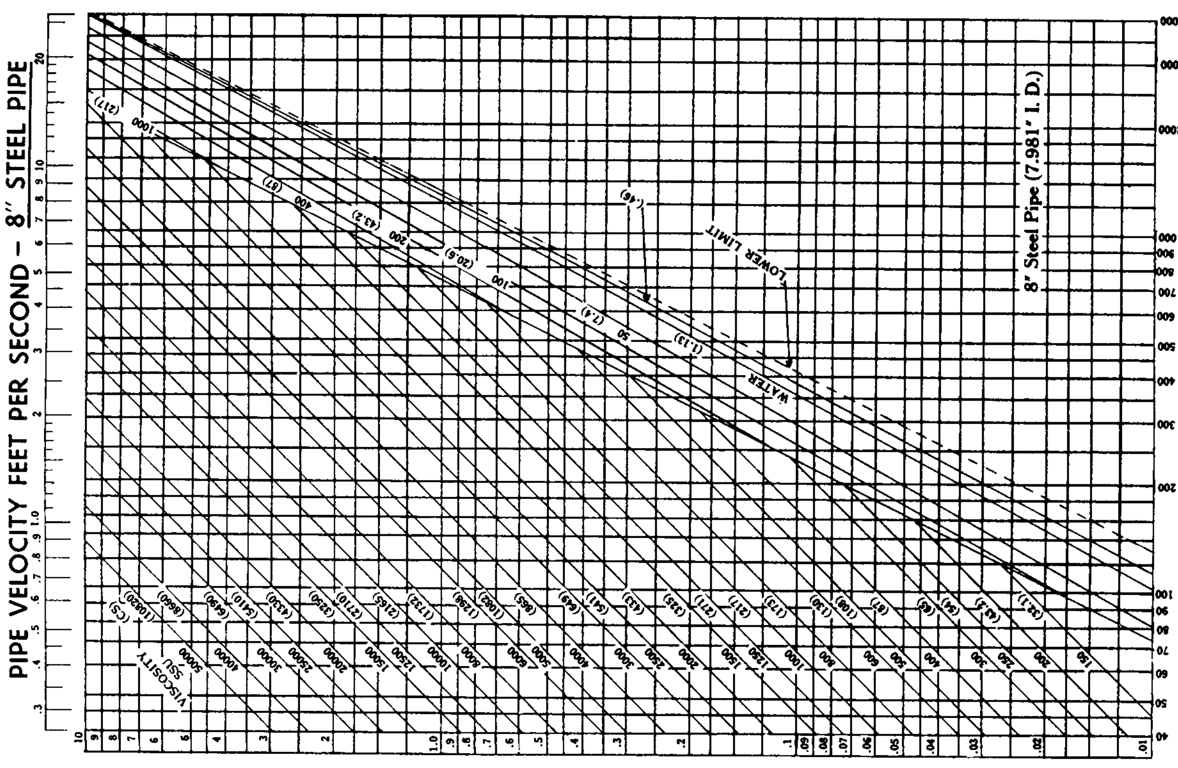
Loss in feet of liquid = Modulus X 2.31





IMPORTANT: Friction values shown in the following charts are for new, clean steel or wrought iron pipes having schedule 40 wall thickness. No allowance has been made for abnormal conditions of interior surface nor for deterioration from age. Roughness of interior surfaces of pipe does not affect the friction loss in laminar flow unless the open area has been reduced. In turbulent flow, however, friction loss is very much affected by roughness. It is recommended that when using 15-year-old pipe of average roughness, friction loss values in the turbulent area as shown on the charts be multiplied by 1.4. (For information on how to use these curves, see page 13.)





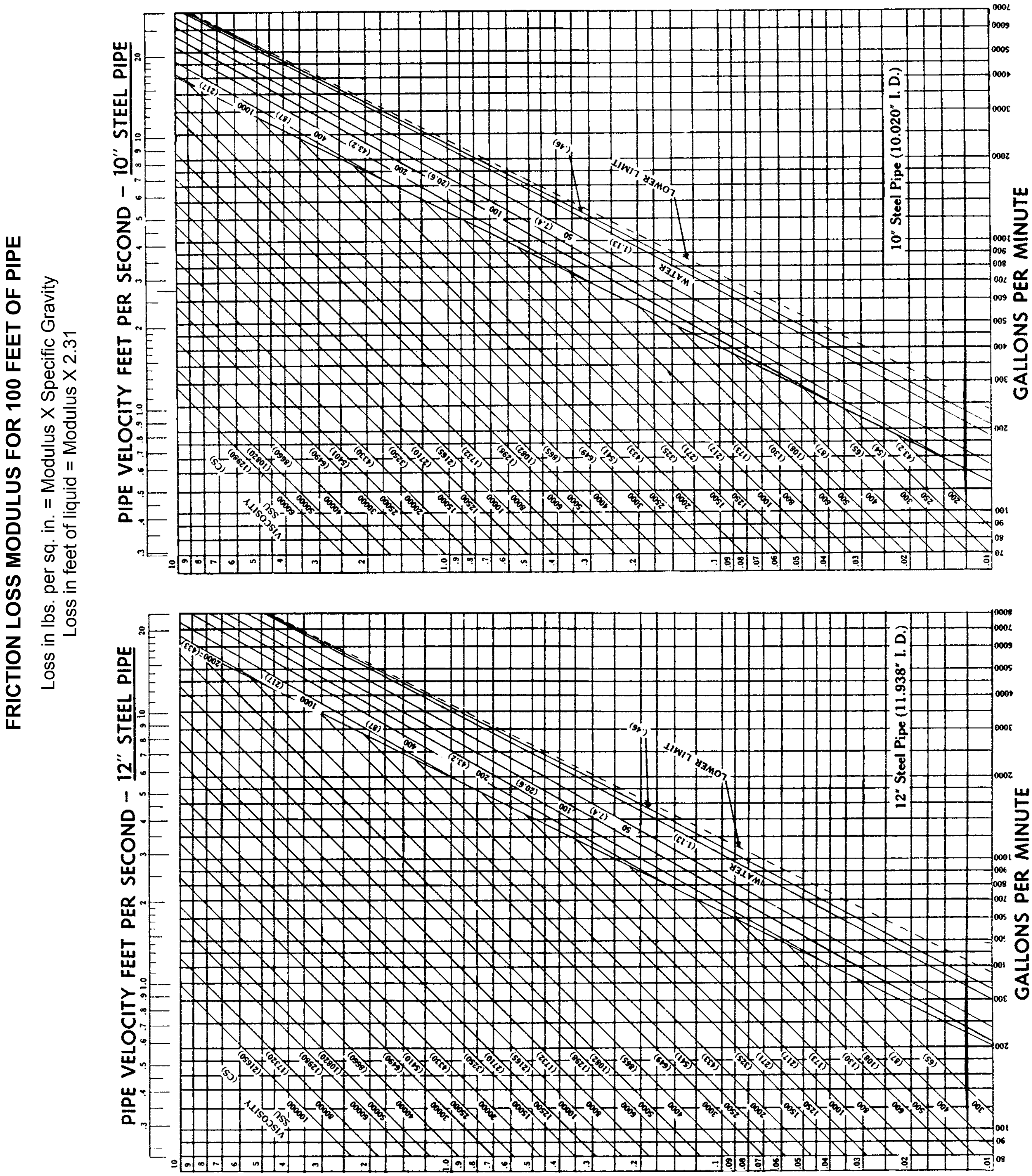
FRICTION LOSS MODULUS FOR 100 FEET OF PIPE

Loss in lbs. per sq. in. = Modulus X Specific Gravity

Loss in feet of liquid = Modulus X 2.31

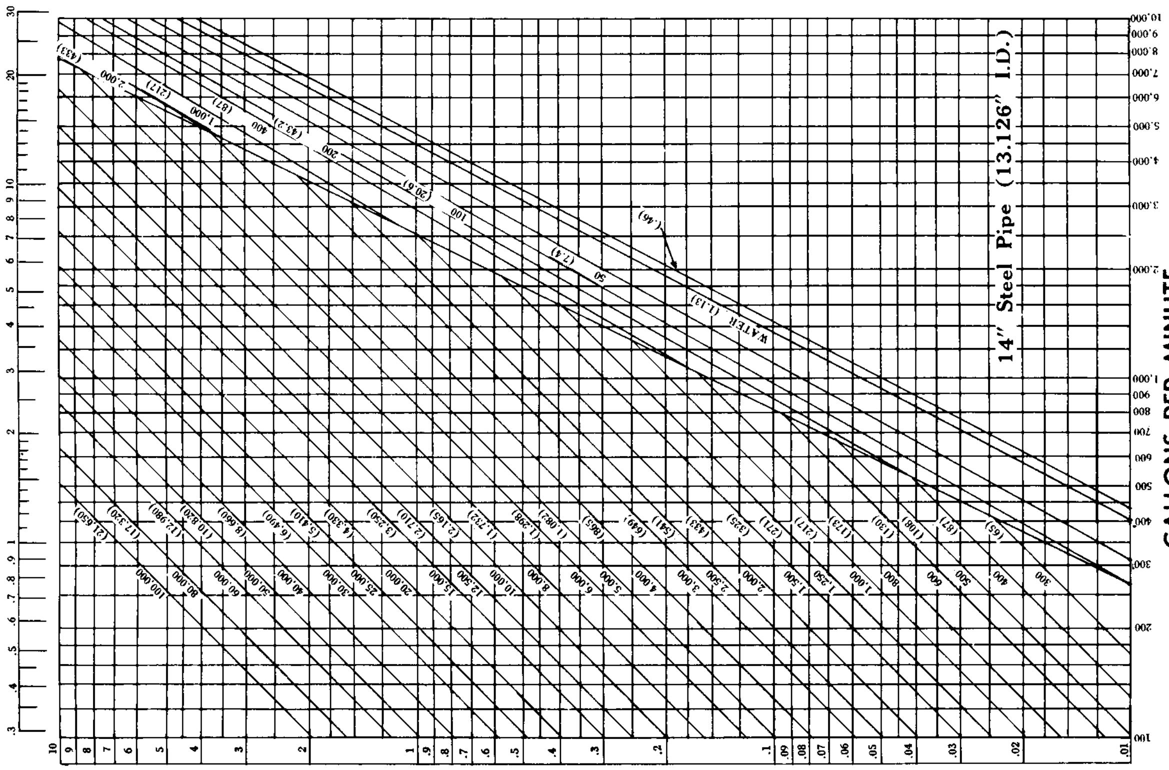
PIPE FRICTION CURVES — 10" and 12" STEEL PIPE

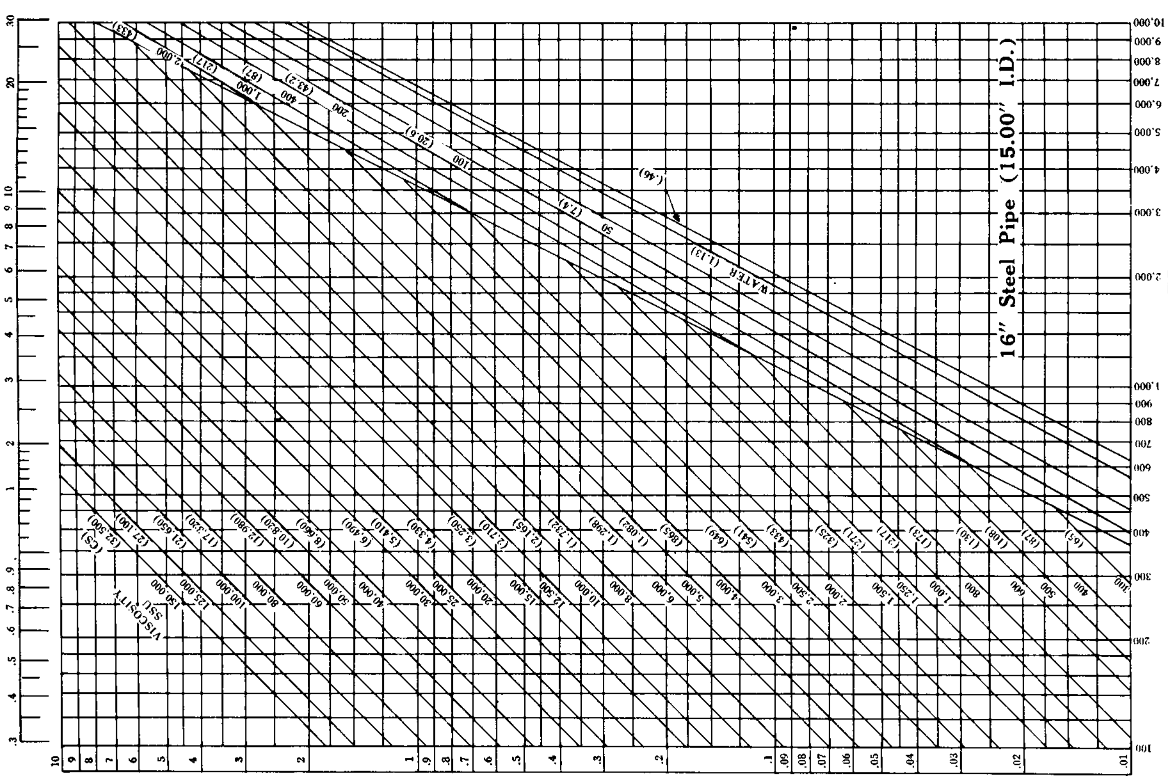
IMPORTANT: Friction values shown in the following charts are for new, clean steel or wrought iron pipes having schedule 40 wall thickness. No allowance has been made for abnormal conditions of interior surface nor for deterioration from age. Roughness of interior surfaces of pipe does not affect the friction loss in laminar flow unless the open area has been reduced. In turbulent flow, however, friction loss is very much affected by roughness. It is recommended that when using 15-year-old pipe of average roughness, friction loss values in the turbulent area as shown on the charts be multiplied by 1.4. (For information on how to use these curves, see page 13.)



PIPE FRICTION CURVES — 14" and 16" STEEL PIPE

IMPORTANT: Friction values shown in the following charts are for new, clean steel or wrought iron pipes having schedule 40 wall thickness. No allowance has been made for abnormal conditions of interior surface nor for deterioration from age. Roughness of interior surfaces of pipe does not affect the friction loss in laminar flow unless the open area has been reduced. In turbulent flow, however, friction loss is very much affected by roughness. It is recommended that when using 15-year-old pipe of average roughness, friction loss values in the turbulent area as shown on the charts be multiplied by 1.4. (For information on how to use these curves, see page 13.)





FRICTION LOSS MODULUS FOR 100 FEET OF PIPE

Loss in lbs. per sq. in. = Modulus X Specific Gravity

Loss in feet of liquid = Modulus X 2.31

SELECTING PUMP CONSTRUCTION

1. **SOLUTION TO BE PUMPED** (Give common name, where possible, such as aviation gasoline, No. 2 fuel oil, perchlorethylene, etc.) ....

2. **PRINCIPAL CORROSIVES** (H_2S0_4, HCL, etc.) ....% by weight
   (In the case of mixtures, state definite percentages by weight. For example: mixture contains *2%* acid, in terms of 96.5% H_2S0_4.)

3. pH (if aqueous solution) .... at .... F

4. **IMPURITIES OR OTHER CONSTITUENTS NOT GIVEN IN "2"** (List amounts of any metallic salts, such as chlorides, sulphates, sulphides, chromates, and any organic materials which may be present, even though in percentages as low as .01%. Indicate, where practical, whether they act as accelerators or inhibitors on the pump material.) ....

....

5. **SPECIFIC GRAVITY** (solution pumped) .... at .... F

6. **TEMPERATURE OF SOLUTION:** maximum .... F, minimum .... F, normal .... F

7. **VAPOR PRESSURES AT ABOVE TEMPERATURES:** maximum.......... minimum .... normal ....
   (Indicate units used, such as pounds gauge, inches water, millimeters mercury.)

8. **VISCOSITY** .... SSU; or .... centistokes; at .... F

9. **AERATION:** air-free .... partial .... saturated ....
   Does liquid have tendency to foam? ....

10. **OTHER GASES IN SOLUTION** .... ppm, or .... cc per liter

11. **SOLIDS IN SUSPENSION:** (state types) ....
    Specific gravity of solids ....
    Quantity of solids .... % by weight
    Particle size .... mesh .... % by weight
    .... mesh .... % by weight
    .... mesh .... % by weight
    Character of solids: pulpy.......... gritty .... hard .... soft ....

12. **CONTINUOUS OR INTERMITTENT SERVICE** ....
    Will pump be used for circulation in closed system or for transfer? ....
    Will pump be operated at times against closed discharge? ....
    If intermittent, how often is pump started? ....times per ....
    Will pump be flushed and drained when not in service? ....

13. **TYPE OF MATERIAL IN PIPE LINES TO BE CONNECTED TO PUMP** ....

14. **IS METAL CONTAMINATION UNDESIRABLE?** ....

15. **PREVIOUS EXPERIENCE** Have you pumped this solution previously? ....
    If so, of what material or materials was pump made? ....
    Service life in months? ....
    In case of trouble, what parts were affected? ....
    Was trouble primarily due to corrosion? .... erosion? ....
    galvanic action? .... stray current? ....
    Was attack uniform? .... If localized, what parts were involved? ....
    If galvanic action, name materials involved ....
    If pitted, describe size, shape and location (A sketch will be helpful in an analysis of problem.) ....
    ....

16. **WHAT IS CONSIDERED AN ECONOMIC LIFE?** ....
    (If replacement does not become too frequent, the use of inexpensive pump materials may be the most economical.)

MISCELLANEOUS CONVERSION FACTORS

To convert from	To	Multiply by
Atmospheres	psi	14.7
Atmospheres	Feet of water	33.9
Atmospheres	Inches of Mercury	29.9
Barrels (U.S. liq.)	Gallons (U.S.)	31.5
Barrels of Oil	Gallons (U.S.)	42.0
B.T.U.	H.P. hr.	.0003929
Centimeters	feet	.03280
Centimeters	inches	.39370
Centimeters/sec	feet/min.	1.96840
Centimeters/sec	feet/sec.	.03280
Centipoises	poises	.01
Centistokes	stokes	.01
Cubic centimeters	cu. ft.	$3.5314x10^{-5}$
Cubic centimeters	cu. in.	.061020
Cubic centimeters	gallons (liq.)	.0002642
Cubic feet	gallons (liq.)	7.4805
Cubic feet	cubic in.	1728.
Cubic feet/min.	g.p.m.	7.4805
Cubic inches	gallons .	.004329
Cubic inches	cubic cm.	16.3870
Cubic inches	cubic ft. .	.0005787
Cubic meters	gallons (liq.)	264.17
Cubic meters	cu. cm.	$1x10^{6}$
Cubic meters	cu. ft.	35.31
Cubic meters	cu. in.	61,023.74
Cubic meters/hr	g.p.m.	4.403
Degrees	Revolutions .	.00277778
Dynes	Pounds	$2.24809x10^{-6}$
Dynes/sq. cm.	psi	$1.45038x10^{-5}$
Fathom	feet	6.
Feet	centimeters	30.48006
Feet	meters	.3048006
Feet of water	atmosphere	.02949
Feet of water	psi	.43300
Feet of water	inches of Hg.	.88265
Feet/hr	miles/hour	.00018939
Feet/min	meters/min.	.30480
Feet/min	miles/hour	.01136
Feet/second	miles per hour	.681818
Foot pounds	H.P. hr.	$5.0505x10^{-7}$
Foot pounds/min	Horsepower	$3.0303x10^{-5}$
Gallons	cubic cm.	3,785.43
Gallons	cubic in.	231.
Gallons	gallon (Imp.)	.83268
Gallons	cu. ft.	.13368
Gallons/min	cu. ft./min.	.13368
Horsepower	ft. lbs./min.	33,000
Horsepower	ft. lbs./sec.	550.
Inches	feet	.083333
Inches	meters	.0254
Inches	millimeters	25.40005
Inches	mils	1000.
Inches of Hg	atmospheres	.033327
Inches of Hg	ft. of water	1.1309
Inches of Hg	psi	.4890
Kilograms	pounds (avdp.)	2.2046
Kilograms/sq. cm	psi	14.2233
Kilograms/sq. mm	psi	1422.330
Liters	gallons	.264178
Meters	feet	3.2808
Meters	inches	39.3700
Poise	centipoise	100.00
Pounds water	gallons	.11985
psi	atmospheres	.06804
psi	Inches of Hg.	2.04179
psi	feet of water	2.31000
Square inches	sq. cm.	6.4516
Square inches	sq. ft.	.006944
Square inches	sq. mm.	645.1630
Square millimeters	sq. in.	.0015499
Tons molasses/hr	g.p.m.	2.78

COMPARATIVE LIQUID EQUIVALENTS

Measures and Weights for Comp.	Measure and Weight Equivalents of Items in First Column						
	U.S Gallon	Imperial Gallon	Cubic Inch	Cubic Foot	Cubic Meter	Liter	Pound Water
U.S. Gal.	1.	.833	231.	.1337	.00378	3.785	8.33
Imp. Gal.	1.20	1.	277.42	.1604	.00454	4.546	10.
Cubic In.	.0043	.00360	1.	.00057	.000016	.0163	.0358
Cubic Ft.	7.48	6.229	1728.	1.	.02827	28.312	62.355
Cubic M.	264.17	220.00	61023.	35.319	1.	1000.	2200.54
Liter	.26417	.2200	61.023	.0353	.001	1.	2.2005
Pound H_2O	.12	.1	27.72	.016	.00045	.454	1.

PRESSURE EQUIVALENTS

1 atmosphere =
- 760 millimeters of mercury at 32°F.
- 14.7 pounds per square inch.
- 29.921 inches of mercury at 32°F.
- 2116 pounds per square foot.
- 1.033 kilograms per square centimeter.
- 33.947 feet of water at 62°F.

1 foot of air at 32°F. and barometer 29.92 =
- .0761 pound per square foot.
- .0146 inch of water at 62°F.

1 foot of water at 62°F =
- .433 pound per square inch.
- 62.355 pounds per square foot.
- .883 inch of mercury at 62°F.
- 821.2 feet of air at 62°F. and barometer 29.92.

1 inch of water 62°F =
- .0361 pound per square inch.
- 5.196 pounds per square foot.
- .5776 ounce per square inch.
- .0735 inch of mercury at 62°F.
- 68.44 feet of air at 62°F. and barometer 29.92.

1 pound per square inch =
- 2.0355 inches of mercury at 32°F.
- 2.0416 inches of mercury at 62°F.
- 2.309 feet of water at 62°F.
- .07031 kilogram per square centimeter.
- .06804 atmosphere.
- 51.7 millimeters of mercury at 32°F.

HORSEPOWER - TORQUE CONVERSION

$$\text{Horsepower} = \frac{\text{Torque (in lb. ft.)} \times \text{RPM}}{5250}$$

FAHRENHEIT - CENTIGRADE CONVERSION TABLE

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

VISCOSITY DEFINITIONS

The pump selection and application outline on page 3 calls attention to the importance of determining the type and viscosity of liquids to be handled. The following definitions should prove helpful in studying these characteristics.

Viscosity is that property of a liquid which resists any force tending to produce motion between its adjacent particles. Viscosity is usually measured by an instrument called a Viscosimeter. The Saybolt Viscosimeter is commonly used in the United States. A Saybolt Universal machine is used for liquids of medium viscosity, and a Saybolt Furol is used for those of higher viscosity. These viscosity ratings are expressed in Seconds Saybolt Universal (SSU) or Seconds Saybolt Furol (SSF). The viscosity, as determined by this type of Viscosimeter, is known as kinematic viscosity. This is not a true measure of a liquid's viscosity but is affected by the specific gravity of the liquid. The effect of specific gravity on viscosity determination can best be illustrated by visualizing two viscosity cups side by side, each containing a liquid of different specific gravity but of the same true viscosity. When a hole is opened in the bottom of each cup, liquid will run through because of the pull of gravity on the liquid. The one with the highest specific gravity will be pulled through the orifice at a higher rate; therefore, its viscosity will be expressed in less seconds than the lighter liquid whereas their true viscosity is the same. The force required to overcome viscosity of a liquid flowing through a pipe is not dependent on the specific gravity of a liquid but on its true or absolute viscosity. For this reason in computing pipe friction it is necessary to multiply the SSU viscosity by the specific gravity in order to arrive at the friction loss.

Blackmer sales engineers use a form of computing pressure and vacuum at the pump. This form contains a space for the insertion of the static head or lift which is expressed in feet of liquid. The friction tables which are based on SSU also give values expressed in feet of liquid. After these two values are added together to get a total discharge head in feet of liquid, the sum is multiplied by the specific gravity which automatically corrects this value to true viscosity.

The viscosity of a liquid should not be confused with its specific gravity. The specific gravity of a liquid is its weight compared to the weight of an equal volume of pure water both measured at a temperature of 60° Fahrenheit. The viscosity of all liquids varies appreciably with changes in temperature, usually decreasing when the liquid is heated. This makes the knowledge of the pumping temperature of the liquid a very important factor. Consideration must also be given to the fact that a heated liquid may have a relatively low viscosity when the pump is in operation. However, when the pump is shut down, the liquid which then remains in the pump will be subject to cooling, and its viscosity will increase accordingly. In many cases it will become so thick and sticky that the pump cannot be turned, in which case it is necessary to apply heat by means of steam connected to jacketed head pumps that "thaw out" the liquid which has "set up" in the pump prior to operation.

The effect of agitation on viscous liquids varies according to the type of liquid. The most common types are:

1. Newtonian liquids — such as water and mineral oils which are referred to as "true liquids", and their viscosity or consistency is not affected by agitation at a constant temperature.
2. Thixotropic liquids — are those which reduce their viscosity as the agitation is increased at a constant temperature. Examples of this type of liquid are asphalts, cellulose, glue, paints, greases, soap, starches, tars, printing ink, resin, varnish, vegetable oil, shortening, lacquer, wax, lard, etc.
3. Dilatant liquids — are those whose viscosity increases as the agitation is increased at a constant temperature. Examples are clay, slurry, candy compounds, and some starches. Most dilatant liquids will return to their original viscosity as soon as agitation ceases. Some liquids may change from thixotropic to dilatant or vice versa as the temperature of concentration is varied.
4. Colloidal liquids — are those which act like thixotropic liquids but will not recover their original viscosity when agitation is stopped. Colloidal solutions of soaps in water or oils at low viscosities, lotions, shampoos, and gelatinous compounds are in this class.
5. Rheopectic liquids — are those whose apparent viscosity increases with time to some maximum value at any constant rate of agitation.

The viscosity of the liquid is a very important factor in the selection of the proper pump for the installation. It is the determining factor in pipe friction and the power and speed requirements of the unit. Frequently when pumping liquids with high viscosity, it is necessary to use a larger pump operating at a slower speed.

VISCOSITY & SPECIFIC GRAVITY OF COMMON LIQUIDS

LIQUID	*SPECIFIC GRAVITY AT 60°F.	VISCOSITIES IN SSU AT VARIOUS TEMPERATURES							
		30°F	60°F	80°F	100°F	130°F	170°F	210°F	250°F
Corn Starch Solutions									
22 Baumé	1.18	190	160	144	130	115	99	88	79
24 Baumé	1.20	1,025	680	550	440	330	240	178	140
25 Baumé	1.21	3,600	1,745	1,170	800	500	295	187	130
Freon	1.37 to 1.49 % 70°F								
Glycerin 99% Soluble		10,200	2,260	1,190	620	280	128	74	54
Glycerin 100%	1.26% 68°F	21,000	4,200	1,700	813	325	130	74	52
Glycol:									
Propylene	1.038 @ 68°F			240 @ 70°					
Triethylene	1.125 @ 68°F			185 @ 70°					
Diethylene	1.12			149 @ 70^0					
Ethylene	1.125			88 @ 70°					
Glucose — Corn Products									
2 Star	1.35 to 1.44					12,500	1,500	340	121
Glucose — Corn Products									
3 Star	1.35 to 1.44					10,200	2,400	750	300
Honey — (Raw)					340				
Hydrochloric Acid	1.05 @ 68°F								
Ink — Newspaper		65,000	20,000	1 0,000	5,500	2,400	1,025	500	280
Ink — Printers	1.00 to 1.38		100,000	30,300	12,500	3,800	1,100	420	200
Kerosene	78 to 82				32.6				
Lard	.96				287	160	91	62.5	49.5
Mercury	13.6								
Molasses									
A. Max.	1.40 to 1.46	42,500	22,500	15,000	10,000	5,900			
A. Min.		9,000	3,600	2,100	1,300	700			
B. Max.	1.43 to 1.48				60,000	15,000			
B. Min.		70,000	22,000	10,900	6,500	3,000			
C. Max.	1.46 to 1.49				250,000	75,000			
C. Min.			90,000	35,000	17,000	6,000			
Oils — Auto. Lubricating									
S.A.E. 10 Max.	.880 to .935	4,400	1,090	430	240	120	66		
20 Max.	.880 to .935	6,900	1,650	750	400	185	90	57	
30 Max.	.880 to .935	13,000	2,700	1,200	580	255	120	66	49
40	.880 to .935	25,000	4,850	2,000	950	380	150	80	55
50	.880 to .935	58,000	10,000	3,700	1,600	600	220	105	67
60	.880 to .935	100,000	15,000	5,300	2,300	800	285	128	76
70	.880 to .935		22,000	7,500	3,100	1,050	342	150	86
10 W	.880 to .935								
20 W	.880 to .935								
Oil — Castor	.96 © 68°F	35,000	7,500	3,200	1,500	600	228	116	73
Oil — Chinawood	.943	6,900	2,000	1,040	580	285	135	82	58
Oil — Cocoanut	.925	2,250	550	270	150	81	50.5		
Oil — Cod	.928	2,350	620	310	175	92	55		
Oil — Corn	.924	2,150	740	410	250	135	77.5	54.8	
Oil — Cotton	.88 to .925	1,590	525	295	176	100	61.5		
Oil — Cylinder — 600 W	.82 to .95	80,000	14,500	6,000	2,650	1,000	360	165	94
Oil — Diesel Fuel No. 2D	.82 to .95	138	70	53.6	45.5	39			
Oil — Diesel Fuel No. 3D	.82 to .95	390	145	92	65	48	39		
Oil — Diesel Fuel No. 4D	.82 to .95	4,400	700	280	140	70	44.2		
Oil — Diesel Fuel No. 5D	.82 to .95	16,500	3,500	1,500	750	320	136	76.5	54
Oil — Fuel No. 1	.82 to .95				35				
Oil — Fuel No. 2	.82 to .95	104	56	45.5	40				
Oil — Fuel No. 3	.82 to .95	126	68	53	45	39			
Oil — Fuel No. 5A	.82 to .95	1,480	420	215	125	72	48		
Oil — Fuel No. 5B	.82 to .95	850	600	490	400	315	235	178	141
Oil — Fuel No. 6	.82 to .95		72,000	21,500	7,800	2,150	590	225	110
Oil — Fuel — Navy Spec.	.989 Max.	3,300	1,100	600	360	190	100	66	50.2
Oil — Fuel — Navy II	1.0 Max.		24,000	8,600	3,500	1,150	370	160	89

* Depends on origin, or percent and type of solvent used.

VISCOSITY & SPECIFIC GRAVITY OF COMMON LIQUIDS, cont.

LIQUID	*SPECIFIC GRAVITY AT 60°F.	VISCOSITIES IN SSU AT VARIOUS TEMPERATURES							
		30°F	60°F	80°F	100°F	130°F	170°F	210°F	250°F
Oil — Gas	.887	205	89	62.5	50	41			
Oil — Insulating		439	152	92	65	47.5	38.6		
Oil — Lard	.912 to .925	1,400	560	340	220	128	76	55.2	
Oil — Menhadden	.933	750	330	210	140	90	60.5		
Oil — Neats Foot	.917		1.020	440	235	120	74		
Oil — Olive	.912 to .918	1,500	550	320	200	115	70	51.5	
Oil — Palm	.924	1,790	640	360	221	125	74	53	
Oil — Peanut	.920	1,325	515	300	195	112	69.5	51.5	
Oil — Quenching	None Given		850	350	240	148	87	61	
Oil — Rape Seed	.919	1,550	625	340	250	145	87	61.5	49.5
Oil — Rosin	.980	35,400	7,600	3,200	1,500	600	238	115	72.5
Oil — Rosin (Wood)	1.09 Avg.							9,000	750
Oil — Sesame	.923	1,150	470	282	184	110	69	52	44
Oil — Soya Bean	.927 to .98	1,320	470	265	165	96	60		
Oil — Sperm	.883	400	215	150	110	78	57		
Oil — Turbine Heavy	.91 Avg.	4,800	1,280	625	350	170	86	57	
Oil — Turbine Light	.91 Avg.	770	330	208	138	87	58.8		
Oil — Whale	.925	1.070	460	280	184	112	72	53.5	45
Petrolatum	.825	350	220	167	130	97	72	58	50
Phenol (Carbolic Acid)	.95 to 1.08	6	65@65°						
Silicate of Soda, Baumé 41° Ratio 1:3.3		3,500	350	125	66	42.5			
Silicate of Soda, Baumé 41° Ratio 1:3.22		800	195	100	64	45			
Silicate of Soda, Baumé 42° Ratio		1,650	380	180	104	60.5	45.5		
Syrup — Corn — Karo			60,000	15,500	5,000	1,300	350	136	
Syrup — Orange	None Given	50,000	9,400	3,700	1,690	650	242	117	72.6
Syrup — Corn 41° Baumé	1.395		70,000	25,000	11,000	3,600	1,100	450	225
Syrup — Corn 42° Baumé	1.409			54,000	20,000	6,000	1,650	600	280
Syrup — Corn 43° Baumé	1.423				42,500	10,000	2,200	700	300
Syrup — Corn 44° Baumé	1.437					22,500	3,900	1,050	380
Syrup — Corn 45° Baumé	1.450					55,000	7,000	1,460	480
Syrups — Sugar:									
60 Brix.	1.29	1,650	350	162	92	54.7	40.3		
62 Brix.	1.30	2,600	480	215	111	62	42.5		
64 Brix.	1.31	4,400	720	298	148	72	45.5		
66 Brix.	1.326	7,400	1,100	420	195	86	49.5		
68 Brix.	1.338	12,000	1,650	620	275	114	57.5	42.1	
70 Brix.	1.35	28,000	3,100	1,000	400	145	63.5	44	
72 Brix.	1.36	45,000	4,800	1,550	640	220	85	51.5	
73 Brix.	1.37	26,500	3,800	1,325	580	220	89	54	42.9
74 Brix.	1.376		11,000	3,050	1,100	340	112	60	44.5
76 Brix.	1.39		19,000	5,500	2,000	620	190	87.9	56
Sweetose	None Given	70,000	7,700	2,400	950	320	114	62	46
Sulphuric Acid	1.83								
Tallow	.918 Avg.								
Tar — Coke Oven	1.12 +		19,000	4,500	1,400	380	114	58.5	43.5
*Tar — Gas House	1.1 6 to 1.30		33,000	7,000	2,000	480	128	61	44
Tar — Pine	1.06		55,000	10,000	2,500	550	135	61.8	43.7
Tar — Road — RT 2	1.07	1 4,000	2,800	1,180	580	250	107	63.6	49
Tar — Road — RT 4	1.08		13,900	4,300	1,650	540	180	85	55
Tar — Road — RT 6	1.09		80,000	1 9,500	5,900	1,400	350	130	71
Tar — Road — RT 8	1.13				30,000	5,000	850	240	100
Tar — Road — RT 10	1.14 +			FIGS. TOO HIGH FOR LOG PAPER					
Tar — Road — RT 12	1.15 +			FIGS. TOO HIGH FOR LOG PAPER					
Varnish — Spar	.9	3,800	1,600	1,000	650	370	200	125	87

* Depends on origin, or percent and type of solvent used.

SPECIFIC GRAVITY CONVERSION TABLES

CONVERSION TABLE BAUMÉ-SPECIFIC GRAVITY-weight per gallon for liquids HEAVIER than water

A.P.I. or BAUMÉ	SPECIFIC GRAVITY	WGHT PER GAL.	A.P.I. or BAUMÉ	SPECIFIC GRAVITY	WGHT. PER GAL.	A.P.I. or BAUMÉ	SPECIFIC GRAVITY	WGHT. PER GAL.	A.P.I. or BAUMÉ	SPECIFIC GRAVITY	WGHT. PER GAL	A.P.I. or 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	1.124	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 BAUMÉ-SPECIFIC GRAVITY-weight per gallon for liquids LIGHTER than water

A.P.I. or BAUMÉ	SPECIFIC GRAVITY	WGHT PER GAL.	A.P.I. or BAUMÉ	SPECIFIC GRAVITY	WGHT. PER GAL.	A.P.I. or BAUMÉ	SPECIFIC GRAVITY	WGHT. PER GAL.	A.P.I. or BAUMÉ	SPECIFIC GRAVITY	WGHT. PER GAL	A.P.I. or BAUMÉ	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	6.25	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	7.75	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	----	----	----	----	----	----

The specific gravity of a substance is its weight as compared with the weight of an equal bulk of pure water.
For making specific gravity determinations the temperature of the water is usually taken at 62° F. when 1 cubic foot of water weighs 62.355 lbs.
Water is at its greatest density at 39.2° F. or 4° Centigrade.

CONVERSION TABLE BRIX TO SPECIFIC GRAVITY AND BAUMÉ

Brix	Sp. Gr.	Bé	Brix	Sp. Gr.	Bé	Brix	Sp. Gr.	Bé	Brix	Sp. Gr.	Bé	Brix	Sp. Gr.	Bé
0	1.00	0	24	1.101	13.35	48	1.220	26.30	64	1.314	34.64	79	1.410	42.10
2	1.01	1.13	26	I.110	14.45	50	1.230	27.38	66	1.326	35.66	80	1.420	42.60
4	1.02	2.24	28	1.120	15.54	51	1.238	27.91	68	1.340	36.67	82	1.430	43.50
6	1.02	3.37	30	1.130	16.63	52	1.244	28.43	70	1.351	37.66	84	1.440	44.50
8	1.03	4.49	32	1.140	17.73	53	1.249	28.96	71	1.357	38.17	86	1.460	45.44
10	1.04	5.60	34	1.150	18.81	54	1.255	29.48	72	1.364	38.66	88	1.470	46.40
12	1.046	6.71	36	1.160	19.90	55	1.261	30.00	73	1.370	39.16	90	1.480	47.30
14	1.057	7.81	38	1.170	20.98	56	1.267	30.53	74	1.376	39.65	92	1.500	48.20
16	1.066	8.94	40	1.180	22.10	57	1.272	31.05	75	1.383	40.15	94	1.510	49.10
18	1.074	10.04	42	1.190	23.13	58	1.278	31.56	76	1.389	40.64	96	1.530	50
20	1.083	11.15	44	1.200	24.20	60	1.290	32.60	77	1.396	41.12	98	1.540	51
22	1.092	12.30	46	1.210	25.26	62	1.302	33.60	78	1.403	41.61	100	1.560	52

APPROXIMATE VISCOSITY COMPARISONS

The following tables list several commonly used viscosity measurements and permit quick, easy conversion from one to another. Although the values are only approximate, they are sufficiently accurate for most pump calculations. The tables are especially useful because all values may be compared directly with each other. Take particular notice that the absolute viscosities (centipoises) on the right-hand page depend on the specific gravity of the liquid. Hence, in dealing with centipoises (or poises), it is necessary to know the specific gravity in order to select viscosity values from the appropriate column on the right. For specific gravities not listed in the table, the absolute viscosity (in centipoises) may be found by multiplying the kinematic viscosity (in centistokes) by the specific gravity of the liquid.

KINEMATIC VISCOSITY

SSF SAYBOLT SECONDS FUROL	REDWOOD NO. 1 STANDARD SECONDS	REDWOOD NO. 2 ADMIRALTY SECONDS	ENGLER SECONDS	ENGLER SPECIFIC DEGREES	CENTISTOKES (100 Centistokes = 1 Stoke)	SSU SAYBOLT SECONDS UNIVERSAL	FORD #3 SECONDS	FORD #4 SECONDS
10,000	91,300	9,130	144,000	2,880	21,000	100,000	8,750	5,670
9,000	82,100	8,210	130,000	2,590	18,900	90,000	7,860	5.100
8,000	73,000	7,300	120,000	2,300	16,800	80,000	7,000	4,540
7,000	64,000	6,400	100,000	2,010	14,700	70,000	6,120	3,970
6,000	54,900	5,490	86,500	1,730	12,600	60,000	5,240	3,420
5,000	45,700	4,570	72,000	1,440	10,500	50,000	4,370	2,840
4,500	41,100	4,110	64,500	1,295	9,450	45,000	3,930	2,550
4,000	36,500	3,680	60,000	1,150	8,500	40,000	3,500	2,270
3,500	32,000	3,200	50,000	1,000	7,350	35,000	3,060	1,990
3,000	27,400	2,760	45,000	860	6,300	30,000	2,620	1,710
2,500	22,800	2,280	36,000	720	5,250	25,000	2,180	1,420
2,000	18,400	1,840	30,000	580	4,250	20,000	1,750	1,140
1,500	13,700	1,370	21,500	430	3,150	15,000	1,310	855
1,000	9,000	900	15,000	290	2,200	10,000	875	567
900	8,000	800	13,000	260	1,950	9,000	786	510
800	7,100	710	12,000	235	1,700	8,000	700	454
700	6,200	620	10,500	210	1,500	7,000	612	397
600	5,400	540	9,000	180	1,300	6,000	524	342
500	4,300	430	7,500	150	1,050	5,000	437	284
400	3,600	360	5,500	115	850	4,000	350	227
300	2,600	260	4,500	88	630	3,000	262	171
200	1,800	195	3,000	58	420	2,000	175	114
100	900	90	1,500	31	220	1,000	87.5	56.7
90	800	80	1,300	27	195	900	78.6	51.0
80	710	71	1,200	24	170	800	70.0	45.4
70	620	62	1,050	21	150	700	61.2	39.7
60	540	54	900	18	130	600	52.4	34.2
50	430	43	750	14	105	500	43.7	28.4
40	340	36	550	11	85	400	35.0	22.7
33	260	26	450	9	63	300	26.2	17.1
24	195	20	300	6	42	200	17.5	11.4
15	90		150	3	22	100	8.8	5.7
	80		130		19	90	7.9	5.1
	70		120		17	80	7.0	4.5
	62		100		15	70	6.1	4.0
	54		90		10	60	5.2	3.4
	43		75		7	50	4.4	2.8
	36		55		4	40	3.5	2.3

ABSOLUTE VISCOSITY (For specific gravities listed below)

CENTIPOISES (100 CENTIPOISES EQUAL 1 POISE)						
FOR SPECIFIC GRAVITY OF **0.8**	FOR SPECIFIC GRAVITY OF **0.9**	FOR SPECIFIC GRAVITY OF **1.0**	FOR SPECIFIC GRAVITY OF **1.1**	FOR SPECIFIC GRAVITY OF **1.2**	FOR SPECIFIC GRAVITY OF **1.3**	FOR SPECIFIC GRAVITY OF **1.4**
16,800	18,900	21,000	23,100	25,200	27,300	29,400
15,100	17,000	18,900	20,800	22,680	24,560	26,440
13,440	15,100	16,800	18,500	20,180	21,820	23,500
11,750	13,230	14,700	16,180	17,640	19,100	20,590
10,080	11,340	12,600	13,860	15,120	16,480	17,630
8,400	9,450	10,500	11,550	12,600	13,650	14,700
7,560	8,500	9,450	10,400	11,350	12,300	13,240
6,800	7,650	8,500	9,350	10,200	11,050	11,900
5,880	6,620	7,350	8,090	8,830	9,560	10,300
5,040	5,670	6,300	6,940	7,560	8,200	8,830
4,200	4,720	5,250	5,780	6,300	6,830	7,350
3,400	3,820	4,250	4,680	5,100	5,530	5,950
2,520	2,840	3,150	3,460	3,780	4,090	4,410
1,760	1,980	2,200	2,420	2,640	2,860	3,080
1,560	1,750	1,950	2,150	2,340	2,530	2,730
1,360	1,530	1,700	1,870	2,040	2,210	2,380
1,200	1,350	1,500	1,650	1,800	1,950	2,100
1,040	1,170	1,300	1,430	1,560	1,690	1,820
840	945	1,050	1.150	1,260	1,370	1,470
680	765	850	935	1,020	1,100	1,190
505	567	630	694	756	820	883
336	378	420	462	504	546	588
176	198	220	242	264	286	308
156	175	195	214	234	253	273
136	153	170	187	204	221	238
120	135	150	165	180	195	210
104	117	130	143	156	169	182
84	94	105	109	126	136	147
68	77	85	94	102	111	119
50	57	63	69	76	82	88
34	38	42	46	50	55	59
18	20	22	24	26	29	31
15	17	19	21	23	25	27
14	15	17	19	20	22	24
12	14	15	17	18	20	21
8	9	10	11	12	13	14
6	6	7	8	8	9	10
3	4	4	4	5	5	6

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