GORMAN-RUPP PUMPS

ENGINEERING DATA

Engineering specification reference for industrial & municipal markets:

- Contractor
- Industrial Service
- Irrigation
- Sanitation
- Mining
- Firefighting & Prevention
- Petroleum Production

GENERAL INFORMATION

WATER

One miner's inch = 1-1/2 cubic feet per minute = 11.25 U.S. gallons per minute = flow per minute through 1 inch square opening in 2 inch thick plank under a head of 6-1/2 inches to center of orifice in Arizona, California, Montana, Nevada and Oregon. Nine U.S. gallons per minute in Idaho, Kansas, Nebraska, New Mexico, North Dakota, South Dakota, Utah.

One horsepower = 33,000 foot pounds per minute.

$$\text{Cubic feet per second} = \frac{\text{U.S. GPM}}{449}$$

$$\text{Theoretical water horsepower} = \frac{\text{U.S. GPM x head in feet x Sp. Gr.}}{3960}$$

$$\text{Theoretical water horsepower} = \frac{\text{U.S. GPM x head in pounds}}{1714}$$

$$\text{Brake horsepower} = \frac{\text{theoretical water horsepower}}{\text{pump efficiency}}$$

$$\text{Velocity in feet per second} = \frac{.408 \text{ x U.S. GPM}}{(\text{diameter of pipe in inches})^2} = \frac{.32 \text{ x GPM}}{\text{pipe area}}$$

One acre-foot = 325,850 U.S. gallons.

1,000,000 U.S. gallons per day = 695 U.S. gallons per minute.

500 pounds per hour = 1 U.S. gallon per minute.

Doubling the diameter of a pipe or cylinder increases its capacity four times.

Friction of liquids in pipes increases as the square of the velocity.

Velocity in feet per minute necessary to discharge a given volume of water, in a given time

$$= \frac{\text{cu. ft. of water x 144}}{\text{area of pipe in sq. inches}}$$

Area of required pipe, the volume and velocity of water being given

$$= \frac{\text{no. cu. ft. water x 144}}{\text{velocity in ft. per minute}}$$

From this area the size pipe required may be selected from the table of standard pipe dimensions. Atmospheric pressure at sea level is 14.7 pounds per square inch. This pressure with a perfect vacuum will maintain a column of mercury 29.9 inches or a column of water 33.9 feet high. This is the theoretical distance that water may be drawn by suction. In practice, however, pumps should not have a total dynamic suction lift greater than 25 feet.

STATIC HEAD

Static head is the vertical distance between the free level of the source of supply and the point of free discharge, or to the level of the free surface of the discharged liquid.

TOTAL DYNAMIC HEAD

Total dynamic head is the vertical distance between source of supply and point of discharge when pumping at required capacity, plus velocity head, friction, entrance and exit losses.

Total dynamic head, as determined on test where Suction lift exists, is the reading of the mercury column connected to the suction nozzle of the pump, plus the reading of a pressure gauge connected to discharge nozzle of pump, plus vertical distance between point of attachment of mercury column and center of gauge, plus excess, if any, of velocity head of discharge over velocity head of suction, as measured at points where the instruments are attached, plus head of water resting on mercury column, if any.

Total dynamic head, as determined on tests where suction head exists, is the reading of the gauge attached to the discharge nozzle of pump, minus the reading of gauge connected to the suction nozzle of pump, plus or minus vertical distance between centers of gauges (depending upon whether suction gauge is below or above discharge gauge), plus excess, if any, of the velocity head of discharge over velocity head of suction as measured at points where instruments are attached.

Total dynamic discharge head is the total dynamic head minus dynamic suction lift, or plus dynamic suction head.

SUCTION LIFT

Suction Lift: Suction lift exists when the suction measured at the pump nozzle and corrected to the centerline of the pump is below atmospheric pressure.

Static suction lift is the vertical distance from the free level of the source of supply to centerline of pump.

Dynamic suction lift is the vertical distance from the source of supply when pumping at required capacity, to centerline of pump, plus velocity head, entrance, and friction loss, but not including internal pump losses, where static suction head exists. But where the losses exceed the static suction head the dynamic suction lift is the sum of the velocity head, entrance, friction, minus the static suction head, but not including the internal pump losses.

Dynamic suction lift as determined on test, is the reading of the mercury column connected to suction nozzle of pump, plus vertical distance between point of attachment of mercury column to centerline of pump, plus head of water resting on mercury column, if any.

SUCTION HEAD

Suction head (sometimes called head of suction) exists when pressure measured at the suction nozzle and corrected to the centerline of the pump is above atmospheric pressure.

Static suction head is the vertical distance from the free level of the source of supply to centerline of pump.

Dynamic suction head is the vertical distance from the source of supply, when pumping at required capacity, to centerline of pump, minus velocity head, entrance, friction, but not minus internal pump losses.

Dynamic suction head, as determined on test, is the reading of a gauge connected to suction nozzle of pump, minus vertical distance from center of gauge to centerline of pump. Suction Head, after deducting the various losses, may be a negative quantity, in which case a condition equivalent to suction lift will prevail.

VELOCITY HEAD

The velocity head (sometimes called "head due to velocity") of water moving with a given velocity, is the equivalent head through which it would have to fall to acquire the same Velocity, or the head necessary merely to accelerate the water. Knowing the velocity, we can readily figure the velocity head from the simple formula:

$h = \frac{V^2}{2g}$ in which "g" is acceleration due to gravity, or 32.16 feet per second; or knowing the head, we can transpose the formula to

$V = \sqrt{2gh}$ and thus obtain the velocity.

The velocity head is a factor in figuring the total dynamic head, but the value is usually small, and in most cases negligible; however, it should be considered when the total head is low and also when the suction lift is high.

Where the suction and discharge pipes are the same size, it is only necessary to include in the total head the velocity head generated in the suction piping. If the discharge piping is of different size than the suction piping, which is often the case, then it will be necessary to use the velocity in the discharge pipe for computing the velocity head rather than the velocity in the suction pipe.

Velocity head should be considered in accurate testing also, as it is a part of the total dynamic head and consequently affects the duty accomplished.

In testing a pump, a vacuum gauge or a mercury column is generally used for obtaining dynamic suction lift. The mercury column or vacuum gauge will show the velocity head combined with entrance head, friction head, and static suction lift. On the discharge side, a pressure gauge is usually used, but a pressure gauge will not indicate velocity head, and this must, therefore, be obtained either by calculating the velocity, or taking readings with a pitometer. Inasmuch as the velocity varies considerably at different points in the cross section of a stream it is important, in using the pitometer, to take a number of readings at different points in the cross section.

A table giving the relation between velocity and velocity head is printed below.

Velocity in Feet per Sec.	Velocity Head in Feet	Velocity in Feet per Sec.	Velocity Head in Feet	Velocity in Feet per Sec.	Velocity Head in Feet	Velocity in Feet per Sec.	Velocity Head in Feet
1	.02	6	.56	9.5	1.4	12	2.24
2	.06	7	.76	10	1.55	13	2.62
3	.14	8	1.0	10.5	1.7	14	3.05
4	.25	8.5	1.12	11	1.87	15	3.50
5	.39	9	1.25	11.5	2.05		

NET POSITIVE SUCTION HEAD

NPSH stands for "Net Positive Suction Head." It is defined as the suction gauge reading in feet absolute taken on the suction nozzle corrected to pump centerline, minus the vapor pressure in feet absolute corresponding to the temperature of the liquid, plus velocity head at this point. When boiling liquids are being pumped from a closed vessel, NPSH is the static liquid head in the vessel above the pump centerline minus entrance and friction losses.

VISCOSITY

Viscosity is the internal friction of a liquid tending to reduce flow.

Viscosity is ascertained by an instrument termed a viscosimeter, of which there are several makes, viz. Saybolt Universal, Tangliabue, Engler (used chiefly in Continental countries), Redwood (used in British Isles and Colonies). In the United States the Saybolt and Tangliabue instruments are in general use. With few exceptions, viscosity is expressed as the number of seconds required for a definite volume of fluid under an arbitrary head to flow through a standardized aperture at constant temperature.

SPECIFIC GRAVITY

Specific Gravity – The ratio of the weight of any volume to the weight of an equal volume of some other substance taken as a standard at stated temperatures. For solids or liquids the standard is usually water, and for gases the standard is air or hydrogen.

ELECTRICAL DATA

FOOT-POUNDS = Unit of Work.

HORSEPOWER (hp) = (33,000 ft. pounds per min.– 746 watts–.746 kilowatts) Unit for measurement of power or rate of work.

VOLT AMPERES = Product of volts and amperes.

KILOVOLT-AMPERES (KVA) = 1000 volt-amperes.

WATT-HOUR = Small unit of electrical work–watts times hours.

KILOWATT-HOUR (K.W.Hr.) = Large unit of electrical work –1000 watt-hours.

HORSEPOWER-HOUR (H.P.Hr.) = Unit of mechanical work.

To determine the cost of power, for any specified period of time-working hours per day, week, month or year:

$$\frac{\text{no. working hours x .746 x hp motor}}{\text{efficiency of motor}} = \text{K.W. Hr. consumed at motor terminals}$$

K.W.Hr. consumed at motor terminals x rate per K.W.Hr. = total cost current for time specified.

TORQUE is that force which produces or tends to produce torsion (around a axis). Turning effort. It may be thought of as a twist applied to turn a shaft. It can be defined as the push or pull in pounds, along an imaginary circle of one foot radius which surrounds the shaft, or, in an electric motor, as the pull or drag at the surface of the armature multiplied by the radius of the armature, the term being usually expressed in foot-pounds (or pounds at 1 foot radius).

STARTING TORQUE is the torque which a motor exerts when starting. It can be measured directly by fastening a piece of belt to a 24" diameter pulley, wrapping it part way round and measuring the pounds pull the motor can exert, with a spring balance. In practice, any pulley can be used, for torque = lbs. pull x pulley radius in feet. A motor that has a heavy starting torque is one that starts up easily with a heavy load.

RUNNING TORQUE is the pull in pounds a motor exerts on a belt running over a pulley 24" in diameter.

FULL LOAD TORQUE is the turning moment required to develop normal horsepower output at normal speed.

The torque of any motor at any output with a known speed may be determined by the formula:

$$T = \frac{\text{Brake hp}}{\text{RPM}} \times 5250.$$

With a known foot-pounds torque, the horsepower at any given speed can be determined by the formula:

$$hp = \frac{T \times RPM}{5250} \quad \text{or}$$

$$hp = \frac{T \times \text{speed of belt on 24" pulley in feet per minute}}{33000}$$

COST OF PUMPING WATER

Cost per 1000 gallons pumped:

$$\frac{.189 \times \text{power cost per kilowatt-hour} \times \text{head in feet}}{\text{pump eff.} \times \text{motor eff.} \times 60}$$

Example: Power costs .01 per k.w.-hour; pump efficiency is 75%; motor efficiency is 85%; total head is 50 feet:

$$\frac{.189 \times .01 \times 50}{.75 \times .85 \times 60} = \$\ .0025$$

The cost of pumping 1000 gallons of water under the above conditions is 1/4 of a cent.

Cost per hour of pumping:

$$\frac{.000189 \times \text{GPM} \times \text{head in feet} \times \text{power cost per k.w.-hr.}}{\text{pump eff.} \times \text{motor eff.}}$$

Cost per acre foot of water:

$$\frac{1.032 \times \text{head in feet} \times \text{power per k.w.-hr.}}{\text{pump eff.} \times \text{motor eff.}}$$

Pump efficiency:

$$\frac{\text{GPM} \times \text{head in feet}}{3960 \times \text{BHP (to pump)}}$$

Head:

$$\frac{3960 \times \text{pump eff.} \times \text{BHP}}{\text{GPM}}$$

BHP (brake horsepower) to pump:

$$\text{BHP:} \quad \frac{\text{GPM} \times \text{head in feet}}{3960 \times \text{pump eff.}}$$

Motor efficiency x hp at motor:

$$\text{GPM:} \quad \frac{3960 \times \text{pump eff.} \times \text{BHP}}{\text{head in feet}}$$

WATER REQUIREMENTS

Domestic Use

To supply water for each member of a family for all uses including kitchen, laundry and bath .... 30 gallons per day

To flush toilet .... 6 gallons per day

To fill average bathtub ...... 30 gallons per day

To fill ordinary lavatory ..... 1-1/2 gallons per day

Average shower bath .... 30 gallons per day

Continuous flow drinking fountain .... 50 to 100 gallons per day

Note: The above requirements are only approximate, as the consumption of individuals and animals will vary by the seasons and weather conditions.

In selecting the proper size pump, it is essential that the pump capacity be in excess of maximum requirements in order to provide a reserve in the event that water is required from several fixtures at the same time. For example, watering the lawn, drawing a bath, and water used in the kitchen simultaneously, is a common occurrence. It is also advisable to allow for the water level in the well lowering during dry years, thus decreasing pump capacity.

FRICTION LOSS IN POUNDS PRESSURE THROUGH ALUMINUM PIPE

GPM	Pipe Size	Length of Pipe in Feet							
		100'	200'	500'	1000'	2000'	3000'	4000'	5000'
50	2" 3" 4"	2.97 0.37 0.09	6. 0.74 0.18	15. 2. 1.	30. 4. 1.	60. 8. 2.	90. 12. 3.	119. 15. 4.	149. 19. 5.
100	2" 3" 4"	11.02 1.38 0.32	22. 3. 0.64	56. 7. 2.	111 14. 4.	221. 28. 7.	 42. 10.	 56. 13.	 69. 16.
150	2" 3" 4"	20.13 2.82 0.69	41. 6. 2.	101. 15. 4.	202. 29. 7.	 57. 14.	 85. 21.	 113. 28.	 141. 35.
200	3" 4" 6"	5.13 1.21 0.16	11. 3. 0.32	26. 7. 1.	52. 13. 2.	103. 25. 4.	154. 37. 5.	206. 49. 7.	257. 61. 8.
300	3" 4" 6"	11.05 2.60 0.34	22. 6. 0.68	56. 13. 2.	111. 26. 4.	221. 52. 7.	332. 78. 11.	 104. 14.	 130. 17.
400	4" 6" 8"	4.50 0.59 0.14	9. 1. 0.28	23. 3. 1.	45. 6. 2.	90. 12. 3.	135. 18. 5.	180. 24. 6.	225. 30. 7.
500	4" 6" 8"	6.83 0.89 0.22	14. 2. 0.44	35. 5. 2.	69. 9. 3.	137. 18. 5.	205. 27. 7.	274. 36. 9.	342. 45. 11.
600	4" 6" 8"	9.75 1.28 0.31	20. 3. 0.62	49. 7. 2.	98. 13. 4.	195. 26. 7.	293. 39. 10.	 52. 13.	 64. 16.
700	6" 8"	1.70 0.42	4. 1.	9. 3.	17. 5.	34. 9.	51. 13.	68. 17.	85. 21.
800	6" 8"	2.18 0.54	5. 1.	11. 3.	22. 6.	44. 11.	66. 17.	88. 22.	109. 27.
900	6" 8"	2.76 0.68	6. 2.	14. 4.	28. 7.	56. 14.	83. 21.	111. 28.	138. 34.
1000	6" 8"	3.35 0.82	7. 2.	17. 5.	34. 9.	67. 17.	101. 25.	134. 33.	168. 41.
1200	6" 8"	4.72 1.16	10. 3.	24. 6.	48. 12.	95. 24.	142. 35.	189. 47.	236. 58.
1400	6" 8"	6.36 1.56	13. 3.	32. 8.	64. 16.	128. 32.	191. 47.	255. 63.	318. 78.

Note: Loss in couplings not included

GORMAN-RUPP PUMPS

CAPACITIES, IN U.S. GALLONS, OF CYLINDERS OF VARIOUS DIAMETERS AND LENGTHS

Diameter Inches	Length of Cylinder																			Diameter Inches
	1"	1'	5'	6'	7'	8'	9'	10'	11'	12'	13'	14'	15'	16'	17'	18'	20'	22'	24'	
1	....	0.04	0.20	0.24	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.80	0.88	0.96	1
2	0.01	0.16	0.80	0.96	1.12	1.28	1.44	1.60	1.76	1.92	2.08	2.24	2.40	2.56	2.72	2.88	3.20	3.52	3.84	2
3	0.03	0.37	1.84	2.20	2.56	2.92	3.30	3.68	4.04	4.40	4.76	5.12	5.48	5.84	6.22	6.60	7.36	8.08	8.80	3
4	0.05	0.65	3.26	3.92	4.58	5.24	5.88	6.52	7.18	7.84	8.50	9.16	9.82	10.5	11.1	11.8	13.0	14.4	15.7	4
5	0.08	1.02	5.10	6.12	7.14	8.16	9.18	10.2	11.2	12.2	13.3	14.3	15.3	16.3	17.3	18.4	20.4	22.4	24.4	5
6	0.12	1.47	7.34	8.80	10.3	11.8	13.2	14.7	16.1	17.6	19.1	20.6	22.0	23.6	25.0	26.4	29.4	32.2	35.2	6
7	0.17	2.00	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0	34.0	36.0	40.0	44.0	48.0	7
8	0.22	2.61	13.0	15.6	18.2	20.8	23.4	26.0	28.6	31.2	33.8	36.4	39.0	41.6	44.2	46.8	52.0	57.2	62.4	8
9	0.28	3.31	16.5	19.8	23.1	26.4	29.8	33.0	36.4	39.6	43.0	46.2	49.6	52.8	56.2	60.0	66.0	72.4	79.2	9
10	0.34	4.08	20.4	24.4	28.4	32.6	36.8	40.8	44.8	48.8	52.8	56.8	61.0	65.2	69.4	73.6	81.6	89.6	97.6	10
11	0.41	4.94	24.6	29.6	34.6	39.4	44.4	49.2	54.2	59.2	64.2	69.2	74.0	78.8	83.8	88.8	98.4	104.	118.	11
12	0.49	5.88	29.4	35.2	41.0	46.8	52.8	58.8	64.6	70.4	76.2	82.0	87.8	93.6	99.6	106.	118.	129.	141.	12
13	0.57	6.90	34.6	41.6	48.6	55.2	62.2	69.2	76.2	83.2	90.2	97.2	104.	110.	117.	124.	138.	152.	166.	13
14	0.67	8.00	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.	112.	120.	128.	136.	144.	160.	176.	192.	14
15	0.77	9.18	46.0	55.2	64.4	73.6	82.8	92.0	101.	110.	120.	129.	138.	147.	156.	166.	184.	202.	220.	15
16	0.87	10.4	52.0	62.4	72.8	83.2	93.6	104.	114.	125.	135.	146.	156.	166.	177.	187.	208.	229.	250.	16
17	0.98	11.8	59.0	70.8	81.6	94.4	106.	118.	130.	142.	153.	163.	177.	189.	201.	212.	236.	260.	283.	17
18	1.10	13.2	66.0	79.2	92.4	106.	119.	132.	145.	158.	172.	185.	198.	211.	224.	240.	264.	290.	317.	18
19	1.23	14.7	73.6	88.4	103.	118.	132.	147.	162.	177.	192.	206.	221.	235.	250.	265.	294.	324.	354.	19
20	1.36	16.3	81.6	98.0	114.	130.	147.	163.	180.	196.	212.	229.	245.	261.	277.	294.	326.	359.	392.	20
21	1.50	18.0	90.0	108.	126.	144.	162.	180.	198.	216.	238.	252.	270.	288.	306.	324.	360.	396.	432.	21
22	1.65	19.8	99.0	119.	139.	158.	178.	198.	218.	238.	257.	277.	297.	317.	337.	356.	396.	436.	476.	22
23	1.80	21.6	108.	130.	151.	173.	194.	216.	238.	259.	281.	302.	324.	346.	367.	389.	432.	476.	518.	23
24	1.96	23.5	118.	141.	165.	188.	212.	235.	259.	282.	306.	330.	353.	376.	400.	424.	470.	518.	564.	24
25	2.12	25.5	128.	153.	179.	204.	230.	255.	281.	306.	332.	358.	383.	408.	434.	460.	510.	562.	612.	25
26	2.30	27.6	138.	166.	193.	221.	248.	276.	304.	331.	359.	386.	414.	442.	470.	496.	552.	608.	662.	26
27	2.48	29.7	148.	178.	208.	238.	267.	297.	326.	356.	386.	416.	426.	476.	504.	534.	594.	652.	712.	27
28	2.67	32.0	160.	192.	224.	256.	288.	320.	352.	384.	416.	448.	480.	512.	544.	576.	640.	704.	768.	28
29	2.86	34.3	171.	206.	240.	274.	309.	343.	377.	412.	446.	480.	514.	548.	584.	618.	686.	754.	824.	29
30	3.06	36.7	183.	220.	257.	294.	330.	367.	404.	440.	476.	514.	550.	588.	624.	660.	734.	808.	880.	30
32	3.48	41.8	209.	251.	293.	334.	376.	418.	460.	502.	544.	586.	628.	668.	710.	752.	836.	920.	1004.	32
34	3.93	47.2	236.	283.	330.	378.	424.	472.	520.	566.	614.	660.	708.	756.	802.	848.	944.	1040.	1132.	34
36	4.41	52.9	264.	317.	370.	422.	476.	528.	582.	634.	688.	740.	792.	844.	898.	952.	1056.	1164.	1268.	36

CAPACITY OF ROUND TANK – Per Foot of Depth

Diameter	Gallons	Area Sq. Ft.	Diameter	Gallons	Area Sq. Ft.	Diameter	Gallons	Area Sq. Ft.	Diameter	Gallons	Area Sq. Ft.
1'	5.87	.785	4'	94.00	12.566	11'	710.90	95.03	22'	2843.60	380.13
1' 1"	6.89	.922	4' 1"	97.96	13.095	11' 3"	743.58	99.40	22' 3"	2908.60	388.82
1' 2"	8.00	1.069	4' 2"	102.00	13.635	11' 6"	776.99	103.87	22' 6"	2974.30	397.61
1' 3"	9.18	1.227	4' 3"	106.12	14.186	11' 9"	811.14	108.43	22' 9"	3040.80	406.49
1' 4"	10.44	1.396	4' 4"	110.32	14.748	12'	846.03	113.10	23'	3108.00	415.48
1' 5"	11.79	1.576	4' 5"	114.61	15.321	12' 3"	881.65	117.86	23' 3"	3175.90	424.56
1' 6"	13.22	1.767	4' 6"	118.97	15.90	12' 6"	918.00	122.72	23' 6"	3244.60	433.74
1' 7"	14.73	1.969	4' 7"	123.42	16.50	12' 9"	955.09	127.68	23' 9"	3314.00	443.01
1' 8"	16.32	2.182	4' 8"	127.95	17.10	13'	992.91	132.73	24'	3384.10	452.39
1' 9"	17.99	2.405	4' 9"	132.56	17.72	13' 3"	1031.50	137.89	24' 3"	3455.00	461.86
1' 10"	19.75	2.640	4' 10"	137.25	18.35	13' 6"	1070.80	142.14	24' 6"	3526.60	471.44
1' 11"	21.58	2.885	4' 11"	142.02	18.99	13' 9"	1110.80	148.49	24' 9"	3598.90	481.11
2'	23.50	3.142	5' 8"	188.66	25.22	14'	1151.50	153.94	25'	3672.00	490.87
2' 1"	25.50	3.409	5' 9"	194.25	25.97	14' 3"	1193.00	159.48	25' 3"	3745.80	500.74
2' 2"	27.58	3.687	5' 10"	199.92	26.73	14' 6"	1235.30	165.13	25' 6"	3820.30	510.71
2' 3"	29.74	3.976	5' 11"	205.67	27.49	14' 9"	1278.20	170.87	25' 9"	3895.60	527.77
2' 4"	31.99	4.276	6'	211.51	28.27	15'	1321.90	176.71	26'	3971.60	530.93
2' 5"	34.31	4.587	6' 3"	229.50	30.68	15' 3"	1366.40	182.65	26' 3"	4048.40	541.19
2' 6"	36.72	4.909	6' 6"	248.23	35.18	15' 6"	1411.50	188.69	26' 6"	4125.90	551.55
2' 7"	39.21	5.241	6' 9"	267.69	35.78	15' 9"	1457.40	194.83	26' 9"	4204.10	562.00
2' 8"	41.78	5.585	7'	287.88	38.48	16'	1504.10	201.06	27'	4283.00	572.66
2' 9"	44.43	5.940	7' 3"	308.81	41.28	16' 3"	1551.40	207.39	27' 3"	4362.70	583.21
2' 10"	47.16	6.305	7' 6"	330.48	44.18	16' 6"	1599.50	213.82	27' 6"	4443.10	593.96
2' 11"	49.98	6.681	7' 9"	352.88	47.17	16' 9"	1648.40	220.35	27' 9"	4524.30	604.81
3'	52.88	7.069	8'	376.01	50.27	19'	2120.90	283.53	28'	4606.20	615.75
3' 1"	55.86	7.467	8' 3"	399.80	53.46	19' 3"	2177.10	291.04	28' 3"	4688.80	626.80
3' 2"	58.92	7.876	8' 6"	424.48	56.75	19' 6"	2234.00	298.65	28' 6"	4772.10	637.94
3' 3"	62.06	8.296	8' 9"	449.82	60.13	19' 9"	2291.70	306.35	28' 9"	4856.20	649.18
3' 4"	65.28	8.727	9'	475.89	63.62	20'	2350.10	314.16	29'	4941.00	660.52
3' 5"	68.58	9.168	9' 3"	502.70	67.20	20' 3"	2409.20	322.06	29' 3"	5026.60	671.96
3' 6"	71.97	9.621	9' 6"	530.24	70.88	20' 6"	2469.10	330.06	29' 6"	5112.90	683.49
3' 7"	75.44	10.085	9' 9"	558.51	74.66	20' 9"	2529.60	338.16	29' 9"	5199.90	695.13
3' 8"	78.99	10.559	10'	587.52	78.54	21'	2591.00	346.36	30'	5287.70	706.86
3' 9"	82.62	11.045	10' 3"	617.26	82.52	21' 3"	2653.00	354.66	30' 3"	5376.20	718.69
3' 10"	86.33	11.541	10' 6"	640.74	86.59	21' 6"	2715.80	363.05	30' 6"	5465.40	730.62
3' 11"	90.13	12.048	10' 9"	678.95	90.76	21' 9"	2779.30	371.54	30' 9"	5555.40	742.64

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

CAPACITY OF SQUARE TANKS

Dimensions in Feet	Contents in Gallons for Depth in Feet of:							
	1'	4'	5'	6'	8'	10'	11'	12'
4 x 4	119.68	479.	598.	718.	957.	1197.	1316.	1436.
5 x 5	187.00	748.	935.	1202.	1516.	1870.	2057.	2244.
6 x 6	269.28	1077.	1346.	1616.	2154.	2693.	2968.	3231.
7 x 7	366.52	1466.	1833.	2199.	2922.	3665.	4032.	4398.
8 x 8	478.72	1915.	2394.	2872.	3830.	4787.	5266.	5745.
9 x 9	605.88	2424.	3029.	3635.	4847.	6059.	6665.	7272.
10 x 10	748.08	2992.	3740.	4488.	5984.	7480.	8228.	8976.
11 x 11	905.08	3620.	4525.	5430.	7241.	9051.	9956.	10861.
12 x 12	1077.12	4308.	5386.	6463.	8617.	10771.	11848.	12925.

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

CYLINDRICAL TANKS SET HORIZONTALLY AND PARTIALLY FILLED

Diameter	Gallons Per Foot of Length When Tank Is Filled								
	1/10	1/5	3/10	2/5	1/2	3/5	7/10	4/5	9/10
1'..........	.3	.8	1.4	2.1	2.9	3.6	4.3	4.9	5.5
2'..........	1.2	3.3	5.9	8.8	11.7	14.7	17.5	20.6	22.2
3'..........	2.7	7.5	13.6	19.8	26.4	33.0	39.4	45.2	50.1
4'..........	4.9	13.4	23.8	35.0	47.0	59.0	70.2	80.5	89.0
5'..........	7.6	20.0	37.0	55.0	73.0	92.0	110.0	126.0	139.0
6'..........	11.0	30.0	53.0	78.0	106.0	133.0	158.0	182.0	201.0
7'..........	15.0	41.0	73.0	107.0	144.0	181.0	215.0	247.0	272.0
8'..........	19.0	52.0	96.0	140.0	188.0	235.0	281.0	322.0	356.0
9'..........	25.0	67.0	112.0	178.0	238.0	298.0	352.0	408.0	450.0
10'..........	30.0	83.0	149.0	219.0	294.0	368.0	440.0	504.0	556.0
11'..........	37.0	101.0	179.0	265.0	356.0	445.0	531.0	610.0	672.0
12'..........	44.0	120.0	214.0	315.0	423.0	530.0	632.0	741.0	800.0
13'..........	51.0	141.0	250.0	370.0	496.0	621.0	740.0	850.0	940.0
14'..........	60.0	164.0	291.0	430.0	576.0	722.0	862.0	989.0	1084.0
15'..........	68.0	188.0	334.0	494.0	661.0	829.0	988.0	1134.0	1253.0

FORMULAE

$$V = CR^{0.63}\left(\frac{H}{L}\right)^{0.54} \times 1.32$$

where V = velocity in feet per sec.

R = hydraulic radius = $\frac{\text{dia. pipe in feet}}{4}$

H = friction head

L = length of piping in feet

C = constant depending upon roughness of pipe, also upon R

or

$$H = \left(\frac{147.85Q}{CD^{2.63}}\right)^{1.852}$$

where $\frac{H}{10}$ = friction head for L = 100 ft.

Q= GPM

D= dia. of pipe in inches (actual)

C= 100–For other value of C the figures in the table should be multiplied by

$$K = \left(\frac{100}{C}\right)^{1.852}$$

TABLE GIVING COEFFICIENT "C" AND FACTOR "K" FOR DIFFERENT KINDS AND SIZES OF PIPES

VARIOUS KINDS PIPE			Corresponding years of service of cast iron pipe in soft, clear, unfiltered river water.																
Coefficient	Factor	Size of Pipe in Inches 1/8" to 3"	Coefficient	Factor	Size of Pipe in Inches 4	5	6	8	10	12	16	20	24	30	36	42	48	54	60
C	K	CONDITION OF PIPE	C	K	Years of Service														
140	.54	Very Smooth & Straight W.I., Brass, Tin, Copper & Lead Pipe..........	140	.54	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
130	.62	Ordinary Straight Brass, Tin, Copper & Lead Pipe..........	130	.62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	.71	Smooth New W.I. Pipe..........	120	.71	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6
110	.84	Fairly Smooth New W.I. Pipe..........	110	.84				10	10	10	11	11	11	12	12	12	12	12	12
100	1.00	Ordinary W.I. Pipe..........	100	1.00	13	14	15	16	17	17	18	19	19	19	20	20	20	20	20
90	1.22	Medium Old W.I. Pipe..........	90	1.22						26	27	28	29	30	30	30	30	31	31
80	1.52	Old W.I. Pipe..........	80	1.52	26	28	30	33	35	37	39	41	42	43	44	45	45	46	47
60	2.58	Very Rough Pipe..........	60	2.58	45	50	55	62	68										
40	5.46	Badly Tuberculated Pipe..........	40	5.46	75	87	95												

00 Indicates the very best new cast iron pipe, laid perfectly straight. 0 Indicates good new cast iron pipe.

The foregoing values can also be used for welded steel pipe.

For riveted steel pipe the average value of "C" is lower than for cast iron pipe. The data on hand indicate a value of "C" equals 110 for new riveted pipe, decreasing in the course of about 10 years to 100. For older pipes riveted steel pipe of a given age will carry the same quantity of water as cast iron pipe of the same size and 10 years older.

For gasoline C= 130 factor K x Sp. Gr.

FRICTION LOSS OF WATER IN FEET PER 100 FEET LENGTH OF PIPE

Based on Hazen & Williams formula using constant 100.0 sizes of standard pipe in inches.

U.S. Gallons Per Min.	Velocity Feet Per Sec.	Loss in Feet	Velocity Feet Per Sec.	Loss in Feet	Velocity Feet Per Sec.	Loss in Feet	Velocity Feet Per Sec.	Loss in Feet	Velocity Feet Per Sec.	Loss in Feet	Velocity Feet Per Sec.	Loss in Feet	Velocity Feet Per Sec.	Loss in Feet	Velocity Feet Per Sec.	Loss in Feet	Velocity Feet Per Sec.	Loss in Feet	Velocity Feet Per Sec.	Loss in Feet	Velocity Feet Per Sec.	Loss in Feet
2	2.10	7.40	1.20	1.90																		
4	4.21	27.00	2.41	7.00	1.49	2.14	0.86	0.57	0.63	0.26												
6	6.31	57.00	3.61	14.70	2.23	4.55	1.29	1.20	0.94	0.56	0.61	0.20										
8	8.42	98.00	4.81	25.00	2.98	7.80	1.72	2.03	1.26	0.95	0.82	0.33	0.52	0.11								
10	10.52	147.00	6.02	38.00	3.72	11.70	2.14	3.05	1.57	1.43	1.02	0.50	0.65	0.17	0.45	0.07						
12			7.22	53.00	4.46	16.40	2.57	4.30	1.89	2.01	1.23	0.79	0.78	0.23	0.54	0.10						
15	1/2"		9.02	80.00	5.60	25.00	3.21	6.50	2.36	3.00	1.53	1.08	0.98	0.36	0.68	0.15						
18			10.84	108.20	6.69	35.00	3.86	9.10	2.83	4.24	1.84	1.49	1.18	0.50	0.82	0.21						
20			12.03	136.00	7.44	42.00	4.29	11.10	3.15	5.20	2.04	1.82	1.31	0.61	0.91	0.25	0.51	0.06				
25					9.30	64.00	5.36	16.60	3.80	7.30	2.55	2.73	1.63	0.92	1.13	0.38	0.64	0.09				
30					11.15	89.00	6.43	23.00	4.72	11.00	3.06	3.84	1.96	1.29	1.36	0.54	0.77	0.13	0.49	0.04		
35			3/4"		13.02	119.00	7.51	31.20	5.51	14.70	3.57	5.10	2.29	1.72	1.59	0.71	0.89	0.17	0.57	0.06		
40					14.88	152.00	8.58	40.00	6.30	18.80	4.08	6.60	2.61	2.20	1.82	0.91	1.02	0.22	0.65	0.08		
45							9.65	50.00	7.08	23.20	4.60	8.20	2.94	2.80	2.04	1.15	1.15	0.28	0.73	0.09		
50							10.72	60.00	7.87	28.40	5.11	9.90	3.27	3.32	2.27	1.38	1.28	0.34	0.82	0.11	0.57	0.04
55					1"		11.78	72.00	8.66	34.00	5.62	11.80	3.59	4.01	2.45	1.58	1.41	0.41	0.90	0.14	0.62	0.05
60							12.87	85.00	9.44	39.60	6.13	13.90	3.92	4.65	2.72	1.92	1.53	0.47	0.98	0.16	0.68	0.06
65							13.92	99.70	10.23	45.90	6.64	16.10	4.24	5.40	2.89	2.16	1.66	0.53	1.06	0.19	0.74	0.07
70							15.01	113.00	11.02	53.00	7.15	18.40	4.58	6.20	3.18	2.57	1.79	0.63	1.14	0.21	0.79	0.08
75							16.06	129.00	11.80	60.00	7.66	20.90	4.91	7.10	3.33	3.00	1.91	0.73	1.22	0.24	0.85	0.10
80							17.16	145.00	12.59	68.00	8.17	23.70	5.23	7.90	3.63	3.28	2.04	0.81	1.31	0.27	0.91	0.11
85							18.21	163.80	13.38	75.00	8.68	26.50	5.56	8.10	3.78	3.54	2.17	0.91	1.39	0.31	0.96	0.12
90							19.30	180.00	14.71	84.00	9.19	29.40	5.88	9.80	4.09	4.08	2.30	1.00	1.47	0.34	1.02	0.14
95									14.95	93.00	9.70	32.60	6.21	10.80	4.22	4.33	2.42	1.12	1.55	0.38	1.08	0.15
100	8"						1-1/4"		15.74	102.00	10.21	35.80	6.54	12.00	4.54	4.96	2.55	1.22	1.63	0.41	1.13	0.17
110									17.31	122.00	11.23	42.90	7.18	14.50	5.00	6.00	2.81	1.46	1.79	0.49	1.25	0.21
120									18.89	143.00	12.25	50.00	7.84	16.80	5.45	7.00	3.06	1.17	1.96	0.58	1.36	0.24
130									20.46	166.00	13.28	58.00	8.48	18.70	5.91	8.10	3.31	1.97	2.12	0.67	1.47	0.27
140	0.90	0.08							22.04	190.00	14.30	67.00	9.15	22.30	6.35	9.20	3.57	2.28	2.29	0.76	1.59	0.32
150	0.96	0.09									15.32	76.00	9.81	25.50	6.82	10.50	3.82	2.62	2.45	0.88	1.70	0.36
160	1.02	0.10	10"						1-1/2"		16.34	86.00	10.46	29.00	7.26	11.80	4.08	2.91	2.61	0.98	1.82	0.40
170	1.08	0.11									17.36	96.00	11.11	34.10	7.71	13.30	4.33	3.26	2.77	1.08	1.92	0.45
180	1.15	0.13									18.38	107.00	11.76	35.70	8.17	14.00	4.60	3.61	2.94	1.22	2.04	0.50
190	1.21	0.14									19.40	118.00	12.42	39.60	8.63	15.50	4.84	4.01	3.10	1.35	2.16	0.55
200	1.28	0.15									20.42	129.00	13.07	43.10	9.08	17.80	5.11	4.40	3.27	1.48	2.27	0.62
220	1.40	0.18	0.90	0.06							22.47	154.00	14.38	52.00	9.99	21.30	5.62	5.20	3.59	1.77	2.50	0.73
240	1.53	0.22	0.98	0.07	12"						24.51	182.00	15.69	61.00	10.89	25.10	6.13	6.20	3.92	2.08	2.72	.87
260	1.66	0.25	1.06	0.08							26.55	211.00	16.99	70.00	11.80	29.10	6.64	7.20	4.25	2.41	2.95	1.00
280	1.79	0.28	1.15	0.09									18.30	81.00	12.71	33.40	7.15	8.20	4.58	2.77	3.18	1.14
300	1.91	0.32	1.22	0.11									19.61	92.00	13.62	38.00	7.66	9.30	4.90	3.14	3.40	1.32
320	2.05	0.37	1.31	0.12							2"		20.92	103.00	14.52	42.80	8.17	10.50	5.23	3.54	3.64	1.47
340	2.18	0.41	1.39	0.14									22.22	116.00	15.43	47.90	8.68	11.70	5.54	3.97	3.84	1.62
360	2.30	0.45	1.47	0.15			14"						23.53	128.00	16.34	53.00	9.19	13.10	5.87	4.41	4.08	1.83
380	2.43	0.50	1.55	0.17	1.08	0.06							24.84	142.00	17.25	59.00	9.69	14.00	6.19	4.86	4.31	2.00
400	2.60	0.54	1.63	0.19	1.14	0.07							26.14	156.00	18.16	65.00	10.21	16.00	6.54	5.40	4.55	2.20
450	2.92	0.68	1.84	0.23	1.28	0.96									20.40	78.00	11.49	19.80	7.35	6.70	5.11	2.74
500	3.19	0.82	2.04	0.28	1.42	0.11	1.04	0.06							22.70	98.00	12.77	24.00	8.17	8.10	5.68	2.90
550	3.52	0.97	2.24	0.33	1.56	0.13	1.15	0.07							24.96	117.00	14.04	28.70	8.99	9.60	6.25	3.96
600	3.84	1.14	2.45	0.39	1.70	0.15	1.25	0.08	16"				2-1/2"		27.23	137.00	15.32	33.70	9.80	11.30	6.81	4.65
650	4.16	1.34	2.65	0.45	1.84	0.19	1.37	0.09									16.59	39.00	10.62	13.20	7.38	5.40
700	4.46	1.54	2.86	0.52	1.99	0.22	1.46	0.10									17.87	44.90	11.44	15.10	7.95	6.21
750	4.80	1.74	3.06	0.59	2.13	0.24	1.58	0.11									19.15	51.00	12.26	17.20	8.50	7.12
800	5.10	1.90	3.26	0.66	2.27	0.27	1.67	0.13							3"		20.42	57.00	13.07	19.40	9.08	7.96
850	5.48	2.20	3.47	0.75	2.41	0.31	1.79	0.14	1.36	0.08	20"						21.70	64.00	13.89	21.70	9.65	8.95
900	5.75	2.46	3.67	0.83	2.56	0.34	1.88	0.16	1.44	0.08							22.98	71.00	14.71	24.00	10.20	10.11
950	6.06	2.87	3.88	0.91	2.70	0.38	2.00	0.18	1.52	0.09									15.52	26.70	10.77	11.20
1000	6.38	2.97	4.08	1.03	2.84	0.41	2.10	0.19	1.60	0.10	1.02	0.04							16.34	29.20	11.34	12.04
1100	7.03	3.52	4.49	1.19	3.13	0.49	2.31	0.23	1.76	0.12	1.12	0.04							17.97	34.90	12.48	14.55
1200	7.66	4.17	4.90	1.40	3.41	0.58	2.52	0.27	1.92	0.14	1.23	0.05					4"		19.61	40.90	13.61	17.10
1300	8.30	4.85	5.31	1.62	3.69	0.67	2.71	0.32	2.08	0.17	1.33	0.06	24"								14.72	18.40
1400	8.95	5.50	5.71	1.87	3.98	0.78	2.92	0.36	2.24	0.19	1.43	0.06									15.90	22.60
1500	9.58	6.24	6.12	2.13	4.26	0.89	3.15	0.41	2.39	0.21	1.53	0.07									17.02	25.60
1600	10.21	7.00	6.53	2.39	4.55	0.98	3.34	0.47	2.56	0.24	1.63	0.08							5"		18.10	26.90
1800	11.50	8.78	7.35	2.96	5.11	1.21	3.75	0.58	2.87	0.30	1.84	0.10	1.28	0.04								
2000	12.78	10.71	8.16	3.59	5.68	1.49	4.17	0.71	3.19	0.37	2.04	0.12	1.42	0.05	30"							
2200	14.05	12.78	8.98	4.24	6.25	1.81	4.59	0.84	3.51	0.44	2.25	0.15	1.56	0.06							6"	
2400	15.32	14.20	9.80	5.04	6.81	2.08	5.00	0.99	3.83	0.52	2.45	0.17	1.70	0.07	1.09	0.02						
2600			10.61	5.81	7.38	2.43	5.47	1.17	4.15	0.60	2.66	0.20	1.84	0.08	1.16	0.02						
2800			11.41	6.70	7.96	2.75	5.84	1.32	4.47	0.68	2.86	0.23	1.98	0.09	1.27	0.03						
3000			12.24	7.62	8.52	3.15	6.01	1.49	4.79	0.78	3.08	0.27	2.13	0.10	1.37	0.03						
3200			13.05	7.80	9.10	3.51	6.68	1.67	5.12	0.88	3.27	0.30	2.26	0.12	1.46	0.04						
3500			14.30	10.08	9.95	4.16	7.30	1.97	5.59	1.04	3.59	0.35	2.49	0.14	1.56	0.04						
3800			15.51	13.40	10.80	4.90	7.98	2.36	6.07	1.20	3.88	0.41	2.69	0.17	1.73	0.05						
4200					11.92	5.88	8.76	2.77	6.70	1.44	4.29	0.49	2.99	0.20	1.91	0.07						
4500					12.78	6.90	9.45	3.22	7.18	1.64	4.60	0.56	3.20	0.22	2.04	0.08						
5000					14.20	8.40	10.50	3.92	8.01	2.03	5.13	0.68	3.54	0.27	2.26	0.09						
5500							11.55	4.65	8.78	2.39	5.64	0.82	3.90	0.33	2.50	0.11						
6000							12.60	5.50	9.58	2.79	6.13	0.94	4.25	0.38	2.73	0.13						
6500							13.65	6.45	10.39	3.32	6.64	1.10	4.61	0.45	2.96	0.15						
7000							14.60	7.08	11.18	3.70	7.15	1.25	4.97	0.52	3.18	0.17						
8000									12.78	4.74	8.17	1.61	5.68	0.66	3.64	0.23						
9000									14.37	5.90	9.20	2.01	6.35	0.81	4.08	0.28						
10000									15.96	7.19	10.20	2.44	7.07	0.98	4.54	0.33						
12000											12.25	3.41	8.50	1.40	5.46	0.48						
14000											14.30	4.54	9.95	1.87	6.37	0.63						
16000													11.38	2.40	7.28	0.81						
18000													12.76	2.97	8.18	1.02						
20000													14.20	3.60	9.10	1.23						

FRICTION LOSSES THROUGH SCREW PIPE FITTINGS IN TERMS OF EQUIVALENT LENGTHS OF STANDARD PIPE

Nominal Pipe Size Inches	Actual Inside Diameter Inches	Gate Valve	Long-Sweep Elbow or on Run of Standard Tee	Medium–Sweep Elbow or on Run of Tee Reduced in Size 1/4	Standard Elbow or on Run of Tee Reduced in Size 1/2	Angle Valve	Close Return Bend	Tee Through Side Outlet	Globe Valve
Factor of Resistance		0.25	0.33	0.42	0.67	0.90	1.00	1.33	2.00
1/2	0.662	0.335	0.442	0.56	0.89	1.20	1.34	1.79	2.68
3/4	0.824	0.475	0.627	0.79	1.27	1.71	1.90	2.52	3.80
1	1.049	0.640	0.844	1.07	1.72	2.30	2.56	3.40	5.12
1-1/4	1.38	0.902	1.19	1.51	2.42	3.24	3.61	4.80	7.22
1-1/2	1.61	1.09	1.43	1.83	2.92	3.92	4.36	5.79	8.72
2	2.06	1.49	1.96	2.50	3.99	5.36	5.96	7.92	11.92
2-1/2	2.46	1.86	2.46	3.13	5.00	6.72	7.47	9.93	14.94
3	3.06	2.46	3.25	4.11	6.66	8.87	9.86	13.11	19.72
4	4.026	3.44	4.53	5.77	9.22	12.37	13.70	18.28	27.50
5	5.047	4.57	6.00	7.68	12.20	16.47	18.30	24.33	36.60
6	6.065	5.72	7.55	9.61	15.30	20.61	22.90	30.45	45.00
7	7.024	6.90	9.10	11.60	18.50	24.84	27.60	36.70	55.20
8	7.981	8.10	10.70	13.60	21.71	29.16	32.40	43.09	64.80
10	10.020	10.70	14.10	17.97	28.70	38.52	42.80	56.92	85.60
12	12.090	12.50	17.80	22.68	36.28	48.60	54.00	71.82	108.00

This table is based on Fosters formula: $L = 53.75\ rd.^{125}$
In which L = equivalent length of straight pipe in feet
r = resistance factor
d = diameter of fitting in feet
Foot valve loss = zero provided foot valve has area of 150% of suction pipe.
(A.S.M.E. Trans. Volume 42, pg. 648, 1920)

FRICTION LOSSES IN PIPE FITTINGS IN TERMS OF EQUIVALENT LENGTHS OF STRAIGHT PIPE

Nominal Pipe Size Inches	Standard Gate Valve or Exp'n Joint	Long Rad. 90° Elbow or Run of Standard Tee	Med. Sweep 90° Elbow or Run of Tee Reduced 1/4	Standard 90° Elbow or Run of Tee Reduced 1/2	Square 90° Elbow Welded Construction	Standard 45° Elbow	Standard Tee through Side Outlet	Standard Tee Side Inlet Divided Outlet	Ordinary Entrance Loss
14	18.5	24.5	31	49	58	14.5	98	70	22.5
16	21.5	28.5	36	58	66	16.5	115	80	26.0
18	25.0	33	42	67	75	18.5	132	91	29.5
20	28.5	38	48	78	83	20.5	150	102	32
24	36	47	60	98	101	25	185	121	40
30	47	61	80	126	127	32	242	151	50
36	59	79	100	156	150	38	305	179	60
42	71	95	120	189	175	44	370	210	70
48	83	110	139	219	200	50	435	242	80

WATER FRICTION IN 100 FEET OF SMOOTH BORE HOSE.

For various flows and hose sizes, table gives velocity of water and feet of head lost in friction in 100 feet of smooth bore hose. Sizes of hose shown are actual inside diameters.

Flow in U.S. Gallons Per Min.	Velocity in Feet Per Sec.	Friction Head in Feet	Velocity in Feet Per Sec.	Friction Head in Feet	Velocity in Feet Per Sec.	Friction Head in Feet	Velocity in Feet Per Sec.	Friction Head in Feet	Velocity in Feet Per Sec.	Friction Head in Feet	Velocity in Feet Per Sec.	Friction Head in Feet
	1"		1½"									
5	2.0	2.2	.9	.3								
					2"							
10	4.1	7.8	1.8	1.0	1.0	.2						
15	6.1	16.8	2.7	2.3	1.5	.5	2½"					
20	8.2	28.7	3.6	3.9	2.0	.9	1.3	.32				
25	10.2	43.2	4.5	6.0	2.5	1.4	1.6	.51	3"			
30	12.2	61.2	5.4	8.5	3.1	2.0	2.0	.70	1.4	.3		
35	14.3	80.5	6.4	11.2	3.6	2.7	2.3	.93	1.6	.4		
40			7.3	14.3	4.1	3.5	2.6	1.2	1.8	.5		
45			8.2	17.7	4.6	4.3	2.9	1.5	2.0	.6		
50			9.1	21.8	5.1	5.2	3.3	1.8	2.3	.7		
60			10.9	30.2	6.1	7.3	3.9	2.5	2.7	1.0		
70			12.7	40.4	7.1	9.8	4.6	3.3	3.2	1.3		
80			14.5	52.0	8.2	12.6	5.2	4.3	3.6	1.7	4"	
90			16.3	64.2	9.2	15.7	5.9	5.3	4.1	2.1	2.3	.5
100			18.1	77.4	10.2	18.9	6.5	6.5	4.5	2.6	2.5	.6
125					12.8	28.6	8.2	9.8	5.7	4.0	3.2	.9
150					15.3	40.7	9.8	13.8	6.8	5.6	3.8	1.3
175	5"		6"		17.9	53.4	11.4	18.1	7.9	7.4	4.5	1.8
200	3.3	.8	2.3	.32	20.4	68.5	13.1	23.4	9.1	9.6	5.1	2.3
225	3.7	1.0	2.6	.40			14.7	29.0	10.2	11.9	5.7	2.9
250	4.1	1.2	2.8	.49			16.3	35.0	11.3	14.8	6.4	3.5
275	4.5	1.4	3.1	.58			18.0	42.0	12.5	17.2	7.0	4.2
300	4.9	1.7	3.3	.69			19.6	49.0	13.6	20.3	7.7	4.9
325	5.3	2.0	3.7	.80					14.7	23.5	8.3	5.7
350	5.7	2.3	4.0	.90					15.9	27.0	8.9	6.6
375	6.1	2.6	4.3	1.0	8"				17.0	30.7	9.6	7.4
400	6.5	2.9	4.5	1.1	2.6	.28	10"				10.2	8.4
450	7.4	3.6	5.1	1.4	2.9	.35					11.5	10.5
500	8.2	4.3	5.7	1.7	3.2	.43					12.8	12.7
600	9.8	6.1	6.8	2.4	3.8	.60					15.3	17..8
700	11.4	8.1	7.9	3.3	4.5	.80					17.9	23.7
800	13.1	10.3	9.1	4.2	5.1	1.1						
900	14.7	12.8	10.2	5.2	5.8	1.3						
1000	16.3	15.6	11.4	6.4	6.4	1.6						
1100	17.9	18.5	12.5	7.6	7.0	1.9						
1200			13.6	9.2	7.7	2.3						
1300			14.7	10.0	8.3	2.6						
1400			15.9	11.9	8.9	3.0						
1500			17.0	13.6	9.6	3.3						
1600					10.2	3.7						
1800					11.5	4.7						
2000					12.8	5.7						
2500					16.0	8.6						
3000					19.1	12.2						

STEEL PIPE TABLE

NOMINAL SIZE	NO. THREADS PER INCH	DIAMETER ACTUAL EXTERNAL	TAP DRILLS & DIA. BORE	Standard								Extra Heavy							
				DIAMETER ACTUAL INTERNAL	INTERNAL AREA SQUARE INCH	GPM AT ONE FOOT PER SECOND VELOCITY	NOMINAL WEIGHT LBS. PER FOOT	BURSTING PRESSURE				DIAMETER ACTUAL INTERNAL	INTERNAL AREA SQUARE INCH	GPM AT ONE FOOT PER SECOND VELOCITY	NOMINAL WEIGHT LBS. PER FOOT	BURSTING PRESSURE			
								(a) LAP WELD	*	(b) BUTT WELD	*					(a) LAP WELD	*	(b) BUTT WELD	*
1/8"	27	0.405	11/32	0.27	0.06	0.18	0.24	....	1250	13750	2500	0.22	0.04	0.11	0.31	....	2000	19800	3500
1/4"	18	0.540	7/16	0.36	0.10	0.32	0.42	....		13350		0.30	0.07	0.22	0.54	....		19000	
3/8"	18	0.675	19/32	0.49	0.19	0.60	0.57	....		11050	1500	0.42	0.14	0.44	0.74	....		15500	2500
1/2"	14	0.840	23/32	0.62	0.30	0.95	0.85	....		10650		0.55	0.23	0.73	1.09	....		14600	
3/4"	14	1.050	15/16	0.82	0.53	1.66	1.13	....		8850		0.74	0.43	1.35	1.47	....		11900	2000
1"	11-1/2	1.315	1-5/32	1.05	0.86	2.69	1.68	....		8275		0.96	0.72	2.24	2.17	....		11400	
1-1/4"	11-1/2	1.660	1-1/2	1.38	1.50	4.46	2.27	....		6900	1000	1.28	1.28	4.00	3.00	....		9600	1500
1-1/2"	11-1/2	1.900	1-23/32	1.61	2.04	6.35	2.72	....		6275		1.50	1.77	5.51	3.36	....		8850	
2"	11-1/2	2.375	2-3/16	2.07	3.36	10.5	3.65	6750		5325		1.94	2.95	9.20	5.02	9750	1500	7700	1250
2-1/2"	8	2.875	2-5/8	2.47	4.79	14.9	5.79	7350	1000	5800	750	2.32	4.24	13.2	7.66	10100		7950	
3"	8	3.500	3-1/4	3.07	7.39	23.0	7.58	6425		5050		2.90	6.61	20.6	10.25	.9150	1250	7200	
4"	8	4.500	4-1/4	4.03	12.73	39.7	10.79	5475	750	....		3.83	11.50	35.8	14.98	7900		....	
5"	8	5.563	5-5/16	5.05	20.01	62.4	14.62	4825		....		4.81	18.19	56.7	20.78	6950		....	
6"	8	6.625	6-3/8	6.07	28.89	90.0	18.97	4375	650	....		5.76	26.07	81.2	28.57	6850	1000	....	
8"	8	8.625	8-11/32	7.98	50.02	156.0	28.55	3875		....		7.63	45.66	142	43.34	6050		....	
10"	8	10.75	10-7/16	10.02	78.85	246.0	40.48	3525	500	....		9.75	74.66	233	54.74	4825	750	....	
12"	8	12.75	12-7/16	12.00	113.1	353.0	49.56	3050		....		11.75	108.4	338	65.42	4075		....	

Bursting pressures (cold water) based on Barlow's formula $P = \frac{2ft}{D}$ where P=pressure in lbs. per sq. In.; f= Fiber; t=thickness in inches; D=outside diameter in inches.
Stress (a) 41,000, (b) 52,000, (c) 62000 lbs. per sq. In. * Pipes serviceable for pressure indicated. If subjected to severe shocks, reduce pressures indicated.

TABLE FOR EQUALIZING PIPES

The size of the main pipe is given in the column at the left. The number of branches is given in the line on top, and the proper size of branches is given in the body of the table on the line of each main and beneath the desired number of branches.

In commercial sizes the nominal 1-1/4 inch pipe is generally oversize, often as large as 1-3/8. It is safe to call it 1.3 inch, and it is so figured in the table. Exact sizes are given for branch pipes. The designer of the pipe system can thus better select the commercial sizes to be used.

Size of Main Pipe	NUMBER OF BRANCHES															Size of Main Pipe
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	.758	.644	.574	.525	.488	.459	.435	.415	.398	.383	.370	.358	.348	.338	.330	1
1-1/4	.985	.838	.747	.683	.635	.597	.556	.540	.518	.498	.482	.466	.452	.440	.428	1-1/4
1-1/2	1.14	.967	.861	.788	.733	.689	.653	.623	.597	.575	.555	.538	.522	.508	.494	1-1/2
2	1.52	1.29	1.15	1.05	.977	.918	.870	.830	.796	.766	.740	.717	.696	.677	.660	2
2-1/2	1.89	1.61	1.44	1.31	1.22	1.15	1.09	1.04	.995	.958	.925	.896	.870	.846	.825	2-1/2
3	2.27	1.92	1.72	1.58	1.47	1.38	1.31	1.25	1.19	1.15	1.11	1.08	1.04	1.02	.989	3
3-1/2	2.65	2.26	2.01	1.84	1.71	1.61	1.52	1.45	1.39	1.34	1.30	1.25	1.22	1.18	1.15	3-1/2
4	3.03	2.58	2.30	2.10	1.95	1.84	1.74	1.66	1.59	1.53	1.48	1.43	1.39	1.35	1.32	4
4-1/2	3.41	2.90	2.58	2.36	2.20	2.07	1.96	1.87	1.79	1.72	1.67	1.61	1.57	1.52	1.48	4-1/2
5	3.79	3.22	2.87	2.63	2.44	2.30	2.18	2.08	1.99	1.92	1.85	1.79	1.74	1.69	1.65	5
6	4.55	3.87	3.45	3.15	2.93	2.75	2.61	2.49	2.39	2.30	2.22	2.15	2.09	2.03	1.98	6
7	5.30	4.51	4.02	3.68	3.42	3.21	3.05	2.91	2.79	2.68	2.59	2.51	2.44	2.37	2.31	7
8	6.06	5.16	4.59	4.20	3.91	3.67	3.48	3.32	3.18	3.09	2.96	2.87	2.78	2.71	2.64	8
9	6.82	5.80	5.17	4.73	4.40	4.13	3.92	3.74	3.58	3.45	3.33	3.23	3.13	3.04	2.97	9
10	7.58	6.44	5.74	5.25	4.88	4.59	4.35	4.15	3.98	3.83	3.70	3.59	3.48	3.38	3.30	10
12	9.08	7.73	6.89	6.30	5.86	5.51	5.22	4.98	4.78	4.60	4.44	4.30	4.18	4.06	3.96	12

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	3/8	1/2	5/8	3/4	7/8
10	23.1	38.6	0.37	1.48	3.32	5.91	13.3	23.6	36.9	53.1	72.4
15	34.6	47.25	0.45	1.81	4.06	7.24	16.3	28.9	45.2	65.0	88.5
20	46.2	54.55	0.52	2.09	4.69	8.35	18.8	33.4	52.2	75.1	102
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	1010	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	799	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 percent of the figures given in the tables.

CONVERSION TABLE CENTIGRADE AND FAHRENHEIT DEGREES

Degrees															
C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F
0	32.0	13	55.4	26	78.8	39	102.2	52	125.6	65	149.0	78	172.4	91	195.8
1	33.8	14	57.2	27	80.6	40	104.0	53	127.4	66	150.8	79	174.2	92	197.6
2	35.6	15	59.0	28	82.4	41	105.8	54	129.2	67	152.6	80	176.0	93	199.4
3	37.4	16	60.8	29	84.2	42	107.6	55	131.0	68	154.4	81	177.8	94	201.2
4	39.2	17	62.6	30	86.0	43	109.4	56	132.8	69	156.2	82	179.6	95	203.0
5	41.0	18	64.4	31	87.8	44	111.2	57	134.6	70	158.0	83	181.4	96	204.8
6	42.8	19	66.2	32	89.6	45	113.0	58	136.4	71	159.8	84	183.2	97	206.6
7	44.6	20	68.0	33	91.4	46	114.8	59	138.2	72	161.6	85	185.0	98	208.4
8	46.4	21	69.8	34	93.2	47	116.6	60	140.0	73	163.4	86	186.8	99	210.2
9	48.2	22	71.6	35	95.0	48	118.4	61	141.8	74	165.2	87	188.6	100	212.0
10	50.0	23	73.4	36	96.8	49	120.2	62	143.6	75	167.0	88	190.4	....	....
11	51.8	24	75.2	37	98.6	50	122.0	63	145.4	76	168.8	89	192.2	....	....
12	53.6	25	77.0	38	100.4	51	123.8	64	147.2	77	170.6	90	194.0	....	....

EFFECTIVE FIRE STREAMS (John R. Freeman, M.E.)

Pressure at Nozzle	Gallons Discharged Per Minute	Vertical Distance of Stream	Horizontal Distance of Stream	Pressure in pounds required at hydrant or pump to maintain pressure at nozzle through various lengths of 2-1/2" smooth rubber-lined hose. 100 Feet	200 Feet	300 Feet	400 Feet	500 Feet	Gallons Discharged Per Minute	Vertical Distance of Stream	Horizontal Distance of Stream	Pressure in pounds required at hydrant or pump to maintain pressure at nozzle through various lengths of 2-1/2" smooth rubber-lined hose. 100 Feet	200 Feet	300 Feet	400 Feet	500 Feet
	3/4 Inch Smooth Nozzle								7/8 Inch Smooth Nozzle							
35	97	55	41	38	40	42	44	46	133	56	46	40	44	48	52	56
40	104	60	44	43	46	48	50	53	142	62	49	46	50	55	59	64
45	110	64	47	48	51	54	57	59	150	67	52	51	57	62	67	72
50	116	67	50	54	57	60	63	66	159	71	55	57	63	69	74	80
55	122	70	52	59	63	66	69	73	166	74	58	63	69	75	82	88
60	127	72	54	65	68	72	76	79	174	77	61	69	75	82	89	96
65	132	74	56	70	74	78	82	86	181	79	64	74	82	89	96	104
70	137	76	58	75	80	84	88	92	188	81	66	80	88	96	104	112
75	142	78	60	81	85	90	94	99	194	83	68	86	94	103	111	120
80	147	79	62	86	91	96	101	106	201	85	70	91	101	110	119	128
85	151	80	64	92	97	102	107	112	207	87	72	97	107	116	126	136
90	156	81	65	97	102	108	113	119	213	88	74	103	113	123	134	144
95	160	82	66	102	108	114	120	125	219	89	75	109	119	130	141	152
100	164	83	68	108	114	120	126	132	224	90	76	114	126	137	148	160
	1 Inch Smooth Nozzle								1-1/8 Inch Smooth Nozzle							
35	174	58	51	44	51	57	64	71	222	59	54	49	60	71	82	94
40	186	64	55	50	58	66	73	81	238	65	59	56	69	81	94	107
45	198	69	58	56	65	71	83	91	252	70	63	63	77	92	106	120
50	208	73	61	62	72	82	92	102	266	75	66	70	86	102	118	134
55	218	76	64	69	79	90	101	112	279	80	69	77	95	112	130	147
60	228	79	67	75	87	98	110	122	291	83	72	84	103	122	141	160
65	237	82	70	81	94	107	119	132	303	86	75	91	112	132	153	174
70	246	85	72	87	101	115	128	142	314	88	77	98	120	143	165	187
75	255	87	74	94	110	123	138	152	325	90	79	105	129	153	177	201
80	263	89	76	100	115	131	147	162	336	92	81	112	138	163	188	214
85	274	91	78	106	123	139	156	173	346	94	83	119	146	173	200	227
90	279	92	80	112	130	147	165	183	356	96	85	126	155	183	212	241
95	287	94	82	118	137	156	174	193	366	98	87	133	163	194	224	254
100	295	96	83	125	144	164	183	203	376	99	89	140	172	204	236	
	1-1/4 Inch Smooth Nozzle								1-3/8 Inch Smooth Nozzle							
35	277	60	59	57	74	91	109	126	340	62	62	67	94	120	146	172
40	296	67	63	65	84	104	124	144	363	69	66	77	107	137	166	196
45	314	72	67	73	95	117	140	162	385	74	70	87	120	154	187	221
50	331	77	70	81	106	130	155	180	406	79	73	96	134	171	208	245
55	347	81	73	89	116	143	170	198	426	83	76	106	147	188	229	270
60	363	85	76	97	127	156	186	216	445	87	79	116	160	205	250	
65	377	88	79	105	137	169	201	234	463	90	82	125	174	222		
70	392	91	81	113	148	182	217	252	480	92	84	135	187	239		
75	405	93	83	121	158	195	232		497	95	86	145	201	256		
80	419	95	85	129	169	208	248		514	97	88	154	214			
85	432	97	88	137	179	221			529	99	90	164	227			
90	444	99	90	145	190	234			545	100	92	173	240			
95	456	100	92	154	210	247			560	101	94	183	254			
100	468	101	93	162	211	261			574	103	96	193				

The pressures given are indicated pressures, not effective pressures. Effective pressures would be slightly greater.

The horizontal and vertical distances given are for good, efficient fire streams. The distances to which isolated drops would be thrown are very much greater.

The pressures stated are based on the hose being coupled directly to the pump or hydrant and while the stream is flowing. A good standard fire stream is 250 gallons per minute with 80 pounds of pressure at the hydrant or pump.

GORMAN-RUPP PUMPS

PRESSURE AND EQUIVALENT FEET HEAD OF WATER

Pounds Per Sq. Inch	Feet Head	Pounds Per Sq. Inch	Feet Head	Pounds Per Sq. Inch	Feet Head	Pounds Per Sq. Inch	Feet Head
1	2.31	20	46.18	120	277.07	225	519.51
2	4.62	25	57.72	125	288.62	250	577.24
3	6.93	30	69.27	130	300.16	275	643.03
4	9.24	40	92.36	140	323.25	300	692.69
5	11.54	50	115.45	150	346.34	325	750.41
6	13.85	60	138.54	160	369.43	350	808.13
7	16.16	70	161.63	170	392.52	375	865.89
8	18.47	80	184.72	180	415.61	400	922.58
9	20.78	90	207.81	190	438.90	500	1154.48
10	23.09	100	230.90	200	461.78	1000	2309.00
15	34.63	110	253.98	....	....	....	....

FEET HEAD OF WATER AND EQUIVALENT PRESSURES

Feet Head	Pounds Per Sq. Inch	Feet Head	Pounds Per Sq. Inch	Feet Head	Pounds Per Sq. Inch	Feet Head	Pounds Per Sq. Inch
1	.43	30	12.99	140	60.63	300	129.93
2	.87	40	17.32	150	64.96	325	140.75
3	1.30	50	21.65	160	69.29	350	151.58
4	1.73	60	25.99	170	73.63	400	173.24
5	2.17	70	30.32	180	77.96	500	216.55
6	2.60	80	34.65	190	82.29	600	259.85
7	3.03	90	38.98	200	86.62	700	303.16
8	3.46	100	43.31	225	97.45	800	346.47
9	3.90	110	47.65	250	108.27	900	389.78
10	4.33	120	51.97	275	119.10	1000	433.09
20	8.66	130	56.30	....	....	....	....

EQUIVALENT VALUES OF PRESSURE
Inches of Mercury – Feet of Water – Pounds Per Square Inch

Inches of Mercury	Feet of Water	Pounds Per Square Inch	Inches of Mercury	Feet of Water	Pounds Per Square Inch	Inches of Mercury	Feet of Water	Pounds Per Square Inch
1	1.13	0.49	11	12.45	5.39	21	23.78	10.3
2	2.26	0.98	12	13.57	5.87	22	24.88	10.8
3	3.39	1.47	13	14.70	6.37	23	26.00	11.28
4	4.52	1.95	14	15.82	6.86	24	27.15	11.75
5	5.65	2.44	15	16.96	7.35	25	28.26	12.25
6	6.78	2.93	16	18.09	7.84	26	29.40	12.73
7	7.91	3.42	17	19.22	8.33	27	30.52	13.23
8	9.04	3.91	18	20.35	8.82	28	31.65	13.73
9	10.17	4.40	19	21.75	9.31	29	32.80	14.22
10	11.30	4.89	20	22.60	9.80	29.929	33.947	14.6969

PRACTICAL SUCTION LIFTS AT VARIOUS ELEVATIONS ABOVE SEA LEVEL

Elevation	Barometer Reading Pounds Per Square Inch	Theoretical Suction Lift Feet	Practical Suction Lift Feet	Vacuum Gauge* Inches
At Sea Level	14.7	34.0	22	19.5
1/4 mile–1,320 feet–above sea level	14.0	32.4	21	18.6
1/2 mile–2,640 feet–above sea level	13.3	30.8	20	17.7
3/4 mile–3,960 feet–above sea level	12.7	29.2	18	15.9
1 mile–5,280 feet–above sea level	12.0	27.8	17	15.0
1-1/4 miles–6,600 feet–above sea level	11.4	26.4	16	14.2
1-1/4 miles–7,920 feet–above sea level	10.9	25.1	15	13.3
2 miles–10,560 feet–above sea level	9.9	22.8	14	12.4

NOTE: Multiply barometer in inches by .491 to obtain pounds per square inch. *Vacuum gauge readings in inches correspond to practical suction lift in feet only when pump is stopped. Pipe friction increases vacuum gauge readings when pump is running. For quiet operation, vacuum gauge should never register more than 20 inches when pump is running.

WATER TEMPERATURES IN DEGREES FAHRENHEIT

Altitude	120	130	140	150	160	170	180	190	200	210
SeaLevel	–10	–7	–5	–2	0	+3	+5	+7	+10	+12
2000	–7	–5	–2	+1	+3	+5	+7	+10	+12	+15
4000	–5	–2	+1	+3	+5	+7	+10	+12	+14	
6000	0	+1	+3	+5	+7	+10	+12	+14	+16	
8000	0	+3	+5	+7	+9	+12	+14	+16		
10000	+2	+4	+7	+9	+11	+14	+16	+18		

This table gives the maximum permissible suction lift or the minimum head permitted on the suction side of a pump at various altitudes and liquid temperatures. A minus sign before a number indicates maximum suction lift. A plus sign before a number indicates minimum head. These figures are to be used as a guide and are not guaranteed.

When pumping volatile liquids such as gasoline and naphtha, special consideration must be given to the amount of suction lift and the size of the suction pipe used. Whether it is actual vertical lift or lift caused by pipe line friction, the suction lift on such liquids must be kept as low as possible and should never exceed 12 feet.

A suction lift up to 24 feet at sea level is usually satisfactory for liquids such as lube oil, molasses, etc.

DECIMAL EQUIVALENTS

1/64	.015625	9/64	.140625	17/64	.265625	25/64	.390625	33/64	.515625	41/64	.640625	49/64	.765625	57/64	.890625
1/32	.03125	5/32	.15625	9/32	.28125	13/32	.40625	17/32	.53125	21/32	.65625	25/32	.78125	29/32	.90625
3/64	.046875	11/64	.171875	19/64	.171875	27/64	.421875	35/64	.546875	43/64	.671875	51/64	.796875	59/64	.921875
1/16	.0625	3/16	.1875	5/16	.3125	7/16	.4375	9/16	.5625	11/16	.6875	13/16	.8125	15/16	.9375
5/64	.078125	13/64	.203125	21/64	.328125	29/64	.453125	37/64	.578125	45/64	.703125	53/64	.828125	61/64	.953125
3/32	.09375	7/32	.21875	11/32	.34375	15/32	.46875	19/32	.59375	23/32	.71875	27/32	.84375	31/32	.96875
7/64	.109375	15/64	.234375	23/64	.359375	31/64	.484375	39/64	.609375	47/64	.734375	55/64	.859375	63/64	.984375
1/8	.125	1/4	.250	3/8	.375	1/2	.500	5/8	.625	3/4	.750	7/8	.875		1.000

CAPACITY AND FLOW CHART

Table One

Amount of Water Per Foot in Excavations

Diameter of Pool of Water	U.S. Gallons Per Foot of Depth
1'	6
2'	24
3'	53
4'	94
5'	147
6'	212
7'	288
8'	376
9'	476
10'	587
15'	1320
20'	2350
25'	3672
30'	5275
35'	7200
40'	9400
45'	11900
50'	14700

Table Two

Approximate Flow of Streams in U.S. Gallons Per Minute (Stream flow rate: 1' per second)

Depth of Stream at Midpoint	Width of Stream in Feet			
	1	3	5	10
1"	14	43	72	144
2"	39	121	202	404
3"	71	221	370	740
4"	108	338	569	1139
5"	148	470	794	1588
6"	190	614	1040	2080
7"	244	771	1304	2608
8"		935	1582	3164
9"		1106	1879	3759
10"		1286	2196	4392
11"		1486	2542	5084
12"		1674	2866	5732
13"		1864	3204	6408
14"		2086	3592	7184
15"		2296	3968	7936
16"		2516	4360	8720
17"		2770	4788	9576
18"		2964	5160	10320
19"		3192	5576	11152

EFFECT OF CHANGE OF SPEED OR SLIGHT CHANGE OF IMPELLER DIAMETER ON CENTRIFUGAL PUMP

H: Head in feet　　D: Diameter of impeller in inches　　R: Revolutions per minute

G: Gallons per minute　　P: Brake horsepower

Capacity varies directly as the speed or diameter:

$G_2 = G_1\ (R_2/R_1)$　　or　　$G_2 = G_1\ (d_2/d_1)$

Head varies as the square of the speed or diameter:

$H_2 = H_1\ (R_2/R_1)^2$　　or　　$H_2 = H_1\ (d_2/d_1)^2$

Horsepower varies as the cube of the speed or diameter:

$P_2 = P_1\ (R_2/R_1)^3$　　or　　$P_2 = P_1\ (d_2/d_1)^3$

PULLEYS

D: Diameter of driver　　d: Diameter of driven　　R: RPM of driver

r: RPM of driven　　C: Distance between shafts

D=dr/R　　d=DR/r　　R=dr/D　　r=DR/d

$$\text{Length of Belt} = \frac{3.1416\ (D-d)}{2} \text{ plus } 2C$$

GORMAN-RUPP PUMPS

Viscosity of Liquids.

Viscosity is that property of a liquid that resists any force tending to produce flow. Viscosity is a property independent of specific gravity. Table shows temperature in degrees Fahrenheit at which liquids have the viscosity indicated at the top of the columns.

VISCOSITY – SAYBOLT SECONDS UNIVERSAL

Liquid	31	43	61	125	237	475	950	1425	1900	2400	3000	5000	10000	15000	20000	25000	30000
Alcohol	Room																
Benzine	Room																
Creosote																	
Dyes	Room																
Gasoline	Room																
Glycerine–Diluted				30													
Glycerine–Drugstore				167	138	116	97	88	82	77	72	62	51	46	41		
Glycerine–99% Soluble				170	138	112	90	80	73	68	62	52	44				
Glucose–Corn Products–2 Star										160	165	151	134	125	119	115	111
Glucose–Corn Products–3 Star										170	165	150	135	128	120	118	115
Ink–Printers							175	160	148	139	98	84	70	62	58	54	52
Ink–Newspaper									193	130	123	120					
Kerosene	Room																
Lard, Hot	Normal*																
Molasses–A. Max											175	139	113	105	91	88	86
A. Min											80	72	67	65	63	62	61
B. Max											187	165	143	133	122	111	108
B. Min											130	117	91	85	80	76	75
C. Max																171	163
C. Min											162	144	123	113	103	94	91
Naphtha	Room																
Oil–Absorption	Normal*																
Oil–Castor				210	172	140	114	102	93	88	82	72	59	55	50	47	44
Oil–China Wood				192	147	112	83	69	58	52	45						
Oil–Coconut				82	78	74	70										
Oil–Cod				100	80	62	49	42									
Oil–Cotton			178	119	88	67	52	46	41								
Oil–Crude Light	Room																
Oil–Cylinder 600W						158	134	122	114	108	97	86	77	73	65	59	56
Oil–Diesel	Room																
Oil–Distillate	Room																
Oil–Fuel 22-27 A.P.I.						70											
Oil–Fuel No. 2		104	63	34	17	3											
Oil–Fuel No. 3		144	90	55	36	20	6										
Oil–Fuel No. 4			141	98	73	53	36										
Oil–Fuel No. 5					177	148	124	112	103	97	92	80	65	57	52	49	46
Oil–Fuel No. 6 (Bunker C)						177	151	140	130	124	117	106	90	83	77	74	71
Oil–Fuel Navy No. 1					164	135	110	99	89	83	78	67	52	45	40		
Oil–Fuel Navy No. 2						180	157	145	135	129	123	111	95	88	82	78	76
Oil–Gas	Room																
Oil–Furnace	Room																
Oil–Lard			188	126	93	72	57	51	47	44	42						
Oil–Linseed Raw				100	80	62	49	42									
Oil–Lube–Naphthenic Base–10W						58	42	33	26	21	16	2					
Oil–Lube–Naphthenic Base–20W							63	54	47	43							
Oil–Lube–Naphthenic Base–10				130	106	84	69	60	53	48	44						
Oil–Lube–Naphthenic Base–20				149	123	102	85	79	75	64	60	45	40				
Oil–Lube–Naphthenic Base–30				160	133	112	95	84	77	73	69	59	48	43			
Oil–Lube–Naphthenic Base–40				181	153	128	111	101	93	88	83	73	62	57	51	45	42
Oil–Lube–Naphthenic Base–50				203	174	147	128	117	110	105	100	89	77	72	66	59	57

Normal* indicates temperature at which material is usually pumped.

VISCOSITY – SAYBOLT SECONDS UNIVERSAL

Liquids	31	43	61	125	237	475	950	1425	1900	2400	3000	5000	10000	15000	20000	25000	30000
Oil–Lube–Naphthenic Base–60	...	...	...	210	183	157	137	126	117	112	107	96	84	79	73	66	63
Oil–Lube–Naphthenic Base–70	...	...	...	...	192	165	145	132	123	118	113	102	90	83	77	70	68
Oil–Lube–Penn Base–10W	...	...	...	114	85	61	43	...	...	...	...	...	...	...	...	...	...
Oil–Lube–Penn Base–10	...	...	...	132	102	77	58	47	40	...	...	...	...	...	...	...	...
Oil–Lube–Penn Base–20	...	...	...	152	121	96	75	64	57	52	46	...	...	14	...	...	...
Oil–Lube–Penn Base–30	...	...	...	165	134	107	86	75	67	63	57	46	...	...	...	...	...
Oil–Lube–Penn Base–40	...	...	...	175	142	114	92	x 86	73	68	62	50	...	...	...	...	...
Oil–Lube–Penn Base–50	...	...	...	200	164	134	110	98	89	83	77	64	51	43	...	...	...
Oil–Lube–Penn Base–60	...	...	...	210	175	144	120	107	98	94	86	74	60	53	47	...	...
Oil–Lube–Penn Base–70	...	...	...	...	187	155	129	115	106	100	93	81	65	58	52	44	41
Oil–Menhadden	...	...	...	100	80	62	49	42	...	...	...	...	...	...	...	...	...
Oil–Mineral Seal	Room	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Oil–Neats Foot	...	...	197	135	101	77	62	56	53	51	48	45	41	40	...	...	...
Oil–Olive	...	...	188	126	93	72	57	51	47	44	42	...	...	...	...	...	...
Oil–Palm	...	...	197	135	101	77	62	56	53	51	48	45	41	40	...	...	...
Oil–Peanut	...	...	188	126	93	72	57	51	47	44	42	...	...	...	...	...	...
Oil–Quenching	...	...	210	142	105	77	58	51	45	42	...	...	...	...	...	...	...
Oil–Sea Same	...	...	161	114	87	65	47	...	...	...	...	...	...	...	...	...	...
Oil–Sperm	...	...	114	86	70	57	46	...	...	...	...	...	...	...	...	...	...
Oil–Soya-Bean	...	...	175	116	85	63	47	...	...	...	...	...	...	...	...	...	...
Oil–Range Burner	Room	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Oil–Rape	...	...	210	142	105	77	58	51	45	42	...	...	...	...	...	...	...
Oil–Rosin	...	...	...	...	...	...	...	...	100	...	...	...	...	...	...	...	...
Oil–Transil	Room	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Oil–Turbine, Light	...	...	...	112	82	57	...	...	...	...	...	...	...	...	...	...	...
Oil–Turbine, Heavy	...	...	...	147	114	89	68	58	50	45	40	...	...	...	...	...	...
Oil–Whale	...	...	175	116	85	63	47	...	...	...	...	...	...	...	...	...	...
Paint–Spraying and Lacquer	Room	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Silicate of Soda–Baumé 41–Ratio 1:3.3	...	...	117	80	62	45	...	...	...	...	...	...	...	...	...	...	...
Silicate of Soda–Baumé 41–Ratio 1:3.22	...	...	74	55	45	...	...	...	...	...	...	...	...	...	...	...	...
Silicate of Soda–Baumé 42–Ratio 1:3.22	...	...	103	72	55	40	...	...	...	...	...	...	...	...	...	...	...
Soap–Liquid	Room	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Syrup–Karo Corn	...	...	...	...	...	...	...	...	121	116	113	100	67	33	...	...	...
Syrup–Corn, 41° Baumé	...	...	...	...	...	...	...	150	141	134	128	115	101	94	87	80	77
Syrup–Corn, 42° Baumé	...	...	...	...	...	...	...	...	157	150	144	131	116	109	102	95	93
Syrup–Corn, 43° Baumé	...	...	...	...	...	...	...	...	...	163	157	144	130	124	117	108	106
Syrup–Corn, 44° Baumé	...	...	...	...		Consult Factory		...	...	...	177	164	158	142	135	126	124
Syrup–Corn, 45° Baumé	...	...	...	...		Consult Factory		...	...	...	190	179	165	157	150	142	140
Syrup–Orange	...	...	...	208	172	142	117	105	96	90	84	72	57	52	46	...	...
Syrup–Sugar, 68° Brix	...	...	...	...	...	82	66	58	50	44	40	...	...	...	...	...	...
Syrup–Sugar, 73° Brix	...	...	...	...	...	104	89	80	74	69	65	55	44	...	...	...	...
Syrup–Sugar, 76° Brix	...	...	...	...	...	...	101	94	89	84	76	72	60	54	48	42	40
Sweetose	...	...	...	170	146	121	103	91	84	80	77	68	56	50	47	44	42
Tar–Coke Oven	...	...	...	149	125	108	92	84	79	75	71	58	55	...	...	...	...
Tar–Gas House	Normal*	...	...	...	...	...	...	...	...	...	110	92	89	70	66	62	60
Turpentine	Room	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Varnish–Spar	...	...	...	190	140	107	80	68	60	55	51	40	...	...	...	...	...

Normal* indicates temperature at which material is usually pumped.

GORMAN-RUPP PUMPS

VISCOSITY CONVERSION TABLE

Kinematic Viscosity Centistokes = K	Seconds Saybolt Universal	Seconds Saybolt Furol	Seconds Redwood	Seconds Redwood Admiralty	Degrees Engler	Degrees Barbey
1.00	31	....	29.	....	1.00	6200
2.56	35	....	32.1	....	1.16	2420
4.30	40	....	36.2	5.10	131	1440
5.90	45	....	40.3	5.52	1.46	1050
7.40	50	....	44.3	5.83	1.58	838
8.83	55	....	48.5	6.35	1.73	702
10.20	60	....	52.3	6.77	1.88	618
11.53	65	....	56.7	7.17	2.03	538
12.83	70	12.95	60.9	7.60	2.17	483
14.10	75	13.33	65.0	8.00	2.31	440
15.35	80	13.70	69.2	8.44	2.45	404
16.58	85	14.10	73.3	8.86	2.59	374
17.80	90	14.44	77.6	9.30	2.73	348
19.00	95	14.85	81.5	9.70	2.88	326
20.20	100	15.24	85.6	10.12	3.02	307
31.80	150	19.3	128	14.48	4.48	195
43.10	200	23.5	170	18.90	5.92	144
54.30	250	28.0	212	23.45	7.35	114
65.40	300	32.5	254	28.0	8.79	95
76.50	350	35.1	296	32.5	10.25	81
87.60	400	41.9	338	37.1	11.70	70.8
98.60	450	46.8	381	41.7	13.15	62.9
110.	500	51.6	423	46.2	14.60	56.4
121.	550	56.6	465	50.8	16.05	51.3
132.	600	61.4	508	55.4	17.50	47.0
143.	650	66.2	550	60.1	19.00	43.4
154.	700	71.1	592	64.6	20.45	40.3
165.	750	76.0	635	69.2	21.90	37.6
176.	800	81.0	677	73.8	23.35	35.2
187.	850	86.0	719	78.4	24.80	33.2
198	990	91.0	762	83.0	26.30	31.3
209	950	95.8	804	87.6	27.70	29.7
220	1000	100.7	846	92.2	29.20	28.2
330	1500	150	1270	138.2	43.80	18.7
440	2000	200	1690	184.2	58.40	14.1
550	2500	250	2120	230	73.00	11.3
660	3000	300	2540	276	87.60	9.4
770	3500	350	2960	322	100.20	8.05
880	4000	400	3380	368	117.00	7.05
990	4500	450	3810	414	131.50	6.26
1100	5000	500	4230	461	146.00	5.64
1210	5500	550	4650	507	160.50	5.13
1320	6000	600	5080	553	175.00	4.70
1430	6500	650	5500	559	190.00	4.34
1540	7000	700	5920	645	204.50	4.03
1650	7500	750	6350	691	219.00	3.76
1760	8000	800	6770	737	233.50	3.52
1870	8500	850	7190	783	248.00	3.32
1980	9000	900	7620	829	263.00	3.13
2090	9500	950	8040	875	277.00	2.97
2200	10000	1000	8460	921	292.00	2.82

The viscosity is often expressed in terms of viscosimeters other than the Saybolt Universal. The formulas for the various viscosimeters are as follows:

Kinematic viscosity equals $\frac{\text{absolute viscosity}}{\text{specific gravity}}$

Redwood $K = .26\ t - \frac{188}{t}$ (British)

Redwood Admiralty $K = 2.39\ t - \frac{40.3}{t}$ (British)

Saybolt Universal $K = .22\ t - \frac{180}{t}$ (American)

Saybolt Furol $K = 2.2\ t - \frac{203}{t}$ (American)

Engler $K = .147\ t - \frac{347}{t}$ (German)

t = Engler Degrees x 51.3

If viscosity is given at any two temperatures, the viscosity at any other temperature can be obtained by plotting the viscosity against temperature in degrees Fahrenheit on special Log paper. The points for a given oil lie in a straight line.

MATERIALS FOR PUMPING VARIOUS LIQUIDS

This list has been compiled for the convenience of pump users and represents the best known practice for handling various liquids. Viscosity in Seconds Saybolt Universal (S.S.U.) except as noted.

Liquid	Condition	Chemical Symbols	Specific Gravity	Viscosity	Material Recommended
Acid, Acetic	Conc.	CH_2COOH	1.005	32@68°F.	Lead, Alum., Brz., Monel®, Cr. Ni. Stainless St.
Acid, Acetic	Dil.				Lead, Monel®, Cr. Ni Stainless St.
Acid, Arsenic		AS_2O_5			All Iron, Cr. Ni. Stainless St.
Acid, Boric					Alum., Brz., Monel®, Cr. Ni., Stainless St.
Acid, Carbolic (Phenol)	Conc.	C_6H_5OH	1.071	56@68°F.	All Iron
Acid, Carbonic		CO_2+H_2O			All Bronze
Acid, Citric		$C_6H_8O_7+H_2O$	1.54		Plain fitted, Cr. Ni., Stainless St.
Acid, Cyanic		CNOH			All Iron
Acid, Fatty					Aluminum Bronze, Monel®
Acid, Fruit					Monel®, Cr. Ni. Stainless St.
Acid, Hydrochloric	Comml.	HCl	1.16(20 Be)	31.5 (EST.)	Enamel, High Silicon Iron, Hastelloy®.
Acid, Hydrocyanic		HCN	.70		All Iron
Acid, Hydrofluosilicic		H_2SiF_1			Alum., Brz., Monel®
Acid, Mine Water					High Lead Brz., Cr. Ni., Stainless St.
Acid, Muriatic					See Acid Hydrochloric
Acid, Nitric	Conc.	HNO_3	1.41	31.5@68°F.	Lead, Cr. Ni. Stainless St.
Acid, Nitric	Dil.				All Iron, Cr. Ni., Stainless St.
Acid, Oxalic	To 50%	$CO_2CHO_2H_12H_2O$			High Sil. Iron, Cr. Ni. Stainless St.
Acid, Phosphoric	Crude 50%	H_2PO_4	1.36–1.4		Cr. Ni. Stainless Steel
Acid, Picric					High Sil. Iron, Cr. Ni. Stainless St.
Acid, Pyrogallic					Cr. Ni. Stainless St.
Acid, Pyroligneous		$H_2C_2H_3O_2$	1.018–1.03		All Brz., Cr. Ni. Stainless St.
Acid, Sulphuric	Conc.	H_2SO_4	1.835	66@68°F.	All Iron, High Silicon Iron
Acid, Sulphuric	Hot 60° Be				High Silicon Iron
Acid, Sulphuric	Dil.		1.07		Silicon Brz., Alum. Brz., Lead, Monel®
Acid, Sulphuric	Fuming	$H_2SO_4+SO_3$			Plain Fitted, Steel
Acid, Sulfurous	Conc.	H_2SO_3			Enamel, Lead, Aluminum Brz.
Acid, Tannic		$C_{14}H_{10}O_9$			All Brz., Monel®, Cr. Ni., Stainless St.
Alcohol, (Grain)		C_2H_5OH	.7939	33@68°F.	All Bronze
Alcohol, (Wood)		CH_3OH	.7965	31@68°F.	All Bronze
Alkaline Liquid	Conc. & Dil.				Enamel, All Iron.
Aluminum Sulfate	H_2O & Acid	$N_2(SO_4)_3$			Plain Fitted, High Silicon Iron
Ammonia		NH_3	.623@32°F.	29.5@32°F.	All Iron
Ammonium Bicarbonate	Aq. Sol.	NH_4HCO_3			All Iron
Ammonium Chloride	Aq. Sol.	NH_4Cl			All Iron, Cr. Ni., Stainless Steel Alloy
Ammonium Nitrate	Aq. Sol	NH_4NO_3			All Iron, Cr. Ni. Stainless Steel Alloy
Ammonium Sulfate	Aq. Sol	$(NH_4)_2SO_4$			All Iron, Cr. Ni. Stainless Steel Alloy
Aniline Water					All Iron
Asphaltum	Hot		.98–1.4		All Iron
Barium Chloride		$BaCl_2$			All Iron, Cr. Ni. Stainless Steel Alloy
Barium Nitrate		$Ba(NO_3)_2$			All Iron, Cr. Ni. Stainless Steel Alloy
Beer			1.01	32@68°F.	All Bronze, Cr. Ni. Stainless Steel Alloy
Beer Wort					All Bronze, Cr. Ni. Stainless Steel Alloy
Beet Juice (Thin)					All Bronze, Cr. Ni. Stainless Steel Alloy
Benzine (Coal Tar Product)		C_6H_6	.88	31@68°F.	All Iron
Benzine (Oil Dist. Product)			.64–.66		Brz. Fitted
Bichloride of Mercury	Dil.	$HgCl_2$			All Iron, Cr. Ni. Stainless St.
Bitterwasser					All Bronze
Bleach Solutions					Bronze Fitted
Brine Calcium Chloride	Pure	$CaCl_2$	Up to 1.3	32–42@60°F.	All Iron
Brine Calcium & Sodium Chloride					All Bronze
Brine Gun Cotton					All Bronze
Brine Sodium Chloride	3% Salt	NaCl	1.02	32–35@60°F.	All Bronze, All Iron
Brine Sodium Chloride	Over 3% Salt		1.02–1.20	32–35@60°F.	All Brz., Monel®, Cr. Ni. Stainless St.
Cachaza					Bronze Fitted
Cadmium Electrolyte					High Silicon Iron, Non-Metallic
Calcium Bisulfite		$Ca(HSO_3)_2$	1.04		Cr. Ni. Stainless St. Alloy
Calcium Chlorate	Aq. Sol.	$Ca(ClO_3)_22H_2O$			Cr. Ni. Stainless St. Alloy
Calcium Hyprochlorite		$Ca(OCl)_2$			Enamel, All Iron, High Si. Iron
Calcium Magnesium Chloride					All Bronze
Cane Juice					Bronze Fitted
Carbon BiSulfide		CS_2			All Iron
Carbonate of Soda (Soda Ash)	Aq. Sol.	Na_2CO_3			All Iron
Carbon Tetrachloride		CCl_4	1.58	31@77°F.	Plain Fitted, All Iron

GORMAN-RUPP PUMPS

MATERIALS FOR PUMPING VARIOUS LIQUIDS (CONT.)

Liquid	Condition	Chemical Symbols	Specific Gravity	Viscosity	Material Recommended
Caustic Chloride of Magnesium	Hot	$MgClOH$			Hard Lead
Caustic Chloride of Sodium		$NaClOH$			All Iron
Caustic Cyanogen		$CNOH$			All Iron
Caustic Manganese		$Mn(OH)_2$			All Iron
Caustic Potash		KOH			All Iron, Cr. Ni. Stainless St.
Caustic Soda		$NaOH$			All Iron, Cr. Ni. Stainless St.
Caustic Strontia		$Sr(OH)_2$			All Bronze
Caustic Sulfide		KSH			All Bronze
Caustic Zinc Chloride		$ZNClOH$			Bronze Fitted
Cellulose					High Silicon Iron, Plain Fitted
Chloride of Zinc		$ZnCl_2$			All Iron
Chlorine Water					High Silicon Iron, Non. Met., Hastelloy® C.
Chlorine (Dry Gas)		Cl			Cu. N,. & Mn Alloy
Chlorobenzene		$C_6H_5C_1$	1.1		Std. Fitted
Chloroform		$CHCl_3$	1.5		Lead, Cr. Ni. Stainless St. Alloy
Chrome Alum					High Silicon Iron
Coal Tar Oil					All Iron
Copperas (Green Vitriol)		$FeSO_4$			All Iron, Lead, High Silicon Iron
Copper Acetate	Aq. Sol.	$Cu(C_2H_3O_2)_2+H_2O$			Cr. Ni. Stainless St. Alloy
Copper Chloride	Aq. Sol.	$CuCl_2$			High Silicon Iron, Hastelloy® C
Copper Nitrate		$Cu(NO_3)_2$			Cr. Ni. Stainless Steel Alloy
Copper Sulfate (Blue Vitriol)	Aq. Sol.	$CuSO_4$			Lead, High Sil. Iron, Cr. Ni. Stainless St.
Creosote			.93		All Iron
Creosote Oil					All Iron
Cresol, Meta		$CH_3C_6H_4OH$	1.04		All Iron
Cyanide		$NaCN$			All Iron
Cyanide of Potassium		KCN			All Iron
Cyanogen		CN			All Iron
Cyanogen Slime					All Iron
Diffusion Water					Plain Fitted
Diphenyl	In Alcohol	$C_6H_5C_6H_5$			All Iron
Dish Water					Plain Fitted
Distillery Wort					All Bronze
Dye Wood Liquor					Bronze Fitted
Ethyl Acetate		$CH_3COOC_2H_5$	.90		All Iron, Cr. Ni. Stainless St.
Ethylene Chloride	Cold	$C_2H_4(Cl)_2$	1.28		Lead, High Sil. Iron
Ferric Chloride	Aq. Sol.	$FeCl_3$			High Sil. Iron, Hastelloy® C, Non-Met.
Ferric Chloride	Hot	$FeCl_3$			High Sil. Iron, Hastelloy® C, Non-Met.
Ferrous Chloride	Cold Aq.	$FeCl_2$			All Iron (Oxidizes to Ferric Conditions)
Ferrous Sulfate (See Copperas)					
Fruit Juices					Monel®, High Sil. Iron, Cr. Ni. Stainless
Furfural		C_4H_3OCHO	1.16		All Iron, Cr. Ni. Stainless St.
Gasoline		C_6H_{14}	.68–.75	30@68°F.	Bronze Fitted
Glue	Hot				Bronze Fitted
Glycerine		$C_3H_5(OH)_3$	1.262	2950@68.6°F.	All Bronze
Grape Juice					All Bronze
Heptane		C_7H_{16}	.69		Bronze Fitted
Hops					Bronze Fitted
Hydrogen Peroxide (Perbydrol)	Comml.	H_2O_2			All Iron, Cr. Ni. Stainless St.
Hydrogen Sulfide	In Water	H_2S			Ni-Resist, Cr. Ni. Stainless St.
Lard	Hot				All Iron
Lead Acetate (Sugar of Lead)	Aq. Sol.	$Pb(C_2H_3O_2)_2+3H_2O$			High Sil. Iron, Cr. Ni. Stainless St.
Lead Molten					All Iron
Lime Water (Milk of Lime)		$Ca(OH)_2$			All Iron
Lye, Caustic					All Iron
Lye, Salty					Brz. Fitted or all bronze
Lye, Solution containing sand					All Iron
Magnesium Acid Sulfate	Conc.				All Bronze
Magnesium Acid Sulfate	Dil.				All Iron
Magnesium Chloride	Aq. Sol.	$MgCl_2$			Hard Lead, High Sil. Iron
Magnesium Oxychloride		$MgClOH$			Lead
Magnesium Sulfate (Epson Salt)	Aq. Sol.	$MgSO_4$			All Iron
Magma (Thick Residue)					All Brz. Cr. Ni. Stainless St.
Marsh Gas		CH_4			Plain Fitted
Mash					Brz. Fitted or all bronze

MATERIALS FOR PUMPING VARIOUS LIQUIDS (CONT.)

Liquid	Condition	Chemical Symbols	Specific Gravity	Viscosity	Material Recommended
Mercuric Chloride	Very Dil.	$HgCl_2$			High Silicon Iron
Mercuric Chloride	Comml. Conc.	$HgCl_2$			High Sil. Iron, Hastelloy® C., Enamel
Mercuric Sulfate	In H_2SO_4	$HgSO_4$			High Sil. Iron, Enamel
Mercurous Sulfate	In H_2SO_4	$H_{22}(SO_4)_2$			High Sil. Iron, Enamel
Methyl Acetate		$CH_3CO_2CH_3$	.924		Cr. Ni. Stainless Steel
Methyl Chloride		CH_3Cl	.92		All Iron
Methylene Chloride		CH_2Cl_2	1.26		All Iron
Milk			1.028–1.035	32@68°F.	Bronze Tinned, All Bronze
Molasses					Bronze Fitted
Naphtha			.665		Bronze Fitted
Naphtha Crude					Std. Fitted
Nickel Chloride	Low pH Sol.	$NiCl_2$			High Sil. Iron, Copper
Nickel Sulfate	Low pH Sol.	$NiSO_4$			High Sil. Iron, Copper
Nicotine Sulfate		$C_{10}H_{14}N_2H_2SO_4$			High Sil. Iron
Oil, Crude (Asphalt Base)	Hot				Std. Fitted
Oil, Crude (Paraffine Base)	Cold				Std. Fitted
Oil, Fuel			.825–.95		Std. Fitted
Oil, Kerosene			.81@68°F.	35@68°F.	Std. Fitted
Oil, Lubricating Lt. or Hy.					Std. Fitted
Oil, Mineral					Std. Fitted
Oil, Vegetable					All Iron
Oil, Purifying					All Iron
Oil, Coal Tar					All Iron
Oil, Creosote			1.04–1.10		All Iron
Oil, Turpentine			.87	33@68°F.	All Iron
Oil, Linseed			.94	143@100°F.	All Iron, Monel®
Oil, Rapeseed			.92		All Bronze, Monel®
Paraffine (45° to 60° C.)	Hot				Bronze Fitted
Petroleum					Plain Fitted
Photographic Developers					High Sil. Iron, Non-Metallic
Potash Sulfide		K_2S			All Iron
Potassium Alum.		$Al_2K_2(SO_4)_4$			Attacks C.I. Slowly
Potassium Bichromate	Aq. Sol.	$K_2Cr_2O_7$			All Iron
Potassium Carbonate	Aq. Sol.	K_2CO_3			All Iron
Potassium Chloride	Aq. Sol.	KCl			All Brz., Cr. Ni. Stainless St.
Potassium Cyanide	Aq. Sol.	KCN			All Iron
Potassium Nitrate	Aq. Sol.	KNO_3			All Iron, Cr. Ni. Stainless St.
Potassium Sulfate	Aq. Sol.	K_2SO_4			All Iron, All Brz.
Pyridine		$CH(CHCH)_2N$	.975		All Iron
Rectifying Pump (Distillery)					All Bronze
Rhigolene (Oil Dist)					Bronze Fitted
Salammoniac		NH_4Cl			See Ammonium Chloride
Salt Cake	Aq. Sol.				All Iron, All Bronze
Sewage					Bronze Fitted
Silver Nitrate		$AgNO_3$			High Sil. Iron, Cr. Ni. Stainless St.
Slop, Brewery					Bronze Fitted
Soap Liquor	Thin				All Iron
Soda		$NaOH$			All Iron
Sodium Bicarbonate		$NaHCO_3$			All Iron
Sodium BiSulfate	Aq. Sol.	$NaHSO_4$			High Sil. Iron, Lead
Sodium Carbonate (Soda Ash)		Na_2CO_3			All Iron
Sodium HydroSulfite	Aq. Sol.	$Na_2S_2O_4$			Lead, Cr. Ni. Stainless St.
Sodium Hypochlorite		$NaOCl$			High Sil. Iron, Lead, Non-Metallic
Sodium Hyposulphite	See Sodium ThioSulfate				
Sodium Nitrate	Aq. Sol.	$NaNO_3$			All Iron
Sodium Sulfate	Aq. Sol.	Na_2SO_4			All Iron
Sodium Sulfide	Aq. Sol.	Na_2S			All Iron, All Brz., Lead
Sodium Sulphite	Aq. Sol.	$NaSO_3$			All Brz., Lead, Cr. Ni. St. Steel
Sodium ThioSulfate	Aq. Sol.	$NaS_2O_35H_2O$			Cr. Ni. Stainless St., Monel®, High Sil. Iron, En.
Stannic Chloride	Aq. Sol.	$SnCl_4$			High Sil. Iron, Non-Metallic
Stannous Chloride	Aq. Sol.	$SnCl_2$			High Sil. Iron, Non-Metallic
Starch		$C_6H_{10}O_5$			Bronze Fitted
Strontium Nitrate	Aq. Sol.	$Sr(NO_3)_2$			All Iron
Sugar	40% Sol.			43@68°F.	All Bronze
Sulfate of Lime		$CaSO_4$			All Bronze

GORMAN-RUPP PUMPS

MATERIALS FOR PUMPING VARIOUS LIQUIDS (CONT.)

Liquid	Condition	Chemical Symbols	Specific Gravity	Viscosity	Material Recommended
Sulfide of Hydrogen		H_2S			Plain Fitted
Sulfide of Sodium	Hot	Na_2S			All Iron
Sulfide of Sodium	Cold				Plain Fitted
Sulfolignic Salts	Conc.				All Bronze
Sulfolignic Salts	Dil.				Bronze Fitted
Sulphur	In Water				All Iron, All Bronze
Sulphur Chloride	Cold	S_2Cl_2			All Iron, Lead
Sulphur Dioxide		SO_2			All Bronze
Sweet Water					Bronze Fitted
Syrup					All Bronze
Tanning Liquor	Veg.				All Bronze
Tar					All Iron
Tar and Ammonia	Aq. Sol.				All Iron
Tetachloride of Tin		(See Stannic Chloride)			
Tetraethyl Lead		$Pb(C_2H_5)_4$	1.65		All Iron
Toluene (Toluol)		$CH_3C_6H_5$	.86		All Iron, Std. Fitted
Trichloroethyline		C_2HCl_3	1.47		All Iron, Std. Fitted
Urine					All Bronze
Varnish				32@68°F.	All Bronze, Monel®
Vinegar			1.08		All Brz., High Sil. Iron
Vitriol, Blue	(See Copper Sulfate)				Cr. Ni. Stainless Steel
Vitriol, Green	(See Ferrous Sulfate)				
Vitrol, Oil of	(See Acid, Sulphuric)				
Vitrol, White	(See Zinc Sulfate)				
Water, Distilled			1.00	31.5@60°F.	Bronze Fitted
Water, Fresh			1.00		Bronze Fitted
Water, Salt & Sea	(See Brines)				
Whiskey					All Bronze
Wine					All Bronze
Wood Pulp					Bronze Fitted
Wood Vinegar	(See Pyroligneous Acid)				
Wort					All Bronze
Yeast					All Bronze or Bronze Fitted
Zinc, Chloride	Aq. Sol.				Spl. Brz. Alum. Brz. High Sil. Iron
Zinc, Electrolyte					Lead, High Sil. Iron
Zinc, Nitrate		$Zn(NO_3)_2$			All Bronze
Zinc, Sulfate		$ZnSO_4$			All Brz., High Sil. Iron, Cr. Ni., Stainless Steel

ELECTRICAL FORMULAE

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

DIRECT CURRENT

Kilowatts $= \dfrac{\text{Volts x Amperes}}{1{,}000}$

Horsepower $= \dfrac{\text{Volts x Amperes x Efficiency}}{746}$

Kilowatts $= \dfrac{\text{Horsepower x 746}}{1{,}000 \text{ x Efficiency}}$

ALTERNATING CURRENT

Single-phase W= EI x P.F.

Two-phase W= 2EI x P.F.

Three-phase W= 1.732EI x P.F.

W= Watts; E= average volts between line terminals;

I = average line current; P.F. = power factor expressed as a decimal fraction

KVA $= \dfrac{\text{Volts x Amperes}}{1{,}000}$

KW = KVA x P.F.

Horsepower $= \dfrac{\text{KW x Efficiency}}{746}$

HOW TO DETERMINE DISTANCE TO WATER LEVEL

EQUIPMENT. Install a small pipe or tubing (about 1/8" or 1/4") in the well. Each joint should be absolutely tight. The exact length must be carefully measured so that it is known. The end of the air pipe should extend to the bottom of the pump suction.

Attach the upper end of this air line securely to the foundation or some object near the pump. Braze or otherwise connect an ordinary tire valve so that the air pump may be used for forcing air down the pipe. Install a reliable pressure gauge so that the exact air pressure in pounds may be shown when the hand pump is operated.

OPERATION. Attach hand tire –pump and fill pipe until further pumping will not increase the reading on the gauge.

Multiply the reading in pounds by 2.31, and subtract the result from the length of air pipe. The difference will be the distance from the center of the pressure gauge face to the surface of the water. Any HORIZONTAL distance of the pipe line from the well opening has no effect on the result.

EXAMPLE. Air pipe is 100 feet long from center of gauge face to bottom end of pipe. Highest pressure reading is 18 pounds. 18 multiplied by 2.31 is 41.58 feet of lift. 41.58 subtracted from 100 leaves 58.42, showing that the water level is 58.42 feet below center of pressure gauge face.

A.S.M.E. STANDARD KEYWAY SIZES

“Standard” keyways are furnished to the ASME standard, as follows:

Shaft Diameter, Ins.	Keyways, Ins.
5/8 to 7/8	3/16 x 3/32
15/16 to 1-1/4	1/4 x 1/8
1-5/16 to 1-3/8	5/16 x 5/32
1-7/16 to 1-3/4	3/8 x 3/16
1-13/16 to 2-1/4	1/2 x 1/4
2-5/16 to 2-3/4	5/8 x 5/16
2-7/8 to 3-1/4	3/4 x 3/8
3-3/8 to 3-3/4	7/8 x 7/16
3-7/8 to 4-1/2	1 x 1/2

MOTOR SPEEDS

The synchronous speed of any A.C. motor is fixed by the frequency of the applied voltage and the number of pair of poles. Therefore, the maximum synchronous speed is equal to the frequency. For instance, in a 60-cycle system, it will be equal to 60 revolutions per second or 3,600 revolutions per minute. According to the number of pair of poles, the synchronous speed of the motor will be equal to the maximum speed divided by 1,2,3,4, etc., or for 60-cycle,

$$\frac{3{,}600}{2} \text{ x } 1{,}800 \text{ RPM,}$$

$$\frac{3{,}600}{3} \text{ x } 1{,}200 \text{ RPM,}$$

$$\frac{3{,}600}{4} \text{ x } 900 \text{ RPM, etc.}$$

Synchronous motors, as the name implies, run at synchronous speeds, regardless of the load. Squirrel-cage or wound-rotor induction motors lose speed as the load increases. The difference in speed between no load and full load is about 3 to 5%, rather more for very small motors and less for very large motors.

In belt drive calculations, it is necessary to figure on the full load speed, which is the actual speed of the motor when running under normal conditions at full or nearly full capacity.

Direct current motors also vary in speed under load changes and according to voltage. Constant speed D.C. motors operating at full-line voltage usually are made in the following speeds according to type and horsepower = 2,100 RPM, 1,750 RPM, 1,375 RPM, 1,150 RPM, 1,050 RPM, 1,000 RPM, 850 RPM, 575 RPM. Adjustable speed D.C. motors are made in various speed combinations ranging between 300 and 1,200 RPM, and 700 and 2,100 RPM.

NUMBER OF ACRES COVERED IN TWELVE HOURS PUMPING

Gals. Min.	Cu. Ft. Sec.	Cu. Ft. Min.	1 in. Deep	2 in. Deep	3 in. Deep	4 in. Deep	6 in. Deep	8 in. Deep	10 in. Deep	12 in. Deep
20	.0446	2.675	.529	.2645	.1765	.1324	.08825	.06625	.0529	.04415
50	.1112	6.68	1.328	.664	.4425	.332	.2213	.166	.1328	.1105
100	.2225	13.37	2.65	1.325	.883	.6625	.442	.3313	.265	.221
150	.3345	20.05	3.98	1.991	1.328	.995	.664	.4975	.398	.332
225	.502	30.05	5.97	2.985	1.99	1.492	.994	.747	.597	.4975
300	.668	40.01	7.96	3.98	2.655	1.99	1.327	.995	.796	.663
400	.891	53.40	10.61	5.305	3.535	2.652	1.770	1.328	1.061	.884
700	1.560	93.50	18.58	9.28	6.18	4.64	3.095	2.32	1.858	1.548
900	2.008	120.40	23.85	11.95	7.96	5.97	3.98	2.975	2.385	1.99
1200	2.675	160.50	31.82	15.92	10.61	7.95	5.305	3.975	3.182	2.65
3000	6.68	400.50	79.50	39.75	26.50	19.88	13.25	9.94	7.95	6.625
10000	22.25	1337.00	265.00	132.50	88.30	66.25	44.20	33.15	26.50	22.10

1 acrefoot = 1 acre covered to a depth of 1 ft. = 43,560 ft^3

CRUDE OIL

One gallon = 58,310 grains.

One barrel oil = 42 U.S. gallons.

One barrel per hour = .7 U.S. GPM

GPM = bbls. per hr. x .7.

Bbls. per hr. = $\frac{\text{GPM}}{.7}$

One barrel per day = .02917 GPM.

GPM = bbls. per day x .02917.

Velocity in ft. per sec. = $\frac{.0119 \times \text{bbls. per day}}{\text{pipe dia. in inches}^2}$

= $\frac{.2856 \times \text{bbls. per hr.}}{\text{pipe dia. in inches}^2}$

Net horsepower = the theoretical horsepower necessary to do the work.

Net horsepower = barrels per day x pressure x .000017.

Net horsepower = barrels per hour x pressure x .000408.

Net horsepower = GPM x pressure x .000583.

The customary method of indicating specific gravity of petroleum oils in this country is by means of the Baumé scale. Since the Baumé scale, for specific gravities of liquids lighter than water, increases inversely as the true gravity, the heaviest oil, i.e., that which has the highest true specific gravity, is expressed by the lowest figure of the Baumé scale; the lightest by the highest figure.

MISCELLANEOUS

Areas of circles are to each other as squares of their diameters.

Circumference –diameter of circle x 3.1416.

Area of circle–diameter squared x .7854.

Diameter circle–circumference x .31831.

Volume of sphere–cube of diameter x .5236.

Square feet–square inches x .00695.

Cubic feet–cubic inches x .00058.

Cubic yard–cubic feet x .03704.

Statute miles–lineal feet x .00019.

Statute miles–lineal yards x .000568.

1 gallon = 8.33 pounds.

1 liter = .2642 gallons.

1 cu. ft. = 7.48 gallons and/or 62.35 pounds.

1 meter = 3.28 feet.

WATER REQUIREMENTS

WATER REQUIRED BY LIVESTOCK

Each horse .... 10 gallons per day

Each cow .... 15 gallons per day

Each sheep .... 3 gallons per day

Each hog .... 5 gallons per day

Each 100 chickens.................... 5 gallons per day

WATER REQUIRED BY YARD FIXTURES

1/2 inch hose and nozzle........ 200 gallons per hour

3/4 inch hose and nozzle .... 300 gallons per hour

Lawn sprinkler .... 120 gallons per hour

To sprinkle 100 sq. ft. of lawn
(1/4" of water)...................... 16 gallons per day

Note: The above requirements are only approximate, as the consumption of individuals and animals will vary by the seasons and weather conditions.

In selecting the proper size pump, it is essential that the pump capacity be in excess of maximum requirements in order to provide a reserve in the event that water is required from several fixtures at the same time. For example, watering the lawn, drawing a bath, and water used in the kitchen simultaneously, is a common occurrence. It is also advisable to allow for the water level in the well lowering during dry years, thus decreasing pump capacity.

GORMAN-RUPP PUMPS

NOTES

ENGINEERING DATA

Product information is subject to change; consult factory for details.

75 YEARS GORMAN-RUPP PUMPS
A TRADITION OF EXCELLENCE

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