



ENGINEERING DATA

Pumping Facts

Conversion Factors

One (1) U.S. gallon of water weighs 8.33 pounds.
One (1) Cubic foot of water contains 7.48 gallons.
 $8.33 \times 7.48 = 62.3$ Pounds (1 cubic foot of water).
 $62.3 / 144$ (square inches in base of cube) = .433.
.433 PSI - Pressure exerted by a column of water 1" x 1" x 12".
To convert feet of head to pounds pressure multiply by .433.
One (1) pound / .433 = 2.31 feet.
One (1) pound of pressure will raise (elevate) water 2.31 feet.
To convert pounds pressure to feet of head multiply by 2.31.
Deduct 1.2 feet for every 1,000 feet of altitude.

Atmospheric Pressure

14.7 pounds PSI (atmospheric pressure, maximum at sea level) converted to feet of head $14.7 \times 2.31 = 33.96$ feet.
Translated, if a pump installed at sea level and capable of creating a perfect vacuum, (reducing atmospheric pressure to zero) regardless of type, could then pump water from almost 34 feet of depth. The fallacy of this is obvious. A perfect vacuum has never been created, plus, all pumps are not installed at sea level.

Shallow Well and Sources of Supply

Any well, drilled or driven, or other source of supply - lake, pond, river, etc. that is 25 feet (vertical distance) or less from the pumping water level to the pump.

Deep Wells and Source of Supply

Any drilled well or other source of supply which is greater than 25 feet of vertical distance from pump to pumping level.

Total Suction Lift

Consists of two factors:

1. Vertical distance from pumping level of liquid to centerline of pump.
2. Friction loss in pipe valves and fittings.

Total Discharge Head Calculations

Consists of three factors:

1. Elevation from centerline of pump to points of discharge.
2. Friction loss in pipe valves and fittings.
3. Pressure required at point of discharge.

Total Head (TDH)

Consists of two factors:

1. Total Suction Lift.
2. Total Discharge Head.

Centrifugal Pump Types

1. Shallow well jet
2. Deep well jet
3. Multi-stage jets (shallow and deep)
4. Submersibles

The Complete Water System

1. Pressure Switches
2. Gauges
3. Air Volume Controls
4. Pressure Tanks
5. Well Seals and Pitless Adapters

Friction Loss Charts

Loss of head in feet, due to friction per 100 feet of pipe

3/4" Pipe

FLOW US GAL MIN	STEEL C-100 ID .824"	PLASTIC C-140 ID .824"
1.5	1.13	.61
2.0	1.93	1.04
2.5	2.91	1.57
3.0	4.08	2.21
3.5	5.42	2.93
4.0	6.94	3.74
4.5	8.63	4.66
5.0	10.50	5.66
6.0	--	7.95
7.0	--	10.60

1" Pipe

FLOW US GAL MIN	STEEL C-100 ID 1.049"	PLASTIC C-140 ID 1.049"
2	.595	.322
3	1.26	.680
4	2.14	1.15
5	3.42	1.75
6	4.54	2.45
8	7.73	4.16
10	11.70	6.31
12	--	8.85
14	--	11.8

1-1/4" Pipe

FLOW US GAL MIN	STEEL C-100 ID 1.380"	PLASTIC C-140 ID 1.380"
4	.564	.304
5	.853	.460
6	1.20	.649
7	1.59	.860
8	2.04	1.10
10	3.08	1.67
12	4.31	2.33
14	5.73	3.10
16	7.34	3.96
18	9.13	4.93
20	11.10	6.00
25	--	9.06

1-1/2" Pipe

FLOW US GAL MIN	STEEL C-100 ID 1.61"	PLASTIC C-140 ID 1.61"
4	.267	.144
6	.565	.305
8	.962	.520
10	1.45	.785
12	2.04	1.10
14	2.71	1.46
16	3.47	1.87
18	4.31	2.33
20	5.24	2.83
25	7.90	4.26
30	11.10	6.00
35	--	7.94
40	--	10.20

2" Pipe

FLOW US GAL MIN	STEEL C-100 ID 2.067"	PLASTIC C-140 ID 2.067"
10	.431	.233
15	.916	.495
20	1.55	.839
25	2.35	1.27
30	3.29	1.78
35	4.37	2.36
40	5.60	3.03
45	6.96	3.76
50	8.46	4.57
55	10.10	5.46
60	11.90	6.44
70	--	8.53
80	--	10.90

2-1/2" Pipe

FLOW US GAL MIN	STEEL C-100 ID 2.469"	PLASTIC C-140 ID 2.469"
20	.654	.353
30	1.39	.750
40	2.36	1.27
50	3.56	1.92
60	4.99	2.69
70	6.64	3.58
80	8.50	4.59
90	10.60	5.72
100	--	6.90
110	--	8.25
120	--	9.71
130	--	11.30

3" Pipe

FLOW US GAL MIN	STEEL C-100 ID 3.0"	PLASTIC C-140 ID 3.068"
20	.149	.129
30	.316	.267
40	.541	.449
50	.825	.676
60	1.17	.912
70	1.57	1.22
80	2.03	1.56
90	2.55	1.95
100	3.12	2.37
110	3.75	2.84
120	4.45	3.35
130	5.19	3.90
140	6.00	4.50

4" Pipe

FLOW US GAL MIN	STEEL C-100 ID 4.0"	PLASTIC C-140 ID 4.026"
20	.038	.035
30	.076	.072
40	.128	.120
50	.194	.179
60	.273	.250
70	.365	.330
80	.470	.422
90	.588	.523
100	.719	.613
110	.862	.732
120	1.02	.861
130	1.19	1.00
140	1.37	1.15

Example:

10 GPM with 1" plastic pipe has 6.31' of loss per 100 ft. - If your run is 50 ft., multiply by .5, if 250 multiply by 2.5, etc.

Loss through fittings in terms of equivalent lengths of pipe

TYPE FITTING & APPLICATION	PIPE & FTG. MATERIAL (Note 1)	EQUIVALENT LENGTH OF PIPE NOMINAL SIZE FITTING & PIPE						
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
Insert coupling	Plastic	3	3	3	3	3	3	3
Threaded adapter Plastic or copper to thread	Copper	1	1	1	1	1	1	1
	Plastic	3	3	3	3	3	3	3
90° standard elbow	Steel	2	3	3	4	4	5	6
	Copper	2	3	3	4	4	5	6
	Plastic	4	5	6	7	8	9	10
TYPE FITTING & APPLICATION	PIPE & FTG. MATERIAL (Note 1)	EQUIVALENT LENGTH OF PIPE NOMINAL SIZE FITTING & PIPE						
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
Standard tee Flow through side	Steel	4	5	6	8	9	11	14
	Copper	4	5	6	8	9	11	14
	Plastic	7	8	9	12	13	17	20
Gate valve	Note 2	2	3	4	5	6	7	8
Swing check valve	Note 2	4	5	7	9	11	13	16

NOTE 1: Loss figures are based on equivalent lengths of indicated pipe material

NOTE 2: Loss figures are for screwed valves and are based on equivalent lengths of steel pipe

*Loss figures for copper lines are approximately 10% higher than shown for plastic

Pressure, Feet (Head) Of Water To Pound Per Square Inch (PSI)

Lb. / Sq. In. = .4331 x Ft.

Based on water at its greatest density (39.2°F)

Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch
1	0.43	54	23.39	107	46.34	160	69.31	213	92.20	285	123.45
2	0.86	55	23.82	108	46.78	161	69.74	214	92.69	290	125.62
3	1.30	56	24.26	109	47.21	162	70.17	215	93.13	295	127.78
4	1.73	57	24.69	110	47.64	163	70.61	216	93.56	300	129.95
5	2.16	58	25.12	111	48.08	164	71.04	217	93.99	305	132.12
6	2.59	59	25.55	112	48.51	165	71.47	218	94.43	310	134.28
7	3.03	60	25.99	113	48.94	166	71.91	219	94.86	315	136.46
8	3.46	61	26.42	114	49.38	167	72.34	220	95.30	320	138.62
9	3.89	62	26.85	115	49.81	168	72.77	221	95.73	325	140.79
10	4.33	63	27.29	116	50.24	169	73.20	222	96.16	330	142.95
11	4.76	64	27.72	117	50.68	170	73.64	223	96.60	335	145.12
12	5.20	65	28.15	118	51.11	171	74.07	224	97.03	340	147.28
13	5.63	66	28.58	119	51.54	172	74.50	225	97.46	345	149.45
14	6.06	67	29.02	120	51.98	173	74.94	226	97.90	350	151.61
15	6.49	68	29.45	121	52.41	174	75.37	227	98.33	355	153.78
16	6.93	69	29.88	122	52.84	175	75.80	228	98.76	360	155.94
17	7.36	70	30.32	123	53.28	176	76.23	229	99.20	365	158.10
18	7.79	71	30.75	124	53.71	177	76.67	230	99.63	370	160.27
19	8.22	72	31.18	125	54.15	178	77.10	231	100.00	375	162.45
20	8.66	73	31.62	126	54.58	179	77.53	232	100.49	380	164.61
21	9.09	74	32.05	127	55.01	180	77.97	233	100.93	385	166.78
22	9.53	75	32.48	128	55.44	181	78.40	234	101.36	390	168.94
23	9.96	76	32.92	129	55.88	182	78.84	235	101.70	395	171.11
24	10.39	77	33.35	130	56.31	183	79.27	236	102.23	400	173.27
25	10.82	78	33.78	131	56.74	184	79.70	237	102.66	425	184.10
26	11.26	79	34.21	132	57.18	185	80.14	238	103.09	450	195.00
27	11.69	80	34.65	133	57.61	186	80.57	239	103.53	475	205.77
28	12.12	81	35.08	134	58.04	187	81.00	240	103.96	500	216.58
29	12.55	82	35.52	135	58.48	188	81.43	241	104.39	525	227.42
30	12.99	83	35.95	136	58.91	189	81.87	242	104.83	550	238.25
31	13.42	84	36.39	137	59.34	190	82.30	243	105.26	575	249.09
32	13.86	85	36.82	138	59.77	191	82.73	244	105.69	600	259.90
33	14.29	86	37.25	139	60.21	192	83.17	245	106.13	625	270.73
34	14.72	87	37.68	140	60.64	193	83.60	246	106.56	650	281.56
35	15.16	88	38.12	141	61.07	194	84.03	247	106.99	675	292.40
36	15.59	89	38.55	142	61.51	195	84.47	248	107.43	700	303.22
37	16.02	90	38.98	143	61.94	196	84.90	249	107.86	725	314.05
38	16.45	91	39.42	144	62.37	197	85.33	250	108.29	750	324.88
39	16.89	92	39.85	145	62.81	198	85.76	251	108.73	775	335.72
40	17.32	93	40.28	146	63.24	199	86.20	252	109.16	800	346.54
41	17.75	94	40.72	147	63.67	200	86.63	253	109.59	825	357.37
42	18.19	95	41.15	148	64.10	201	87.07	254	110.03	850	368.20
43	18.62	96	41.58	149	64.54	202	87.50	255	110.46	875	379.03
44	19.05	97	42.01	150	64.97	203	87.93	256	110.89	900	389.86
45	19.49	98	42.45	151	65.40	204	88.36	257	111.32	925	400.70
46	19.92	99	42.88	152	65.84	205	88.80	258	111.76	950	411.54
47	20.35	100	43.31	153	66.27	206	89.21	259	112.19	975	422.35
48	20.79	101	53.75	154	66.70	207	89.66	260	112.62	1000	433.18
49	21.22	102	44.18	155	67.14	208	90.10	261	113.06	1500	649.70
50	21.65	103	44.61	156	67.57	209	90.53	262	113.49	2000	866.30
51	22.09	104	45.05	157	68.00	210	90.96	270	116.96	3000	1299.50
52	22.52	105	45.48	158	68.43	211	91.39	275	119.12		
53	22.95	106	45.91	159	68.87	212	91.83	280	121.29		

Pressure, Pound Per Square Inch To Feet (Head) Of Water

Ft. = 2.31 x Lb. / Sq. In.

Based on water at its greatest density (39.2°F)

Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head
1	2.31	53	122.43	105	242.55	157	362.67	209	482.79	261	602.91	365	843.15
2	4.62	54	124.74	106	244.86	158	364.98	210	485.10	262	605.22	370	854.70
3	6.93	55	127.05	107	247.17	159	367.29	211	487.41	263	607.53	375	866.25
4	9.23	56	129.36	108	249.48	160	369.60	212	489.72	264	609.84	380	877.80
5	11.55	57	131.67	109	251.79	161	371.91	213	492.03	265	612.15	385	889.35
6	13.86	58	133.98	110	254.10	162	374.22	214	494.34	266	614.46	390	900.90
7	16.17	59	136.29	111	256.41	163	376.53	215	496.65	267	616.77	395	912.45
8	18.48	60	138.60	112	258.72	164	378.84	216	498.96	268	619.08	400	924.00
9	20.79	61	140.91	113	261.03	165	381.15	217	501.27	269	621.39	405	935.55
10	23.10	62	143.22	114	263.34	166	383.46	218	503.58	270	623.70	410	947.10
11	25.41	63	145.53	115	265.65	167	385.77	219	505.89	271	626.01	415	958.65
12	27.72	64	147.84	116	267.96	168	388.08	220	508.20	272	628.32	420	970.20
13	30.03	65	150.15	117	270.27	169	390.39	221	510.51	273	630.63	425	981.75
14	32.34	66	152.46	118	272.58	170	392.70	222	512.82	274	632.94	430	993.30
15	34.65	67	154.77	119	274.89	171	395.01	223	515.13	275	635.25	435	1004.85
16	36.96	68	157.08	120	277.20	172	397.32	224	517.44	276	637.56	440	1016.40
17	39.27	69	159.39	121	279.51	173	399.63	225	519.75	277	639.87	445	1027.95
18	41.58	70	161.70	122	281.82	174	401.94	226	522.06	278	642.18	450	1039.50
19	43.89	71	164.01	123	284.13	175	404.25	227	524.37	279	644.49	455	1051.05
20	46.20	72	166.32	124	286.44	176	406.56	228	526.68	280	646.80	460	1062.60
21	48.51	73	168.63	125	288.75	177	408.87	229	528.99	281	649.11	465	1074.15
22	50.82	74	170.94	126	291.06	178	411.18	230	531.30	282	651.42	470	1085.70
23	53.13	75	173.25	127	293.37	179	413.49	231	533.61	283	653.73	475	1097.25
24	55.44	76	175.56	128	295.68	180	415.80	232	535.92	284	656.04	480	1108.80
25	57.75	77	177.87	129	297.99	181	418.11	233	538.23	285	658.35	485	1120.35
26	60.06	78	180.18	130	300.30	182	420.42	234	540.54	286	660.66	490	1131.90
27	62.37	79	182.49	131	302.61	183	422.73	235	542.85	287	662.97	495	1143.45
28	64.68	80	184.80	132	304.92	184	425.04	236	545.16	288	665.28	500	1155.00
29	66.99	81	187.11	133	307.23	185	427.35	237	547.47	289	667.59	525	1212.75
30	69.30	82	189.42	134	309.54	186	429.66	238	549.78	290	669.90	550	1270.50
31	71.71	83	191.73	135	311.85	187	431.97	239	552.09	291	672.21	575	1328.25
32	73.92	84	194.04	136	314.16	188	434.28	240	554.40	292	674.52	600	1386.00
33	76.23	85	196.35	137	316.47	189	436.59	241	556.71	293	676.83	625	1443.75
34	78.54	86	198.66	138	318.78	190	438.90	242	559.02	294	679.14	650	1501.50
35	80.85	87	200.97	139	321.09	191	441.21	243	561.33	295	681.45	675	1559.25
36	83.16	88	203.28	140	323.40	192	443.52	244	563.64	296	683.76	700	1617.00
37	85.47	89	205.59	141	325.71	193	445.83	245	565.95	297	686.07	725	1674.75
38	87.78	90	207.90	142	328.02	194	448.14	246	568.26	298	688.38	750	1732.50
39	90.09	91	210.21	143	330.33	195	450.45	247	570.57	299	690.69	775	1790.25
40	92.40	92	212.52	144	332.64	196	452.76	248	572.88	300	693.00	800	1848.00
41	94.71	93	214.83	145	334.95	197	455.07	249	575.19	305	704.55	825	1905.75
42	97.02	94	217.14	146	337.26	198	457.38	250	577.50	310	716.10	850	1963.50
43	99.33	95	219.45	147	339.57	199	459.69	251	579.81	315	727.65	875	2021.25
44	101.64	96	221.76	148	341.88	200	462.00	252	582.12	320	739.20	900	2079.00
45	103.95	97	224.07	149	344.19	201	464.31	253	584.43	325	750.75	925	2136.75
46	106.26	98	226.38	150	346.50	202	466.62	254	586.74	330	762.30	950	2194.50
47	108.57	99	228.69	151	348.81	203	468.93	255	589.05	335	773.85	975	2252.25
48	110.88	100	231.00	152	351.12	204	471.24	256	591.36	340	785.40	1000	2310.00
49	113.19	101	233.31	153	353.43	205	473.55	257	593.67	345	796.95	1500	3465.00
50	115.50	102	235.62	154	355.74	206	475.86	258	595.98	350	808.50	2000	4620.00
51	117.81	103	237.93	155	358.05	207	478.17	259	598.29	355	820.05	3000	6930.00
52	120.12	104	240.24	156	360.36	208	480.48	260	600.60	360	831.60		

Calculating Operating Costs of Pumps

Costs in Cents per 1,000 Gallons	Costs in Cents per Acre-Inch
Cost (→) = $\frac{\text{kw Input} \times r \times 1,000}{\text{GPH}}$	Cost (→) = $\frac{\text{kw Input} \times r \times 452.6}{\text{GPM}}$
Where: r = Cost of power in cents per kw-hr.	

Conversion Tables

Units of Flow					
Convert To →	U.S. Gallons per Minute	Million U.S. Gallons per Day	Cubic Feet per Second	Cubic Meters per Hour	Liters per Second
Convert From ↓	Multiply By:				
(1) U.S. Gallon Per Minute	1	0.001440	0.00223	0.2271	0.0631
(1) Million U.S. Gallons Per Day	694.5	1 ⇨	1.547	157.7	43.8
(1) Cubic Foot Per Second	448.83	0.646	1	101.9	28.32
(1) Cubic Meter Per Hour	4.403	0.00634	0.00982	1	0.2778
(1) Liter Per Second	15.85	0.0228	0.0353	3.60	1

Units of Pressure and Head						
Convert To →	Lbs. per Square Inch	Feet of Water †	Meters of Water †	Inches of Mercury ‡	Atmospheres	Kilograms per Square CM
Convert From ↓	Multiply By:					
(1) Lb. Per Square Inch	1	2.31	0.704	2.04	0.0680	0.0703
(1) Foot Of Water †	0.433	1	0.305	0.881	0.02945	0.0304
(1) Meter Of Water †	1.42	3.28	1	2.89	0.0966	.1
(1) Inch Of Mercury ‡	0.491	1.135	0.346	1	0.0334	0.0345
(1) Atmosphere (at Sea Level)	14.70	33.96	10.35	29.92	1	1.033
(1) Kilogram Per Square CM	14.22	32.9	10	28.96	0.968	1

Units of Volume Weight								
Convert To →	U.S. Gallons	Imperial Gallons	Cubic Inches	Cubic Feet	Acre Feet	Pounds ††	Cubic Meters	Liters
Convert From ↓	Multiply By:							
(1) U.S. Gallon	1	0.833	231	0.1337	3.07x10 ⁻⁶	8.34	0.003785	3.785
(1) Imperial Gallon	1.201	1	277.4	0.1605	3.69x10 ⁻⁶	10.01	0.004546	4.546
(1) Cubic Inch	0.00433	0.00360	1	0.000579	—	0.0361	1.64x10 ⁻⁵	0.0164
(1) Cubic Foot	7.48	6.23	1728	1	2.30x10 ⁻⁵	62.4	0.02832	28.32
(1) Acre Foot	325,850	271,355	—	43,560	1	2.7x10 ⁶	1233.5	123x10 ⁶
(1) Pound ††	0.120	0.0998	27.7	0.0160	3.68x10 ⁻⁷	1	4.54x10 ⁻⁴	0.454
(1) Cubic Meter	264.2	220	61,024	35.315	8.11x10 ⁻⁴	2202	1	1000
(1) Liter	0.2642	0.220	61.024	0.0353	8.11x10 ⁻⁷	2.202	0.001	1

(†) Equivalent units are based on density of fresh water at 68°F.

(‡) Equivalent units are based on density of mercury at 32°F.

(††) Weight equivalent basis water at 60°F.

Each 1,000 feet of ascent decreases pressure about 1/2 pound per square inch.

Units of Length
(1) Inch = 0.0833 Feet = 0.0278 Yards = 25.4 Millimeters = 2.54 Centimeters
(1) Foot = 12 Inches = 0.333 Yards = 30.48 Centimeters = 0.3048 Meters
(1) Yard = 36 Inches = 3 Feet = 91.44 Centimeters = 0.9144 Meters
(1) Mile = 5280 Feet = 1760 Yards = 1.61 Kilometers = 1609 Meters
(1) Meter = 3.281 Feet = 39.37 Inches = 0.000621 Miles = 0.001 Kilometers
(1) Kilometer = 1000 Centimeters = 1093.61 Yards = 0.62137 Miles = 3281 Feet

**60 Hertz to 50 Hertz
and
50 Hertz to 60 Hertz
CONVERSION TABLES**

To Convert	Multiply By	To Obtain
60 Hz GPM	.833	50 Hz GPM
60 Hz Feet Head	.69	50 Hz Feet Head
60 Hz HP	.579	50 Hz HP
50 Hz GPM	1.2	60 Hz GPM
50 Hz Feet Head	1.44	60 Hz Feet Head
50 Hz HP	1.728	60 Hz HP
Gallons	3.785	Liters
Liters	.2642	Gallons
Gallons (U.S.)	.83267	Gallons (Imperial)
Gallons (Imperial)	1.2	Fallons (U.S.)
Cubic Meters/Hour	4.4	GPM
GPM	.2271	Cubic Meters/Hour
Million Gallons/Day	694.5	GPM
Horsepower	754.7	Watts
Horsepower	.7457	Kilowatts
Feet Head	.433	PSI
PSI	2.31	Feet Head

Units of Measurement/Conversions

Volume

1 U.S. Gallon	231 cu. in. 0.137 cu. ft. 3.785 liters .00379 cu. meters 0.833 Imp. gal. .0238 42-gal. barrel
1 Imperial Gallon	1.2 U.S. gal
1 Cubic Foot	7.48 U.S. gal. 0.0283 cu. meter
1 Liter	0.2642 U.S. gal.
1 Cubic Meter	35.314 cu. ft. 264.2 U.S. gal.
1 Acre Foot	43,560 cu. ft. 325,829 U.S. gal.
1 Acre Foot	3,630 cu. ft. 27,100 U.S. gal.

Length

1 Inch	2.54 centimeters
1 Rod	3.28 feet
1 Meter	16.5 feet
1 Mile	5280 ft. (1.61 kilometers)

Weight

1 U.S. Gallon of Water	8.33 lb.
1 Cubic Foot of Water	62.35 lb.
1 Kilogram or Litre	2.2 lb.
1 Imperial Gallon	0.0 lb.

Temperature Conversions

Degrees C	=	$\frac{5}{9}$ x Degrees F - 32
Degrees F	=	$\frac{5}{9}$ x Degrees C + 32

Head

1 Pound Per Square Inch (PSI)	2.31 ft. head of water 2.04 in. mercury 0.07 kg. per sq. cm.
1 Foot of Water	0.433 lb. per sq. in. 885 in. mercury
1 Inch of Mercury (or vacuum)	1.132 ft. of water
1 Kilogram Per Square Cm	14.22 lb. per sq. in. 14.7 lb. per sq. in.
1 Atmosphere (at sea level)	34.0 ft. of water 10.35 meters of water
1 Meter of Water	3.28 feet of water

To Find Capacity of a Tank or a Cistern

Diameter of Tank in Feet
x .7854
x Height of Tank in Feet
x 7.48
= Capacity in U.S. Gallons

Work, Power and Efficiency

Mechanical Power is measured in horsepower (HP). One HP is the theoretical power required to raise 33,000 pounds to a height of one foot in one minute, or:

$$1 \text{ HP} = 33,000 \text{ ft.-lb. / minute}$$

$$= 550 \text{ ft.-lb. / second}$$

Electrical Power is measured in watts (w) or kilowatts (kw) and:

$$1,000 \text{ w} = 1 \text{ kw} = 1.34 \text{ HP or}$$

$$1 \text{ HP} = 746 \text{ w} = 0.746 \text{ kw}$$

Water Horsepower

Water horsepower is the power required to raise water at a specified rate against a specified head, assuming 100% efficiency.

$$= \frac{\text{GPM} \times 8.33 \times \text{Head}}{33,000} = \frac{\text{GPM} \times \text{Head}}{3,960}$$

GPM = Gallons per Minute

8.33 = Pounds of Water per Gallon

33,000 = Ft.-lb. per Minute in One HP

Laboratory BHP

$$= \frac{\text{Head} \times \text{GPM} \times \text{Sp. Gr}}{3,960 \times \text{Eff.}}$$

GPM = Gallon per Minute

Head = Laboratory Head (inc. column loss)

Eff. = Pump only Efficiency

Motor Input HP

= Laboratory BHP

Motor Eff.

Total BHP from above

Motor EFF. from manufacturer

Pump Efficiency

Pumps and motors, like all machines, are not 100% efficient. Not all of the energy supplied to them is converted into useful work. Pump efficiency is the ratio of power output to power input or:

$$\text{Efficiency (\%)} = \frac{\text{Power Output} \times 100}{\text{Power Input}}$$

$$\text{Pump Efficiency (\%)} = \frac{\text{WHP} \times 100}{\text{Pump BHP (Input)}}$$

$$= \frac{\text{GPM} \times \text{Total Pumping Head} \times 100}{3960 \times \text{Pump BHP (Input)}}$$

$$\text{Motor Efficiency (\%)} = \frac{\text{Motor BHP (Output)} \times 100}{1.34 \times \text{kw Input}}$$

$$\text{Plant Efficiency (\%)} = \frac{\text{GPM} \times \text{Total Pumping Head} \times 100}{5,300 \times \text{kw Input}}$$

Unit Efficiency

= Water Horsepower

Motor Input Horsepower

Water Horsepower from above

Input Horsepower from above

Electric Power

AC = Alternating current power

DC = Direct current

E = Volts = Electrical pressure (similar to head)

I = Amperes = Electrical current (similar to rate of flow)

W = Watts = Electrical power (similar to head capacity)

KW = Kilowatts = 1000 watts

Apparent Power = Volts x Amperes = Voltamperes

Apparent Power = E I

Useful Power W = E I x P.F.

Power Factor = Ratio of useful power to apparent power

$$\text{Power Factor} = \text{PF} = \frac{W}{E I}$$

KW Hr. = Kilowatt hour

Single Phase Power W = E x I x PF

Three Phase Power W = 1.73 x I x PF

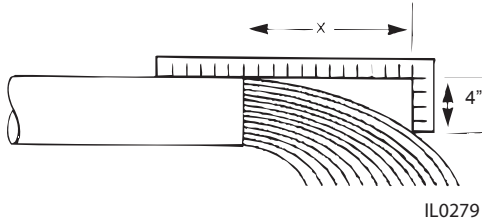
Where E = Average voltage between phases

I = Average current in each phase

Miscellaneous Data, Formulas and Conversions

Calculating Discharge Rate by Using the Horizontal Open Discharge Method

The most reliable method of measuring flow is to use a flow meter. When a flow meter is not available, however, it is possible to estimate the discharge capacity by constructing an "L" shaped measuring stick similar to the figure below. With the water flowing from the pipe, place the long end of the "L" on top of the pipe. Position the "L" so that the end of the short 4 inch side just touches the stream of water as the stream slants downward. Note the horizontal distance "X" from this point to the open end of the discharge pipe. With the value "X" and the nominal inside diameter of the pipe, use the table below to find the discharge rate in gallons per minute.



Example: Horizontal distance "X" is measured to be 12 inches. The size of the pipe is known to be 1-1/2" (nominal diameter). Find 12 inches in the left hand column of the chart and move across to the 1-1/2" pipe size column. The table below indicates that the discharge rate is 40.0 gallons per minute.

Discharge Rate in Gallons Per Minute (GPM) for Large Capacity Systems										
Nominal Pipe Size (In Inches)										
Horizontal Distance (X) (In Inches)	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6	8
	Discharge Rate in Gallons Per Minute (GPM)									
4	5.7	9.8	13.3	22.0	31	48	83			
5	7.1	12.2	16.6	27.5	39	61	104	163		
6	8.5	14.7	20.0	33.0	47	73	125	195	285	
7	10.0	17.1	23.2	38.5	55	85	146	228	334	380
8	11.3	19.6	26.5	44.0	62	97	166	260	380	665
9	12.8	22.0	29.8	49.5	70	110	187	293	430	750
10	14.2	24.5	33.2	55.5	78	122	208	326	476	830
11	15.6	27.0	26.5	60.5	86	134	229	360	525	915
12	17.0	29.0	40.0	66.0	94	146	250	390	570	1000
13	18.5	31.5	43.0	71.5	102	158	270	425	620	1080
14	20.0	34.0	46.5	77.0	109	170	292	456	670	1160
15	21.3	36.3	50.0	82.5	117	183	312	490	710	1250
16	22.7	39.0	53.0	88.0	125	196	334	520	760	1330
17		41.5	56.5	93.0	133	207	355	550	810	1410
18			60.0	99.0	144	220	375	590	860	1500
19				100.	148	232	395	620	910	1580
20				0	156	244	415	650	950	1660
21						256	435	685	1000	1750

Calculating Low Capacity Outlets:

A simple procedure for measuring low capacity outlets such as small pump outlets, hose spigots and faucets is to record the amount of time it takes to fill a container of known size.

Example: Select a container of known size, such as a 5 gallon paint bucket. With a watch, measure, in seconds, the amount of time it takes to fill a 5 gallon bucket. For example: It takes 30 seconds to fill the 5 gallon bucket. The table indicates that the flow is 10.0 gallons per minute. To obtain gallons per hour (GPH) multiply 10.0 x 60 to obtain 600 GPH.

Discharge Rate in Gallons Per Minute (GPM) for Low Capacity Systems								
Capacity of Container (Gallons)	Time (In Seconds) to Fill Container							
	10	15	20	30	45	60	90	120
Discharge Rate in Gallons Per Minute (GPM)								
1	6.0	4.0	3.0	2.0	1.3	1.0	.7	.5
3	18.0	12.0	9.0	6.0	4.0	3.0	2.0	1.5
5	30.0	20.0	15.0	10.0	6.7	5.0	3.3	2.5
10	60.0	40.0	30.0	20.0	13.3	10.00	6.7	5.0

THESE ARE COMMON INDUSTRY TERMS & ABBREVIATIONS

AMER STD	AMERICAN STANDARD
AMS	AERONAUTICAL MATERIAL SPECIFICATIONS OF THE SOCIETY OF AUTOMOTIVE ENGINEERS
ASME	AMERICAN SOCIETY OF MECHANICAL ENGINEERS'
ASTM	AMERICAN SOCIETY OF TESTING MATERIALS
ATM	ATMOSPHERE
BB	BOLTED BONNET
BLR	BOILER
BTU	BRITISH THERMAL UNIT (s)
C	DEGREE CENTIGRADE
CXC	COPPER X COPPER
COND	CONDENSER
COP	COPPER
CSA	CANADIAN STANDARDS ASSOCIATION
CV	CHECK VALVE
DC	DIRECT CURRENT
DD	DOUBLE DISC
EXP VLV	EXPANSION VALVE
F	DEGREE FAHRENHEIT
FLG	FLANGED END
FM	INDICATED PRODUCT HAS BEEN APPROVED BY FACTORY MUTUAL LABORATORIES
FSPS	FEMALE STANDARD PIPE SIZE
GPF	GALLONS PER FOOT
GPH	GALLONS PER HOUR
GPM	GALLONS PER MINUTE

INDUSTRY TERMS & ABBREVIATIONS (cont.)

IBBM	IRON BODY, BRONZE MOUNTED
MSS	MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTING INDUSTRY
NEC	NATIONAL ELECTRIC CODE
NPT	NATIONAL STANDARD TAPER PIPE THREAD
NRS	NON-RISING STEM
OS & Y	OUTSIDE SCREW AND YOKE
PRV	PRESSURE REDUCING VALVE
PSI	POUNDS PER SQUARE INCH
PSIA	POUNDS PER SQUARE INCH ABSOLUTE
PSIG	POUNDS PER SQUARE INCH GAUGE
RS	RISING STEM
S.A.E.	SOCIETY OF AUTOMOTIVE ENGINEERS
SB	SCREW IN BONNET
SE	SCREWED (THREADED) END
SJ	SOLDER JOINT
STD	STANDARD
SWP	STEAM WORKING PRESSURE
TRIM	TERM DESIGNATING CERTAIN VALVE PARTS, SUCH AS DISCS, SEAT RINGS, STEMS AND REPACKING SEAT BUSHINGS
UB	UNION BONNET
UL	INDICATES PRODUCT HAS BEEN APPROVED BY UNDERWRITERS LABORATORIES, INC.
VAC	VACUUM
VOL	VOLUME
WOG	WATER, OIL OR GAS WORKING PRESSURE
WWP	WATER WORKING PRESSURE