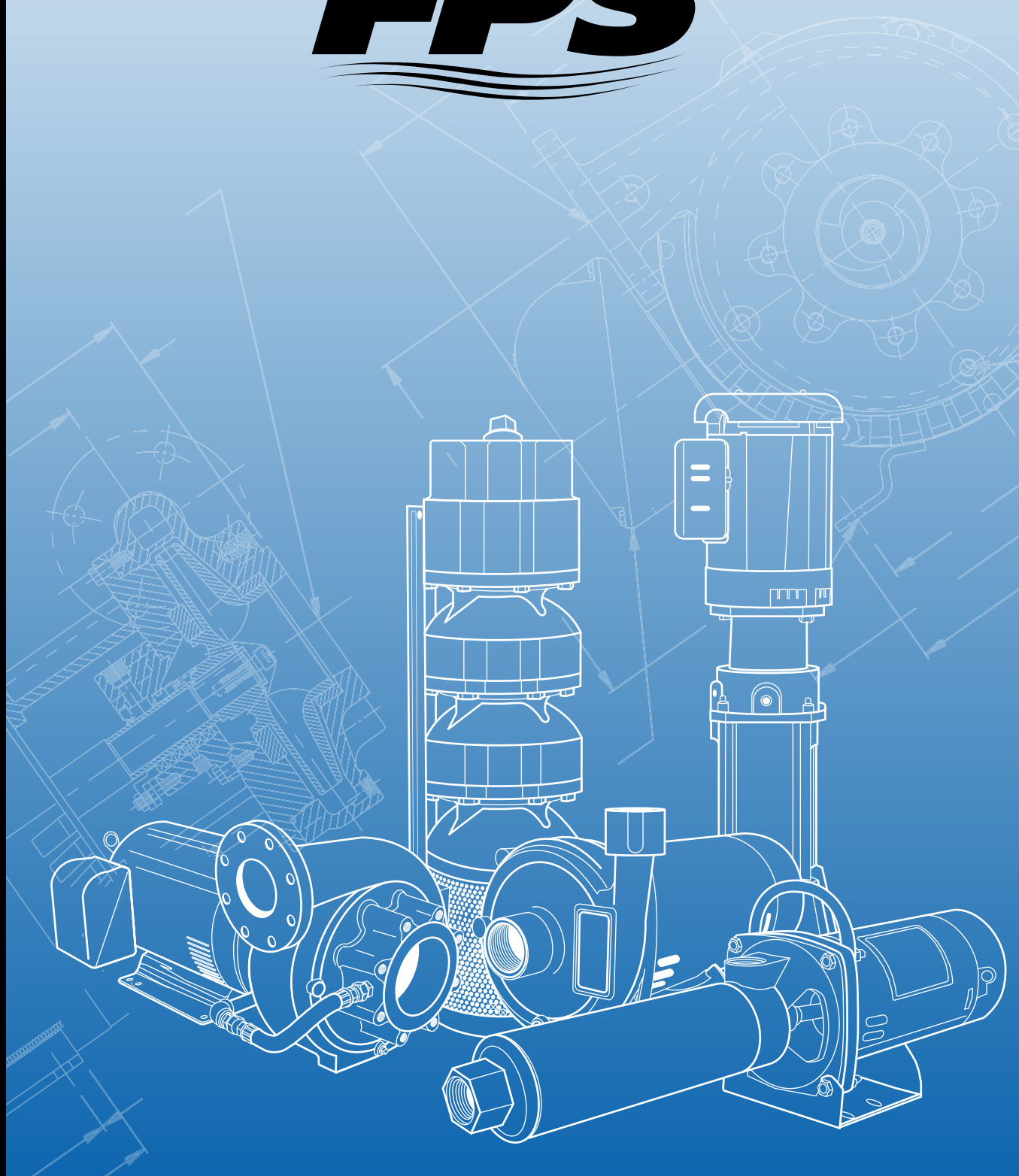


Irrigation & Industrial Pumps Engineering Manual

FPS



 Franklin Electric

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Friction Loss

Friction Loss - PVC Schedule 80 IPS Plastic Pipe in Feet per 100 feet of pipe

Pipe Size	1/2"		3/4"		1"		1 1/4"		1 1/2"		2"		2 1/2"		3"		4"	
	Head Loss	Vel (ft./s)	Head Loss	Vel (ft./s)	Head Loss	Vel (ft./s)	Head Loss	Vel (ft./s)	Head Loss	Vel (ft./s)	Head Loss	Vel (ft./s)	Head Loss	Vel (ft./s)	Head Loss	Vel (ft./s)	Head Loss	Vel (ft./s)
1	1.87	1.37	0.42	0.74	0.12	0.45	0.03	0.25	0.01	0.18								
2	6.74	2.74	1.52	1.48	0.44	0.89	0.11	0.50	0.05	0.36	0.01	0.22						
3	14.29	4.11	3.21	2.23	0.93	1.34	0.23	0.75	0.10	0.54	0.03	0.33	0.01	0.23				
4	24.34	5.48	5.47	2.97	1.59	1.78	0.39	1.00	0.18	0.73	0.05	0.43	0.02	0.30				
5	36.79	6.85	8.27	3.71	2.40	2.23	0.59	1.25	0.27	0.91	0.08	0.54	0.03	0.38	0.01	0.24		
6	51.57	8.22	11.59	4.45	3.36	2.68	0.82	1.50	0.38	1.09	0.11	0.65	0.04	0.45	0.02	0.29		
7	68.61	9.59	15.43	5.19	4.47	3.12	1.09	1.75	0.50	1.27	0.14	0.76	0.06	0.53	0.02	0.34		
8	87.86	10.96	19.75	5.94	5.73	3.57	1.40	2.00	0.64	1.45	0.18	0.87	0.08	0.61	0.03	0.39		
9	109.27	12.33	24.57	6.68	7.12	4.01	1.74	2.25	0.80	1.63	0.23	0.98	0.01	0.68	0.03	0.44		
10	132.82	13.70	29.86	7.42	8.66	4.46	2.12	2.50	0.97	1.82	0.28	1.09	0.12	0.76	0.04	0.49		
11			35.63	8.16	10.33	4.91	2.53	2.75	1.16	2.00	0.33	1.20	0.14	0.83	0.05	0.53		
12			41.86	8.90	12.14	5.35	2.97	3.00	1.36	2.18	0.39	1.30	0.16	0.91	0.06	0.58		
14			55.69	10.39	16.15	6.24	3.95	3.50	1.81	2.54	0.52	1.52	0.22	1.06	0.07	0.68		
16			71.31	11.87	20.68	7.14	5.06	4.00	2.32	2.90	0.67	1.74	0.28	1.21	0.09	0.78		
18			88.69	13.36	25.72	8.03	6.30	4.50	2.89	3.27	0.83	1.96	0.34	1.36	0.12	0.87		
20			107.80	14.84	31.26	8.92	7.65	5.00	3.51	3.63	1.01	2.17	0.42	1.51	0.14	0.97	0.04	0.56
22					37.29	9.81	9.13	5.50	4.19	3.99	1.20	2.39	0.50	1.67	0.17	1.07	0.04	0.61
24					43.81	10.70	10.72	6.00	4.92	4.36	1.41	2.61	0.59	1.82	0.20	1.17	0.05	0.67
26					50.81	11.60	12.44	6.50	5.71	4.72	1.64	2.83	0.68	1.97	0.23	1.26	0.06	0.73
28					58.29	12.49	14.27	7.00	6.55	5.08	1.88	3.04	0.78	2.12	0.26	1.36	0.07	0.78
30					66.23	13.38	16.21	7.50	7.44	5.45	2.13	3.26	0.89	2.27	0.30	1.46	0.08	0.84
35							21.57	8.75	9.89	6.35	2.84	3.80	1.18	2.65	0.40	1.70	0.10	0.98
40							27.62	10.00	12.67	7.26	3.63	4.35	1.51	3.03	0.51	1.94	0.13	1.12
45							34.36	11.25	15.76	8.17	4.52	4.89	1.88	3.41	0.64	2.19	0.17	1.26
50	0.03	0.62					41.76	12.51	19.16	9.08	5.49	5.44	2.28	3.78	0.77	2.43	0.20	1.40
55	0.03	0.68					49.82	13.76	22.85	9.99	6.55	5.98	2.72	4.16	0.92	2.67	0.24	1.53
60	0.04	0.74					58.53	15.01	26.85	10.89	7.70	6.52	3.20	4.54	1.09	2.91	0.28	1.67
65	0.04	0.80							31.14	11.80	8.93	7.07	3.71	4.92	1.26	3.16	0.33	1.81
70	0.05	0.86							35.72	12.71	10.24	7.61	4.25	5.30	1.45	3.40	0.38	1.95
75	0.06	0.92							40.59	13.62	11.64	8.15	4.83	5.68	1.64	3.64	0.43	2.09
80	0.07	0.98							45.74	14.52	13.12	8.70	5.45	6.06	1.85	3.89	0.48	2.23
85	0.07	1.05							51.18	15.43	14.68	9.24	6.09	6.43	2.07	4.13	0.54	2.37
90	0.08	1.11							56.89	16.34	16.32	9.78	6.77	6.81	2.30	4.37	0.60	2.51
95	0.09	1.17							62.88	17.25	18.03	10.33	7.49	7.19	2.54	4.61	0.66	2.65
100	0.01	1.23							69.15	18.16	19.83	10.87	8.23	7.57	2.80	4.86	0.73	2.79
125	0.15	1.54	0.04	0.88							29.98	13.59	12.45	9.46	4.23	6.07	1.01	3.49
150	0.21	1.85	0.05	1.05							42.02	16.31	17.45	11.35	5.93	7.29	1.54	4.19
175	0.28	2.15	0.07	1.23									23.21	13.25	7.89	8.50	2.05	4.88
200	0.36	2.46	0.09	1.41	0.03	0.89							29.72	15.14	10.01	9.71	2.62	5.58
250	0.54	3.08	0.14	1.76	0.05	1.12							44.93	18.92	15.27	12.14	3.96	6.98
300	0.76	3.69	0.19	2.11	0.06	1.34											5.56	8.37
350	1.01	4.31	0.26	2.46	0.09	1.56	0.04	1.11									7.39	9.77
400	1.29	4.92	0.33	2.81	0.11	1.79	0.05	1.26									9.47	11.16
450	1.61	5.54	0.41	3.16	0.14	2.01	0.06	1.42										
500	1.95	6.15	0.50	3.51	0.17	2.23	0.07	1.58										
750	4.14	9.23	1.06	5.27	0.35	3.35	0.15	2.37										
1000	7.05	12.31	1.80	7.03	0.60	4.47	0.26	3.16										
1250			2.73	8.78	0.91	5.58	0.39	3.95										
1500			3.82	10.54	1.27	6.70	0.55	4.74										
2000					2.16	8.94	0.93	6.32										
2500					3.27	11.17	1.41	7.89										
3000					4.58	13.40	1.97	9.47										
3500							2.62	11.05										
4000							3.36	12.63										

Note: Suction Velocities should not exceed 8 feet per second. Calculated using Williams and Hazen formula using C = 150.

Friction Loss

Friction Loss - Water in Feet per 100 feet of Steel Pipe

GPM	Pipe Size 4"			Pipe Size 5"			Pipe Size 6"		
	Actual size 4.026			Actual size 5.047			Actual size 6.065		
	Friction	Vel (ft/sec)	Vel Head (ft)	Friction	Vel (ft/sec)	Vel Head (ft)	Friction	Vel (ft/sec)	Vel Head (ft)
20	0.061	0.504	0.004						
21	0.067	0.529	0.004						
22	0.073	0.554	0.005						
23	0.079	0.580	0.005						
24	0.085	0.605	0.006						
25	0.092	0.630	0.006						
26	0.099	0.655	0.007						
27	0.106	0.680	0.007						
28	0.114	0.706	0.008						
29	0.121	0.731	0.008						
30	0.129	0.756	0.009						
32	0.146	0.806	0.010						
34	0.163	0.857	0.011						
36	0.181	0.907	0.013						
38	0.200	0.958	0.014						
40	0.220	1.008	0.016	0.073	0.641	0.006			
42	0.241	1.059	0.017	0.080	0.674	0.007			
44	0.263	1.109	0.019	0.087	0.706	0.008			
46	0.285	1.159	0.021	0.095	0.738	0.008			
48	0.309	1.210	0.023	0.103	0.770	0.009			
50	0.333	1.260	0.025	0.111	0.802	0.001			
55	0.397	1.386	0.030	0.132	0.882	0.012			
60	0.466	1.512	0.036	0.155	0.962	0.014			
65	0.541	1.638	0.042	0.180	1.042	0.017			
70	0.621	1.764	0.048	0.207	1.123	0.020			
75	0.705	1.890	0.056	0.235	1.203	0.022			
80	0.795	2.016	0.063	0.265	1.283	0.026			
85	0.889	2.142	0.071	0.296	1.363	0.029			
90	0.988	2.268	0.080	0.329	1.443	0.032			
95	1.092	2.394	0.089	0.364	1.524	0.036			
100	1.201	2.520	0.099	0.400	1.604	0.040	0.164	1.111	0.019
110	1.433	2.772	0.119	0.477	1.764	0.048	0.195	1.222	0.023
120	1.684	3.024	0.142	0.561	1.924	0.058	0.229	1.333	0.028
130	1.953	3.276	0.167	0.650	2.085	0.068	0.266	1.444	0.032
140	2.240	3.528	0.193	0.746	2.245	0.078	0.305	1.555	0.038
150	2.546	3.780	0.222	0.848	2.406	0.090	0.347	1.666	0.043
160	2.869	4.032	0.253	0.955	2.566	0.102	0.391	1.777	0.049
170	3.210	4.284	0.285	1.069	2.726	0.116	0.437	1.888	0.055
180	3.568	4.536	0.320	1.188	2.887	0.130	0.486	1.999	0.062
190	3.944	4.788	0.356	1.313	3.047	0.144	0.537	2.110	0.069
200	4.337	5.040	0.395	1.444	3.207	0.160	0.591	2.221	0.077
220	5.174	5.545	0.478	1.723	3.528	0.193	0.705	2.443	0.093
240	6.079	6.049	0.569	2.024	3.849	0.230	0.828	2.665	0.110
260	7.050	6.553	0.667	2.348	4.170	0.270	0.960	2.887	0.130
280	8.087	7.057	0.774	2.693	4.490	0.313	1.101	3.109	0.150
300	9.190	7.561	0.888	3.060	4.811	0.360	1.252	3.332	0.173
350	12.226	8.821	1.209	4.071	5.613	0.490	1.665	3.887	0.235
400	15.656	10.081	1.580	5.213	6.415	0.640	2.132	4.442	0.307
450	19.473	11.341	1.999	6.484	7.217	0.809	2.652	4.997	0.388
500	23.668	12.601	2.468	7.881	8.019	0.999	3.223	5.553	0.479
550	28.238	13.861	2.986	9.402	8.820	1.209	3.846	6.108	0.580
600	33.175	15.121	3.554	11.046	9.622	1.439	4.518	6.663	0.690
650	38.476	16.382	4.171	12.811	10.424	1.689	5.240	7.218	0.810
700	44.136	17.642	4.837	14.696	11.226	1.959	6.011	7.774	0.939
750	50.152	18.902	5.553	16.699	12.028	2.248	6.830	8.329	1.078
800	56.520	20.162	6.318	18.819	12.830	2.558	7.697	8.884	1.227
850	63.235	21.422	7.132	21.055	13.631	2.888	8.612	9.439	1.385
900	70.296	22.682	7.996	23.407	14.433	3.238	9.574	9.995	1.553
950	77.700	23.942	8.909	25.872	15.235	3.608	10.582	10.550	1.730
1000	85.443	25.202	9.872	28.450	16.037	3.997	11.637	11.105	1.917
1100				33.942	17.641	4.837	13.883	12.216	2.319
1200				39.877	19.244	5.756	16.311	13.326	2.760
1300				46.249	20.848	6.755	18.917	14.437	3.239
1400				53.053	22.452	7.835	21.700	15.547	3.757
1500				60.284	24.056	8.994	24.657	16.658	4.313
1600				67.938	25.659	10.233	27.788	17.768	4.907

Note: Suction Velocities should not exceed 8 feet per second.

Friction Loss

Friction Loss - Water in Feet per 100 feet of Steel Pipe

GPM	Pipe Size 16"			Pipe Size 18"			Pipe Size 20"		
	Actual size 16			Actual size 17.18			Actual size 19.18		
	Friction	Vel (ft/sec)	Vel Head (ft)	Friction	Vel (ft/sec)	Vel Head (ft)	Friction	Vel (ft/sec)	Vel Head (ft)
500	0.029	0.798	0.001	0.020	0.692	0.007	0.012	0.555	0.005
550	0.034	0.878	0.012	0.024	0.761	0.009	0.014	0.611	0.006
600	0.040	0.957	0.014	0.028	0.830	0.011	0.017	0.666	0.007
650	0.047	1.037	0.017	0.033	0.900	0.013	0.019	0.722	0.008
700	0.054	1.117	0.019	0.038	0.969	0.015	0.022	0.777	0.009
750	0.061	1.197	0.022	0.043	1.038	0.017	0.025	0.833	0.011
800	0.069	1.277	0.025	0.049	1.107	0.019	0.028	0.888	0.012
850	0.077	1.356	0.029	0.054	1.176	0.022	0.032	0.944	0.014
900	0.085	1.436	0.032	0.060	1.246	0.024	0.035	0.999	0.016
950	0.094	1.516	0.036	0.067	1.315	0.027	0.039	1.055	0.017
1000	0.104	1.596	0.040	0.073	1.384	0.030	0.043	1.110	0.019
1100	0.124	1.755	0.048	0.088	1.522	0.036	0.051	1.221	0.023
1200	0.145	1.915	0.057	0.103	1.661	0.043	0.060	1.333	0.028
1300	0.169	2.074	0.067	0.119	1.799	0.050	0.070	1.444	0.032
1400	0.193	2.234	0.078	0.137	1.938	0.058	0.080	1.555	0.038
1500	0.220	2.394	0.089	0.156	2.076	0.067	0.091	1.666	0.043
1600	0.248	2.553	0.101	0.175	2.214	0.076	0.103	1.777	0.049
1700	0.277	2.713	0.114	0.196	2.353	0.086	0.115	1.888	0.055
1800	0.308	2.872	0.128	0.218	2.491	0.096	0.128	1.999	0.062
1900	0.341	3.032	0.143	0.241	2.630	0.107	0.141	2.110	0.069
2000	0.375	3.191	0.158	0.265	2.768	0.119	0.155	2.221	0.077
2100	0.410	3.351	0.175	0.290	2.906	0.131	0.170	2.332	0.085
2200	0.447	3.511	0.192	0.316	3.045	0.144	0.185	2.443	0.093
2300	0.485	3.670	0.209	0.343	3.183	0.157	0.201	2.554	0.101
2400	0.525	3.830	0.228	0.371	3.322	0.171	0.217	2.665	0.110
2500	0.566	3.989	0.247	0.401	3.460	0.186	0.234	2.776	0.120
2600	0.609	4.149	0.268	0.431	3.598	0.201	0.252	2.887	0.130
2700	0.653	4.308	0.289	0.462	3.737	0.217	0.270	2.998	0.140
2800	0.699	4.468	0.310	0.494	3.875	0.233	0.289	3.109	0.150
2900	0.745	4.628	0.333	0.527	4.014	0.250	0.309	3.220	0.161
3000	0.794	4.787	0.356	0.561	4.152	0.268	0.329	3.331	0.172
3100	0.843	4.947	0.380	0.597	4.290	0.286	0.349	3.442	0.184
3200	0.895	5.106	0.405	0.633	4.429	0.305	0.370	3.553	0.196
3300	0.947	5.266	0.431	0.670	4.567	0.324	0.392	3.664	0.209
3400	1.001	5.425	0.457	0.708	4.706	0.344	0.414	3.775	0.222
3500	1.056	5.585	0.485	0.747	4.844	0.365	0.437	3.887	0.235
3600	1.113	5.745	0.513	0.787	4.982	0.386	0.461	3.998	0.248
3700	1.170	5.904	0.542	0.828	5.121	0.408	0.485	4.109	0.262
3800	1.230	6.064	0.571	0.870	5.259	0.430	0.509	4.220	0.277
3900	1.290	6.223	0.602	0.913	5.398	0.453	0.534	4.331	0.291
4000	1.352	6.383	0.633	0.957	5.536	0.476	0.560	4.442	0.307
4100	1.416	6.542	0.665	1.001	5.674	0.500	0.586	4.553	0.322
4200	1.480	6.702	0.698	1.047	5.813	0.525	0.613	4.664	0.338
4300	1.546	6.861	0.732	1.094	5.951	0.550	0.640	4.775	0.354
4400	1.613	7.021	0.766	1.141	6.090	0.576	0.668	4.886	0.371
4500	1.682	7.181	0.801	1.190	6.228	0.603	0.696	4.997	0.388
4600	1.752	7.340	0.837	1.239	6.367	0.630	0.725	5.108	0.406
4700	1.823	7.500	0.874	1.289	6.505	0.658	0.755	5.219	0.423
4800	1.895	7.659	0.912	1.341	6.643	0.686	0.785	5.330	0.442
4900	1.969	7.819	0.950	1.393	6.782	0.715	0.815	5.441	0.460
5000	2.044	7.978	0.989	1.446	6.920	0.744	0.846	5.552	0.479
5500	2.439	8.776	1.197	1.725	7.612	0.901	1.001	6.107	0.580
6000	2.865	9.574	1.425	2.027	8.304	1.072	1.186	6.663	0.690
6500	3.323	10.372	1.672	2.351	8.996	1.258	1.376	7.218	0.810
7000	3.812	11.170	1.939	2.697	9.688	1.459	1.578	7.773	0.939
7500	4.332	11.968	2.226	3.064	10.380	1.675	1.793	8.328	1.078
8000	4.882	12.766	2.533	3.453	11.072	1.905	2.021	8.883	1.227

Note: Suction Velocities should not exceed 8 feet per second.

Friction Loss

Friction Loss - Water in Feet per 100 feet of Steel Pipe

GPM	Pipe Size 24"			Pipe Size 30"			Pipe Size 36"		
	Actual size 24			Actual size 30			Actual size 36		
	Friction	Vel (ft/sec)	Vel Head (ft)	Friction	Vel (ft/sec)	Vel Head (ft)	Friction	Vel (ft/sec)	Vel Head (ft)
350	0.002	0.248	0.000						
400	0.003	0.284	0.001						
450	0.003	0.319	0.002						
500	0.004	0.355	0.002						
550	0.005	0.390	0.002						
600	0.006	0.426	0.003						
650	0.006	0.461	0.003						
700	0.007	0.496	0.004	0.003	0.318	0.002			
750	0.008	0.532	0.004	0.003	0.340	0.002			
800	0.001	0.567	0.005	0.003	0.363	0.002			
850	0.011	0.603	0.006	0.004	0.386	0.002			
900	0.012	0.638	0.006	0.004	0.408	0.003			
950	0.013	0.674	0.007	0.004	0.431	0.003			
1000	0.014	0.709	0.008	0.005	0.454	0.003			
1100	0.017	0.780	0.009	0.006	0.499	0.004			
1200	0.020	0.851	0.011	0.007	0.545	0.005			
1300	0.023	0.922	0.013	0.008	0.590	0.005			
1400	0.027	0.993	0.015	0.009	0.635	0.006	0.004	0.441	0.003
1500	0.031	1.064	0.018	0.010	0.681	0.007	0.004	0.473	0.003
1600	0.034	1.135	0.020	0.012	0.726	0.008	0.005	0.504	0.004
1700	0.039	1.206	0.023	0.013	0.772	0.009	0.005	0.536	0.004
1800	0.043	1.277	0.025	0.014	0.817	0.010	0.006	0.567	0.005
1900	0.047	1.347	0.028	0.016	0.862	0.012	0.007	0.599	0.006
2000	0.052	1.418	0.031	0.018	0.908	0.013	0.007	0.630	0.006
2100	0.057	1.489	0.034	0.019	0.953	0.014	0.008	0.662	0.007
2200	0.062	1.560	0.038	0.021	0.999	0.015	0.009	0.693	0.007
2300	0.067	1.631	0.041	0.023	1.044	0.017	0.009	0.725	0.008
2400	0.073	1.702	0.045	0.025	1.089	0.018	0.010	0.756	0.009
2500	0.079	1.773	0.049	0.027	1.135	0.020	0.011	0.788	0.010
2600	0.085	1.844	0.053	0.029	1.180	0.022	0.012	0.820	0.010
2700	0.091	1.915	0.057	0.031	1.225	0.023	0.013	0.851	0.011
2800	0.097	1.986	0.061	0.033	1.271	0.025	0.014	0.883	0.012
2900	0.104	2.057	0.066	0.035	1.316	0.027	0.014	0.914	0.013
3000	0.110	2.128	0.070	0.037	1.362	0.029	0.015	0.946	0.014
3100	0.117	2.199	0.075	0.040	1.407	0.031	0.016	0.977	0.015
3200	0.124	2.269	0.080	0.042	1.452	0.033	0.017	1.009	0.016
3300	0.132	2.340	0.085	0.044	1.498	0.035	0.018	1.040	0.017
3400	0.139	2.411	0.090	0.047	1.543	0.037	0.019	1.072	0.018
3500	0.147	2.482	0.096	0.050	1.589	0.039	0.020	1.103	0.019
3600	0.155	2.553	0.101	0.052	1.634	0.041	0.022	1.135	0.020
3700	0.163	2.624	0.107	0.055	1.679	0.044	0.023	1.166	0.021
3800	0.171	2.695	0.113	0.058	1.725	0.046	0.024	1.198	0.022
3900	0.179	2.766	0.119	0.061	1.770	0.049	0.025	1.229	0.023
4000	0.188	2.837	0.125	0.063	1.816	0.051	0.026	1.261	0.025
4100	0.197	2.908	0.131	0.066	1.861	0.054	0.027	1.292	0.026
4200	0.206	2.979	0.138	0.070	1.906	0.056	0.029	1.324	0.027
4300	0.215	3.050	0.145	0.073	1.952	0.059	0.030	1.355	0.029
4400	0.224	3.120	0.151	0.076	1.997	0.062	0.031	1.387	0.030
4500	0.234	3.191	0.158	0.079	2.042	0.065	0.033	1.418	0.031
4600	0.244	3.262	0.165	0.082	2.088	0.068	0.034	1.450	0.033
4700	0.254	3.333	0.173	0.086	2.133	0.071	0.035	1.481	0.034
4800	0.264	3.404	0.180	0.089	2.179	0.074	0.037	1.513	0.036
4900	0.274	3.475	0.188	0.092	2.224	0.077	0.038	1.544	0.037
5000	0.284	3.546	0.195	0.096	2.269	0.080	0.040	1.576	0.039
5500	0.339	3.901	0.236	0.115	2.496	0.097	0.047	1.734	0.047
6000	0.398	4.255	0.281	0.135	2.723	0.115	0.055	1.891	0.056
6500	0.462	4.610	0.330	0.156	2.950	0.135	0.064	2.049	0.065
7000	0.530	4.964	0.383	0.179	3.177	0.157	0.074	2.206	0.076
7500	0.602	5.319	0.440	0.203	3.404	0.180	0.084	2.364	0.087
8000	0.679	5.674	0.500	0.229	3.631	0.205	0.094	2.522	0.099

Note: Suction Velocities should not exceed 8 feet per second.

Friction Loss

Smooth Bore Hose

Flow of Water in GPM	Head Loss (ft / 100ft)						
	Actual Inside Diameter in Inches						
	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"
1	3.257						
2	11.758	1.640					
5	63.987	8.894	2.195	0.739	0.300		
10	231	32.109	7.900	2.657	1.086	0.277	
15		67.914	16.724	5.636	2.31	0.578	0.185
20		115.5	28.413	9.610	3.950	0.970	0.323
25		174.636	42.966	14.507	5.983	1.478	0.485
30		244.86	60.291	20.328	8.362	2.056	0.693
35		325.71	80.157	27.027	11.134	2.749	0.924
40			102.564	34.65	14.253	3.511	1.178
45			127.743	42.966	17.718	4.366	1.478
50			155.001	52.437	21.529	5.313	1.779
60			217.371	73.227	30.261	7.438	2.518
70			288.75	97.482	40.194	9.887	3.326
80				124.74	51.282	12.659	4.274
90				155.232	63.987	15.731	5.313
100				188.727	77.616	19.127	6.445
125				284.13	117.348	28.875	9.748
150					164.241	40.425	13.65
175					218.526	53.823	18.16
200					279.51	68.838	23.33
225						85.701	28.88
250						104.181	35.11
275						124.278	41.81
300						145.992	49.2
350						194.04	65.37
400						249.48	83.85
450							104.2
500							126.6
600							177.4
700							235.6
800							302.6
1000							

Flow of Water in GPM	Head Loss (ft / 100ft)						
	Actual Inside Diameter in Inches						
	3"	4"	5"	6"	8"	10"	12"
25							
30	0.277						
35	0.370						
40	0.485						
45	0.601						
50	0.739						
60	1.040						
70	1.363						
80	1.756						
90	2.195	0.531					
100	2.657	0.647					
125	4.019	0.993					
150	5.613	1.386	0.462				
175	7.484	1.848	0.624				
200	9.563	2.356	0.993				
225	11.897	2.934	0.993				
250	14.461	3.557	1.201				
275	17.256	4.250	1.432				
300	20.259	4.990	1.686	0.693			
350	27.027	6.630	2.241	0.924			
400	34.419	8.501	2.864	1.178			
450	42.966	10.557	3.557	1.478			
500	52.206	12.844	4.343	1.779	0.439		
600	72.996	17.995	6.075	2.495	0.624		
700	97.251	24.024	8.062	3.326	0.809	0.277	
800	124.278	30.723	10.326	4.250	1.040	0.347	
1000	188.034	46.2	15.616	6.422	1.594	0.531	0.231
1200	263.34	64.911	21.876	9.009	2.218	0.739	0.300
1400	351.12	86.163	29.106	11.966	2.957	0.993	0.416
1600		110.418	37.191	15.338	3.788	1.271	0.531
1800		137.445	46.2	19.058	4.689	1.594	0.647
2000		166.782	56.364	23.1	5.706	1.917	0.785
2500			85.008	35.112	8.616	2.911	1.201
3000			119.196	48.972	12.081	4.066	1.686

Note: These tables show the friction loss in water hose in pounds per square in. per 100 feet length, for straight, smooth bore hose.

NPSH - Net Positive Suction Head

IMPORTANT!

$NPSH_A$ should exceed $NPSH_R$ for optimum pump performance and to prevent severe pump damage.

NPSH Example - Suction Lift

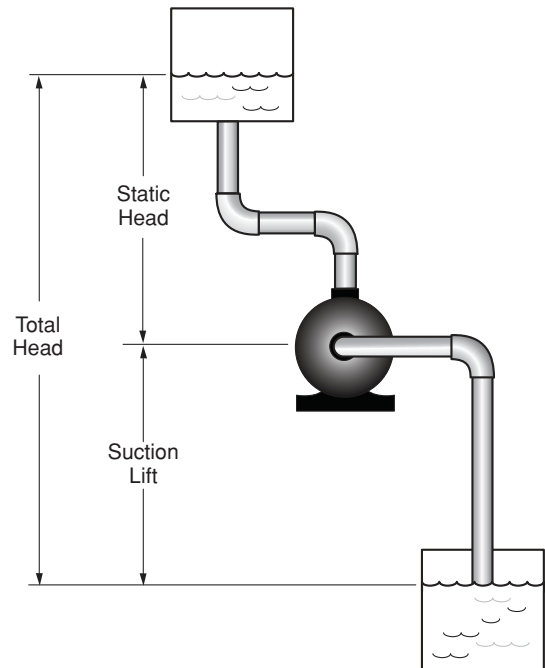
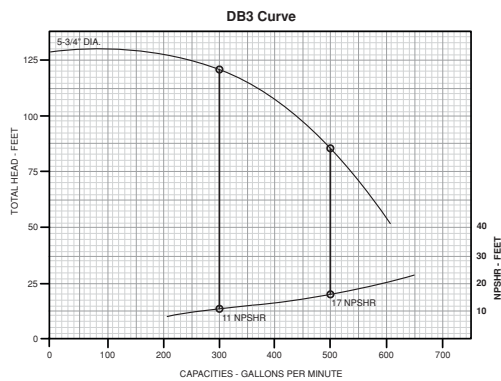
$$NPSH_A = H_a - H_{vp} - H_f - H_s$$

H_a = Absolute Pressure

H_{vp} = Vapor Pressure

H_f = Friction Losses

H_s = Distance of liquid level above or below impeller eye (if level is above eye, H_s is positive. If level is below the eye, H_s will be negative.)



Example 1:

Elevation = 500 ft above sea level

Water Temp = 70° F

Suction Head (H_s) = 13 feet

Capacity = 300 Gallons per Minute (GPM)

Suction Pipe Length (Steel) = 13 feet

Pipe Diameter = 4 inches

H_a = 33.3 feet (From pg.12- Atmospheric Pressure)

H_{vp} = .84 feet head (From pg.12- Prop. of Water)

H_f = $(9.19/100) * 13' + (9.19/100) * 12' = 1.19$ (Pipe Losses) + 1.10(Fitting Losses) = 2.29 feet

H_s = 13 feet

$$NPSH_A = 33.3' - .84' - 2.29 - 13' = 17.2 \text{ feet}$$

$NPSH_R$ for DB3 @ 300GPM = 11 feet

$17.2 > 11 \rightarrow$ Acceptable

Example 2:

Elevation = 500 ft above sea level

Water Temp = 70° F

Suction Head (H_s) = 13 feet

Capacity = 500 Gallons per Minute (GPM)

Suction Pipe Length (Steel) = 13 feet

Pipe Diameter = 4 inches

H_a = 33.3 feet (From pg.12- Atmospheric Pressure)

H_{vp} = .84 feet head (From pg.12- Prop. of Water)

H_f = $(23.668/100) * 13' + (23.668/100) * 12' = 3.08$ (Pipe Losses) + 2.84 (Fitting Losses) = 5.92 feet

H_s = 13 feet

$$NPSH_A = 33.3' - .84' - 5.92 - 13' = 13.54 \text{ feet}$$

$NPSH_R$ for DB3 @ 300GPM = 17 feet

$13.54 < 17 \rightarrow NPSH_R$ exceeds $NPSH_A$, Cavitation occurs

Reference Tables

Equivalent Values of Pressure

Inches of Mercury	Feet of Water	PSI
1	1.13	0.49
2	2.26	0.98
3	3.39	1.47
4	4.52	1.95
5	5.65	2.44
6	6.78	2.93
7	7.91	3.42
8	9.04	3.91
9	10.17	4.4
10	11.3	4.89
11	12.45	5.39
12	13.57	5.87
13	14.7	6.37
14	15.82	6.86
15	16.96	7.35
16	18.09	7.84
17	19.22	8.33
18	20.35	8.82
19	21.75	9.31
20	22.6	9.8
21	23.78	10.3
22	24.88	10.8
23	26	11.28
24	27.15	11.75
25	26.26	12.25
26	29.4	12.73
27	30.52	13.23
28	31.65	13.73
29	32.8	14.22
29.929	33.947	14.697

Properties of Water

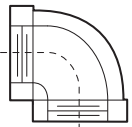
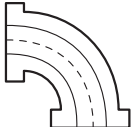

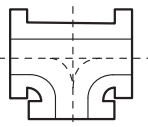

Temp. of Water (°F)	Pressure (ft Water)
60	0.59
70	0.84
80	1.17
90	1.61
100	2.19
110	2.94
120	3.91
130	5.14
140	6.67
150	8.58
160	10.9
170	13.8
180	17.3
190	21.6
200	26.6
210	32.6
212	34

Atmospheric Pressure at Various Elevations

Altitude Feet Above Sea Level	Atmospheric Pressure		
	Pounds per Square Inch (PSI)	Feet of Water	Inches of Mercury
Sea Level	14.7	33.8	29.9
500	14.4	33.3	29.4
1000	14.2	32.6	28.8
2000	13.7	31.4	27.8
3000	13.2	30.3	26.8
4000	12.7	29.2	25.8
5000	12.2	28.2	24.9
6000	11.8	27.1	24
7000	11.3	26.1	23.1
8000	10.9	25.1	22.2
9000	10.5	24.2	21.4
10000	10.1	23.2	20.6

Friction Loss

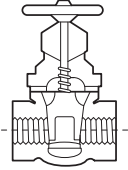
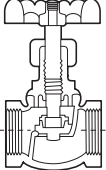
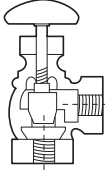
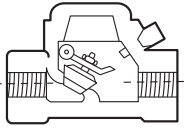
Pipe Fittings

Friction losses in terms of equivalent lengths of standard pipe					
Pipe Size	Standard 90° Elbow	Long Radius Elbow	45° Elbow	Tee	Return Bend
					
1/2"	1.5	1.1	0.77	3.4	3.8
3/4"	2.2	1.4	1	4.5	5
1"	2.7	1.7	1.3	5.8	6.1
1-1/4"	3.7	2.4	1.6	7.8	8.5
1-1/2"	4.3	2.8	2	9	10
2"	5.5	3.5	2.5	11	13
2-1/2"	6.5	4.2	3	14	15
3"	8.1	5.1	3.8	17	18
3-1/2"	9.5	6	4.4	19	21
4"	11	7	5	22	24
4-1/2"	12	7.9	5.6	24	27
5"	14	8.9	6.1	27	31
6"	16	11	7.7	33	37
8"	21	14	10	43	49
10"	26	17	13	56	61
12"	32	20	15	66	73
14"	36	23	17	76	85
16"	42	27	19	87	100
18"	46	30	21	100	110
20"	52	34	23	110	120
22"	58	37	25	130	140
24"	63	40	28	140	150
30"	79	50	35	165	190
36"	94	60	43	200	220
42"	120	72	50	240	260
48"	135	82	58	275	300

Friction Loss

Pipe Fittings

Friction losses in terms of equivalent lengths of standard pipe

Pipe Size	Gate Valve Open	Globe Valve Open	Angle Valve Open	Swing Check Valve
				
1/2"	0.35	16	8.4	4
3/4"	0.47	22	12	5
1"	0.6	27	15	7
1-1/4"	0.8	37	18	9
1-1/2"	0.95	44	22	11
2"	1.2	57	28	13
2-1/2"	1.4	66	33	16
3"	1.7	85	42	20
3-1/2"	2	99	50	
4"	2.3	110	58	26
4-1/2"	2.6	130	61	
5"	2.9	140	70	33
6"	3.5	160	83	39
8"	4.5	220	110	52
10"	5.7	290	140	65
12"	6.7	340	170	
14"	8	390	190	
16"	9	430	220	
18"	10.2	500	250	
20"	12	560	280	
22"	13	610	310	
24"	14	680	340	
30"	17	860	420	
36"	20	1000	500	
42"	23	1200	600	
48"	26	1400	680	

Pressure Loss

Swing Check Valves

Flow GPM	Pressure Loss (PSI)						Flow GPM	Pressure Loss (PSI)					
	Valve Size							Valve Size					
	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"		1-1/4"	1-1/2"	2"	2-1/2"	3"	4"
2	0.2						46	2.1	1.1	0.4			
3	.05						48	2.2	1.2	0.5			
6	1.0	0.3					50	2.4	1.3	0.5			
8	1.7	0.5					55	2.9	1.5	0.6			
10	2.6	0.8	0.3				60	3.4	1.8	0.7			
12	3.6	1.1	0.5				65	3.9	2.0	0.8			
14	4.8	1.5	0.6				70	4.5	2.4	0.9	0.4		
16		2.0	0.9				75		2.7	1.0	0.5		
18		2.4	1.0				80		3.0	1.2	0.6		
20		3.0	1.2	0.4			90		3.7	1.5	0.7		
22		3.5	1.4	0.5			100		4.6	1.8	0.9	0.4	
24		4.1	1.7	0.6			120			2.5	1.2	0.5	
26		4.8	2.0	0.7	0.4		140			3.3	1.6	0.7	
28			2.2	0.8	0.5		160			4.3	2.1	0.9	0.3
30			2.5	0.9	0.5		180			5.3	2.6	1.1	0.4
32			2.9	1.1	0.6		200			6.5	3.1	1.4	0.5
34			3.2	1.2	0.6		250				4.7	2.1	0.7
36			3.6	1.3	0.7		300				6.6	2.9	1.0
38			3.9	1.5	0.8		350					3.8	1.3
40			4.3	1.6	0.8	0.3	400					4.9	1.7
42			4.7	1.7	0.9	0.3	450						2.1
44				1.9	1.0	0.4	500						2.6

Bronze Gate Valves

Flow GPM	Pressure Loss (PSI)									
	Valve Size									
	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"	
1										
2	.01									
5	.06	.02								
8	.16	.05	.02							
10	.24	.08	.03	.01						
15		.17	.06	.02	.01					
20		.31	.11	.03	.02					
30			.24	.07	.04	.01				
40			.43	.13	.07	.02	.01			
50			.67	.21	.11	.04	.02			
60				.30	.15	.05	.03	.01		
80				.54	.28	.10	.05	.02		
100					.43	.15	.07	.03		
120					.62	.22	.10	.04	.02	
140					.85	.30	.14	.06		
160						.40	.18	.07	.03	
180						.50	.23	.09		
200						.62	.29	.11	.04	
220							.42	.14	.05	
240								.17	.06	
260								.19	.07	
280								.23	.09	
300								.26	.10	
380									.14	
400									.18	
450									.23	
500									.28	
550									.34	
600									.40	

Pressure Loss

Water Meters - AWWA Standard

Flow GPM	Pressure Loss						
	Normal Size						
	5/8"	3/4"	1"	1-1/2"	2"	3"	4"
1	0.2	0.1					
2	0.3	0.2					
3	0.4	0.3					
4	0.6	0.5	0.1				
5	0.9	0.6	0.2				
6	1.3	0.7	0.3				
7	1.8	0.8	0.4				
8	2.3	1.0	0.5				
9	3.0	1.3	0.6				
10	3.7	1.6	0.7				
11	4.4	1.9	0.8				
12	5.1	2.2	0.9				
13	6.1	2.6	1.0				
14	7.2	3.1	1.1				
15	8.3	3.6	1.2				
16	9.4	4.1	1.4	0.4			
17	10.7	4.6	1.6	0.5			
18	12.0	5.2	1.8	0.6			
19	13.4	5.8	2.0	0.7			
20	15.0	6.5	2.2	0.8			
22		7.9	2.8	1.0			
24		9.5	3.4	1.2			
26		11.2	4.0	1.4			
28		13.0	4.6	1.6			
30		15.0	5.3	1.8	0.7		
32			6.0	2.1	0.8		
34			6.9	2.4	0.9		
36			7.8	2.7	1.0		
38			8.7	3.0	1.2		
40			9.6	3.3	1.3		
42			10.6	3.6	1.4		
44			11.7	3.9	1.5		
46			12.8	4.2	1.6		
48			13.9	4.5	1.7		
50			15.0	4.9	1.9		
52				5.3	2.1		
54				5.7	2.2		
56				6.2	2.3		
58				6.7	2.5		
60				7.2	2.7	1.0	
65				8.3	3.2	1.1	
70				9.8	3.7	1.3	
75				11.3	4.3	1.5	
80				12.8	4.9	1.6	0.7
90				16.1	6.2	2.0	0.8
100				20.0	7.8	2.5	0.9
110					9.5	2.9	1.0
120					11.3	3.4	1.2
130					13.0	3.9	1.4
140					15.1	4.5	1.6
150					17.3	5.1	1.8
160					20.0	5.8	2.1
170						6.5	2.4
180						7.2	2.7
190						8.0	3.0
200						9.0	3.2
220						11.0	3.9
240						13.0	4.7
260						15.0	5.5
280						17.3	6.3
300						20.0	7.2
350							10.0
400							13.0
450							16.2
500							20.0

ANSI Standard C.I. Flange Dimensions

Nominal Pipe Size	Diameter of Flange (in)	Thickness of Flange (in)	Diameter of Bolt Circle (in)	Number of Bolts	Diameter of Bolts (in)	Diameter of Drilled Boltholes (in)	Size of Ring Gasket (in)
2"	6	5/8	4 3/4	4	5/8	3/4	2 x 4 1/8
2.5"	7	11/16	5 1/2	4	5/8	3/4	2 1/2 x 4 7/8
3"	7.5	3/4	6	4	5/8	3/4	3 x 5 3/8
3.5"	8.5	13/16	7	8	5/8	3/4	3 1/2 x 6 3/8
4"	9	15/16	7 1/2	8	5/8	3/4	4 x 6 7/8
5"	10	15/16	8 1/2	8	3/4	7/8	5 x 7 3/4
6"	11	1	9 1/2	8	3/4	7/8	6 x 8 3/4
8"	13.5	1 1/8	11 3/4	8	3/4	7/8	8 x 11
10"	16	1 3/16	14 1/4	12	7/8	1	10 x 13 3/8
12"	19	1 1/4	17	12	7/8	1	12 x 16 1/8
14" O.D.	21	1 3/8	18 3/4	12	1	1 1/8	14 x 17 3/4
16" O.D.	23.5	1 7/16	21 3/4	16	1	1 1/8	16 x 20 1/4
18" O.D.	25	1 9/16	22 3/4	16	1 1/8	1 1/4	18 x 21 5/8
20" O.D.	27.5	1 11/16	25	20	1 1/8	1 1/4	20 x 23 7/8
24" O.D.	32	1 7/8	29 1/2	20	1 1/4	1 3/8	24 x 28 1/4
30" O.D.	38.75	2 1/8	36	28	1 1/4	1 3/8	30 x 34 5/8
36" O.D.	46	2 3/8	42 3/4	32	1 1/2	1 5/8	36 x 41 1/4

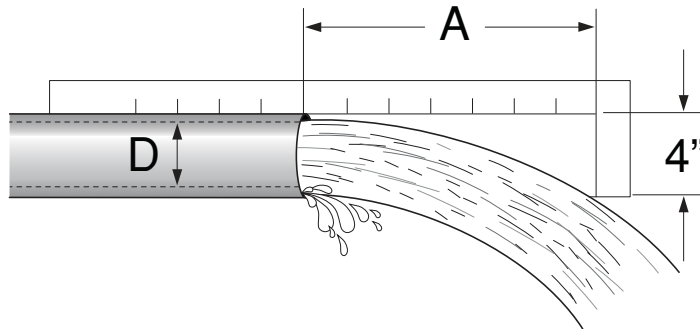
Flow Measurement

Estimating Output from Pipe - Horizontal Open Discharge Method

For Full Flowing Pipes - The output in GPM can be approximated by constructing an L-shaped gauge like that shown, with the short leg 4 inches long. Make the long leg to suit the pipe sizes and capacities for which the gauge will be used (refer to table) and mark it in inches.

Lay the gauge along the top of the pipe with the short leg barely touching the stream of water, and note distance A. Read the discharge rate from the table. Table is based on formula $Q = 1.28 \times A \times D^2$.

Example: D = 3"; A = 15" : Q = 183 GPM



A (inches)	Nominal Size of Pipe (D)												Average Velocity (ft/sec)	
	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	5"	6"	8"	10"	12"		
	Discharge Rate (Q) - Gallons per Minute													
4	537	9.8	13.3	22	31.3	48.5	83.5							2.1
5	7.1	12.2	16.3	27.5	39	61	104	163						2.6
6	8.5	14.7	20	33	47	73	125	195	285					3.1
7	10	17.1	23.2	38.5	55	85	146	228	334	580				3.7
8	11.3	19.6	26.5	44	62.5	97.5	166	260	380	665	1060			4.2
9	12.8	22	29.8	49.5	70	110	187	293	430	750	1190	1660		4.7
10	14.2	24.5	33.2	55.5	78.2	122	208	326	476	830	1330	1850		5.3
11	15.6	27	36.5	60.5	86	134	229	360	525	915	1460	2020		5.8
12	17	29	40	66	94	146	250	390	570	1000	1600	2220		6.2
13	18.5	31.5	43	71.5	102	158	270	425	620	1080	1730	2400		3.9
14	20	34	46.5	77	109	170	292	456	670	1160	1860	2590		7.4
15	21.3	36.3	50	82.5	117	183	312	490	710	1250	2000	2780		7.9
16	22.7	39	53	88	125	196	334	520	760	1330	2120	2960		8.4
17		41.5	56.5	93	133	207	355	550	810	1410	2260	3140		9.1
18			60	99	144	220	375	590	860	1500	2390	3330		9.7
19				110	148	232	395	620	910	1580	2520	3500		10.4
20					156	244	415	650	950	1660	2660	3700		10.6
21						256	435	685	1000	1750	2800	3890		11.4
22							460	720	1050	1830	2920	4060		11.8
23								750	1100	1910	3060	4250		12.4
24									1140	2000	3200	4440		13

Partially Filled Pipe - Area Factor Method

Flow (Q) = A x H x F x 1.039

A = Area of pipe in square inches

H = Horizontal distance in inches

F = Effective area factor from chart

Pipe Area = Inside diameter² x 0.7854

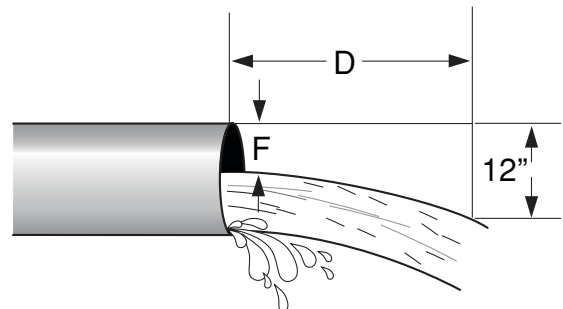
Example: Inside Diameter = 3.8"; H = 15"; F = .75"

A = 3.8 x 3.8 x 0.7854 = 11.34 sq. inches

F/D Ratio = .75/3.8 = 20%

F = 0.858

Q (GPM) = 11.34 x 15 x 1.039 = **177 GPM**



Nozzle Discharge

Nozzle discharge in U.S. gallons per minute at 100% efficiency

PSI	Feet head	Discharge Velocity (ft/sec)	Nozzle Diameter in Inches										
			5/32"	11/64"	3/16"	13/64"	7/32"	15/64"	1/4"	17/64"	9/32"	19/64"	5/16"
10	23.1	38.6	2.31	2.80	3.34	3.90	4.53	5.21	5.91	6.68	7.50	8.35	9.23
15	34.6	47.2	2.83	3.43	4.08	4.77	5.54	6.36	7.24	8.17	9.17	10.4	11.3
20	46.2	54.5	3.26	3.92	4.69	5.51	6.37	7.35	8.35	9.45	10.5	11.8	13.1
25	57.7	60.9	3.64	4.38	5.25	6.16	7.13	8.21	9.34	10.5	11.8	13.2	14.6
30	69.2	66.8	4.01	4.83	5.75	6.80	7.85	9.00	10.2	11.6	13.0	14.4	16.0
35	80.8	72.2	4.31	5.18	6.21	7.30	8.43	9.73	11.1	12.5	13.9	15.6	17.2
40	92.4	77	4.61	5.54	6.64	7.80	9.02	10.4	11.8	13.3	14.9	16.6	18.4
45	103.9	81.6	4.91	5.91	7.03	8.30	9.60	11.0	12.5	14.1	15.9	17.6	19.5
50	115.5	86.2	5.15	6.19	7.41	8.71	10.1	11.6	13.2	14.9	16.6	18.6	20.6
60	138.6	94.4	5.65	6.80	8.12	9.56	11.1	12.7	14.5	16.4	18.3	20.4	22.6
70	161.6	102	6.10	7.34	8.78	10.3	12.0	13.8	15.7	17.7	19.8	22.0	24.4
80	184.7	109	6.52	7.84	9.39	11.0	12.7	14.7	16.7	18.9	21.1	23.6	26.1
90	207.8	116	6.91	8.31	9.95	11.7	13.5	15.6	17.7	20.1	22.3	25.1	27.8
100	231	122	7.29	8.76	10.5	12.3	14.2	16.4	18.7	21.2	23.5	26.4	29.2
120	277.2	133	7.96	9.66	11.5	13.4	15.6	17.9	20.4	23.0	25.8	28.8	31.8
140	323.4	144	8.62	10.5	12.4	14.5	16.9	19.4	22.1	24.9	28.0	31.1	34.5
160	369.6	154	9.22	11.2	13.3	15.6	18.1	20.8	23.6	26.7	29.9	33.3	36.9
180	415.7	163	9.76	11.8	14.1	16.5	19.1	22.0	25.0	28.2	31.6	35.2	39.0
200	462	172	10.3	12.5	14.9	17.4	20.2	23.2	26.4	29.8	33.4	37.2	41.2

PSI	Feet head	Discharge Velocity (ft/sec)	Nozzle Diameter in Inches										
			11/32"	3/8"	7/16"	1/2"	9/16"	5/8"	3/4"	7/8"	1"	1-1/8"	1-1/4"
10	23.1	38.6	11.2	13.3	18.1	23.6	30.1	36.9	53.3	72.5	94.8	120	148
15	34.6	47.2	13.7	16.3	22.4	28.9	36.7	45.2	65.1	88.7	116	147	181
20	46.2	54.5	15.8	18.8	25.6	33.4	42.4	52.2	75.3	102	136	169	209
25	57.7	60.9	17.7	21.0	28.6	37.3	47.3	58.4	84.0	115	149	189	234
30	69.2	66.8	19.4	23.1	31.4	40.9	51.9	63.9	92.2	126	164	208	256
35	80.8	72.2	21.0	25.0	33.9	44.2	56.1	69.0	99.8	136	177	224	276
40	92.4	77	22.4	26.6	36.2	47.3	59.9	73.8	106	145	189	239	295
45	103.9	81.6	23.7	28.2	38.3	50.1	63.4	78.2	113	153	200	254	313
50	115.5	86.2	25.0	29.8	40.5	52.8	67.0	82.5	119	162	211	268	330
60	138.6	94.4	27.4	32.6	44.3	57.8	73.3	90.4	130	177	232	293	362
70	161.6	102	29.6	35.3	47.9	62.6	79.3	97.8	141	192	251	317	391
80	184.7	109	31.7	37.7	51.2	66.8	84.8	105	151	205	268	339	418
90	207.8	116	33.7	40.1	54.5	70.8	90.3	111	160	218	285	360	445
100	231	122	35.4	32.2	57.3	74.9	95.0	117	169	229	300	379	468
120	277.2	133	38.6	46.0	62.5	81.8	103	128	184	250	327	413	510
140	323.4	144	41.8	49.8	67.6	88.4	112	138	199	271	354	447	554
160	369.6	154	44.7	53.3	72.3	94.6	120	148	213	289	378	478	591
180	415.7	163	47.4	56.4	76.5	100	127	156	225	306	400	506	625
200	462	172	50.0	59.5	81.7	106	134	165	238	323	423	535	660

Electrical Information

Efficiencies, Fuse Sizes, and Wire Sizes for Single Phase Electric Motors							
HP Rating of Motor	Typical Full Load Eff. %	115 Volts			230 Volts		
		Full Load Amps	Max Fuse Size	Min Wire Size	Full Load Amps	Max Fuse Size	Min Wire Size
1/4	63	5.8	20	14	2.9	15	14
1/3	66	7.2	25	14	3.6	15	14
1/2	69	9.8	30	14	4.9	15	14
3/4	71	13.8	45	12	6.9	25	14
1	71	16	50	12	8	25	14
1-1/2	71	20	60	10	10	30	14
2	73	24	80	10	12	40	14
3	75	34	110	6	17	60	10
5	76	-	-	-	28	90	8
7-1/2	77	-	-	-	40	125	6

Efficiencies, Fuse Sizes, and Wire Sizes for Three Phase Electric Motors										
HP Rating of Motor	Typical Full Load Eff. %	230 Volts			460 Volts			575 Volts		
		Full Load Amps	Max Fuse Size	Min Wire Size	Full Load Amps	Max Fuse Size	Min Wire Size	Full Load Amps	Max Fuse Size	Min Wire Size
1/4	66	-	15	14	-	15	14	-	15	14
1/3	69	-	15	14	-	15	14	-	15	14
1/2	72	2	15	14	1	15	14	0.8	15	14
3/4	74	2.8	15	14	1.4	15	14	1.1	15	14
1	76	3.6	15	14	1.8	15	14	1.4	15	14
1-1/2	77	5.2	15	14	2.6	15	14	2.1	15	14
2	79	6.8	25	14	3.4	15	14	2.7	15	14
3	80	9.6	30	12	4.8	15	14	3.9	15	14
5	82	15.2	45	10	7.6	25	14	6.1	20	14
7-1/2	83	22	70	8	11	35	14	9	30	14
10	84	28	90	6	14	45	12	11	35	14
15	85	42	125	4	21	60	10	17	50	12
20	86	54	175	3	27	80	8	22	70	10
25	86	68	200	2	34	100	8	27	80	8
30	87	80	250	1	40	125	6	32	100	8
40	88	104	350	1	52	175	4	41	125	6
50	89	130	400	00	65	200	3	52	150	4
60	90	154	450	000	77	250	2	62	200	3
75	91	198	600	250	96	300	1	77	225	2
100	92	248	800	400	124	400	00	99	300	1

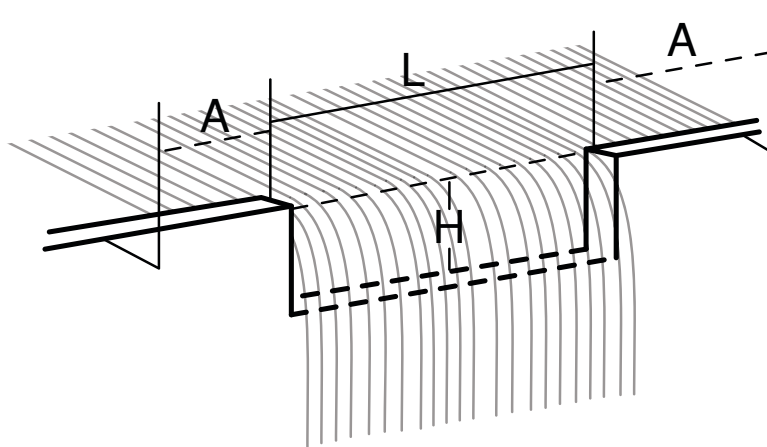
Pressure Tank Sizing

Pressure Tank Selection Chart - Minimum tank volumes for proper system life

Pump Capacity		Minimum Drawdown	Total Tank Volume (Gallons)								
			Switch Setting (PSI)								
			20-40			30-50			40-60		
GPH	GPM	Gallons	A	B	C	A	B	C	A	B	C
240	4	4	10	15	25	15	15	40	15	15	55
300	5	5	15	15	30	15	20	50	20	20	70
360	6	6	15	20	40	20	20	60	20	25	85
420	7	7	20	20	45	35	25	70	25	30	100
480	8	8	20	25	50	35	25	80	30	30	110
540	9	9	25	25	60	30	30	90	35	35	125
600	10	10	30	30	65	30	35	100	40	40	140
660	11	12	35	35	80	40	40	120	45	45	165
720	12	13	35	40	85	40	45	130	50	50	180
780	13	15	40	45	100	50	50	150	55	60	210
840	14	17	45	50	110	55	55	170	65	65	235
900	15	19	50	55	125	60	65	190	70	75	265
960	16	20	55	55	160	65	65	200	75	75	280
1020	17	23	6	65	150	75	75	230	85	90	320
1080	18	25	70	70	160	80	85	250	95	95	350
1140	19	27	75	75	175	85	90	270	100	105	375
1200	20	30	80	85	195	95	100	300	110	115	415
1260	21	33	90	90	215	105	110	330	125	125	460
1320	22	36	100	100	235	115	120	360	135	135	500
1380	23	38	105	105	345	125	125	380	140	145	530
1440	24	41	110	115	365	135	135	410	155	155	570
1500	25	44	120	120	385	140	145	440	165	165	610
1560	26	47	130	130	305	150	155	470	175	180	655
1620	27	50	135	140	325	160	165	500	185	190	700
1680	28	53	145	145	345	170	175	530	200	200	735
1740	29	57	155	160	370	185	185	570	215	215	790
1800	30	60	165	165	390	195	195	600	225	225	835

Note: A - Bladder or Diaphragm Tank Design
 B - Floating Wafer Tank Design
 C - Plain Steel Tank Design

Discharge from Rectangular Weir with End Contractions



Head (H) inches	Length (L) of Weir (ft)				Head (H) inches	Length (L) of Weir (ft)		
	1	3	5	Additional GPM for each ft over 5 ft		3	5	Additional GPM for each ft over 5 ft
1	35.4	107.5	179.8	36.05	8	2328	3956	814
1 1/4	49.5	150.4	250.4	50.4	8 1/4	2442	4140	850
1 1/2	64.9	197	329.5	66.2	8 1/2	2540	4312	890
1 3/4	81	248	415	83.5	8 3/4	2656	4511	929
2	98.5	302	506	102	9	2765	4699	970
2 1/4	117	361	605	122	9 1/4	2876	4899	1011
2 1/2	136.2	422	706	143	9 1/2	2985	5098	1051
2 3/4	157	485	815	165	9 3/4	3103	5288	1091
3	177.8	552	926	187	10	3216	5490	1136
3 1/4	199.8	624	1047	211	10 1/2	3480	5940	1230
3 1/2	222	695	1167	236	11	3716	6355	1320
3 3/4	245	769	1292	261	11 1/2	3960	6780	1410
4	269	846	1424	288	12	4185	7165	1495
4 1/4	293.6	925	1559	316	12 1/2	4430	7595	1575
4 1/2	318	1006	1696	345	13	4660	8010	1660
4 3/4	344	1091	1835	374	13 1/2	4950	8510	1780
5	370	1175	1985	405	14	5215	8980	1885
5 1/4	395.5	1262	2130	434	14 1/2	5475	9440	1985
5 1/2	421.6	1352	2282	465	15	5740	9920	2090
5 3/4	449	1442	2440	495	15 1/2	6015	10400	2165
6	476.5	1535	2600	528	16	6290	10900	2300
6 1/4		1632	2760	560	16 1/2	6565	11380	2410
6 1/2		1742	2920	596	17	6925	11970	2520
6 3/4		1826	3094	630	17 1/2	7140	12410	2640
7		1928	3260	668	18	7410	12900	2745
7 1/4		2029	3436	701.5	18 1/2	7695	13410	2855
7 1/2		2130	3609	736	19	7980	13940	2970
7 3/4		2238	3785	774	19 1/2	8280	14460	3090

Note: L - Length of weir opening in feet (should be 4 to 8 times H)
H - Head on weir in feet (to be measured at least 6 ft back of weir opening)
A - Should be at least 3 H

Pump Speed / Impeller Diameter Change

Use the following laws of affinity to determine the effects of speed or impeller diameter changes when the desired speed is not shown on pump curve:

Variables				
H_1	G_1	R_1	d_1	P_1
Existing Head in feet	Existing Gallons per minute (GPM)	Existing Revolutions per minute (RPM)	Existing diameter of impeller in inches	Existing Brake Horsepower (BHP)
H_2	G_2	R_2	d_2	P_2
Desired Head in feet	Desired Gallons per minute (GPM)	Desired Revolutions per minute (RPM)	Desired diameter of impeller in inches	Desired Brake Horsepower (BHP)

Capacity varies directly as the speed or diameter:

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

Example Speed Change: 100 GPM x (3500 RPM / 1750 RPM) = 200 GPM

Example Diameter Change: 100 GPM x (6 in / 5 in) = 120 GPM

Head varies as the square of the speed or diameter:

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

Example Speed Change: 50 ft. head x (3500 RPM / 1750 RPM)² = 200 ft head

Example Diameter Change: 50 ft. head x (6 in / 5 in)² = 72 ft head

Horsepower varies as the cube of the speed or diameter:

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

Example Speed Change: 9 HP x (3500 RPM / 1750 RPM)³ = 72 HP

Example Diameter Change: 9 HP x (6 in / 5 in)³ = 15.6 HP

Specific Gravity Effect

Specific gravity affects the output pressure of a pump. The heavier the liquid, the more force will be required to pump at the same performance. Brake horsepower varies directly with specific gravity. If the liquid has specific gravity other than water (1.0), multiply the brake horsepower for water by the specific gravity of the liquid to be handled.

Materials of Construction

Materials For Pumping Various Liquids

Liquid	Condition	Chem. Symb.	Sp. Gr.	Visc.	Material Recommended	Mech. Seal Mtrl Code
Acid, Acetic	Conc.	CH ₃ COOH	1.055	32 @ 68° F.	Lead, Alum., Brz., Monel, Cr. Ni. Stainless St.	XFICI
Acid, Acetic	Dil.				Lead, Monel, Cr. Ni. Stainless St.	
Acid, Arsenic		As ₂ O ₃			All Iron, Cr. Ni. Stainless St.	
Acid, Boric					Alum., Brz., Monel, Cr. Ni., Stainless St.	
Acid, Carboic (Phenol)	Conc.	C ₆ H ₅ OH	1.071	56 @ 68° F.	All Iron	BFICI
Acid, Carbonic		CO ₂ + H ₂ O			All Bronze	BFICI
Acid, Citric		C ₆ H ₇ O ₇ + H ₂ O	1.54		Plain Fitted, Cr. Ni, Stainless St.	BFICI
Acid, Cyanic		CNOH			All Iron	
Acid, Fatty					Aluminum Bronze, Monel	XFICI
Acid, Fruit					Monel, Cr. Ni. Stainless St.	BFICI
Acid, Hydrochloric	Comml.	HCl	1.16 (20 Be)	31.5 (EST.)	Enamel, High Silicon Iron, Hastelloy	
Acid, Hydrocyanic		HCN	.70		All Iron	BFICI
Acid, Hydrofluosilicic		H ₂ SiF ₂			Alum. Brz., Monel	
Acid, Mine Water					High Lead Brz., Cr. Ni., Stainless St.	XFICI
Acid, Muriatic					See Acid Hydrochloride	
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 ₂ CHO ₃ H ₁₂ H ₂ O			High Sil. Iron, Cr. Ni. Stainless St.	
Acid, Phosphoric	Crude 50%	H ₃ PO ₄	1.36-1.4		Cr. Ni. Stainless St.	
Acid, Picric					High. Sil. Iron, Cr. Ni. Stainless St.	
Acid, Pyrogallic					Cr. Ni. Stainless St.	
Acid, Pyroigneous		H ₂ C ₂ H ₃ O ₂	1.018-1.03		All Brz., Cr. Ni. Stainless St.	QFICI
Acid, Sulphuric	Conc.	H ₂ SO 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 ₂ SO ₄ +SO ₃			Plain Fitted, Steel	
Acid, Sulphurous	Conc.	H ₂ SO ₃			Enamel, Lead, Aluminium Brz.	XFICI (Carp 20)
Acid, Tannic		C ₁₄ H ₁₀ O ₃			All Brz., Monel, Cr. Ni., Stainless St.	BFICI
Alcohol (Grain)		C ₂ H ₅ OH	.7939	33 @ 68° F.	All Bronze	BFICI
Alcohol (Wood)		CH ₂ OH	.7965	31 @ 68° F.	All Bronze	BFICI
Alkaline Liquid	Conc. & Dil.				Enamel, All Iron	
Aluminum Sulphate	H ₂ O & Acid	N ₂ (SO ₄) ₃			Plain Fitted, High Silicon Iron	
Ammonia		NH ₃	.623 @ 32° F.	29.5 @ 32° F.	All Iron	BFICI
Ammonium Bicarbonate	Aq. Sol.	NH ₄ HCO ₃			All Iron	BFICI
Ammonium Chloride	Aq. Sol.	NH ₄ Cl			All Iron, Cr. Ni., Stainless Steel Alloy	
Ammonium Nitrate	Aq. Sol.	NH ₄ NO ₃			All Iron, Cr. Ni., Stainless Steel Alloy	QFICI
Ammonium Sulphate	Aq. Sol.	(NH ₄) ₂ SO ₄			All Iron, Cr. Ni., Stainless Steel Alloy	XFICI
Aniline Water					All Iron	XFICI
Asphaltum	Hot		.98-1.4		All Iron	
Barium Chloride		BaCl ₂			All Iron, Cr. Ni., Stainless Steel Alloy	XFICI
Barium Nitrate		Ba(NO ₂) ₃			All Iron, Cr. Ni., Stainless Steel Alloy	BFICI
Beer			1.01	32 @ 68° F.	All Bronze, Cr. Ni., Stainless Steel Alloy	BFICI
Beer Wort					All Bronze, Cr. Ni., Stainless Steel Alloy	BFICI
Beet Juice (Thin)					All Bronze, Cr. Ni., Stainless Steel Alloy	BFICI
Benzine (Coal Tar Product)		C ₆ H ₆	.88	31 @ 68° F.	All Iron	XFICI
Benzine (Oil Dist. Product)			.64-.66		Brz. Fitted	XFICI
Bichloride of Mercury	Dil.	HgCl ₃			All Iron, Cr. Ni., Stainless Steel	
Bitterwasser					All Bronze	
Bleach Solutions					Bronze Fitted	
Brine Calcium Chloride	Pure	CaCl ₂	Up to 1.3	32-42 @ 60° F.	All Iron	BFICI
Brine, Calcium & Sodium Chloride					All Bronze	BFICI
Brine Gun Cotton					All Bronze	
Brine Sodium Chloride	3% Salt	NaCl	1.02	32-35 @ 60° F.	All Bronze, All Iron	BFICI
Brine Sodium Chloride	Over 3% Salt		1.02-1.20	32-35 @ 60° F.	All Brz., Monel, Cr. Ni. Stainless Steel	BFICI
Cachaza					Bronze Fitted	
Cadmium Electrolyte					High Silicon Iron, Non-Metallic	
Calcium Bisulphite		Ca(HSO ₃) ₂	1.04		Cr. Ni. Stainless St. Alloy	
Calcium Chlorate	Aq. Sol.	Ca(ClO ₃) ₂ H ₂ O			Cr. Ni. Stainless St. Alloy	
Calcium Hydrochlorite		Ca(OCl) ₂			Enamel, All Iron, High St. Iron	QFICI
Calcium Magnesium Chloride					All Bronze	
Cane Juice					Bronze Fitted	
Carbon Bisulphide		CS ₂			All Iron	BFICI
Carbonate of Soda (Soda Ash)	Aq. Sol.	Na ₂ CO ₃			All Iron	
Carbon Tetrachloride		CCl ₄	1.58	31 @ 77° F.	Plain Fitted, All Iron	XFICI
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 Sulphide		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 ₆ H ₅ C ₁	1.1		Std. Fitted	XFICI
Chloroform		CHCl ₃	1.5		Lead, Cr. Ni. Stainless St. Alloy	XFICI

Materials of Construction

Materials For Pumping Various Liquids

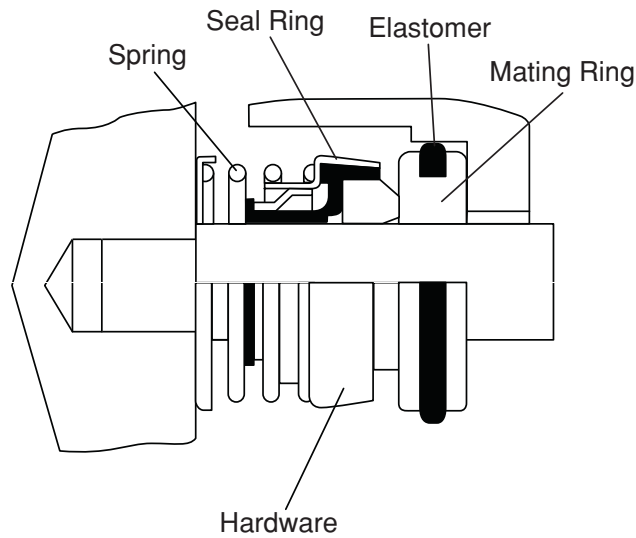
Liquid	Condition	Chem. Symb.	Sp. Gr.	Visc.	Material Recommended	Mech. Seal Mtrl Code
Chrome Alum					High Silicon Iron	
Coal Tar Oil					All Iron	
Copperas (Green Vitriol)		FeSO ₄			All Iron, Lead, High Silicon Iron	
Copper Acetate	Aq. Sol	Cu(C ₂ H ₃ O ₂) ₂ +H ₂ O			Cr. Ni. Stainless St. Alloy	
Copper Chloride	Aq. Sol	CuCl ₂			High Silicon Iron, Hastelloy C	
Copper Nitrate		Cu(NO ₃) ₂			Cr. Ni. Stainless Steel Alloy	
Copper Sulphate (Blue Vitriol)	Aq. Sol	CuSO ₄			Lead, High Sil. Iron, Cr. Ni. Stainless St.	
Creosote			.93		All Iron	
Creosote Oil					All Iron	QFICI
Cresol, Meta		CH ₃ C ₆ H ₄ OH	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 ₆ H ₅ C ₆ H ₅			All Iron	QFICI
Dish Water					Plain Fitted	
Distillery Wort					All Bronze	
Dye Wood Liquor					Bronze Fitted	
Ethyl Acetate		CH ₃ COOC ₂ H ₅	.90		All Iron, Cr. Ni. Stainless St.	
Ethylene Chloride	Cold	C ₂ H ₄ (Cl) ₂	1.28		Lead, High Sil. Iron	XFICI
Ferrie Chloride	Aq. Sol	FeCl ₃			High Sil. Iron, Hastelloy C. Non-Met	
Ferrie Chloride	Hot	FeCl ₃			High Sil. Iron, Hastelloy C. Non-Met	
Ferrous Chloride	Cold Aq.	FeCl ₃			All Iron (Oxidizes to Ferric Acid Conditions)	
Ferrous Sulphate (See Copperas)						
Fruit Juices					Monel, High Sil. Iron, Cr. Ni. Stainless	BFICI
Furfural		C ₄ H ₃ OCHO	1.16		All Iron, Cr. Ni. Stainless St.	QFICI
Gasoline		C ₈ H ₁₄	.66-.75	30 @ 68° F.	Bronze Fitted	BFICI
Glue	Hot				Bronze Fitted	
Glycerine		C ₃ H ₃ (OH) ₃	1.262	2950 @ 68° F.	All Bronze	BFICI
Grape Juice					All Bronze	
Heptane		C ₇ H ₁₆	.69		Bronze Fitted	BFICI
Hops					Bronze Fitted	
Hydrogen Peroxide (Perbydrol)	Comml.	H ₂ O ₂			All Iron, Cr. Ni. Stainless St.	
Hydrogen Sulphide	In Water	H ₂ S			Ni-Resist, Cr. Ni. Stainless St.	
Lard	Hot				All Iron	BFICI
Lead Acetate (Sugar of Lead)	Aq. Sol	Pb(C ₂ H ₃ O ₂) ₂ + 3H ₂ O			High Sil. Iron, Cr. Ni. Stainless St.	
Lead Molten					All Iron	
Lime Water (Milk of Lime)		Ca(OH) ₂			All Iron	XFICI
Lye, Caustic					All Iron	QFICI
Lye, Salty					Brz. Fitted or all bronze	
Lye, Solution containing sand					All Iron	
Magnesium Acid Sulphate	Cone.				All Bronze	
Magnesium Acid Sulphate	Dil.				All Iron	
Magnesium Chloride	Aq. Sol	MgCl ₂			Hard Lead, High Sil. Iron	BFICI
Magnesium Oxchloride		MgClOH			Lead	
Magnesium Sulphate (Epsom Salt)	Aq. Sol	MgSO ₆			All Iron	
Magma (Thick Residue)					All Brz, Cr. Ni. Stainless St.	
Marsh Gas		CH ₄			Plain Fitted	
Mash					Brz. Fitted or all bronze	
Mercuric Chloride	Very Dil.	HgCl ₂			High Silicon Iron	
Mercuric Chloride	Comml. Cone.	HgCl ₂			High Sil. Iron, Hastelloy C., Enamel	
Mercuric Sulphate	In H ₂ SO ₄	HgSO ₄			High Sil. Iron, Enamel	
Mercurous Sulphate	In H ₂ SO ₄	H ₂ (SO ₄) ₂			High Sil. Iron, Enamel	
Methyl Acetate		CH ₃ CO ₂ CH ₃	.924		Cr. Ni. Stainless Steel	
Methyl Chloride		CH ₃ Cl	.92		All Iron	XFICI
Methylene Chloride		CH ₂ Cl ₂	1.26		All Iron	QFICI
Milk			1.028-1.035	32 @ 68° F.	Bronze Tinned, All Bronze	
Molasses					Bronze Fitted	
Naphtha			.665		Bronze Fitted	BFICI
Naphtha Crude					Std. Fitted	BFICI
Nickel Chloride	Low pH Sol.	NiCl ₂			High Sil. Iron, Copper	
Nickel Sulphate	Low pH Sol.	NiSO ₄			High Sil. Iron, Copper	
Nicotine Sulphate		C ₁₀ H ₁₄ N ₂ H ₂ SO ₄			High Sil. Iron, Copper	
Oil, Crude (Asphalt Base)	Hot				Std. Fitted	
Oil, Crude (Paraffine Base)	Cold				Std. Fitted	BFICI
Oil, Fuel			.825-.95		Std. Fitted	BFICI
Oil, Kerosene			.81 @ 68° F.	35 @ 68° F.	Std. Fitted	BFICI
Oil, Lubricating Lt. or Hy					Std. Fitted	BFICI
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	BFICI
Oil, Linseed			.94	143 @ 100° F.	All Iron, Monel	BFICI
Oil, Rapeseed			.92		All Bronze, Monel	BFICI
Paraffine (45° to 60° C.)	Hot				Bronze Fitted	BFICI
Petroleum					Plate Fitted	
Photographic Developers					High Sil. Iron, Non-Metallic	

Materials of Construction

Materials For Pumping Various Liquids

Liquid	Condition	Chem. Symb.	Sp. Gr.	Visc.	Material Recommended	Mech. Seal Mtrl Code
Potash Sulphide		K ₂ S			All Iron	
Potassium Alum		Al ₂ K ₂ (SO ₄) ₄			Attacks C. I. slowly	
Potassium Bichromate	Aq. Sol.	K ₂ Cr ₂ O ₇			All Iron	BFICI
Potassium Carbonate	Aq. Sol.	K ₂ CO ₃			All Iron	BFICI
Potassium Chloride	Aq. Sol.	KCl			All Brz., Cr. Ni. Stainless St	BFICI
Potassium Cyanide	Aq. Sol.	KCN			All Iron	BFICI
Potassium Nitrate	Aq. Sol.	KNO ₃			All Iron, Cr. Ni. Stainless St.	BFICI
Potassium Sulphate	Aq. Sol.	K ₂ SO ₄			All Iron, All Brz.	BFICI
Pyridine		CH(CHCH) ₂ N	.975		All Iron	QFICI
Rectifying Pump (Distillery)					All Bronze	
Rhigolene (Oil Dist)					Bronze Fitted	
Salammoniac		NH ₄ Cl			See Ammonium Chloride	
Salt Cake	Aq. Sol.				All Iron, All Bronze	
Sewage					Bronze Fitted	BFICI
Silver Nitrate		AgNO ₃			High Sil. Iron, Cr. Ni. Stainless St.	
Slop, Brewery					Bronze Fitted	
Soap Liquor	Thin				All Iron	XFICI
Soda		NaOH			All Iron	
Sodium Bicarbonate		NaHCO ₃			All Iron	BFICI
Sodium Bisulphate	Aq. Sol.	NaHSO ₄			High Sil. Iron, Lead	
Sodium Carbonate (Soda Ash)		Na ₂ CO ₃			All Iron	
Sodium Hydrosulphite	Aq. Sol.	Na ₂ S ₂ O ₆			Lead, Cr. Ni. Stainless St.	
Sodium Hypochlorite		NaOCl			High Sil, Iron, Lead. Non-Metallic	
Sodium Hyposulphite	(See Sodium Thiosulphate)					
Sodium Nitrate	Aq. Sol.	NaNO ₃			All Iron	QVICI
Sodium Sulphate	Aq. Sol.	Na ₂ SO ₄			All Iron	BFICI
Sodium Sulphide	Aq. Sol.	Na ₂ S			All Iron, All Brz., Lead	BFICI
Sodium Sulphite	Aq. Sol.	NaSO ₃			All Brz., Lead, Cr. Ni. St. Steel	
Sodium Thiosulphate	Aq. Sol.	Na ₂ S ₂ O ₅ ·5H ₂ O			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 ₂ H ₁₀ O ₃			Bronze Fitted	
Strontium Nitrate	Aq. Sol.	Sr(NO ₃) ₂			All Iron	BFICI
Sugar	40% Sol.			43@68° F.	All Bronze	
Sulphate of Lime		CaSO ₄			All Bronze	
Sulphide of Hydrogen		H ₂ S			Plain Fitted	
Sulphide of Sodium	Hot	Na ₂ S			All Iron	BFICI
Sulphide of Sodium	Cold				Plain Fitted	
Sulpholignic Salts	Cone.				All Bronze	
Sulpholignic Salts	Dil.				Bronze Fitted	
Sulphur	In Water				All Iron, All Bronze	QFICI
Sulphur Chloride	Cold	S ₂ Cl ₂			All Iron, Lead	
Sulphur Dioxide		SO ₂			All Bronze	
Sweet Water					Bronze Fitted	
Syrup					All Bronze	
Tanning Liquor	Veg.				All Bronze	XFICI
Tar					All Iron	QFICI
Tar and Ammonia	Aq. Sol.				All Iron	QFICI
Tetrachloride of Tin		(See Sannic Chloride)				
Tetraethyl Lead		Pb(C ₂ H ₅) ₄	1.65		All Iron	QFICI
Toluene (Toluol)		CH ₂ C ₆ H ₆	.86		All Iron, Std. Fitted	XFICI
Trichloroethylene		C ₂ HCl ₃	1.47		All Iron, Std. Fitted	XFICI
Urine					All Bronze	BFICI
Varnish					All Bronze, Monel	
Vinegar			1.08	32@68° F.	All Brz., High Sil. Iron	XFICI
Vitriol, Blue	(See Copper Sulphate)				Cr. Ni. Stainless Steel	
Vitriol, Green	(See Ferrous Sulphate)					
Vitriol, Oil of	(See Acid Sulphuric)					
Vitriol, White	(See Zinc Sulphate)					
Water, Distilled			1.00	31.5@60° F.	Bronze Fitted	XFICI
Water, Fresh			1.00		Bronze Fitted	BFICI
Water, Salt & Sea	(See Brines)					QFICI
Whiskey					All Bronze	BFICI
Wine					All Bronze	BFICI
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, Sulphate		ZnSO ₄			All Brz., High Sil. Iron, Cr. Ni., Stainless Steel	BFICI

Material Code Identification



Symbols reference material codes:

Symbol	Material
B	Buna-N (Rubber)
X	Viton-A (Rubber)
Q	Chemlon (TFE)
F	Carbon
C	Ceramic
I	Stainless Steel

Sequential order of the symbols has a specific meaning:

- 1st Symbol = Elastomer
- 2nd Symbol = Sealing Ring
- 3rd Symbol = Hardware
- 4th Symbol = Mating Ring
- 5th Symbol = Spring

NET POSITIVE SUCTION HEAD

NPSH stands for Net Positive Suction Head. It is defined as the suction gage reading in feet absolute taken on the suction nozzle corrected to pump centerline, minus the vapor pressure in 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. See NPSH example on pg. 11.

SPECIFIC GRAVITY

Specific gravity is 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 the gasses, the standard is air or hydrogen.

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 discharge liquid.

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 internal pump losses.

Dynamic suction head, 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.

TOTAL DYNAMIC HEAD (TDH)

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 gage connected to discharge nozzle of pump plus vertical distance between point of attachment of mercury column and center of gage, 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 gage attached to the discharge nozzle of pump minus the reading of a gage connected to the suction nozzle of pump, 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 HEAD

Suction head (sometimes called head of suction) exists when the 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 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 gage connected to suction nozzle of pump, minus vertical distance from center of gage 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 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 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 part of the total dynamic head and consequently affects the duty accomplished.

In testing a pump, a vacuum gage or a mercury column is generally used for obtained dynamic suction lift. The mercury column or vacuum gage will show the velocity head combined with entrance head, friction head, and static suction lift. On the discharge side, a pressure gage is usually used, but a pressure gage will not indicate velocity head, and this must, therefore, be obtained either by calculating the velocity, or taking readings with a 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 shown below:

Velocity (ft/sec)	Velocity Head in ft.	Velocity (ft/sec)	Velocity Head in ft.	Velocity (ft/sec)	Velocity Head in ft.	Velocity (ft/sec)	Velocity Head in ft.
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	-	-

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. 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.

General Information

STATIC PRESSURE

One foot of elevation change results in a change in static pressure of .433 psi. Dynamic Pressure in a piping system (when water is flowing) varies according to these following five factors, but is always less than static pressure for that same point.

1. Velocity (of water-normally measured in ft. per sec.)
2. Inside Diameter (of pipe)
3. Roughness (of inside wall of pipe)
4. Length (of pipe)
5. Change of Direction (such as elbows and tees)

Note: This does not include remote control valves, backflow prevention devices, etc. The manufacturer's performance charts must be consulted for pressure loss information.

PIPE SIZING

Two methods used to determine the pipe sizing are the velocity limit method which is recommended for main line sizing and the friction factor method for sizing laterals.

VELOCITY LIMIT PIPE SIZING FORMULA

Velocity of flow values is computed using the general equation:

$$V = .408 \frac{Q}{d^2}$$

V = Velocity in feet per second

Q = Flow Volume (GPM)

d = Inside diameter of pipe

Atmospheric pressure at sea level is 14.7 lb/in². 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.

FRICITION FACTOR PIPE SIZING FORMULA

$$F_f = \frac{P_o \times P_v}{L_c}$$

F_f = Allowable psi loss per 100" of pipe

P_o = Operating pressure of sprinkler

P_v = Allowable percentage pressure variance

L_c = Longest run of lateral line (critical length)

This formula is used to determine the allowable pressure loss per 100" of lateral pipe. Multiplying the operating pressure by the percentage variation and dividing that number by the longest run of pipe from the control valve to the farthest head (divided by 100" length) gives us a guideline by which each section of pipe can be sized.

Note: We recommend 10% as an acceptable operating pressure variation within a lateral line.

$$\text{Efficiency} = \frac{\text{Power Output}}{\text{Power Input}}$$

$$\text{Pump Eff.} = \frac{\text{GPM} \times \text{Total Head (ft)}}{3960 \times \text{BHP}}$$

$$\text{Motor Eff.} = \frac{\text{HP Output}}{\text{Kw input} \times 1.34}$$

$$\text{Head} = \frac{3960 \times \text{Pump Eff.} \times \text{BHP}}{\text{GPM}}$$

$$\text{Torque} = \frac{\text{BHP} \times 5250}{\text{RPM}}$$

$$\text{Theoretical water HP} = \frac{\text{GPM} \times \text{Head (ft)} \times \text{Specific Gravity}}{3960}$$

$$\text{Brake HP (BHP)} = \frac{\text{Theoretical water HP}}{\text{Pump Efficiency}}$$

CAPACITIES OF ROUND TANKS

$$\text{GPM} = \text{Diameter of Tank (ft)}^2 \times .7854 \times \text{Tank Height (ft)} \times 7.48$$

Conversions

HEAD		
To Convert From	To	Multiply By
PSI	Feet	2.31
PSI	Inches of Mercury	2.04
Feet	PSI	0.433
Feet	Meters	0.305
Feet	Inches of Mercury	0.885
Inches of Mercury	Feet of Water	1.132
Meters	Feet	3.28
Kilograms per sq. in.	PSI	14.22
ATM	PSI	14.7
ATM	Feet of Water	34
ATM	Meters of Water	10.35

VOLUME		
To Convert From	To	Multiply By
Gallons	Liters	3.785
Gallons	Cubic Inches	231
Gallons	Cubic Feet	0.137
Gallons	Cubic Meters	0.004
Liters	Gallons	0.264
Barrel (Oil)	Gallons	42
Cubic Feet	Gallons	7.48
Cubic Feet	Cubic Meters	0.028
Acre Foot	Cubic Feet	43560
Acre Foot	Gallons	325829
Acre Inch	Cubic Feet	3630
Acre Inch	Gallons	27100

CAPACITY		
To Convert From	To	Multiply By
Gallons Per Minute	Liters/Sec.	0.063
Gallons Per Minute	Liters/Hr.	227.1
Gallons Per Minute	Cubic Meters/Hr.	0.227
Gallons Per Minute	Cubic Feet/Sec.	0.002
Gallons Per Minute	Pounds Per Hour	500
Cubic Meters/Hr.	Gallons Per Minute	4.402
Cubic Meters/Hr.	Liters/Sec.	0.278
Cubic Feet/Sec.	Gallons Per Minute	448.831
Acre Foot	Gallons	325.85
Acre Foot per Day	Gallons Per Minute	227
Acre Inch per Hour	Gallons Per Minute	454
Litre per Second	Gallons Per Minute	15.85
Miner's Inch (NE,NM,ND,SD,UT,WA)	Gallons Per Minute	9
Miner's Inch (AZ,CA,MT,NV,OR)	Gallons Per Minute	11.22

HORSEPOWER		
To Convert From	To	Multiply By
H.P.	Kilowatts	0.746
H.P.	Ft. lbs. per minute	33000
H.P.	Ft. lbs. per second	550
Kilowatts	H.P.	1.341

LENGTH		
To Convert From	To	Multiply By
Inches	Centimeters	2.54
Meters	Feet	3.28
Miles	Feet	5280
Rods	Feet	16.5

WEIGHT		
To Convert From	To	Multiply By
Gallons	Pounds	8.33
Cubic Feet of Water	Pounds	62.35
Kilograms	Pounds	2.2

TEMPERATURE		
To Convert From	To	Multiply By
Fahrenheit	Celsius	$5/9 \times (^{\circ}\text{F} - 32)$
Celsius	Fahrenheit	$(9/5) \times ^{\circ}\text{C} + 32$

1,000,000 US gal. / day = 695 US gal. / minute



TOLL FREE HELP FROM A FRIEND

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1-260-827-5102 FAX

Phone Franklin's toll free SERVICE HOTLINE for answers to your pump and motor installation questions. When you call, a Franklin expert will offer assistance in troubleshooting and provide immediate answers to your system application questions. Technical support is also available online. Visit our website at:

www.franklinwater.com



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