TORO®

Technical Data

Technical Data

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I. Pipe Data Introduction:

The basic essential for proper hydraulic design of any sprinkler irrigation system is the proper calculation of pressure loss from friction through the piping. Proper pipe sizing is of the utmost importance in order to achieve a good combination of economy, long pipe and fitting life and the correct operating pressures at each and every sprinkler.

It is of importance to note here that all pressure loss charts in this manual have been calculated on the conservative side by using a lower C factor than even many pipe manufacturers use. It is our belief that using a C factor of 150 for plastic pipe reflects an absolute maximum flow under ideal circumstances and leaves no safety factor whatsoever.

The use of different C factors for pipe is as follows:

P.V.C. pipe is given a 140 value for C as it is extremely smooth and it is chemically inert so it does not deteriorate internally.

Asbestos-cement, Copper and Polyethylene pipes are given a 140 value for C as they also have smooth inside walls. AC and PE do not deteriorate in most conditions.

Cast Iron and Galvanized Steel pipes are given a 100 value for C as this assumes an average 10 year old pipe. As both pipes are highly susceptible to deterioration caused by minerals in the water, the roughness will vary with the locale and the irrigation use of the pipe. In some areas, the pipe will reach the 100 value in 2 years, while in other areas the pipe may not reach the 100 value for 15 to 20 years. Generally, if water is continually flowing through the pipe, deterioration is reduced compared to having water at rest in the pipe.

To adjust the friction losses to a different C value, multiply the loss shown in the friction loss tables by the factor selected from the following table:

C FACTOR GIVEN IN TABLE	TO CHANGE TO C CONSTANT OF							
	80	90	100	110	120	130	140	150
100	1.50	1.22	1.00	.84	.72	.63	.54	.47
120			1.41	1.18	1.00	.86	.76	.66
140				1.60	1.34	1.15	1.00	.87
150					1.54	1.32	1.15	1.00

The velocity of flow is of almost equal importance as friction loss and is a factor all too often overlooked by many designers. To fully realize the importance of velocity, please study the information on surges and water hammer detailed on page 36. These factors play an important part in the hydraulic design of every sprinkler system. Each pressure loss chart faces the velocity of flow chart for convenient access of the information.

II. Standard Pipe Dimensions (Inches)

RIGID PLASTIC PIPE

Nominal Pipe Size	Outside Diameter	SDR 26		SDR 21		SDR 17		SDR 13.5	
		Inside Diameter	Wall Thickness	Inside Diameter	Wall Thickness	Inside Diameter	Wall Thickness	Inside Diameter	Wall Thickness
1/2	.840							.716	.062
3/4	1.050			.930	.060	.926	.062	.894	.078
1	1.315	1.195	.060	1.189	.063	1.161	.077	1.121	.097
1¼	1.660	1.532	.064	1.502	.079	1.464	.098	1.414	.123
1½	1.900	1.754	.073	1.720	.090	1.676	.112	1.618	.141
2	2.375	2.193	.091	2.149	.113	2.095	.140	2.023	.176
2½	2.875	2.655	.110	2.601	.137	2.537	.169	2.449	.213
3	3.500	3.230	.135	3.166	.167	3.088	.206	2.982	.259
3½	4.000	3.692	.154	3.620	.190	3.530	.235	3.408	.296
4	4.500	4.154	.173	4.072	.214	3.970	.265	3.834	.333

BELL & RING PVC

125 PSI		*-SDR 32.5	
Nominal Pipe Size	Outside Diameter	Inside Diameter	Wall Thickness
1½	1.900	1.784	.058
2	2.375	2.231	.072
2½	2.875	2.701	.087
*3	3.500	3.284	.108
*4	4.500	4.224	.138
*6	6.625	6.217	.204
160 PSI		SDR 26	
1½	1.900	1.754	.073
2	2.375	2.193	.091
2½	2.875	2.655	.110
3	3.500	3.230	.135
4	4.500	4.154	.173
6	6.625	6.115	.255

PLASTIC DWV - ABS

Nominal Pipe Size	Outside Diameter	Inside Diameter	Wall Thickness
1¼	1.660	1.380	.140
1½	1.900	1.610	.145
2	2.375	2.067	.154
3	3.500	3.068	.216
4	4.500	4.026	.237

SCHED. 40 PLASTIC PIPE

Nominal Pipe Size	Outside Diameter	Inside Diameter	Wall Thickness
1/2	.840	.622	.109
3/4	1.050	.824	.113
1	1.315	1.049	.133
1¼	1.660	1.380	.140
1½	1.900	1.610	.145
2	2.375	2.067	.154
2½	2.875	2.469	.203
3	3.500	3.068	.216
3½	4.000	3.548	.226
4	4.500	4.026	.237

SCHED. 80 PLASTIC PIPE

Nominal Pipe Size	Outside Diameter	Inside Diameter	Wall Thickness
1/2	.840	.546	.147
3/4	1.050	.742	.154
1	1.315	.957	.179
1¼	1.600	1.278	.191
1½	1.900	1.500	.200
2	2.375	1.939	.218
2½	2.875	2.323	.276
3	3.500	2.900	.300
4	4.500	3.826	.337

FLEXIBLE POLYETHYLENE PIPE

Nominal Pipe Size	Inside Diameter	SDR 15		SDR 11.5		SDR 9		SDR 7	
		Outside Diameter	Wall Thickness	Outside Diameter	Wall Thickness	Outside Diameter	Wall Thickness	Outside Diameter	Wall Thickness
1/2	.622	.742	.060	.742	.060	.760	.069	.800	.089
3/4	.824	.944	.060	.968	.072	1.008	.092	1.060	.118
1	1.049	1.189	.070	1.231	.091	1.283	.117	1.349	.150
1¼	1.380	1.564	.092	1.620	.120	1.686	.153	1.774	.197
1½	1.610	1.824	.107	1.890	.140	1.968	.179	2.070	.230
2	2.067	2.343	.138	2.427	.180	2.527	.230	2.657	.295
2½	2.469	2.799	.165	2.899	.215				

Standard Pipe Dimensions (Inches)

COPPER WATER TUBE										
Nominal Pipe Size	Outside Diameter	Drain, Waste & Vent		Type M		Type L		Type K		
		Inside Diameter	Wall Thickness	Inside Diameter	Wall Thickness	Inside Diameter	Wall Thickness	Inside Diameter	Wall Thickness	
1/2	.625			.569	.028	.545	.040	.527	.049	
3/4	.875			.811	.032	.785	.045	.745	.065	
1	1.125			1.055	.035	1.025	.050	.995	.065	
1¼	1.375	1.295	.040	1.291	.042	1.265	.055	1.245	.065	
1½	1.625	1.541	.042	1.527	.049	1.505	.060	1.481	.072	
2	2.125	2.041	.042	2.009	.058	1.985	.070	1.959	.083	
2½	2.625			2.495	.065	2.465	.080	2.435	.095	
3	3.125	3.035	.045	2.981	.072	2.945	.090	2.907	.109	
4	4.125	4.009	.058	3.953	.095	3.905	.110	3.857	.134	

CLASS 150 CAST IRON PIPE (346′ Head)			
Nominal Pipe Size	Outside Diameter	Inside Diameter	Wall Thickness
3	3.96	3.32	.32
4	4.80	4.10	.35
6	6.90	6.14	.38
8	9.05	8.23	.41
10	11.10	10.22	.44
12	13.20	12.24	.48
14	15.30	14.28	.51
16	17.40	16.32	.54
18	19.50	18.34	.58
20	21.60	20.36	.62
24	25.80	24.34	.73

ALUMINUM PIPE			
Nominal Pipe Size	Outside Diameter	Inside Diameter	Wall Thickness
3	3.0	2.914	.043
4	4.0	3.906	.047
5	5.0	4.896	.052
6	6.0	5.884	.058
7	7.0	6.872	.064
8	8.0	7.856	.072
10	10.0	9.818	.091

SCHED. 40 STEEL PIPE			
Nominal Pipe Size	Outside Diameter	Inside Diameter	Wall Thickness
1/2	.840	.622	.109
3/4	1.050	.824	.113
1	1.315	1.049	.133
1¼	1.660	1.380	.140
1½	1.900	1.610	.145
2	2.375	2.067	.154
2½	2.875	2.469	.203
3	3.500	3.068	.216
3½	4.000	3.548	.226
4	4.500	4.026	.237

CLASS 150 ASBESTOS — CEMENT PIPE (325′ Head)			
Nominal Pipe Size	Outside Diameter	Inside Diameter	Wall Thickness
3	4.10	3.00	.550
4	5.07	4.00	.535
5	6.18	5.00	.590
6	7.17	5.85	.660
8	9.37	7.85	.760
10	11.92	10.00	.960
12	14.18	12.00	1.090
14	16.48	14.00	1.240
16	18.72	16.00	1.360

III. Pipe Pressure Losses and Velocities of Flow

Pressure Loss From Friction per 100' of Pipe (lbs./sq. in.)

SDR 26 / CLASS 160 PVC 1120, PVC 1220, PVC 2120 C = 140

FLOW GPM	*1/2	*3/4	1	1¼	1½	2	2½	3	4
1	.26	.07							
2	.89	.26							
3	1.86	.52							
4	3.12	.90	.27						
5	4.76	1.37	.40						
6	6.62	1.90	.57						
7	8.82	2.52	.76						
8	11.26	3.21	.98	.31					
9	14.10	4.05	1.19	.41					
10	17.11	4.90	1.48	.45	.23				
11	20.37	5.82	1.77	.55	.29				
12	23.87	6.83	2.08	.65	.33				
13		7.94	2.42	.75	.39				
14		9.11	2.76	.84	.44				
15		10.36	3.17	.95	.50				
20		17.67	5.41	1.64	.84	.29			
25		26.70	8.28	2.45	1.28	.42			
30			11.56	3.34	1.78	.60	.23		
35			15.47	4.45	2.37	.81	.32		
40			19.76	5.65	3.02	1.02	.40		
50			30.55	8.74	4.67	1.59	.63		
60				11.95	6.40	2.18	.88		
70					8.52	2.91	1.16	.46	
80					10.82	3.68	1.48	.57	
90					13.47	4.57	1.84	.72	
100					16.57	5.62	2.24	.88	.25
110						6.59	2.63	1.02	.30
120						7.81	3.16	1.20	.36
130						9.16	3.68	1.42	.42
140						10.38	4.18	1.62	.49
150						11.81	4.76	1.84	.55
160						13.34	5.38	2.09	.64
170						14.81	5.97	2.31	.70
180						16.48	6.63	2.56	.77
190						18.18	7.31	2.81	.85
200						20.08	8.07	3.10	.95
210							8.96	3.45	1.04
220							9.80	3.80	1.15
230							10.48	4.06	1.23
240							11.30	4.36	1.32
250							12.11	4.67	1.41
260							12.90	4.99	1.50
270							14.17	5.47	1.65
280							15.23	5.89	1.78
290							15.91	6.15	1.85
300							16.86	6.50	1.95
320								7.57	2.27
340								8.30	2.50
360								9.18	2.77
380								10.20	3.09
400								11.41	3.45

*1/2" and 3/4" Class 160 not included in SDR 26. Above figures show losses for 1/2" Class 315 and 3/4" Class 200 wall thicknesses.

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

SDR 26 Plastic Pipe

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	*1/2	*3/4	1	1¼	1½	2	2½	3	4
1	.80	.47							
2	1.59	.94							
3	2.39	1.42							
4	3.19	1.89	1.14						
5	3.98	2.36	1.43						
6	4.78	2.83	1.72						
7	5.58	3.30	2.00						
8	6.38	3.78	2.29	1.39					
9	7.17	4.25	2.57	1.57					
10	7.97	4.72	2.86	1.74	1.33				
11	8.77	5.19	3.15	1.91	1.46				
12	9.56	5.66	3.43	2.09	1.59				
13		6.14	3.72	2.26	1.73				
14		6.61	4.01	2.44	1.86				
15		7.08	4.29	2.61	1.99				
20		9.44	5.72	3.48	2.66	1.70			
25		11.80	7.15	4.35	3.32	2.12			
30			8.58	5.22	3.98	2.55	1.74		
35			10.01	6.09	4.65	2.97	2.03		
40			11.44	6.96	5.31	3.40	2.32		
50			14.30	8.70	6.64	4.25	2.90		
60				10.44	7.97	5.10	3.48		
70					9.29	5.95	4.06	2.74	
80					10.62	6.80	4.64	3.13	
90					11.95	7.64	5.22	3.52	
100					13.28	8.49	5.80	3.92	2.37
110						9.34	6.37	4.31	2.60
120						10.19	6.95	4.70	2.84
130						11.04	7.53	5.09	3.08
140						11.89	8.11	5.48	3.31
150						12.74	8.69	5.87	3.55
160						13.59	9.27	6.26	3.79
170						14.44	9.85	6.66	4.02
180						15.29	10.43	7.05	4.26
190						16.14	11.01	7.44	4.50
200						16.99	11.59	7.83	4.73
210							12.17	8.22	4.97
220							12.75	8.61	5.21
230							13.33	9.01	5.44
240							13.91	9.40	5.68
250							14.49	9.79	5.92
260							15.07	10.18	6.15
270							15.65	10.57	6.39
280							16.23	10.96	6.63
290							16.81	11.35	6.87
300							17.39	11.75	7.10
320								12.53	7.58
340								13.31	8.05
360								14.10	8.52
380								14.88	9.00
400								15.66	9.47

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

SDR 21 / CLASS 200 PVC 1120, PVC 1220, PVC 2120 C = 140

TORO

FLOW GPM	*1/2	3/4	1	1¼	1½	2	2½	3	4
1	.26	.07							
2	.89	.26							
3	1.86	.52							
4	3.12	.90	.28						
5	4.76	1.37	.42						
6	6.62	1.90	.59						
7	8.82	2.52	.80						
8	11.26	3.21	1.02	.31					
9	14.10	4.05	1.24	.40					
10	17.11	4.90	1.52	.50	.26				
11	20.37	5.82	1.81	.59	.30				
12	23.87	6.83	2.14	.69	.36				
13		7.94	2.51	.80	.41				
14		9.11	2.86	.90	.48				
15		10.36	3.26	1.02	.56				
20		17.67	5.53	1.76	.90	.31			
25		26.70	8.36	2.67	1.39	.48			
30			11.66	3.72	1.93	.66	.27		
35			15.56	4.96	2.56	.89	.36		
40			19.87	6.33	3.28	1.16	.46		
50			30.66	9.78	5.08	1.77	.71		
60				13.41	6.97	2.42	.98		
70				17.90	9.28	3.22	1.28	.50	
80				22.70	11.79	4.10	1.62	.63	
90					14.66	5.10	2.00	.80	.24
100					18.06	6.24	2.44	.99	.30
110						7.30	2.90	1.15	.35
120						8.68	3.43	1.36	.40
130						10.18	4.01	1.60	.47
140						11.56	4.56	1.80	.52
150						13.16	5.20	2.05	.60
160						14.90	5.90	2.33	.70
170						16.55	6.56	2.59	.76
180						18.38	7.26	2.88	.85
190						20.24	8.00	3.16	.94
200						22.36	8.81	3.50	1.03
210							9.80	3.88	1.15
220							10.76	4.25	1.25
230							11.49	4.55	1.35
240							12.36	4.90	1.44
250							13.26	5.25	1.55
260							14.16	5.60	1.64
270							15.45	6.13	1.80
280							16.65	6.60	1.95
290							17.86	6.90	2.03
300							19.06	7.30	2.15
320								8.48	2.50
340								9.30	2.75
360								10.28	3.03
380								11.46	3.36
400								12.80	3.77

*1/2" Class 200 not included in SDR 21. Above figures show losses for Class 315 wall thickness.

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

SDR 21 / CLASS 200 Plastic Pipe

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	.80	.47							
2	1.59	.94							
3	2.39	1.42							
4	3.19	1.89	1.16						
5	3.98	2.36	1.45						
6	4.78	2.83	1.73						
7	5.58	3.30	2.02						
8	6.38	3.78	2.31	1.46					
9	7.17	4.25	2.60	1.64					
10	7.97	4.72	2.89	1.82	1.38				
11	8.77	5.19	3.18	2.00	1.52				
12	9.56	5.66	3.47	2.18	1.66				
13		6.14	3.76	2.37	1.79				
14		6.61	4.05	2.55	1.93				
15		7.08	4.34	2.73	2.07				
20		9.44	5.78	3.64	2.76	1.77			
25		11.80	7.23	4.55	3.45	2.21			
30			8.67	5.46	4.14	2.66	1.81		
35			10.12	6.37	4.83	3.10	2.11		
40			11.56	7.28	5.52	3.54	2.41		
50			14.45	9.10	6.90	4.43	3.02		
60				10.92	8.28	5.31	3.62		
70				12.74	9.66	6.20	4.22	2.86	
80				14.56	11.04	7.08	4.82	3.26	
90					12.42	7.97	5.43	3.67	2.21
100					13.80	8.85	6.03	4.08	2.46
110						9.74	6.63	4.49	2.71
120						10.62	7.24	4.90	2.95
130						11.51	7.84	5.30	3.20
140						12.39	8.44	5.71	3.44
150						13.28	9.05	6.12	3.69
160						14.16	9.65	6.53	3.94
170						15.05	10.25	6.94	4.18
180						15.93	10.85	7.34	4.43
190						16.82	11.46	7.75	4.66
200						17.70	12.06	8.16	4.92
210							12.66	8.57	5.17
220							13.27	8.98	5.41
230							13.87	9.38	5.66
240							14.47	9.79	5.90
250							15.08	10.20	6.15
260							15.68	10.61	6.40
270							16.28	11.02	6.64
280							16.88	11.42	6.89
290							17.49	11.83	7.13
300							18.09	12.24	7.38
320								13.06	7.87
340								13.87	8.36
360								14.69	8.86
380								15.50	9.35
400								16.32	9.84

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

SDR 13.5 / CLASS 315 PVC 1120, PVC 1220, PVC 2120 / CLASS 160 ABS 1210 | **C = 140**

TORO

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	.26	.08							
2	.89	.30							
3	1.86	.63							
4	3.12	1.09	.37						
5	4.76	1.66	.56						
6	6.62	2.30	.77						
7	8.82	3.06	1.01	.46					
8	11.26	3.90	1.31	.56					
9	14.10	4.88	1.63	.66					
10	17.11	5.90	2.00	.79	.34				
11	20.37	7.03	2.36	.92	.41				
12	23.87	8.26	2.77	1.09	.49				
13		9.67	3.24	1.23	.56				
14		11.00	3.70	1.40	.65				
15		12.50	4.20	2.40	.76				
20		21.32	7.18	3.61	1.26	.42			
25		32.21	10.86	5.03	1.89	.64			
30			15.13	6.70	2.62	.89	.36		
35			20.16	8.58	3.50	1.18	.47		
40			25.77	13.26	4.47	1.50	.60		
50			39.76	18.19	6.90	2.34	.93	.36	
60				24.26	9.47	3.20	1.28	.50	
70					12.61	4.24	1.71	.66	
80					16.00	5.41	2.17	.84	
90					19.90	6.76	2.70	1.05	.32
100					24.50	8.32	3.31	1.30	.39
110						9.71	3.88	1.50	.46
120						11.53	4.60	1.80	.54
130						13.50	5.39	2.10	.64
140						15.30	6.15	2.38	.72
150						17.46	6.97	2.70	.82
160						19.76	7.89	3.06	.93
170						21.90	8.76	3.40	1.03
180						24.36	9.73	3.77	1.15
190						26.81	10.70	4.17	1.26
200						29.60	11.80	4.60	1.40
210							13.04	5.10	1.55
220							14.24	5.59	1.70
230							15.36	5.97	1.83
240							16.53	6.44	1.97
250							17.64	6.90	2.10
260							18.88	7.34	2.24
270							20.64	8.05	2.45
280							22.34	8.67	2.65
290							23.96	9.05	2.75
300							25.66	9.60	2.93
320								11.15	3.40
340								12.25	3.72
360								13.52	4.12
380								15.05	4.59
400								16.85	5.14

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

SDR 13.5 Plastic Pipe

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	.80	.51							
2	1.59	1.02							
3	2.39	1.53							
4	3.19	2.04	1.30						
5	3.98	2.56	1.63						
6	4.78	3.07	1.95						
7	5.58	3.58	2.28	1.43					
8	6.38	4.09	2.60	1.63					
9	7.17	4.60	2.93	1.84					
10	7.97	5.11	3.25	2.04	1.56				
11	8.77	5.62	3.58	2.25	1.72				
12	9.56	6.13	3.90	2.45	1.87				
13		6.64	4.23	2.66	2.03				
14		7.16	4.55	2.86	2.18				
15		7.67	4.88	3.07	2.34				
20		10.22	6.50	4.09	3.12	2.00			
25		12.78	8.13	5.11	3.90	2.50			
30			9.75	6.13	4.68	2.99	2.04		
35			11.38	7.15	5.46	3.49	2.38		
40			13.00	8.17	6.24	3.99	2.72		
50			16.25	10.22	7.80	4.99	3.41	2.30	
60				12.26	9.36	5.99	4.09	2.76	
70					10.92	6.99	4.77	3.22	
80					12.48	7.99	5.45	3.68	
90					14.12	8.98	6.13	4.13	2.50
100					15.60	9.98	6.81	4.59	2.78
110						10.98	7.49	5.05	3.06
120						11.98	8.17	5.51	3.33
130						12.98	8.85	5.97	3.61
140						13.97	9.54	6.43	3.89
150						14.97	10.22	6.89	4.17
160						15.97	10.90	7.35	4.45
170						16.97	11.58	7.62	4.72
180						17.97	12.26	8.27	5.00
190						18.96	12.94	8.73	5.28
200						19.96	13.62	9.19	5.56
210							14.30	9.65	5.84
220							14.98	10.11	6.11
230							15.67	10.57	6.39
240							16.35	11.03	6.67
250							17.03	11.48	6.95
260							17.71	11.94	7.23
270							18.39	12.40	7.50
280							19.07	12.86	7.78
290							19.75	13.32	8.06
300							20.43	13.78	8.34
320								14.70	8.89
340								15.62	9.45
360								16.54	10.00
380								17.46	10.56
400								18.38	11.12

Pressure Loss From Friction per 100' of Pipe (lbs./sq. in.)

SCHEDULE 40 PLASTIC PIPE C = 140

TORO

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	.49	.13							
2	1.78	.45							
3	3.75	.95							
4	6.40	1.63	.50						
5	9.64	2.46	.75						
6	13.5	3.45	1.05						
7	18.0	4.59	1.38						
8	23.0	5.85	1.81	.48					
9	28.6	7.28	2.23	.60					
10	34.8	8.84	2.75	.72	.34				
11	41.5	10.60	3.26	.86	.40				
12	48.8	12.40	3.85	1.01	.48				
13		14.40	4.44	1.17	.55				
14		16.50	5.10	1.35	.63				
15		18.70	5.79	1.52	.72				
20		32.00	9.85	2.60	1.24	.36			
25		48.30	14.90	3.92	1.85	.55			
30			20.90	5.50	2.60	.77	.32		
35			27.70	7.30	3.45	1.02	.43		
40				9.37	4.43	1.31	.55		
50				14.10	6.67	1.98	.84		
60				19.90	9.35	2.79	1.17		
70					12.40	3.70	1.55	.54	
80					15.90	4.72	2.00	.70	
90					19.80	5.88	2.49	.87	
100					24.00	7.14	3.00	1.05	.28
110						8.50	3.59	1.25	.33
120						10.00	4.22	1.46	.39
130						11.60	4.90	1.70	.46
140						13.30	5.60	1.95	.53
150						15.10	6.40	2.23	.60
160						17.00	7.19	2.50	.67
170						19.00	8.02	2.80	.74
180						21.20	8.91	3.10	.83
190						23.40	9.85	3.43	.91
200						25.70	10.80	3.78	1.00
210							11.90	4.12	1.10
220							12.90	4.50	1.20
230							14.00	4.89	1.30
240							15.20	5.30	1.41
250							16.40	5.70	1.52
260							17.60	6.13	1.63
270							18.90	6.56	1.75
280							20.20	7.03	1.87
290							21.50	7.50	2.00
300							22.90	7.98	2.14
320								9.00	2.40
340								10.10	2.68
360								11.20	2.98
380								12.30	3.30
400								13.60	3.63

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

PLASTIC SCHEDULE 40 I.D. PIPE

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	1.06	.60							
2	2.11	1.20							
3	3.17	1.80							
4	4.22	2.41	1.48						
5	5.28	3.01	1.86						
6	6.33	3.61	2.23						
7	7.39	4.21	2.60						
8	8.45	4.81	2.97	1.72					
9	9.50	5.41	3.34	1.93					
10	10.56	6.02	3.71	2.15	1.58				
11	11.61	6.62	4.08	2.36	1.73				
12	12.67	7.22	4.45	2.57	1.89				
13		7.82	4.83	2.79	2.05				
14		8.42	5.20	3.00	2.21				
15		9.02	5.57	3.22	2.36				
20		12.03	7.42	4.29	3.15	1.91			
25		15.04	9.28	5.36	3.94	2.39			
30			11.14	6.44	4.73	2.87	2.01		
35			12.99	7.51	5.52	3.35	2.35		
40				8.58	6.30	3.82	2.68		
50				10.73	7.88	4.78	3.35		
60				12.87	9.46	5.74	4.02		
70					11.03	6.69	4.69	3.04	
80					12.61	7.65	5.36	3.47	
90					14.18	8.60	6.03	3.91	
100					15.76	9.56	6.70	4.34	2.52
110						10.52	7.37	4.77	2.77
120						11.47	8.04	5.21	3.02
130						12.43	8.71	5.64	3.28
140						13.38	9.38	6.08	3.53
150						14.34	10.05	6.51	3.78
160						15.30	10.72	6.94	4.03
170						16.25	11.39	7.38	4.28
180						17.21	12.06	7.81	4.54
190						18.16	12.73	8.25	4.79
200						19.12	13.40	8.68	5.04
210							14.07	9.11	5.29
220							14.74	9.55	5.54
230							15.41	9.98	5.80
240							16.08	10.42	6.05
250							16.75	10.85	6.30
260							17.42	11.28	6.55
270							18.09	11.72	6.80
280							18.76	12.15	7.06
290							19.43	12.59	7.31
300							20.10	13.02	7.56
320								13.89	8.06
340								14.76	8.57
360								15.62	9.07
380								16.49	9.58
400								17.36	10.08

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

SCHEDULE 80 PVC C = 140

TORO

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	.96	.24							
2	3.51	.79							
3	7.36	1.68							
4	12.66	2.85	.82						
5	19.05	4.23	1.26						
6	26.77	6.02	1.75						
7	36.06	7.98	2.31						
8	45.47	10.25	2.95	.66					
9	57.29	13.51	3.72	.82					
10	68.98	15.44	4.50	1.00					
11		18.57	5.34	1.19					
12		21.71	6.27	1.39	.71				
13		25.33	7.29	1.62	.83				
14		28.94	8.36	1.85	.95				
15		32.80	9.51	2.10	1.07				
20		55.90	16.22	3.57	1.81	.48			
25			24.51	5.41	2.75	.70			
30			34.13	7.58	3.85	.98			
35			45.23	10.07	5.13	1.31			
40				12.83	6.57	1.67	.73		
50				19.48	9.92	2.52	1.09		
60				27.27	13.66	3.53	1.53		
70					18.45	4.70	2.04	.75	
80					23.65	6.02	2.59	.96	
90					29.36	7.51	3.23	1.19	
100					35.78	9.10	3.92	1.44	.38
110						10.83	4.70	1.73	.44
120						12.83	5.49	2.02	.52
130						14.82	6.37	2.36	.62
140						16.91	7.31	2.69	.69
150						19.29	8.30	3.06	.79
160						21.76	9.35	3.44	.90
170						24.23	10.45	3.85	.99
180						27.08	11.62	4.28	1.11
190						29.83	12.91	4.72	1.22
200						32.78	14.21	5.20	1.35
210							15.50	5.69	1.50
220							16.79	6.21	1.64
230							18.31	6.73	1.77
240							19.84	7.28	1.90
250							21.37	7.86	2.03
260							23.01	8.44	2.16
270							24.65	9.07	2.36
280							26.30	9.68	2.56
290							28.18	10.34	2.65
300							29.94	11.01	2.83
320								12.43	3.28
340								13.92	3.59
360								15.42	3.98
380								17.03	4.43
400								18.75	4.96

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

SCHEDULE 80 PVC

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	1.37	.74							
2	2.73	1.48							
3	4.10	2.22							
4	5.47	2.96	1.78						
5	6.84	3.70	2.23						
6	8.20	4.44	2.67						
7	9.57	5.18	3.12						
8	10.94	5.92	3.56	2.00					
9	12.31	6.66	4.01	2.25					
10	13.67	7.40	4.45	2.50	1.81				
11	15.04	8.14	4.90	2.74	1.99				
12	16.41	8.88	5.34	2.99	2.17				
13		9.62	5.79	3.24	2.35				
14		10.36	6.23	3.49	2.54				
15		11.10	6.68	3.74	2.72				
20		14.81	8.90	4.99	3.62	2.17			
25		18.51	11.13	6.24	4.53	2.71			
30			13.35	7.49	5.43	3.25	2.27		
35			15.58	8.73	6.34	3.79	2.64		
40				9.98	7.24	4.34	3.02		
50				12.48	9.06	5.42	3.78		
60				14.97	10.87	6.50	4.53		
70					12.68	7.59	5.29	3.40	
80					14.49	8.67	6.04	3.88	
90					16.30	9.76	6.80	4.37	
100					18.11	10.84	7.55	4.85	2.78
110						11.92	8.31	5.34	3.06
120						13.01	9.06	5.82	3.34
130						14.09	9.82	6.31	3.61
140						15.18	10.57	6.79	3.89
150						16.26	11.33	7.28	4.17
160						17.34	12.08	7.76	4.45
170						18.43	12.84	8.25	4.73
180						19.51	13.59	8.73	5.00
190						20.60	14.35	9.22	5.28
200						21.68	15.10	9.70	5.56
210							15.86	10.19	5.84
220							16.61	10.67	6.12
230							17.37	11.16	6.39
240							18.12	11.64	6.67
250							18.88	12.13	6.95
260							19.63	12.61	7.23
270							20.39	13.10	7.51
280							21.14	13.58	7.78
290							21.90	14.07	8.06
300							22.65	14.55	8.34
320								15.52	8.90
340								16.49	9.45
360								17.46	10.01
380								18.43	10.56
400								19.40	11.12

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

BELL AND RING PVC PIPE for 125 PSI SERVICE C = 140

TORO

FLOW GPM	*1½	*2	*2½	3	4	6
16	.53					
18	.65					
20	.79	.26				
25	1.19	.40				
30	1.67	.56	.22			
35	2.24	.74	.30			
40	2.87	.95	.38			
45	3.55	1.21	.47			
50	4.32	1.47	.58			
55	5.15	1.76	.69			
60	6.06	2.01	.81			
65	7.02	2.32	.94			
70	8.06	2.69	1.07	.42		
75		3.01	1.22	.47		
80		3.41	1.38	.53		
85		3.78	1.55	.59		
90		4.24	1.72	.66		
95		4.68	1.90	.73		
100		5.22	2.08	.81		
110		6.09	2.42	.95	.28	
120		7.23	2.88	1.12	.33	
130		8.47	3.37	1.32	.39	
140		9.61	3.82	1.49	.44	
150		10.95	4.36	1.70	.51	
160		12.40	4.93	1.93	.57	
170		13.74	5.47	2.14	.63	
180		15.29	6.08	2.38	.70	
190		16.84	6.70	2.62	.78	
200		18.59	7.40	2.89	.86	
220			9.00	3.52	1.04	
240			10.36	4.05	1.20	
260			11.84	4.63	1.37	.21
280			13.97	5.46	1.62	.25
300			15.45	6.04	1.79	.27
320				7.02	2.08	.31
340				7.71	2.28	.34
360				8.51	2.52	.38
380				9.48	2.81	.42
400				10.60	3.14	.47
450				13.33	3.95	.63
500				16.06	4.76	.76
550						.91
600						1.07
650						1.24
700						1.41

*Sizes under 3″ do not conform to Class Standards. Sizes 3″ and over are within tolerances for SDR 32.5
Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

BELL AND RING PVC PIPE for 125 PSI SERVICE

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1½	2	2½	3	4	6
16	2.05					
18	2.30					
20	2.56	1.64				
25	3.20	2.05				
30	3.84	2.46	1.68			
35	4.48	2.87	1.96			
40	5.12	3.28	2.24			
45	5.76	3.69	2.52			
50	6.40	4.10	2.80			
55	7.04	4.51	3.08			
60	7.68	4.92	3.36			
65	8.32	5.33	3.64			
70	8.96	5.74	3.92	2.65		
75		6.15	4.20	2.84		
80		6.56	4.48	3.03		
85		6.97	4.76	3.22		
90		7.38	5.04	3.41		
95		7.79	5.32	3.60		
100		8.20	5.60	3.79		
110		9.02	6.16	4.17	2.52	
120		9.84	6.72	4.55	2.75	
130		10.66	7.28	4.93	2.98	
140		11.48	7.84	5.31	3.21	
150		12.30	8.40	5.69	3.44	
160		13.12	8.96	6.06	3.66	
170		13.94	9.52	6.44	3.89	
180		14.76	10.08	6.82	4.12	
190		15.58	10.64	7.20	4.35	
200		16.40	11.20	7.58	4.58	
220			12.32	8.34	5.04	
240			13.44	9.10	5.50	
260			14.56	9.85	5.95	2.75
280			15.68	10.61	6.41	2.96
300			16.80	11.37	6.87	3.17
320				12.13	7.33	3.38
340				12.89	7.79	3.59
360				13.64	8.24	3.81
380				14.40	8.70	4.02
400				15.16	9.16	4.23
450				17.06	10.31	4.76
500				18.95	11.45	5.29
550					12.60	5.81
600						6.34
650						6.87
700						7.40

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

BELL AND RING PVC PIPE for 160 PSI SERVICE C = 140

TORO

FLOW GPM	1	1¼	1½	2	2½	3	4	6
16	3.58	1.06	.56					
18	4.44	1.31	.69					
20	5.41	1.64	.84	.29				
25	8.28	2.45	1.28	.42				
30	11.56	3.34	1.78	.60	.23			
35	15.47	4.45	2.37	.81	.32			
40	19.76	5.65	3.02	1.02	.40			
45	24.80	7.06	3.76	1.31	.51			
50	30.55	8.74	4.67	1.59	.63			
55		10.18	5.46	1.90	.75			
60		11.95	6.40	2.18	.88			
65			7.44	2.51	1.02			
70			8.52	2.91	1.16	.46		
75			9.56	3.25	1.32	.51		
80			10.82	3.68	1.48	.57		
85			12.01	4.08	1.67	.64		
90			13.47	4.57	1.84	.72		
95			14.87	5.05	2.05	.79		
100			16.57	5.62	2.24	.88	.25	
110				6.59	2.63	1.02	.30	
120				7.81	3.16	1.20	.36	
130				9.16	3.68	1.42	.42	
140				10.38	4.18	1.62	.49	
150				11.81	4.76	1.84	.55	
160				13.34	5.38	2.09	.64	
170				14.81	5.97	2.31	.70	
180				16.48	6.63	2.56	.77	
190				18.18	7.31	2.81	.85	
200				20.08	8.07	3.10	.95	
220					9.80	3.80	1.15	
240					11.30	4.36	1.32	
260					12.90	4.99	1.55	.23
280					15.23	5.89	1.78	.27
300					16.86	6.50	1.95	.29
320						7.57	2.27	.34
340						8.30	2.50	.37
360						9.18	2.77	.41
380						10.20	3.09	.46
400						11.41	3.45	.51
450						14.34	4.35	.69
500						17.28	5.24	.83
550							5.69	.99
600								1.16
650								1.35
700								1.54

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

BELL AND RING PVC PIPE for 160 PSI SERVICE

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1	1¼	1½	2	2½	3	4	6
16	4.57	2.78	2.12					
18	5.14	3.13	2.39					
20	5.72	3.48	2.66	1.70				
25	7.15	4.35	3.32	2.12				
30	8.58	5.22	3.98	2.55	1.74			
35	10.01	6.09	4.65	2.97	2.03			
40	11.44	6.96	5.31	3.40	2.32			
45	12.84	7.82	5.96	3.82	2.61			
50	14.30	8.70	6.64	4.25	2.90			
55		9.55	7.29	4.67	3.19			
60		10.44	7.97	5.10	3.48			
65			8.61	5.52	3.77			
70			9.29	5.95	4.06	2.74		
75			9.94	6.37	4.35	2.94		
80			10.62	6.80	4.64	3.13		
85			11.26	7.22	4.93	3.33		
90			11.95	7.64	5.22	3.52		
95			12.59	8.07	5.51	3.72		
100			13.28	8.49	5.80	3.92	2.37	
110				9.34	6.37	4.31	2.60	
120				10.19	6.95	4.70	2.84	
130				11.04	7.53	5.09	3.08	
140				11.89	8.11	5.48	3.31	
150				12.74	8.69	5.87	3.55	
160				13.59	9.27	6.26	3.79	
170				14.44	9.85	6.66	4.02	
180				15.29	10.43	7.05	4.26	
190				16.14	11.01	7.44	4.50	
200				16.99	11.59	7.83	4.73	
220					12.75	8.61	5.21	
240					13.91	9.40	5.68	
260					15.07	10.18	6.15	2.83
280					16.23	10.96	6.63	3.05
300					17.39	11.75	7.10	3.27
320						12.53	7.58	3.49
340						13.31	8.05	3.71
360						14.10	8.52	3.92
380						14.88	9.00	4.14
400						15.66	9.47	4.36
450						17.62	10.65	4.91
500						19.58	11.84	5.45
550							13.02	6.00
600								6.54
650								7.09
700								7.63

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

TORO

Standard Polyethylene Pipe C = 140

SRD 15 / 80 PSI PE 2306, PE 3206, PE 3306

SDR 11.5 / 100 PSI PE 2306, PE 3206, PE 3306
80 PSI PE 2305

SDR 9 / 125 PSI PE 2306, PE 3206, PE 3306
100 PSI PE 2305

SDR 7 / 125 PSI PE 2305

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½
1	.51	.15					
2	1.79	.48					
3	3.77	1.00					
4	6.43	1.64	.46				
5	9.69	2.46	.76				
6	13.50	3.45	1.06	.29			
7	18.00	4.59	1.37	.37			
8	23.00	5.85	1.80	.46			
9		7.29	2.23	.59			
10		8.85	2.76	.70	.33		
11		10.60	3.27	.85	.39		
12		12.40	3.85	1.01	.46		
13		14.40	4.45	1.20	.54		
14		16.50	5.10	1.37	.65		
15		18.70	5.76	1.56	.76	.21	
20		31.90	9.90	2.56	1.18	.36	
25			14.90	3.87	1.85	.55	
30			20.90	5.46	2.56	.75	.33
35			27.70	7.30	3.45	.97	.44
40				9.40	4.38	1.28	.56
50				14.10	6.70	1.97	.83
60				19.90	9.40	2.76	1.18
70					12.40	3.70	1.57
80					15.90	4.70	2.00
90					19.80	5.90	2.50
100					24.00	7.10	3.00
110						8.50	3.60
120						10.00	4.20
130						11.60	4.90
140						13.30	5.60
150						15.10	6.40
160						17.00	7.20
170						19.00	8.00
180						21.20	8.90
190						23.40	9.90
200						25.70	10.90
210							11.90
220							12.90
230							14.00
240							15.20
250							16.40
260							17.60
270							18.90
280							20.20
290							21.50
300							22.90

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

STANDARD POLYETHYLENE PIPE

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½
1	1.06	.60					
2	2.11	1.20					
3	3.17	1.80					
4	4.22	2.41	1.48				
5	5.28	3.01	1.86				
6	6.33	3.61	2.23				
7	7.39	4.21	2.60				
8	8.45	4.81	2.97	1.72			
9	9.50	5.41	3.34	1.93			
10	10.56	6.02	3.71	2.15	1.58		
11	11.61	6.62	4.08	2.36	1.73		
12	12.67	7.22	4.45	2.57	1.89		
13		7.82	4.83	2.79	2.05		
14		8.42	5.20	3.00	2.21		
15		9.02	5.57	3.22	2.36		
20		12.03	7.42	4.29	3.15	1.91	
25		15.04	9.28	5.36	3.94	2.39	
30			11.14	6.44	4.73	2.87	2.01
35			12.99	7.51	5.52	3.35	2.35
40				8.58	6.30	3.82	2.68
50				10.73	7.88	4.78	3.35
60				12.87	9.46	5.74	4.02
70					11.03	6.69	4.69
80					12.61	7.65	5.36
90					14.18	8.60	6.03
100					15.76	9.56	6.70
110						10.52	7.37
120						11.47	8.04
130						12.43	8.71
140						13.38	9.38
150						14.34	10.05
160						15.30	10.72
170						16.25	11.39
180						17.21	12.06
190						18.16	12.73
200						19.12	13.40
210							14.07
220							14.74
230							15.41
240							16.08
250							16.75
260							17.42
270							18.09
280							18.76
290							19.43
300							20.10

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

AGED STEEL PIPE — STANDARD WEIGHT (Sched. 40) C = 100

TORO

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	.91	.23							
2	3.28	.83							
3	6.95	1.77	.55						
4	11.81	3.01	.85						
5	17.89	4.55	1.40						
6	25.03	6.37	1.97						
7	33.32	8.47	2.62						
8	42.59	10.83	3.35	.88					
9		13.50	4.16	1.10					
10		16.41	5.06	1.33	.65				
11		19.49	6.05	1.59	.75				
12		23.03	7.09	1.87	.88				
13		26.61	8.22	2.17	1.02				
14		30.50	9.43	2.48	1.17				
15		34.71	10.70	2.82	1.35				
20		59.10	18.21	4.80	2.27	.67			
25			27.62	7.26	3.43	1.02			
30			38.59	10.20	4.81	1.43	.60		
35			51.40	13.49	6.39	1.90	.80		
40				17.32	8.18	2.43	1.02		
50				26.21	12.41	3.66	1.55		
60				36.72	17.30	5.15	2.16	.74	
70					23.03	6.83	2.88	1.00	
80					29.52	8.75	3.68	1.28	
90					36.89	10.89	4.58	1.59	.43
100					44.61	13.21	5.57	1.93	.53
110						15.80	6.65	2.31	.62
120						18.48	7.80	2.71	.72
130						21.50	9.05	3.15	.84
140						24.61	10.41	3.60	.96
150						28.02	11.79	4.10	1.09
160						31.50	13.30	4.61	1.23
170						35.29	14.92	5.16	1.38
180						39.20	16.50	5.74	1.53
190						43.31	18.28	6.35	1.69
200						47.62	20.10	6.97	1.86
210							22.00	7.63	2.03
220							23.89	8.32	2.22
230							26.01	9.03	2.41
240							28.12	9.77	2.60
250							30.31	10.51	2.81
260							32.60	11.30	3.02
270							35.02	12.19	3.25
280							37.39	13.00	3.46
290							39.91	13.88	3.70
300							42.50	14.79	3.95
320								16.59	4.43
340								18.60	4.96
360								20.71	5.51
380								22.92	6.09
400								25.12	6.70

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

NEW STEEL SCHEDULE 40 I.D. PIPE

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	1.06	.60							
2	2.11	1.20							
3	3.17	1.80							
4	4.22	2.41	1.48						
5	5.28	3.01	1.86						
6	6.33	3.61	2.23						
7	7.39	4.21	2.60						
8	8.45	4.81	2.97	1.72					
9	9.50	5.41	3.34	1.93					
10	10.56	6.02	3.71	2.15	1.58				
11	11.61	6.62	4.08	2.36	1.73				
12	12.67	7.22	4.45	2.57	1.89				
13		7.82	4.83	2.79	2.05				
14		8.42	5.20	3.00	2.21				
15		9.02	5.57	3.22	2.36				
20		12.03	7.42	4.29	3.15	1.91			
25		15.04	9.28	5.36	3.94	2.39			
30			11.14	6.44	4.73	2.87	2.01		
35			12.99	7.51	5.52	3.35	2.35		
40				8.58	6.30	3.82	2.68		
50				10.73	7.88	4.78	3.35		
60				12.87	9.46	5.74	4.02		
70					11.03	6.69	4.69	3.04	
80					12.61	7.65	5.36	3.47	
90					14.18	8.60	6.03	3.91	
100					15.76	9.56	6.70	4.34	2.52
110						10.52	7.37	4.77	2.77
120						11.47	8.04	5.21	3.02
130						12.43	8.71	5.64	3.28
140						13.38	9.38	6.08	3.53
150						14.34	10.05	6.51	3.78
160						15.30	10.72	6.94	4.03
170						16.25	11.39	7.38	4.28
180						17.21	12.06	7.81	4.54
190						18.16	12.73	8.25	4.79
200						19.12	13.40	8.68	5.04
210							14.07	9.11	5.29
220							14.74	9.55	5.54
230							15.41	9.98	5.80
240							16.08	10.42	6.05
250							16.75	10.85	6.30
260							17.42	11.28	6.55
270							18.09	11.72	6.80
280							18.76	12.15	7.06
290							19.43	12.59	7.31
300							20.10	13.02	7.56
320								13.89	8.06
340								14.76	8.57
360								15.62	9.07
380								16.49	9.58
400								17.36	10.08

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

CAST IRON PIPE Class 150 (346′ Head) **C = 100**

TORO

FLOW GPM	3	4	6	8	10	12	14	16	18
10	.03								
15	.07								
20	.11	.03							
25	.16	.04							
30	.23	.06							
35	.31	.08	.01						
40	.39	.10	.01						
45	.48	.12	.02						
50	.60	.15	.02						
60	.83	.20	.03						
70	1.11	.27	.04						
80	1.42	.35	.05	.01					
90	1.77	.43	.06	.02					
100	2.15	.53	.07	.02					
125	3.27	.80	.11	.03					
150	4.55	1.12	.16	.04	.01				
175	6.08	1.50	.20	.05	.02				
200		1.91	.26	.07	.02				
250		2.90	.40	.10	.03	.01			
300		4.03	.56	.14	.05	.02			
350			.74	.19	.06	.03	.01		
400			.95	.23	.08	.03	.02		
450			1.19	.29	.10	.04	.02		
500			1.44	.36	.12	.05	.02	.01	
600			2.01	.49	.17	.07	.03	.02	
700			2.69	.66	.23	.09	.04	.02	.01
800			3.45	.85	.29	.12	.06	.03	.02
900				1.06	.36	.15	.07	.04	.02
1000				1.29	.45	.18	.08	.05	.03
1200				1.78	.61	.25	.12	.06	.04
1400				2.38	.81	.34	.16	.08	.05
1600				3.03	1.04	.43	.20	.11	.06
1800					1.28	.52	.25	.13	.07
2000					1.56	.65	.31	.16	.09
2500						.97	.46	.24	.14
3000						1.36	.65	.34	.19
3500							.85	.45	.25
4000							1.08	.57	.32

Velocity of Flow (Ft./Sec.)

CAST IRON PIPE Class 150 (346′ Head)

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	3	4	6	8	10	12	14	16	18
10	.37								
15	.56								
20	.74	.49							
25	.93	.61							
30	1.11	.73							
35	1.30	.85	.38						
40	1.48	.98	.43						
45	1.67	1.10	.49						
50	1.85	1.22	.54						
60	2.22	1.46	.65						
70	2.59	1.71	.76						
80	2.96	1.95	.86	.48					
90	3.33	2.20	.97	.54					
100	3.70	2.44	1.08	.60					
125	4.63	3.05	1.35	.75					
150	5.55	3.66	1.62	.90	.60				
175	6.48	4.27	1.89	1.05	.70				
200		4.88	2.16	1.20	.80				
250		6.10	2.70	1.50	1.00	.68			
300		7.32	3.24	1.80	1.20	.81			
350			3.78	2.10	1.40	.95	.70		
400			4.32	2.40	1.60	1.08	.80		
450			4.86	2.70	1.80	1.22	.90		
500			5.40	3.00	2.00	1.35	1.00	.75	
600			6.48	3.60	2.40	1.62	1.20	.90	
700			7.56	4.20	2.80	1.89	1.40	1.05	.49
800			8.64	4.80	3.20	2.16	1.60	1.20	.56
900				5.40	3.60	2.43	1.80	1.35	.63
1000				6.00	4.00	2.70	2.00	1.50	.70
1200				7.20	4.80	3.24	2.40	1.80	.84
1400				8.40	5.60	3.78	2.80	2.10	.98
1600				9.60	6.40	4.32	3.20	2.40	1.12
1800					7.20	4.86	3.60	2.70	1.26
2000					8.00	5.40	4.00	3.00	1.40
2500						6.75	5.00	3.75	1.75
3000						8.10	6.00	4.50	2.10
3500							7.00	5.25	2.45
4000							8.00	6.00	2.80

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

CLASS 150 (325′ Head) ABESTOS-CEMENT PIPE C = 140

TORO

FLOW GPM	3	4	5	6	8	10	12	14	16
75	.67	.17							
100	1.14	.28	.10	.04					
125	1.73	.43	.14	.07					
150	2.42	.60	.20	.09					
175	3.22	.79	.27	.12					
200	4.13	1.02	.34	.16					
225	5.13	1.27	.43	.21					
250	6.24	1.55	.52	.24					
275	7.45	1.84	.62	.30					
300	8.75	2.15	.73	.34					
325	10.15	2.50	.85	.40	.09				
350	11.64	2.87	.97	.45	.11				
375	13.23	2.26	1.10	.51	.12				
400		3.67	1.25	.58	.14				
425		4.11	1.40	.64	.15				
450		4.57	1.55	.72	.17				
475		5.05	1.70	.80	.19				
500		5.55	1.87	.87	.21	.07			
525		6.07	2.05	.95	.23	.08			
550		6.63	2.23	1.05	.25	.08			
575		7.20	2.42	1.13	.27	.09			
600		7.78	2.62	1.22	.29	.10			
650		9.02	3.05	1.42	.34	.11			
700			3.49	1.62	.39	.13	.06		
750			3.97	1.85	.44	.15	.06		
800			4.47	2.08	.50	.16	.07		
850			5.00	2.33	.56	.18	.08		
900			5.56	2.60	.62	.20	.09		
950			6.14	2.86	.68	.23	.10	.05	
1000			6.76	3.15	.75	.25	.11	.05	
1250				4.75	1.14	.38	.16	.08	.04
1500				6.66	1.60	.53	.23	.11	.06
1750					2.12	.70	.30	.15	.08
2000					2.71	.90	.40	.20	.10
2250					3.37	1.12	.48	.23	.12
2500					4.10	1.36	.60	.28	.15
2750						1.62	.70	.34	.18
3000						1.90	.82	.40	.21
3250						2.21	.95	.46	.24
3500						2.53	1.10	.53	.28
4000						3.25	1.40	.68	.36
4500							1.74	.84	.44
5000							2.12	1.02	.54
5500							2.53	1.22	.65
6000								1.43	.75
6500								1.66	.87
7000								1.90	1.00
7500									1.15
8000									1.30
9000									1.60
10000									1.95

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

Class 150 (325′ Head) Asbestos Cement Pipe

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	3	4	5	6	8	10	12	14	16
75	3.40	1.91							
100	4.54	2.55	1.63	1.19					
125	5.67	3.19	2.04	1.49					
150	6.81	3.83	2.45	1.79					
175	7.94	4.47	2.86	2.09					
200	9.08	5.11	3.27	2.39					
225	10.21	5.74	3.68	2.69					
250	11.35	6.38	4.09	2.98					
275	12.48	7.02	4.49	3.28					
300	13.62	7.66	4.90	3.58					
325	14.75	8.30	5.31	3.88	2.15				
350	15.89	8.94	5.72	4.18	2.32				
375	17.02	9.57	6.13	4.48	2.49				
400		10.21	6.54	4.77	2.65				
425		10.85	6.94	5.07	2.82				
450		11.49	7.35	5.37	2.98				
475		12.13	7.76	5.67	3.15				
500		12.77	8.17	5.97	3.31	2.04			
525		13.40	8.58	6.27	3.48	2.14			
550		14.04	8.99	6.56	3.65	2.25			
575		14.68	9.40	6.86	3.81	2.35			
600		15.32	9.80	7.16	3.98	2.45			
650		16.59	10.62	7.76	4.31	2.65			
700			11.44	8.35	4.64	2.86	1.99		
750			12.26	8.95	4.97	3.06	2.13		
800			13.07	9.55	5.30	3.27	2.27		
850			13.89	10.15	5.63	3.47	2.41		
900			14.71	10.74	5.97	3.68	2.55		
950			15.52	11.34	6.30	3.88	2.69	1.98	
1000			16.34	11.94	6.63	4.08	2.84	2.08	
1250				14.92	8.29	5.10	3.55	2.61	1.99
1500				17.90	9.94	6.13	4.25	3.13	2.39
1750					11.60	7.15	4.96	3.65	2.79
2000					13.26	8.17	5.67	4.17	3.19
2250					14.91	9.19	6.38	4.69	3.59
2500						10.21	7.09	5.21	3.99
2750						11.23	7.80	5.73	4.39
3000						12.25	8.51	6.25	4.79
3250						13.27	9.22	6.77	5.19
3500						14.29	9.93	7.29	5.58
4000						16.34	11.34	8.34	6.38
4500							12.76	9.38	7.18
5000							14.18	10.42	7.98
5500							15.60	11.46	8.78
6000								12.50	9.57
6500								13.55	10.37
7000								14.59	11.17
7500									11.97
8000									12.77
9000									14.36
10000									15.96

Pressure Loss From Friction per 100' of Pipe (lbs./sq. in.)

TYPE M COPPER TUBE **C = 140**

TORO

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	.79	.15							
2	2.85	.51							
3	6.03	1.08							
4	10.31	1.83	.51						
5	15.50	2.77	.77						
6	21.70	3.88	1.08						
7	28.90	5.16	1.43						
8	37.00	6.60	1.85	.63					
9		8.21	2.28	.78					
10		9.97	2.77	.95					
11		11.90	3.31	1.13					
12		14.00	3.89	1.33	.65				
13		16.20	4.51	1.55	.75				
14		18.60	5.17	1.77	.86				
15		21.10	5.87	2.01	.97				
20		36.00	10.00	3.42	1.65	.45			
25			15.10	5.17	2.50	.66			
30			21.20	7.25	3.50	.92	.32		
35			28.20	9.60	4.66	1.23	.43		
40			36.10	12.30	5.96	1.57	.55		
50			54.50	18.60	9.01	2.37	.83		
60				26.10	12.60	3.32	1.16	.49	
70					16.80	4.42	1.55	.65	
80					21.50	5.66	1.97	.83	
90					26.70	7.05	2.45	1.03	
100					32.50	8.55	2.98	1.25	.32
110						10.20	3.56	1.50	.37
120						12.00	4.18	1.76	.43
130						13.90	4.85	2.05	.50
140						15.90	5.56	2.34	.58
150						18.10	6.31	2.66	.66
160						20.40	7.11	2.99	.74
170						22.80	7.95	3.35	.83
180						25.40	8.82	3.72	.92
190						28.00	9.77	4.11	1.02
200						30.80	10.81	4.52	1.12
210							11.80	4.95	1.22
220							12.80	5.40	1.33
230							13.90	5.85	1.45
240							15.10	6.33	1.57
250							16.20	6.83	1.69
260							17.50	7.34	1.82
270							18.70	7.88	1.95
280							20.00	8.42	2.08
290							21.40	8.99	2.22
300							22.80	9.57	2.37
320								10.80	2.67
340								12.10	2.98
360								13.40	3.32
380								14.80	3.50
400								16.30	3.68

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

TYPE M COPPER TUBE

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	1.26	.62							
2	2.52	1.24							
3	3.78	1.86							
4	5.05	2.48	1.47						
5	6.31	3.11	1.84						
6	7.57	3.73	2.20						
7	8.83	4.35	2.57						
8	10.09	4.97	2.94	1.96					
9		5.59	3.30	2.21					
10		6.21	3.67	2.45					
11		6.83	4.04	2.70					
12		7.45	4.40	2.94	2.10				
13		8.07	4.47	3.19	2.28				
14		8.70	5.14	3.43	2.45				
15		9.32	5.51	3.68	2.63				
20		12.42	7.34	4.90	3.50	2.02			
25			9.18	6.13	4.38	2.53			
30			11.01	7.35	5.26	3.04	1.97		
35			12.85	8.58	6.13	3.54	2.30		
40			14.68	9.80	7.01	4.05	2.62		
50			18.35	12.26	8.76	5.06	3.28		
60				14.71	10.51	6.07	3.94	2.76	
70					12.26	7.08	4.59	3.22	
80					14.02	8.10	5.25	3.68	
90					15.77	9.11	5.90	4.14	
100					17.52	10.12	6.56	4.60	2.61
110						11.13	7.21	5.06	2.87
120						12.14	7.87	5.52	3.13
130						13.16	8.53	5.98	3.39
140						14.17	9.18	6.44	3.65
150						15.18	9.84	6.90	3.92
160						16.19	10.50	7.36	4.18
170						17.20	11.15	7.82	4.44
180						18.22	11.81	8.28	4.70
190						19.23	12.46	8.74	4.96
200						20.24	13.12	9.20	5.22
210							13.78	9.66	5.48
220							14.43	10.12	5.74
230							15.09	10.58	6.00
240							15.74	11.04	6.26
250							16.40	11.50	6.53
260							17.06	11.96	6.79
270							17.71	12.42	7.05
280							18.37	12.88	7.31
290							19.02	13.34	7.57
300							19.68	13.80	7.83
320								14.72	8.35
340								15.64	8.87
360								16.56	9.40
380								17.48	9.92
400								18.40	10.44

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

TYPE L COPPER TUBE **C = 140**

TORO

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	.97	.18							
2	3.51	.60							
3	7.42	1.26							
4	12.68	2.15	.59						
5	19.10	3.25	.89						
6	26.70	4.55	1.25						
7	35.60	6.04	1.65						
8	45.50	7.72	2.13	.69					
9		9.61	2.62	.86					
10		11.66	3.19	1.05					
11		13.90	3.81	1.25					
12		16.40	4.47	1.46	.70				
13		19.00	5.19	1.71	.81				
14		21.80	5.95	1.95	.93				
15		24.70	6.75	2.21	1.05				
20		42.10	11.50	3.76	1.78	.48			
25			17.40	5.69	2.70	.70			
30			24.40	7.98	3.78	.98	.35		
35			32.40	10.60	5.03	1.30	.46		
40			41.50	13.50	6.44	1.66	.58		
50			62.70	20.50	9.73	2.51	.88		
60				28.70	13.40	3.52	1.25	.52	
70					18.10	4.69	1.65	.69	
80					23.20	6.00	2.09	.88	
90					28.80	7.47	2.60	1.09	
100					35.10	9.06	3.16	1.33	.34
110						10.80	3.77	1.59	.39
120						12.70	4.43	1.87	.46
130						14.70	5.14	2.17	.53
140						16.90	5.89	2.48	.61
150						19.20	6.69	2.82	.70
160						21.60	7.54	3.17	.78
170						24.20	8.43	3.55	.88
180						26.90	9.40	3.94	.98
190						29.70	10.40	4.36	1.08
200						32.60	11.50	4.79	1.19
210							12.50	5.25	1.29
220							13.60	5.72	1.41
230							14.70	6.20	1.54
240							16.00	6.71	1.66
250							17.20	7.24	1.79
260							18.60	7.50	1.93
270							19.80	8.40	2.07
280							21.20	8.90	2.20
290							22.70	9.50	2.35
300							24.20	10.10	2.51
320								11.40	2.83
340								12.80	3.16
360								14.20	3.52
380								15.70	3.71
400								17.30	3.90

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

TYPE L COPPER TUBE

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	1.38	.66							
2	2.75	1.33							
3	4.13	1.99							
4	5.50	2.65	1.56						
5	6.88	3.31	1.94						
6	8.25	3.98	2.33						
7	9.63	4.64	2.72						
8	11.00	5.30	3.11	2.04					
9		5.97	3.50	2.30					
10		6.63	3.89	2.55					
11		7.29	4.28	2.81					
12		7.95	4.67	3.06	2.16				
13		8.62	5.05	3.32	2.35				
14		9.28	5.44	3.57	2.53				
15		9.94	5.83	3.83	2.71				
20		13.26	7.78	5.11	3.61	2.07			
25			9.72	6.38	4.51	2.59			
30			11.66	7.66	5.41	3.11	2.02		
35			13.61	8.94	6.31	3.63	2.35		
40			15.55	10.21	7.22	4.15	2.69		
50			19.44	12.77	9.02	5.19	3.36		
60				15.32	10.82	6.22	4.03	2.83	
70					12.63	7.26	4.70	3.30	
80					14.43	8.30	5.38	3.77	
90					16.24	9.33	6.05	4.24	
100					18.04	10.37	6.72	4.71	2.68
110						11.41	7.39	5.18	4.05
120						12.44	8.06	5.65	4.42
130						13.48	8.74	6.12	4.78
140						14.52	9.41	6.59	5.15
150						15.56	10.08	7.07	5.52
160						16.59	10.75	7.54	5.89
170						17.63	11.42	8.01	6.26
180						18.67	12.10	8.48	6.62
190						19.70	12.77	8.95	6.69
200						20.74	13.44	9.42	7.36
210							14.11	9.89	7.73
220							14.78	10.36	8.10
230							15.46	10.83	8.46
240							16.13	11.30	8.83
250							16.80	11.78	9.20
260							17.47	12.25	9.57
270							18.14	12.72	9.94
280							18.82	13.19	10.30
290							19.49	13.66	10.67
300							20.16	14.13	11.04
320								15.07	11.78
340								16.01	12.51
360								16.96	13.25
380								17.90	13.98
400								18.84	14.72

Pressure Loss From Friction per 100′ of Pipe (lbs./sq. in.)

TYPE K COPPER TUBE **C = 140**

TORO

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	1.20	.23							
2	4.33	.77							
3	9.17	1.65							
4	15.67	2.78	.68						
5	23.60	4.21	1.02						
6	33.00	5.90	1.44						
7	43.90	7.84	1.90						
8	56.20	10.03	2.46	.75					
9		12.48	3.03	.93					
10		15.15	3.68	1.13					
11		18.10	4.40	1.35					
12		21.30	5.17	1.58	.75				
13		24.60	6.00	1.84	.87				
14		28.30	6.88	2.11	1.00				
15		32.10	7.81	2.39	1.13				
20		54.70	13.30	4.07	1.91	.50			
25			20.10	6.15	2.90	.74			
30			28.20	8.63	4.06	1.03	.36		
35			37.50	11.5	5.41	1.38	.48		
40			48.00	14.6	6.91	1.76	.62		
50			72.50	22.1	10.45	2.65	.93		
60				31.1	14.60	3.72	1.30	.55	
70					19.50	4.95	1.74	.73	
80					25.00	6.34	2.21	.93	
90					31.00	7.90	2.75	1.15	
100					37.70	9.58	3.34	1.40	.36
110						11.40	4.00	1.68	.41
120						13.50	4.68	1.97	.48
130						15.60	5.43	2.30	.56
140						17.80	6.23	2.62	.65
150						20.30	7.07	2.98	.74
160						22.90	7.96	3.35	.83
170						25.50	8.90	3.75	.93
180						28.50	9.90	4.17	1.03
190						31.40	11.00	4.60	1.14
200						34.50	12.10	5.06	1.25
210							13.20	5.54	1.37
220							14.30	6.05	1.49
230							15.60	6.55	1.62
240							16.90	7.09	1.76
250							18.20	7.65	1.89
260							19.60	8.22	2.04
270							21.00	8.83	2.18
280							22.40	9.43	2.33
290							24.00	10.07	2.49
300							25.50	10.72	2.65
320								12.10	2.99
340								13.55	3.34
360								15.01	3.72
380								16.58	3.92
400								18.26	4.12

Flows below heavy lines may develop surge pressures which could cause damage. Use with caution.

Velocity of Flow (Ft./Sec.)

TYPE K COPPER TUBE

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	1/2	3/4	1	1¼	1½	2	2½	3	4
1	1.47	.74							
2	2.94	1.47							
3	4.41	2.21							
4	5.88	2.94	1.65						
5	7.36	3.68	2.06						
6	8.83	4.42	2.48						
7	10.30	5.15	2.89						
8	11.77	5.89	3.30	2.11					
9		6.62	3.71	2.37					
10		7.36	4.13	2.64					
11		8.10	4.54	2.90					
12		8.83	4.95	3.16	2.23				
13		9.57	5.36	3.43	2.42				
14		10.30	5.78	3.69	2.61				
15		11.04	6.19	3.95	2.79				
20		14.72	8.25	5.27	3.72	2.13			
25			10.32	6.59	4.66	2.66			
30			12.38	7.91	5.59	3.19	2.07		
35			14.44	9.22	6.52	3.72	2.41		
40			16.50	10.54	7.45	4.26	2.76		
50			20.63	13.18	9.31	5.32	3.45		
60				15.81	11.17	6.38	4.13	2.90	
70					13.03	7.45	4.82	3.38	
80					14.90	8.51	5.51	3.86	
90					16.76	9.58	6.20	4.35	
100					18.62	10.64	6.89	4.83	2.75
110						11.70	7.58	5.31	3.03
120						12.77	8.27	5.80	3.30
130						13.83	8.96	6.28	3.58
140						14.90	9.65	6.76	3.85
150						15.96	10.34	7.25	4.13
160						17.02	11.02	7.73	4.40
170						18.09	11.71	8.21	4.68
180						19.15	12.40	8.69	4.95
190						20.22	13.09	9.18	5.23
200						21.28	13.78	9.66	5.50
210							14.47	10.14	5.78
220							15.16	10.63	6.05
230							15.85	11.11	6.33
240							16.54	11.59	6.60
250							17.23	12.08	6.88
260							17.91	12.56	7.15
270							18.60	13.04	7.43
280							19.29	13.52	7.70
290							19.98	14.01	7.98
300							20.67	14.49	8.25
320								15.46	8.80
340								16.42	9.35
360								17.39	9.90
380								18.35	10.45
400								19.32	11.00

Pressure Loss From Friction per 100' of Pipe (lbs./sq. in.)

ALUMINUM PIPE WITHOUT COUPLERS

BASED ON SCOBEY'S FORMULA/K_S = .34 for 2" Pipe
K_S = .33 for 3"/K_S = .32 for other sizes

FLOW GPM	CFS	2" O.D.	3" O.D.	4" O.D.	5" O.D.	6" O.D.	7" O.D.	8" O.D.
5	.01	.03						
10	.02	.14	.02					
15	.03	.31	.04					
20	.04	.52	.07	.02				
25	.05	.79	.10	.03				
30	.07	1.12	.14	.03				
40	.09	1.95	.24	.06	.02			
50	.11	2.97	.37	.09	.03	.01		
60	.13	4.19	.52	.12	.04	.02		
70	.16	5.61	.70	.16	.05	.02		
80	.18	7.23	.89	.21	.07	.03	.01	
90	.20	9.01	1.12	.26	.09	.03	.02	
100	.22	11.00	1.38	.32	.10	.04	.02	.01
110	.24		1.64	.38	.12	.05	.03	.01
120	.27		1.95	.46	.15	.06	.03	.02
130	.29		2.24	.53	.17	.07	.04	.02
140	.31		2.60	.61	.20	.08	.04	.02
160	.36		3.36	.79	.26	.10	.05	.03
180	.40		4.19	.98	.32	.13	.06	.03
200	.45		5.12	1.20	.39	.16	.07	.04
220	.49		6.11	1.43	.46	.19	.09	.05
240	.54		7.24	1.69	.55	.23	.10	.06
260	.58		8.41	1.97	.64	.26	.12	.06
280	.62		9.70	2.28	.74	.30	.14	.07
300	.67		11.02	2.59	.84	.34	.16	.08
350	.78			3.48	1.12	.46	.22	.11
400	.89			4.49	1.44	.59	.28	.14
450	1.00			5.59	1.80	.73	.35	.18
500	1.12			6.81	2.20	.89	.42	.22
550	1.23			8.28	2.67	1.08	.51	.27
600	1.34			9.73	3.14	1.27	.60	.31
650	1.45			11.30	3.65	1.48	.70	.36
700	1.56				4.19	1.70	.81	.42
750	1.67				4.79	1.93	.91	.48
800	1.79				5.40	2.18	1.03	.54
850	1.90				6.04	2.44	1.16	.60
900	2.01				6.78	2.75	1.29	.68
950	2.12				7.51	3.04	1.44	.75
1000	2.23				8.27	3.34	1.58	.82
1100	2.46				9.90	3.99	1.89	.98
1200	2.68				11.67	4.71	2.23	1.16
1300	2.90					5.47	2.58	1.34
1400	3.12					6.34	2.99	1.56
1500	3.34					7.22	3.41	1.76
1600	3.57					8.14	3.85	2.00
1700	3.79					9.07	4.31	2.23
1800	4.01					10.22	4.83	2.51
1900	4.24						5.35	2.78
2000	4.46						5.91	3.07

NOTE: This chart shows losses without couplers because of variations in pipe lengths and in losses through various types of couplers. If specific loss figures are not available for type used, add equivalent loss of 6' of pipe per coupler to obtain available loss figure for pipe with couplers.

Velocity of Flow (Ft./Sec.)

ALUMINUM PIPE

$$V = 144 \frac{Q}{A_1}$$

FLOW GPM	2″ O.D.	3″ O.D.	4″ O.D.	5″ O.D.	6″ O.D.	7″ O.D.	8″ O.D.
5	.56						
10	1.11	.48					
15	1.67	.72					
20	2.22	.96	.53				
25	2.78	1.20	.67				
30	3.33	1.44	.80				
40	4.44	1.92	1.07	.68			
50	5.55	2.41	1.34	.85	.59		
60	6.66	2.89	1.61	1.02	.71		
70	7.77	3.37	1.88	1.19	.83		
80	8.88	3.85	2.14	1.36	.94	.69	
90	9.99	4.33	2.41	1.53	1.06	.78	
100	11.10	4.81	2.68	1.70	1.18	.87	.66
110		5.29	2.95	1.87	1.30	.95	.73
120		5.77	3.22	2.04	1.42	1.04	.79
130		6.25	3.48	2.21	1.53	1.12	.86
140		6.73	3.75	2.38	1.65	1.21	.93
160		7.70	4.29	2.72	1.89	1.38	1.06
180		8.66	4.82	3.06	2.12	1.56	1.19
200		9.62	5.36	3.40	2.36	1.73	1.32
220		10.58	5.90	3.74	2.60	1.90	1.46
240		11.54	6.43	4.08	2.83	2.08	1.59
260		12.51	6.97	4.42	3.07	2.25	1.72
280		13.47	7.50	4.76	3.30	2.42	1.85
300		14.43	8.04	5.10	3.54	2.60	1.99
350			9.38	5.95	4.13	3.03	2.32
400			10.72	6.80	4.72	3.46	2.65
450			12.06	7.65	5.31	3.89	2.98
500			13.40	8.50	5.90	4.33	3.31
550			14.74	9.35	6.49	4.76	3.64
600			16.08	10.20	7.08	5.19	3.97
650			17.42	11.05	7.67	5.62	4.30
700				11.90	8.26	6.06	4.63
750				12.75	8.85	6.49	4.97
800				13.60	9.44	6.92	5.30
850				14.45	10.03	7.35	5.63
900				15.30	10.62	7.78	5.96
950				16.15	11.21	8.22	6.29
1000				17.00	11.80	8.65	6.62
1100				18.70	12.98	9.52	7.28
1200				20.40	14.16	10.38	7.94
1300					15.34	11.25	8.61
1400					16.52	12.11	9.27
1500					17.70	12.98	9.93
1600					18.88	13.84	10.59
1700					20.06	14.71	11.25
1800					21.24	15.57	11.92
1900						16.44	12.58
2000						17.30	13.24

IV. Surge Pressures and Water Hammer

Surge pressures and water hammer refer to various degrees of the same phenomenon. When water moves through pipe, kinetic energy is created in relation to the mass of water and the velocity at which it is moving. When the flow is stopped, this kinetic energy exerts itself in the form of a momentary increase in pressure above the normal static pressure. This is called a surge pressure or pressure rise. The intensity of this surge depends on the speed of closure of the valve which stops the flow in addition to the factors mentioned above.

Since this surge varies with these several factors, it may be advisable to calculate actual surge pressures for certain conditions. The pressure loss charts in this book are lined at flows generally recommended by piping manufacturers and hydraulic engineers as those which will normally avoid unusually high or damaging surge pressures, but actual conditions such as unusual length of line or extremely fast closing valves may make further derating of flows advisable in some cases. Because of the variability of the factors involved, comprehensive surge tables would be too large and complex to be practical.

The most commonly used formula for calculating pressure rise is:

$$P = .070 \frac{VL}{T}$$

P = Pressure Rise (psi) above static pressure
V = Velocity of Flow (ft./sec.)
L = Length of Pipe (ft.) on pressure side of valve
T = Closing time of valve (sec.)

Surge pressures at a given velocity are, therefore, dependent on both the length of pipe and the closing time of the valve. For an example of these effects, the following calculations are shown for:

1″ Class 315 PVC pipe
Velocity of flow at 8.13 ft./sec. (25 GPM)
Static pressure 160 psi (maximum recommended for pressure lines)

With 100′ of pipe to valve, and valve closure time of 10 seconds:

$$P = .070 \left(\frac{8.13 \times 100}{10}\right) = .070 \left(\frac{813}{10}\right) = .070 \times 81.3 = 5.69 \text{ psi pressure rise}$$

5.69	psi pressure rise
+ 160.00	psi static pressure
165.69	psi total surge pressure

Same conditions; 100′ of pipe, valve closure time of 1 second:

$$P = .070 \left(\frac{8.13 \times 100}{1}\right) = .070 \left(\frac{813}{1}\right) = .070 \times 813 = 56.9 \text{ psi pressure rise}$$

56.9	psi pressure rise
+ 160.00	psi static pressure
216.9	psi total surge pressure

Surges of this magnitude cause creep in PVC pipe and contribute to eventual fatigue of the pipe. → 216.9 psi total surge pressure

Same conditions; 1000′ of pipe, valve closure time of 10 seconds:

$$P = .070\left(\frac{8.13 \times 1000}{10}\right) = .070\left(\frac{8130}{10}\right) = .070 \times 813 = 56.9 \text{ psi pressure rise}$$

+ 160.00 psi static pressure

216.9 psi total surge pressure

Same conditions; 1000′ of pipe, valve closure time of 1 second:

$$P = .070\left(\frac{8.13 \times 1000}{1}\right) = .070\left(\frac{8130}{1}\right) = .070 \times 8130 = 569.1 \text{ psi pressure rise}$$

+ 160.00 psi static pressure

Severe, damaging water hammer → 729.1 psi total surge pressure

If length of line to valve cannot be changed, water hammer must be reduced to or below the safe working pressure of 315 psi by increasing pipe size for the required flow to reduce velocity, by slowing the closure time for the valve, or both.

Use extreme caution where long main lines and fast closing valves are used.

Comparative Flow Capacities for Pipe

Pipe Size	1/2″	3/4″	1″	1¼″	1½″	2″	2½″	3″	4″	6″	8″
1/2″	1	2½	5	8	13	25					
3/4″		1	2	3	5	10	17	27			
1″			1	2	3	5	9	14	28		
1¼″				1	1½	3	5	8	17		
1½″					1	2	3	5	11	28	
2″						1	1½	3	5½	15	29
2½″							1	1½	3	9½	19
3″								1	2	5½	11
4″									1	3	5½
6″										1	2

Figures in this chart represent approximate comparisons to flow at the same pressure loss. As actual inside diameters of pipes vary in comparison in various schedules or ratings, this can only be used as a general guide.

V. Pressure Losses Through Valves, Meters & Fittings

Pressure Losses Through Standard Water Meters

Pounds per Square Inch

FLOW GPM	5/8	3/4	1	1¼	1½	2	2½	3	4
1	.2	.1							
2	.3	.2							
3	.4	.3							
4	.6	.5	.1						
5	.9	.6	.2						
6	1.3	.7	.3						
7	1.8	.8	.4						
8	2.3	1.0	.5						
9	3.0	1.3	.6						
10	3.7	1.6	.7		.1				
11	4.4	1.9	.8	Not Standard Meter Size	.2		Not Standard Meter Size		
12	5.1	2.2	.9		.2				
13	6.1	2.6	1.0		.3				
14	7.2	3.1	1.1		.3				
15	8.3	3.6	1.2		.4				
16	9.5	4.1	1.4		.4				
17	10.7	4.6	1.6		.5				
18	12.0	5.2	1.8		.6				
19	13.4	5.8	2.0		.7				
20	15.0	6.5	2.2		.8	.4			
25		10.3	3.7		1.3	.5			
30		15.0	5.3		1.8	.7			
35			7.3		2.6	1.0			
40			9.6		3.3	1.3			
50			15.0		4.9	1.9		.8	
60					7.2	2.7		1.0	
70					9.8	3.7		1.3	
80					12.8	4.9		1.6	.7
90					16.1	6.2		2.0	.8
100					20.0	7.8		2.4	.9
110						9.5		2.9	1.0
120						11.3		3.4	1.2
130						13.1		3.9	1.4
140						15.0		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
320									8.1
340									9.0
360									11.0
380									12.0
400									13.0
450									16.2
500									20.0

NOTE: Pressure loss figures shown are to maximum safe flow capacities. Pressure losses may vary with different brands and models. Check manufacturers literature if available.

Pressure Losses* Through Pipe Fittings and Manual Valves

PIPE SIZE	PIPE FITTINGS: STANDARD ELBOW OR RUN OF TEE REDUCED BY 1/2	PIPE FITTINGS: LONG SWEEP ELBOW OR RUN OF STANDARD TEE	PIPE FITTINGS: SIDE OUTLET OF STANDARD TEE	PIPE SIZE
1/2"	.9	.4	1.8	1/2"
3/4"	1.2	.6	2.5	3/4"
1"	1.7	.8	3.4	1"
1-1/4"	2.4	1.2	4.8	1-1/4"
1-1/2"	3.0	1.4	5.8	1-1/2"
2"	4.0	2.0	7.9	2"
2-1/2"	5.0	2.5	9.9	2-1/2"
3"	6.7	3.3	13.1	3"
4"	9.2	4.5	18.3	4"
5"	12.2	6.0	24.3	5"
6"	15.3	7.6	30.5	6"
8"	21.7	10.7	43.1	8"
10"	28.7	14.1	56.9	10"

VALVE SIZE	MANUAL VALVES: GATE VALVES	MANUAL VALVES: ANGLE VALVES	MANUAL VALVES: GLOBE VALVES	VALVE SIZE
1/2"	.3	1.2	2.7	1/2"
3/4"	.5	1.7	3.8	3/4"
1"	.6	2.3	5.1	1"
1-1/4"	.9	3.2	7.2	1-1/4"
1-1/2"	1.1	4.0	8.7	1-1/2"
2"	1.5	5.4	11.9	2"
2-1/2"	1.9	6.7	14.9	2-1/2"
3"	2.5	8.9	19.7	3"
4"	3.4	12.4	27.5	4"
5"	4.6	16.5	36.6	5"
6"	5.7	20.6	45.0	6"
8"	8.1	29.2	64.8	8"
10"	10.7	38.5	85.6	10"

* Losses are expressed in terms of equivalent lengths of pipe. For figuring losses of pipe fittings, use the friction loss table for the same type of pipe as the fittings. For the manual valves, use the friction loss table for galvanized steel pipe.

VI. Design Formulas, Tables and Conversion Charts

Pump Definitions

Net Positive Suction Head, **NPSH Required,** is the pressure required to force a given flow rate of water into the entrance of the pump. When the pump is located above the water surface, this force comes from the weight of the atmosphere. When the pump is located below the water surface, it comes from both the weight of the atmosphere and the weight of the water above the center line of the pump entrance.

The amount of **NPSH Available** must always be greater then the **NPSH Required.** The amount available is calculated by subtracting the total dynamic suction head, **TDSH,** (elevation head, friction head, velocity head and vapor pressure of the water) from 33.9 feet at sea level.

Since velocities in suction pipes are low and water temperatures are generally below 60°F in irrigation, they are usually ignored. The **NPSH Available** at sea level is then determined by subtracting the sum of the elevation head between the water surface and the centerline of the pump entrance, and the friction head of all piping on the suction side of the pump from 33 feet. For every 1,000 feet of elevation above sea level, the **NPSH Available** is reduced by about 1 foot.

Practical Suction Lifts at Various Elevations

ELEVATION		BAROMETER READING IN p.s.i.	THEORETICAL SUCTION LIFT IN FEET	PRACTICAL SUCTION LIFT IN FEET
Sea Level		14.7	34.0	22
1/4 mile	(1,320') above sea level	14.0	32.4	21
1/2 mile	(2,640') above sea level	13.3	30.8	20
3/4 mile	(3,960') above sea level	12.7	29.2	18
1 mile	(5,280') above sea level	12.0	27.8	17
1 1/4 miles	(6,600') above sea level	11.4	26.4	16
1 1/2 miles	(7,920') above sea level	10.9	25.1	15
2 miles	(10,560') above sea level	9.9	22.8	14

Pump Cost and Efficiency Data

COST PER HOUR COMPARISON BETWEEN SINGLE AND THREE PHASE PUMP MOTORS

	Cost per hour for continuous operation at a rate of $.01 per kilowatt-hour*	
MOTOR H.P.	**SINGLE PHASE**	**THREE PHASE**
1/4 H.P.	.0031	—
1/2 H.P.	.0054	.0052
3/4 H.P.	.0076	.0077
1 H.P.	.0099	.0096
1 1/2 H.P.	.0150	.0142
2 H.P.	.0197	.0183
3 H.P.	.0295	.0270
5 H.P.	.0465	.0451
7 1/2 H.P.	—	.0675
10 H.P.	—	.0900

*If prevailing rate is more than $.01, multiply the rate figure by 100 and use the product to multiply by the above given cost figure.

COST OF PUMPING WATER PER 1,000 U.S. GALLONS PUMPED

$$\text{Cost} = \frac{.189 \times \text{Head in feet} \times \text{Power cost per kilowatt-hour}}{\text{Pump efficiency} \times \text{Motor efficiency} \times 60}$$

COST PER HOUR OF PUMPING UNDER CONTINUOUS CONDITIONS

$$\text{Cost} = \frac{.000189 \times \text{Head in feet} \times \text{Power cost per kilowatt-hour}}{\text{Pump efficiency} \times \text{Motor efficiency}}$$

FORMULA FOR FIGURING EFFICIENCY OF PUMP

$$\text{Pump efficiency} = \frac{\text{U.S. gallons per minute rating} \times \text{Head rating in feet}}{3960 \times \text{Brake horse power}}$$

FORMULA FOR DETERMINING PUMP HORSE POWER

$$\text{H.P.} = \frac{\text{g.p.m.} \times \text{Total Head Required}}{3960 \times \text{Pump Efficiency}}$$

Theoretical Discharge of Nozzles

Gallons per Minute

GPM $\sqrt{P} \times D^2 \times 29.82 \times C$

P = Pressure at nozzle (psi)
D = Diameter of nozzle opening (inches)
C = Coefficient of discharge factor

Nozzle Orifice (Inches)	Pressure at Nozzle — Pounds per Square Inch												
	10	20	30	40	50	60	70	80	90	100	110	120	130
1/16	.37	.52	.64	.74	.82	.90	.97	1.04	1.10	1.16	1.22	1.27	1.33
5/64	.58	.81	1.00	1.15	1.29	1.41	1.52	1.63	1.73	1.82	1.91	1.99	2.07
3/32	.83	1.17	1.44	1.66	1.85	2.03	2.19	2.34	2.49	2.62	2.75	2.87	2.99
7/64	1.13	1.60	1.95	2.26	2.52	2.76	2.99	3.19	3.38	3.57	3.74	3.91	4.07
1/8	1.47	2.08	2.55	2.95	3.29	3.61	3.90	4.17	4.42	4.66	4.89	5.10	4.31
9/64	1.87	2.64	3.23	3.73	4.17	4.57	4.93	5.28	5.60	5.90	6.19	6.46	6.72
5/32	2.30	3.25	3.99	4.60	5.14	5.64	6.09	6.51	6.90	7.28	7.63	7.97	8.30
11/64	2.79	3.94	4.82	5.57	6.23	6.82	7.37	7.88	8.36	8.81	9.24	9.65	10.04
3/16	3.32	4.69	5.74	6.63	7.41	8.12	8.77	9.38	9.95	10.48	11.00	11.48	11.95
13/64	3.89	5.50	6.74	7.78	8.70	9.53	10.29	11.00	11.67	12.30	12.90	13.47	14.02
7/32	4.51	6.38	7.82	9.03	10.09	11.05	11.94	12.76	13.54	14.27	14.97	15.63	16.27
15/64	5.18	7.32	8.97	10.35	11.58	12.68	13.70	14.64	15.53	16.37	17.17	17.93	18.66
1/4	5.89	8.34	10.21	11.79	13.18	14.44	15.59	16.67	17.68	18.64	19.55	20.42	21.25
17/64	6.65	9.41	11.52	13.31	14.88	16.30	17.60	18.82	19.96	21.04	22.07	23.05	23.99
9/32	7.46	10.55	12.92	14.92	16.68	18.27	19.74	21.10	22.38	23.59	24.74	25.84	26.89
5/16	9.21	13.02	15.95	18.42	20.59	22.56	24.36	26.05	27.63	29.12	30.54	31.90	33.20
11/32	11.14	15.76	19.30	22.28	24.92	27.29	29.48	31.52	33.43	35.24	36.95	38.60	40.17
3/8	13.26	18.75	22.97	26.52	29.65	32.48	35.08	37.51	39.78	41.93	43.98	45.94	47.81
13/32	15.56	22.00	26.95	31.12	34.79	38.11	41.17	44.01	46.68	49.20	51.60	53.90	56.10
7/16	18.05	25.52	31.26	36.10	40.36	44.21	47.75	51.05	54.15	57.08	59.86	62.52	65.08
15/32	20.72	29.30	35.88	41.44	46.33	50.75	54.81	58.60	62.15	65.52	68.71	71.77	74.70
1/2	23.57	33.34	40.83	47.15	52.72	57.75	62.37	66.68	70.72	74.55	78.19	81.67	85.00
17/32	26.61	37.63	46.09	53.22	59.50	65.18	70.41	75.27	79.83	84.15	88.26	92.18	95.95
9/16	29.84	42.19	51.68	59.67	66.72	73.08	78.94	84.39	89.51	94.35	98.96	103.36	107.58
19/32	33.24	47.01	57.58	66.48	74.33	81.43	87.95	94.02	99.73	105.12	110.25	115.15	119.86
5/8	36.83	52.09	63.80	73.67	82.37	90.23	97.45	104.18	110.50	116.48	122.17	127.60	132.81
11/16	44.58	63.04	77.21	89.15	99.67	109.19	117.94	126.08	133.73	140.96	147.84	154.41	160.72
3/4	53.04	75.02	91.87	106.09	118.61	129.93	140.34	150.03	159.13	167.74	175.93	183.75	191.25
13/16	62.25	88.04	107.83	124.51	139.21	152.50	164.71	176.09	186.77	196.87	206.48	215.66	224.46
7/8	72.20	102.10	125.05	144.40	161.44	176.85	191.02	204.21	216.59	228.31	239.45	250.10	260.31
15/16	82.88	117.21	143.55	165.76	185.33	203.02	219.28	234.42	248.64	262.09	274.88	287.11	298.83
1	94.30	133.36	163.33	188.60	210.86	230.99	249.50	266.72	282.90	298.20	312.76	326.66	340.00
1-1/8	119.35	168.78	206.71	238.69	266.86	292.33	315.76	337.56	358.03	377.40	395.82	413.42	430.30
1-1/4	147.34	208.37	255.20	294.69	329.47	360.92	389.83	416.75	442.03	465.94	488.68	510.41	531.26
1-3/8	178.28	252.13	308.79	356.57	398.65	436.70	471.69	504.26	534.85	563.78	591.30	617.59	642.81
1-1/2	212.17	300.06	367.49	424.35	474.44	519.72	561.36	600.12	636.52	670.95	703.70	735.00	765.00
1-5/8	249.00	352.15	431.29	498.02	556.80	609.94	658.81	704.30	747.02	787.43	825.86	862.59	897.81
1-3/4	288.79	408.41	500.20	577.69	645.76	707.40	764.07	816.83	866.37	913.24	957.82	1000.41	1041.25

*Theoretical discharge rates shown on this chart are calculated with a coefficient of discharge factor of 1. This factor may vary slightly for individual nozzles due to length of orifice and internal configuration. Figures shown are normally maximum discharge. Use for approximation only.

Uniformity and Efficiency

Uniformity relates to how evenly water is spread over the irrigated area. **Uniformity Coefficient** and **Distribution Uniformity** are measurements of this uniformity. Efficiency deals not only with how uniformly the water is spread, but also with losses such as percolation beyond the root zone, wind drift, evaporation, etc.

Uniformity Coefficient

Uniformity coefficient values are determined by catching discharge from sprinklers in evenly spaced cans and evaluating the catchment mathematically. One mathematical description widely used was developed by J.E. Christiansen who called his value the Uniformity Coefficient. This is commonly referred to as the coefficient of uniformity or CU. The coefficient is expressed as a percentage and is dependent on rotation uniformity, speed of rotation (for rotary type sprinklers), geometric layout pattern, nozzle pressure and spacing distances. Christiansen's uniformity is determined by:

$$cu = 100\left(1.0 - \frac{\Sigma x}{mn}\right)$$

where

- cu = Uniformity coefficient in percent
- x = difference between individual catchments and the mean catchment
- m = mean catchment
- n = number of catchments

Values of 80% are considered minimum for field crops and turfs, and 85% for closely-spaced, high value crops. Closer spacings generally result in higher CU values.

System Distribution Uniformity

The CU value describes the uneveness of how water falls from a sprinkler or sprinklers in a geometric pattern. Distribution Uniformity (DU) relates to the differences in discharge between sprinklers in a system due primarily to pressure differentials. There are different formulas describing distribution uniformity with some advocating using the absolute minimum catch and others the lowest 25% of the catchment. Generally the distribution uniformity value is approximately equal to:

$$\left(\frac{\text{minimum}}{\text{average}}\right) \times 100$$

For a sprinkler system, the **System Distribution Uniformity** approximately equals:

(Sprinkler GPM Uniformity) x (Catch can Uniformity) x 100 where the Sprinkler and Catch can uniformities are expressed as decimals. For example, a CU of catch can uniformity is 80%, the minimum sprinkler discharge is 2.5 GPM and the average sprinkler discharge is 3.0 GPM.

$$\text{System Distribution Uniformity} = \left(\frac{2.5\ \text{GPM}}{3.0\ \text{GPM}}\right) \times .80 \times 100 = 67\%$$

Efficiencies

There are a multitude of ways to measure water application efficiencies (WAE). A simple approach is to look at the water used by the plants (satisfy transpiration and leaching requirements) to the total water applied times 100 to convert to a percent.

$$WAE = \frac{\text{Water used by plants}}{\text{Water applied}} \times 100$$

WAE values are usually less then system distribution uniformities because:

1. Most systems have evaporation losses.
2. Many systems have wind losses.
3. Systems are rarely shut off just when the soil moisture deficiency has been satisfied so deep percolation losses occur.

Designing Irrigation System Capabilities

The typical formula used to determine the necessary volume of water or flow rate to apply is:

$$\text{Gross Need} = \frac{\text{(Net need for ET and leaching)}}{\text{(WAE/100)}}$$

The value of WAE must account for the DU, evaporation losses and a reasonable estimate of management (timing).

Example: Find the gross depth which must be applied and the necessary sprinkler GPM.

Sprinklers are spaced at 40 feet x 40 feet. Estimated WAE is 75%. Sprinklers can run for 4 hours and must apply a **net** of 1.5 inches.

Formulas GROSS = Net / (WAE/100)
GPM = (Gross Inches) x (Area in Sq. Ft.) / (Hours x 96.3)
GROSS = 1.5" (75%/100) = 2.0" needed
GPM = (2.0" x 40' x 40') / (4 Hrs. x 96.3)
= 8.3 GPM

Example: Find the necessary flow rate. An irrigation system must be designed to supply a net of .3"/day to meet the peak summer ET requirement. Estimated WAE is 70%. Area is 2.3 acres. The maximum operating period is 8 hours.

Formulas GROSS = Net / (WAE/100)
GPM = (Gross Inches x Area in Sq. Ft.) / (Hours x 96.3)
GROSS = .3" / (70%/100) = .43" needed
GPM = (.43 x 2.3 acres x 43,560 sq. ft.) / (96.3 x 8 Hrs.)
= 56 GPM

Estimated sprinkler efficiencies by climate zone.

CLIMATE	AVERAGE EFFICIENCIES
Low Desert	60%
High Desert	65%
Hot, Dry	70%
Moderate	75%
Cool, Humid	80%

Maximum Sprinkler spacing for Wind.

WIND SPEED MPH	SQUARE SPACING	TRIANGULAR SPACING
0 to 7	50%	55%
8 to 10	45%	50%
over 10	40%	45%

Based on Toro recommended sprinkler diameters.

Average soil infiltration rates for various percents of slope.

Soil Texture, Type	Percent of Slope	0-4%	5-8%	8-12%	12-16%	Over 16%
	Infiltration Rate (Ir)					
Course Sand	**Inches/Hour**	1.25	1.00	.75	.50	.31
Medium Sand		1.06	.85	.64	.42	.27
Fine Sand		.94	.75	.56	.38	.24
Loamy Sand		.88	.70	.53	.35	.22
Sandy Loam		.75	.60	.45	.30	.19
Fine Sandy Loam		.63	.50	.38	.25	.16
V. Fine Sandy Loam		.59	.47	.35	.24	.15
Loam		.54	.43	.33	.22	.14
Silt Loam		.50	.40	.30	.20	.13
Silt		.44	.35	.26	.18	.11
Sandy Clay		.31	.25	.19	.12	.08
Clay Loam		.25	.20	.15	.10	.06
Silty Clay		.19	.15	.11	.08	.05
Clay		.13	.10	.08	.05	.03

***Note:* Rates based on full cover. These figures decrease with time and percent of cover. Derived from USDA information.**

Water-holding estimates of a variety of Soils*

SOIL	Very Coarse	Coarse Sand	Moderately Coarse	Medium & Fine	Moderately Fine
	Gravelly Coarse	Fine sand Loamy Coarse sand	Loamy fine sand Sandy loam Fine sandy loam	Fine sandy loam Loam Silt loam Silt sandy clay Silty clay Clay	Sandy clay loam Clay loam Silty Clay loam
AW - Inches/ft.	**.5"**	**1.0"**	**1.5"**	**2.0"**	**2.2"**
AW - Gallons per cubic foot	**1/3**	**2/3**	**1**	**1-1/3**	**1-2/3**

**From the Soil Conservation Service Handbook*, AW = available water.

Approximate Number of Sprinklers Per Acre

TRIANGULAR SPACING				SQUARE SPACING			
SPACING	HEADS	SPACING	HEADS	SPACING	HEADS	SPACING	HEADS
10′	(504)	70′	(10.5)	8.5′	(552)	60.5′	(12)
15′	(224)	75′	(9)	13′	(258)	65′	(10)
20′	(125)	80′	(8)	17′	(151)	69′	(9)
25′	(80)	85′	(7)	21.5′	(97)	73.5′	(8)
30′	(56)	90′	(6.2)	26′	(65)	78′	(7)
35′	(42)	95′	(5.6)	30′	(48)	82′	(6.4)
40′	(31)	100′	(5.0)	34.5′	(38)	86.5′	(5.8)
45′	(25)	105′	(4.5)	39′	(29)	91′	(5.3)
50′	(20)	110′	(4.2)	43′	(24)	95′	(4.8)
55′	(16.5)	115′	(3.8)	47.5′	(20)	99.5′	(4.4)
60′	(14)	120′	(3.5)	52′	(16)	104′	(4.1)
65′	(12)	125′	(3.3)	56′	(14)	108′	(3.9)

VII. Miscellaneous Data

Areas of circles are to each other as the squares of their diameters.
Doubling the diameter of a pipe or cylinder increases its capacity four times.
Friction of liquids in pipes increases as the squares of the velocity.

$$\text{Velocity in feet per minute necessary to discharge a given volume of water in a given time} = \frac{\text{Cubic feet of water} \times 144}{\text{Area of pipe in square inches}}$$

Precipitation rate of heads in a set pattern in inches per hour:

For square spacing: $\dfrac{\text{g.p.m. of full circle heads} \times 96.3}{\text{head spacing squared}}$

For triangular spacing: $\dfrac{\text{g.p.m. of full circle head} \times 96.3}{\text{head spacing squared} \times .866}$

Voltage Loss Per 100′ of Copper Wire — Two Wire A.C.

	WIRE GAUGE						
AMPS	**14**	**12**	**10**	**8**	**6**	**4**	**2**
.1	.0506	.0319	.0200	.0121	.0076	.0048	.0030
.2	.1013	.0637	.0401	.0243	.0153	.0096	.0060
.3	.1519	.0956	.0601	.0364	.0229	.0144	.0091
.4	.2026	.1274	.0801	.0485	.0305	.0192	.0121
.5	2532	.1593	.1002	.0607	.0382	.0241	.0151
.6	.3038	.1911	.1202	.0728	.0458	.0289	.0181
.7	.3545	.2229	.1402	.0849	.0534	.0337	.0211
.8	.4051	.2548	.1602	.0970	.0610	.0385	.0242
.9	.4558	.2867	.1803	.1092	.0687	.0433	.0272
1.0	.5064	.3185	.2003	.1213	.0763	.0481	.0302
1.5	.7596	.4778	.3005	.1820	.1145	.0722	.0453
2.0	1.0128	.6370	.4006	.2426	.1526	.0962	.0604
2.5	1.2660	.7963	.5008	.3033	.1908	.1203	.0755
3.0	1.5192	.9555	.6009	.3639	.2289	.1443	.0906
3.5	1.7724	1.1148	.7011	.4246	.2671	.1684	.1057
4.0	2.0256	1.2740	.8012	.4852	.3052	.1924	.1208
4.5	2.2788	1.4333	.9014	.5459	.3434	.2165	.1359
5.0	2.5320	1.5925	1.0015	.6065	.3815	.2405	.1510
5.5	2.7852	1.7518	1.1017	.6672	.4197	.2646	.1661
6.0	3.0384	1.9110	1.2018	.7278	.4578	.2886	.1812
6.5	3.2916	2.0703	1.3020	.7885	.4960	.3127	.1963
7.0	3.5448	2.2295	1.4021	.8491	.5341	.3367	.2114

BASED ON $E = \dfrac{K\,L\,I}{CM}$ FOR ONE WIRE

*CM = Circular Mills of Wire
E = Voltage loss
K = Ohms (10.4 for copper)
L = Length
I = Amps

Wire Gauge	*CM
14	4,107
12	6,530
10	10,380
8	16,510
6	26,250
4	41,740

Conversion Table for U.S. and Metric Systems

METRIC TO U.S. MULTIPLY				TO OBTAIN	U.S. TO METRIC MULTIPLY				TO OBTAIN
Millimeters (mm)	x	.03937	=	inches	Inches (in.)	x	25.4	=	millimeters
Centimeters (cm)	x	.3937	=	inches	Inches (in.)	x	2.54	=	centimeters
Meters (m)	x	39.37	=	inches	Inches (in.)	x	.0254	=	meters
Meters (m)	x	3.281	=	feet	Feet (ft.)	x	.3048	=	meters
Meters (m)	x	1.094	=	yards	Yards (yds.)	x	.9144	=	meters
Kilometers (km)	x	.62137	=	miles	Miles (mi.)	x	1.6093	=	kilometers
Kilometers (km)	x	1093.62	=	yards	Yards (yds.)	x	.0009143	=	kilometers
Kilometers (km)	x	3280.87	=	feet	Feet (ft.)	x	.0003048	=	kilometers
Liters (1)	x	1.0567	=	quarts (liq.)	Quarts (qts.)	x	.945	=	liters
Liters (1)	x	.2642	=	gallons (U.S.)	Gallons (gals.)	x	3.78	=	liters
Liters (1)	x	.455	=	pounds	Pounds	x	2.2	=	liters
Temp. in (C° x 1.80)	+	32°	=	temp. in F°	Temp. in F° - 32° x .5666			=	temp. in C°

Kilograms per cubic centimeter (kg/cm^2) x 14.223 = Pounds per square inch (P.S.I.)
Cubic Foot (cu. ft.) x 28.316 = Liters (1.)

Miscellaneous Conversion Factors

Feet head (ft. hd.) x .433	=	Pounds per square inch (P.S.I.)
Pounds per square inch x 2.31	=	Feet head
Meters x 3.28	=	Feet head
Inches of mercury x 1.133	=	Feet head
U.S. gallons per minute x .1337	=	Cubic feet per minute
Cubic feet per minute x 7.48	=	U.S. gallons per minute
British Imperial gallon x 1.201	=	U.S. gallons
Acre inches per hour x 453	=	G.P.M.
Acre foot per day x 226	=	G.P.M.
1,000,000 gallons per day	=	694 G.P.M.
U.S. gallons x .833	=	British Imperial gallon
U.S. gallon x 8.336	=	Pounds
Acre foot x 325,850	=	U.S. gallons
Gallons per day x 1,000,000	=	694 Gallons per minute
U.S. gallons x 231	=	Cubic inches
Horsepower (H.P.) x 746	=	Watts
Horsepower x .746	=	Kilowatts
Calorie x 3.968	=	British Thermal Unit (B.T.U.)
Foot pounds per second x .7373	=	Watts
Kilowatts x 1.34	=	Horsepower
Square foot x 144	=	Square inches
Square yard x 9	=	Square feet
Acre x 4.840	=	Square yards
Acre x 43,560	=	Square feet
Square mile (section) x 640	=	Acres
Mile x 5,280	=	Feet
Cubic yard x 27	=	Cubic feet
Circumference of circle x .3183	=	Diameter of circle
Diameter of circle x 3.1416	=	Circumference of circle
Diameter of circle squared x .7854	=	Area of circle
Radius of circle squared x 3.1416	=	Area of circle
Cubic feet per second x 448.8	=	U.S. Gallons per minute
Cubic feet per second	=	$\frac{\text{Gallons per minute}}{449}$
Velocity in feet per second	=	$\frac{.408 \times \text{U.S. g.p.m.}}{\text{Diam. of pipe squared}}$ or $144 \frac{\text{Q (flow in GPM)}}{A_1 \text{ (Pipe ID}^2)}$

Notes: