FRICTION LOSS CHARACTERISTICS

HDPE DR 9 200 PSI (IPS SIZE, OD CONTROLLED)

Size: 3" thru 18" Flow: 50 thru 4000GPM

ANSI/ASÆ S376.3 PE3408, ASTM D2239 C=150 PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	3"		4"		6"		8"		10"		12"		14"		16"		18"	
Avg.ID	2.674		3.440		5.065		6.593		8.218		9.746		10.700		12.230		13.760	
Pipe OD	3.500		4.500		6.625		8.625		10.750		12.750		14.000		16.000		18.000	
Avg Wall	0.413		0.530		0.780		1.016		1.266		1.502		1.650		1.885		2.120	
Min Wall	0.389		0.500		0.736		0.958		1.194		1.417		1.556		1.778		2.000	
Flow GPM	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss
50	2.85	0.50	1.72	0.15	0.80	0.02												
60	3.42	0.70	2.07	0.20	0.95	0.03												
70	3.99	0.93	2.41	0.27	1.11	0.04												
80	4.56	1.19	2.76	0.35	1.27	0.05												
90	5.14	1.48	3.10	0.43	1.43	0.07												
100	5.71	1.80	3.45	0.53	1.59	0.08	0.94	0.02										
120	6.85	2.52	4.14	0.74	1.91	0.11	1.13	0.03										
140	7.99	3.35	4.83	0.98	2.23	0.15	1.31	0.04										
160	9.13	4.29	5.52	1.26	2.54	0.19	1.50	0.05	0.97	0.02								
180			6.21	1.57	2.86	0.24	1.69	0.07	1.09	0.02								
200			6.90	1.90	3.18	0.29	1.88	0.08	1.21	0.03								
220			7.59	2.27	3.50	0.35	2.06	0.10	1.33	0.03								
240			8.27	2.67	3.82	0.41	2.25	0.11	1.45	0.04	1.03	0.02						
260			8.96	3.10	4.13	0.47	2.44	0.13	1.57	0.04	1.12	0.02						
280			9.65	3.55	4.45	0.54	2.63	0.15	1.69	0.05	1.20	0.02						
300					4.77	0.61	2.82	0.17	1.81	0.06	1.29	0.03	1.07	0.02				
320					5.09	0.69	3.00	0.19	1.93	0.07	1.37	0.03	1.14	0.02				
340					5.41	0.77	3.19	0.21	2.05	0.07	1.46	0.03	1.21	0.02				
360					5.73	0.86	3.38	0.24	2.17	0.08	1.55	0.04	1.28	0.02				
380					6.04	0.95	3.57	0.26	2.30	0.09	1.63	0.04	1.35	0.02				
400					6.36	1.05	3.75	0.29	2.42	0.10	1.72	0.04	1.43	0.03				
450					7.16	1.30	4.22	0.36	2.72	0.12	1.93	0.05	1.60	0.03	1.23	0.02		
500					7.95	1.58	4.69	0.44	3.02	0.15	2.15	0.07	1.78	0.04	1.36	0.02		
550					8.75	1.89	5.16	0.52	3.32	0.18	2.36	0.08	1.96	0.05	1.50	0.03		
600					9.54	2.22	5.63	0.61	3.62	0.21	2.58	0.09	2.14	0.06	1.64	0.03	1.29	0.02
650							6.10	0.71	3.93	0.24	2.79	0.11	2.32	0.07	1.77	0.04	1.40	0.02
700							6.57	0.82	4.23	0.28	3.01	0.12	2.49	0.08	1.91	0.04	1.51	0.02
750							7.04	0.93	4.53	0.32	3.22	0.14	2.67	0.09	2.05	0.05	1.62	0.03
800							7.51	1.05	4.83	0.36	3.44	0.16	2.85	0.10	2.18	0.05	1.72	0.03
850							7.98	1.17	5.14	0.40	3.65	0.17	3.03	0.11	2.32	0.06	1.83	0.03
900							8.45	1.30	5.44	0.45	3.87	0.19	3.21	0.12	2.45	0.06	1.94	0.04
950							8.92	1.44	5.74	0.49	4.08	0.21	3.39	0.14	2.59	0.07	2.05	0.04
1000							9.39	1.58	6.04	0.54	4.30	0.24	3.56	0.15	2.73	0.08	2.15	0.04
1050							9.86	1.73	6.34	0.59	4.51	0.26	3.74	0.16	2.86	0.09	2.26	0.05
1100									6.65	0.65	4.72	0.28	3.92	0.18	3.00	0.09	2.37	0.05
1150									6.95	0.70	4.94	0.31	4.10	0.19	3.14	0.10	2.48	0.06
1200									7.25	0.76	5.15	0.33	4.28	0.21	3.27	0.11	2.59	0.06
1250									7.55	0.82	5.37	0.36	4.45	0.23	3.41	0.12	2.69	0.07
1300									7.85	0.88	5.58	0.38	4.63	0.24	3.55	0.13	2.80	0.07
1350									8.16	0.94	5.80	0.41	4.81	0.26	3.68	0.14	2.91	0.08
1400									8.46	1.01	6.01	0.44	4.99	0.28	3.82	0.15	3.02	0.08
1450									8.76	1.08	6.23	0.47	5.17	0.30	3.96	0.16	3.12	0.09
1500									9.06	1.15	6.44	0.50	5.35	0.32	4.09	0.17	3.23	0.09
1550									9.36	1.22	6.66	0.53	5.52	0.34	4.23	0.18	3.34	0.10
1600									9.67	1.29	6.87	0.56	5.70	0.36	4.36	0.19	3.45	0.11
1650									9.97	1.37	7.09	0.60	5.88	0.38	4.50	0.20	3.56	0.11
1700											7.30	0.63	6.06	0.40	4.64	0.21	3.66	0.12
1750											7.52	0.67	6.24	0.42	4.77	0.22	3.77	0.12
1800											7.73	0.70	6.41	0.45	4.91	0.23	3.88	0.13
1900											8.16	0.78	6.77	0.49	5.18	0.26	4.09	0.14
2000											8.59	0.85	7.13	0.54	5.46	0.28	4.31	0.16
2100											9.02	0.93	7.48	0.59	5.73	0.31	4.53	0.17
2200											9.45	1.02	7.84	0.65	6.00	0.34	4.74	0.19
2300											9.88	1.10	8.20	0.70	6.27	0.37	4.96	0.21
2400													8.55	0.76	6.55	0.40	5.17	0.22
2500													8.91	0.82	6.82	0.43	5.39	0.24
2600													9.27	0.88	7.09	0.46	5.60	0.26
2700													9.62	0.94	7.36	0.49	5.82	0.28
2800													9.98	1.01	7.64	0.53	6.03	0.30
2900															7.91	0.56	6.25	0.32
3000															8.18	0.60	6.46	0.34
3300															9.00	0.71	7.11	0.40
3600															9.82	0.84	7.76	0.47
3900																	8.40	0.55
4000																	8.62	0.57

Shaded area represents velocities over 5 fps. Use with caution.

See page 194 for friction loss formulas.

FRICTION LOSS CHARACTERISTICS

HDPE DR 11 160 PSI (IPS SIZE, OD CONTROLLED)

Size: 3" thru 18" Flow: 50 thru 4000GPM

ANSI/ASÆ S376.2 PE3408, ASTM D2239 C=150 PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	3"		4"		6"		8"		10"		12"		14"		16"		18"	
Avg.ID	2.826		3.632		5.349		6.963		8.678		10.292		11.300		12.914		14.532	
Pipe OD	3.500		4.500		6.625		8.625		10.750		12.750		14.000		16.000		18.000	
Avg Wall	0.337		0.434		0.638		0.831		1.036		1.229		1.350		1.543		1.734	
Min Wall	0.318		0.409		0.602		0.784		0.977		1.159		1.273		1.455		1.636	
Flow GPM	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss
50	2.55	0.38	1.55	0.11	0.71	0.02												
60	3.07	0.53	1.86	0.16	0.86	0.02												
70	3.58	0.71	2.17	0.21	1.00	0.03												
80	4.09	0.91	2.47	0.27	1.14	0.04												
90	4.60	1.13	2.78	0.33	1.28	0.05												
100	5.11	1.37	3.09	0.40	1.43	0.06	0.84	0.02										
120	6.13	1.92	3.71	0.57	1.71	0.09	1.01	0.02										
140	7.15	2.56	4.33	0.76	2.00	0.11	1.18	0.03										
160	8.17	3.28	4.95	0.97	2.28	0.15	1.35	0.04										
180	9.20	4.08	5.57	1.20	2.57	0.18	1.51	0.05										
200	10.22	4.96	6.19	1.46	2.85	0.22	1.68	0.06	1.08	0.02	0.77	0.01						
220	11.24	5.91	6.80	1.74	3.14	0.27	1.85	0.07	1.19	0.03	0.85	0.01						
240	12.26	6.95	7.42	2.05	3.42	0.31	2.02	0.09	1.30	0.03	0.92	0.01						
260			8.04	2.38	3.71	0.36	2.19	0.10	1.41	0.03	1.00	0.01						
280			8.66	2.73	3.99	0.41	2.36	0.11	1.52	0.04	1.08	0.02						
300			9.28	3.10	4.28	0.47	2.52	0.13	1.63	0.04	1.16	0.02						
320			9.90	3.49	4.56	0.53	2.69	0.15	1.73	0.05	1.23	0.02						
340			10.52	3.91	4.85	0.59	2.86	0.16	1.84	0.06	1.31	0.02	1.09	0.02				
360			11.13	4.34	5.13	0.66	3.03	0.18	1.95	0.06	1.39	0.03	1.15	0.02				
380					5.42	0.73	3.20	0.20	2.06	0.07	1.46	0.03	1.21	0.02				
400					5.70	0.80	3.37	0.22	2.17	0.08	1.54	0.03	1.28	0.02				
450					6.42	1.00	3.79	0.28	2.44	0.09	1.73	0.04	1.44	0.03				
500					7.13	1.21	4.21	0.34	2.71	0.12	1.93	0.05	1.60	0.03	1.22	0.02		
550					7.84	1.45	4.63	0.40	2.98	0.14	2.12	0.06	1.76	0.04	1.35	0.02		
600					8.56	1.70	5.05	0.47	3.25	0.16	2.31	0.07	1.92	0.04	1.47	0.02		
650					9.27	1.97	5.47	0.55	3.52	0.19	2.50	0.08	2.08	0.05	1.59	0.03		
700					9.98	2.26	5.89	0.63	3.79	0.21	2.70	0.09	2.24	0.06	1.71	0.03	1.35	0.02
750					10.69	2.57	6.31	0.71	4.06	0.24	2.89	0.11	2.40	0.07	1.83	0.04	1.45	0.02
800							6.73	0.80	4.33	0.27	3.08	0.12	2.56	0.08	1.96	0.04	1.55	0.02
850							7.15	0.90	4.61	0.31	3.27	0.13	2.72	0.09	2.08	0.04	1.64	0.03
900							7.57	1.00	4.88	0.34	3.47	0.15	2.88	0.09	2.20	0.05	1.74	0.03
950							7.99	1.10	5.15	0.38	3.66	0.16	3.04	0.10	2.32	0.05	1.84	0.03
1000							8.42	1.21	5.42	0.42	3.85	0.18	3.20	0.12	2.45	0.06	1.93	0.03
1050							8.84	1.33	5.69	0.45	4.04	0.20	3.36	0.13	2.57	0.07	2.03	0.04
1100							9.26	1.45	5.96	0.50	4.24	0.22	3.51	0.14	2.69	0.07	2.13	0.04
1150							9.68	1.57	6.23	0.54	4.43	0.23	3.67	0.15	2.81	0.08	2.22	0.04
1200							10.10	1.70	6.50	0.58	4.62	0.25	3.83	0.16	2.94	0.08	2.32	0.05
1250							10.52	1.83	6.77	0.63	4.81	0.27	3.99	0.17	3.06	0.09	2.42	0.05
1300									7.04	0.68	5.01	0.29	4.15	0.19	3.18	0.10	2.51	0.05
1350									7.31	0.72	5.20	0.32	4.31	0.20	3.30	0.10	2.61	0.06
1400									7.58	0.78	5.39	0.34	4.47	0.21	3.43	0.11	2.70	0.06
1450									7.86	0.83	5.59	0.36	4.63	0.23	3.55	0.12	2.80	0.07
1500									8.13	0.88	5.78	0.38	4.79	0.24	3.67	0.13	2.90	0.07
1550									8.40	0.94	5.97	0.41	4.95	0.26	3.79	0.14	2.99	0.08
1600									8.67	0.99	6.16	0.43	5.11	0.27	3.91	0.14	3.09	0.08
1650									8.94	1.05	6.36	0.46	5.27	0.29	4.04	0.15	3.19	0.09
1700									9.21	1.11	6.55	0.48	5.43	0.31	4.16	0.16	3.28	0.09
1750									9.48	1.17	6.74	0.51	5.59	0.32	4.28	0.17	3.38	0.10
1800									9.75	1.23	6.93	0.54	5.75	0.34	4.40	0.18	3.48	0.10
1900									10.29	1.36	7.32	0.59	6.07	0.38	4.65	0.20	3.67	0.11
2000											7.70	0.65	6.39	0.42	4.89	0.22	3.86	0.12
2100											8.09	0.72	6.71	0.45	5.14	0.24	4.06	0.13
2200											8.47	0.78	7.03	0.50	5.38	0.26	4.25	0.15
2300											8.86	0.85	7.35	0.54	5.63	0.28	4.44	0.16
2400													7.67	0.58	5.87	0.30	4.64	0.17
2500													7.99	0.63	6.12	0.33	4.83	0.18
2600													8.31	0.68	6.36	0.35	5.02	0.20
2700													8.63	0.72	6.61	0.38	5.22	0.21
2800													8.95	0.77	6.85	0.40	5.41	0.23
2900															7.09	0.43	5.60	0.24
3000															7.34	0.46	5.80	0.26
3300															8.07	0.55	6.38	0.31
3600															8.81	0.64	6.96	0.36
3900																	7.53	0.42
4000																	7.73	0.44

Shaded area represents velocities over 5 fps. Use with caution.

See page 194 for friction loss formulas.

FRICTION LOSS CHARACTERISTICS

HDPE DR 13.5 128 PSI (IPS SIZE, OD CONTROLLED)

Size: 3" thru 18" Flow: 1 thru 4000GPM

ANSI/ASÆ S376.2 PE3408, ASTM D2239 C=150 PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	3"		4"		6"		8"		10"		12"		14"		16"		18"	
Avg.ID	2.950		3.794		5.583		7.269		9.062		10.748		11.802		13.488		15.174	
Pipe OD	3.500		4.500		6.625		8.625		10.750		12.750		14.000		16.000		18.000	
Avg Wall	0.275		0.353		0.521		0.678		0.844		1.001		1.099		1.256		1.413	
Min Wall	0.259		0.333		0.491		0.639		0.796		0.944		1.037		1.185		1.333	
Flow GPM	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss
50	2.34	0.31	1.42	0.09	0.65	0.01												
60	2.81	0.43	1.70	0.13	0.79	0.02												
70	3.28	0.58	1.98	0.17	0.92	0.03												
80	3.75	0.74	2.27	0.22	1.05	0.03												
90	4.22	0.92	2.55	0.27	1.18	0.04												
100	4.69	1.11	2.83	0.33	1.31	0.05	0.77	0.01										
120	5.63	1.56	3.40	0.46	1.57	0.07	0.93	0.02										
140	6.56	2.08	3.97	0.61	1.83	0.09	1.08	0.03										
160	7.50	2.66	4.54	0.78	2.09	0.12	1.24	0.03										
180	8.44	3.31	5.10	0.97	2.36	0.15	1.39	0.04										
200			5.67	1.18	2.62	0.18	1.54	0.05	0.99	0.02	0.71	0.01						
220			6.24	1.41	2.88	0.22	1.70	0.06	1.09	0.02	0.78	0.01						
240			6.80	1.66	3.14	0.25	1.85	0.07	1.19	0.02	0.85	0.01						
260			7.37	1.92	3.40	0.29	2.01	0.08	1.29	0.03	0.92	0.01						
280			7.94	2.20	3.67	0.34	2.16	0.09	1.39	0.03	0.99	0.01						
300					3.93	0.38	2.32	0.11	1.49	0.04	1.06	0.02						
320					4.19	0.43	2.47	0.12	1.59	0.04	1.13	0.02						
340					4.45	0.48	2.63	0.13	1.69	0.05	1.20	0.02	1.00	0.01				
360					4.71	0.54	2.78	0.15	1.79	0.05	1.27	0.02	1.05	0.01				
380					4.97	0.59	2.93	0.16	1.89	0.06	1.34	0.02	1.11	0.02				
400					5.24	0.65	3.09	0.18	1.99	0.06	1.41	0.03	1.17	0.02				
450					5.89	0.81	3.47	0.22	2.24	0.08	1.59	0.03	1.32	0.02				
500					6.54	0.98	3.86	0.27	2.48	0.09	1.77	0.04	1.46	0.03	1.12	0.01		
550					7.20	1.17	4.25	0.33	2.73	0.11	1.94	0.05	1.61	0.03	1.23	0.02		
600					7.85	1.38	4.63	0.38	2.98	0.13	2.12	0.06	1.76	0.04	1.35	0.02		
650					8.51	1.60	5.02	0.44	3.23	0.15	2.30	0.07	1.90	0.04	1.46	0.02		
700							5.41	0.51	3.48	0.17	2.47	0.08	2.05	0.05	1.57	0.03	1.24	0.01
750							5.79	0.58	3.73	0.20	2.65	0.09	2.20	0.05	1.68	0.03	1.33	0.02
800							6.18	0.65	3.97	0.22	2.83	0..10	2.34	0.06	1.79	0.03	1.42	0.02
850							6.56	0.73	4.22	0.25	3.00	0.11	2.49	0.07	1.91	0.04	1.51	0.02
900							6.95	0.81	4.47	0.28	3.18	0.12	2.64	0.08	2.02	0.04	1.59	0.02
950							7.34	0.90	4.72	0.31	3.36	0.13	2.78	0.08	2.13	0.04	1.68	0.02
1000							7.72	0.98	4.97	0.34	3.53	0.15	2.93	0.09	2.24	0.05	1.77	0.03
1050							8.11	1.08	5.22	0.37	3.71	0.16	3.08	0.10	2.35	0.05	1.86	0.03
1100									5.47	0.40	3.89	0.18	3.22	0.11	2.47	0.06	1.95	0.03
1150									5.71	0.44	4.06	0.19	3.37	0.12	2.58	0.06	2.04	0.04
1200									5.96	0.47	4.24	0.21	3.52	0.13	2.69	0.07	2.13	0.04
1250									6.21	0.51	4.41	0.22	3.66	0.14	2.80	0.07	2.21	0.04
1300									6.46	0.55	4.59	0.24	3.81	0.15	2.92	0.08	2.30	0.04
1350									6.71	0.59	4.77	0.26	3.95	0.16	3.03	0.08	2.39	0.05
1400									6.96	0.63	4.94	0.27	4.10	0.17	3.14	0.09	2.48	0.05
1450									7.20	0.67	5.12	0.29	4.25	0.19	3.25	0.10	2.57	0.05
1500									7.45	0.71	5.30	0.31	4.39	0.20	3.36	0.10	2.66	0.06
1550									7.70	0.76	5.47	0.33	4.54	0.21	3.48	0.11	2.75	0.06
1600									7.95	0.80	5.65	0.35	4.69	0.22	3.59	0.12	2.84	0.07
1650									8.20	0.85	5.83	0.37	4.83	0.24	3.70	0.12	2.92	0.07
1700											6.00	0.39	4.98	0.25	3.81	0.13	3.01	0.07
1750											6.18	0.41	5.13	0.26	3.92	0.14	3.10	0.08
1800											6.36	0.44	5.27	0.28	4.04	0.14	3.19	0.08
1900											6.71	0.48	5.57	0.31	4.26	0.16	3.37	0.09
2000											7.06	0.53	5.86	0.34	4.49	0.18	3.54	0.10
2100											7.42	0.58	6.15	0.37	4.71	0.19	3.72	0.11
2200											7.77	0.63	6.44	0.40	4.93	0.21	3.90	0.12
2300											8.12	0.69	6.74	0.44	5.16	0.23	4.08	0.13
2400													7.03	0.47	5.38	0.25	4.25	0.14
2500													7.32	0.51	5.61	0.27	4.43	0.15
2600													7.62	0.55	5.83	0.29	4.61	0.16
2700													7.91	0.59	6.06	0.31	4.78	0.17
2800													8.20	0.63	6.28	0.33	4.96	0.18
2900															6.50	0.35	5.14	0.20
3000															6.73	0.37	5.32	0.21
3300															7.40	0.44	5.85	0.25
3600															8.07	0.52	6.38	0.29
3900																	6.91	0.34
4000																	7.09	0.36

Shaded area represents velocities over 5 fps. Use with caution.

See page 194 for friction loss formulas.

FRICTION LOSS CHARACTERISTICS

C900 DR 18 CLASS 150 (C.I.O.D.)

Size: 4" thru 12" Flow: 25 thru 8500GPM

AWWA C900 ASTM D1784 C=150 PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	4"		6"		8"		10"		12"	
Avg.ID	4.234		6.088		7.984		9.792		11.646	
Pipe OD	4.800		6.900		9.050		11.100		13.200	
Avg Wall	0.283		0.406		0.533		0.654		0.777	
Min Wall	0.267		0.383		0.503		0.617		0.733	
Flow GPM	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss
25	0.57	0.01	0.28	0.00	0.16	0.00	0.11	0.00	0.08	0.00
50	1.14	0.05	0.55	0.01	0.32	0.00	0.21	0.00	0.15	0.00
75	1.71	0.11	0.83	0.02	0.48	0.01	0.32	0.00	0.23	0.00
100	2.28	0.19	1.10	0.03	0.64	0.01	0.43	0.00	0.30	0.00
125	2.84	0.29	1.38	0.05	0.80	0.01	0.53	0.00	0.38	0.00
150	3.41	0.41	1.65	0.07	0.96	0.02	0.64	0.01	0.45	0.00
175	3.98	0.54	1.93	0.09	1.12	0.02	0.74	0.01	0.53	0.00
200	4.55	0.69	2.20	0.12	1.28	0.03	0.85	0.01	0.60	0.01
225	5.12	0.86	2.48	0.15	1.44	0.04	0.96	0.01	0.68	0.01
250	5.69	1.05	2.75	0.18	1.60	0.05	1.06	0.02	0.75	0.01
275	6.26	1.25	3.03	0.21	1.76	0.06	1.17	0.02	0.83	0.01
300	6.83	1.47	3.30	0.25	1.92	0.07	1.28	0.02	0.90	0.01
325	7.40	1.70	3.58	0.29	2.08	0.08	1.38	0.03	0.98	0.01
350	7.97	1.95	3.85	0.33	2.24	0.09	1.49	0.03	1.05	0.01
375	8.53	2.22	4.13	0.38	2.40	0.10	1.60	0.04	1.13	0.02
400	9.10	2.50	4.40	0.43	2.56	0.11	1.70	0.04	1.20	0.02
450			4.95	0.53	2.88	0.14	1.91	0.05	1.35	0.02
500			5.50	0.65	3.20	0.17	2.13	0.06	1.50	0.03
550			6.05	0.77	3.52	0.21	2.34	0.08	1.65	0.03
600			6.60	0.91	3.84	0.24	2.55	0.09	1.80	0.04
700			7.71	1.20	4.48	0.32	2.98	0.12	2.11	0.05
800			8.81	1.54	5.12	0.41	3.40	0.15	2.41	0.07
900			9.91	1.92	5.76	0.51	3.83	0.19	2.71	0.08
1000					6.40	0.62	4.26	0.23	3.01	0.10
1100					7.04	0.74	4.68	0.28	3.31	0.12
1200					7.68	0.87	5.11	0.32	3.61	0.14
1300					8.32	1.01	5.53	0.38	3.91	0.16
1400					8.96	1.16	5.96	0.43	4.21	0.19
1500					9.60	1.32	6.38	0.49	4.51	0.21
1600					10.24	1.49	6.81	0.55	4.81	0.24
1700							7.23	0.62	5.11	0.27
1800							7.66	0.69	5.41	0.29
1900							8.08	0.76	5.72	0.33
2000							8.51	0.83	6.02	0.36
2100							8.94	0.91	6.32	0.39
2200							9.36	0.99	6.62	0.43
2300									6.92	0.46
2400									7.22	0.50
2500									7.52	0.54
2600									7.82	0.58
2700									8.12	0.63
2800										
2900										
3000										
3100										
3200										
3300										
3400										
3500										
3600										
3800										
3900										
4000										
4200										
4400										
4600										
4800										
5000										
5500										
6000										
6500										
7000										
7500										
8000										
8500										

Shaded area represents velocities over 5 fps.
Use with caution.

See page 194 for friction loss formulas.

FRICTION LOSS CHARACTERISTICS

C900 DR 25 CLASS 100 (C.I.O.D.)

Size: 4" thru 12" Flow: 25 thru 8500GPM

AWWA C900 ASTM D1784 C=150 PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	4"		6"		8"		10"		12"	
Avg.ID	4.392		6.314		8.282		10.158		12.080	
Pipe OD	4.800		6.900		9.050		11.100		13.200	
Avg Wall	0.204		0.293		0.384		0.471		0.560	
Min Wall	0.192		0.276		0.362		0.444		0.528	
Flow GPM	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss
25	0.53	0.01	0.26	0.00	0.15	0.00	0.10	0.00	0.07	0.00
50	1.06	0.04	0.51	0.01	0.30	0.00	0.20	0.00	0.14	0.00
75	1.59	0.09	0.77	0.02	0.45	0.00	0.30	0.00	0.21	0.00
100	2.12	0.16	1.02	0.03	0.59	0.01	0.40	0.00	0.28	0.00
125	2.64	0.24	1.28	0.04	0.74	0.01	0.49	0.00	0.35	0.00
150	3.17	0.34	1.54	0.06	0.89	0.02	0.59	0.01	0.42	0.00
175	3.70	0.45	1.79	0.08	1.04	0.02	0.69	0.01	0.49	0.00
200	4.23	0.58	2.05	0.10	1.19	0.03	0.79	0.01	0.56	0.00
225	4.76	0.72	2.30	0.12	1.34	0.03	0.89	0.01	0.63	0.01
250	5.29	0.88	2.56	0.15	1.49	0.04	0.99	0.01	0.70	0.01
275	5.82	1.05	2.81	0.18	1.64	0.05	1.09	0.02	0.77	0.01
300	6.35	1.23	3.07	0.21	1.78	0.06	1.19	0.02	0.84	0.01
325	6.87	1.43	3.33	0.24	1.93	0.07	1.29	0.02	0.91	0.01
350	7.40	1.63	3.58	0.28	2.08	0.07	1.38	0.03	0.98	0.01
375			3.84	0.32	2.23	0.08	1.48	0.03	1.05	0.01
400			4.09	0.36	2.38	0.10	1.58	0.04	1.12	0.02
450			4.61	0.45	2.68	0.12	1.78	0.04	1.26	0.02
500			5.12	0.54	2.97	0.14	1.98	0.05	1.40	0.02
550			5.63	0.65	3.27	0.17	2.17	0.06	1.54	0.03
600			6.14	0.76	3.57	0.20	2.37	0.08	1.68	0.03
700			7.16	1.01	4.16	0.27	2.77	0.10	1.96	0.04
800			8.19	1.29	4.76	0.35	3.16	0.13	2.24	0.05
900			9.21	1.61	5.35	0.43	3.56	0.16	2.52	0.07
1000			10.23	1.95	5.95	0.52	3.95	0.19	2.80	0.08
1100					6.54	0.62	4.35	0.23	3.08	0.10
1200					7.14	0.73	4.74	0.27	3.36	0.12
1300					7.73	0.85	5.14	0.31	3.63	0.14
1400					8.33	0.97	5.54	0.36	3.91	0.16
1500					8.92	1.11	5.93	0.41	4.19	0.18
1600					9.52	1.25	6.33	0.46	4.47	0.20
1700							6.72	0.52	4.75	0.22
1800							7.12	0.57	5.03	0.25
1900							7.51	0.63	5.31	0.27
2000							7.91	0.70	5.59	0.30
2100							8.30	0.76	5.87	0.33
2200							8.70	0.83	6.15	0.36
2300									6.43	0.39
2400									6.71	0.42
2500									6.99	0.45
2600									7.27	0.49
2700									7.55	0.52
2800									7.83	0.56
2900									8.11	0.60
3000									8.39	0.64
3100									8.67	0.68
3200		Shaded area represents velocities over 5 fps. Use with caution.								
3300										
3400										
3500										
3600										
3800										
3900										
4000										
4200										
4400										
4600										
4800										
5000										
5500										
6000										
6500										
7000										
7500										
8000										
8500										

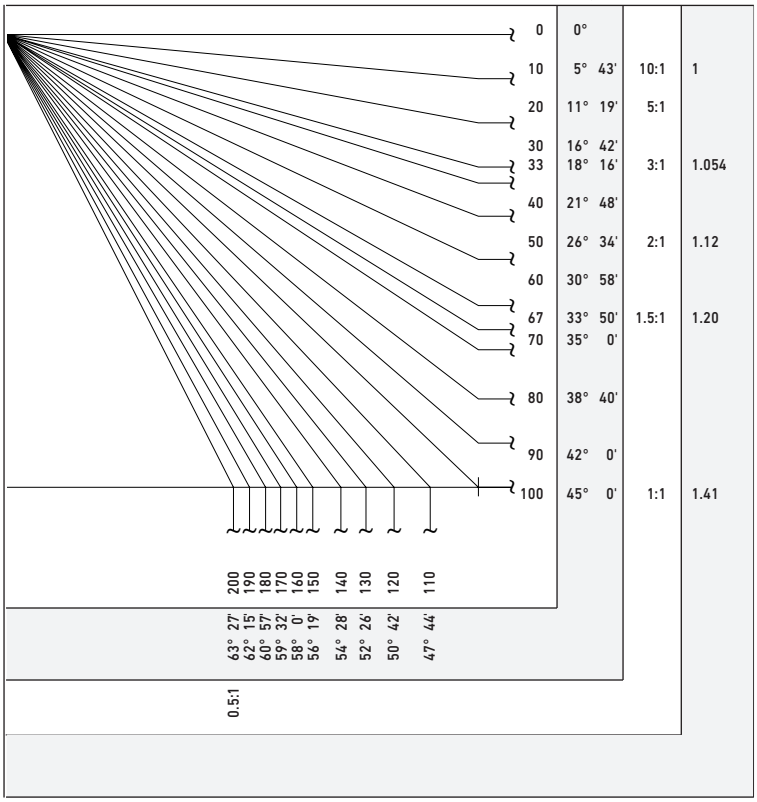
See page 194 for friction loss formulas.

PRESSURE LOSS THROUGH WATER METERS

WATER METER PRESSURE LOSS (PSI)

FLOW GPM	NOMINAL 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	0.7	
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

SLOPE, ANGLE & RATIO PRECIPITATION RATES



MAXIMUM PRECIPITATION RATES

Soil Texture	Maximum Precipitation Rates: Inches Per Hour							
	0 to 5% slope		5 to 8% slope		8 to 12% slope		12% + slope	
	Cover	Bare	Cover	Bare	Cover	Bare	Cover	Bare
Coarse sandy soils	2.00	2.00	2.00	1.50	1.50	1.0	1.0	0.50
Coarse sandy soils over compact subsoils	1.75	1.50	1.25	1.00	1.00	0.75	0.75	0.40
Uniform light sandy loams	1.75	1.00	1.25	0.80	1.00	0.60	0.75	0.40
Light sandy loams over compact subsoils	1.25	0.75	1.00	0.50	0.75	0.40	0.50	0.30
Uniform silt loams	1.00	0.50	0.80	0.40	0.60	0.30	0.40	0.20
Silt loams over compact subsoil	0.60	0.30	0.50	0.25	0.40	0.15	0.30	0.10
Heavy clay or clay loam	0.20	0.15	0.15	0.10	0.12	0.08	0.10	0.06

The maximum PR values listed are as suggested by the United States Department of Agriculture.
The values are average and may vary with respect to actual soil condition and condition of ground cover.

WIRE SIZING

METHOD OF WIRE SIZING FOR ELECTRICAL COMPONENTS OF AN AUTOMATIC IRRIGATION SYSTEM

Data Needed

- Maximum current draw of the electrical unit (valve or controller) in amperes (I)
- Distance in feet (one way) to the electrical unit (F)
- The allowable voltage drop in the wire without affecting functions of the electrical unit (Vd)

Steps

1. Calculate the maximum allowable wire resistance per 1000 feet with the following formula:

$$R = \frac{*500 \times Vd}{F \times I}$$

where R = allowable wire resistance per 1000 feet.

2. Select the wire size from Chart #2 which has a resistance less than that calculated in the above formula.

Example: *A valve with a minimum operating voltage of 20 volts and inrush current of .30 amps is to be located 2680 ft. from a controller. The controller minimum output voltage is 24 V ac.*

The allowable voltage drop
(Vd) = 24 – 20 = 4 volts
The distance to valve (F) = 2680 ft.
The current draw (I) = .3 amps

$$R = \frac{500 \times 4}{2680 \times .3} = 2.49 \text{ ohm/1000 ft.}$$

From Chart #2 we find that #14 AWG wire has slightly too much resistance. Therefore, choose #12 AWG copper wire.

The accompanying charts are useful for quick and easy selection of wire sizes for valves with standard and optional solenoids. Chart #3 is set up to provide maximum wire runs given a standard 24 V ac valve with a minimum operating voltage of 20 volts and a controller output of 24 V ac Chart #4 is a multiplier factor for determining maximum wire runs for other controller output voltages and optional solenoids.

Example: *Determine maximum wire run to a valve with model 24 Vac-D solenoid and controller output voltage of 26 volts and #14 control and ground wire.*

From Chart #3 we find a length of 2590 ft. with #14 ground and control wire. From Chart #4 the multiplier factor at 26 Vac controller output with a model 24 Vac-D solenoid is 4.33. Therefore, the maximum wire distance to the valve is: 4.33 x 2590 feet = 11,215 feet.

** This assumes control wire and ground wire are the same size.*

MINIMUM OPERATING VOLTAGES AT VARIOUS STATIC PRESSURES (STANDARD 24 VAC SOLENOID)

CHART 1

Minimum Solenoid Operating Voltage Under Various Line Pressure

Line Pressure	Voltage (Internal Bleed Configurations)	Voltage (External Bleed Configurations)
200 psi	21.1	
175 psi	20.2	
150 psi	19.1	20.0
125 psi	18.2	19.1
100 psi	17.1	18.2
75 psi	16.1	17.3
50 psi	16.0	16.4

CHART 2

Copper Wire Resistance of Various Sizes

Sizes AWG	Resistance at 20°C Ohms per 1000 ft.
4	0.25
6	0.40
8	0.64
10	1.02
12	1.62
14	2.57
16	4.10
18	6.51

CHART 3

Maximum One-way Distance (ft.) Between Controller and Valve (standard 24 Vac solenoid) †

Valve Wire Sizing							
Ground Wire	Control Wire						
	18	16	14	12	10	8	6
18	1020	1260	1470	1640	1770	1860	1930
16	1260	1630	2000	2330	2610	2810	2960
14	1470	2000	2590	3180	3710	4150	4480
12	1640	2330	3180	4120	5050	5900	6590
10	1770	2610	3710	5050	6540	8030	9380
8	1860	2810	4150	5900	8030	10400	12770
6	1930	2960	4480	6590	9380	12770	16540

† Solenoid Model: 24 V ac Pressure: 150 psi Voltage Drop: 4 V Min. Op. Voltage: 20 V Amperage (peak): 0.3A

MULTIPLIER FACTOR FOR VARIOUS CONTROLLER OUTPUT VOLTAGES AND OPTIONAL LOW-VOLTAGE SOLENOIDS

CHART 5

Controller Output Voltage	24-Volt Solenoids		
	24 Vac	24 Vac-D	24 Vdc
28	2.00	5.77	5.45
27	1.75	5.05	4.77
26	1.50	4.33	4.09
25	1.25	3.61	3.41
24	1.00	2.88	2.73
23	.75	2.16	2.05
22	.50	1.44	1.36

CHART 5

Controller Output Voltage	12-Volt Solenoids		
	12 Vac	12 Vac-D	12 Vdc
16	.58	2.50	1.96
15	.50	2.08	1.63
14	.41	1.67	1.30
13	.33	1.25	.98
12	.25	.83	.65
11	.17	.42	.33

TORO LIMITED WARRANTY FOR IRRIGATION PRODUCTS

The Toro Company and its affiliate, Toro Warranty Company, pursuant to an agreement between them, jointly warrants to the owner each new piece of irrigation product (featured in the current catalog at date of installation) against defects in material and workmanship for a period described herein, provided they are used for irrigation purposes under manufacturer's recommended specifications.

During the warranty period, we will repair or replace, at our option, any part found to be defective. Your remedy is limited solely to the replacement or repair of defective parts. This warranty does not apply (i) to Acts of God (e.g., lightning, flooding, etc.) unless specifically listed under the Extended Lightning Protection Warranty provided herein; or (ii) to products not manufactured by Toro when used in conjunction with Toro products; or (iii) where equipment is used or installation is performed in any manner contrary to Toro's specifications and instructions, or where equipment is altered or modified; or (iv) to natural infestations (e.g., insects, rodents, etc.).

Return the defective part to your irrigation contractor or installer, or your local distributor who may be listed in your telephone/web directory under "Irrigation Supplies" or "Sprinkler Systems", or contact:

The Toro Warranty Company
5825 Jasmine Street, Riverside, California, 92504,
phone (877) 345-8676

For the location of your nearest Toro distributor, or outside the U.S., call (951) 688-9221.

Neither Toro nor Toro Warranty Company is liable for indirect, incidental or consequential damages in connection with the use of equipment, including but not limited to vegetation loss, the cost of substitute equipment or services required during periods of malfunction or resulting non-use, property damage or personal injury resulting from installer's actions, whether negligent or otherwise. Some states do not allow the exclusion of incidental or consequential damages, so this exclusion may not apply to you.

All implied warranties, including those of merchantability and fitness for use, are limited to the duration of this express warranty. Some states do not allow limitations on how long an implied warranty lasts, so this limitation may not apply to you.

This warranty gives you specific legal rights and you may have other rights, which vary from state to state.

STANDARD WARRANTY

Toro Irrigation Business products are covered by this warranty for a period of two years from the date of installation, except as otherwise noted.

EXTENDED THREE-YEAR WARRANTY

The following products are covered by this warranty for three years from date of installation: DDC™ WP Controller.

EXTENDED FIVE-YEAR WARRANTY

The following products are covered by this warranty for five years from date of installation:

Fixed Sprays: All 570Z Series Spray Bodies;

Rotors: T5, T7, TS90, 640 Series, TS120, TS170 and T-P2;

Valves: EZ-Flo® Plus, TPV, P-220 and 220 Brass Series;

Controllers: EVOLUTION®, TMC-424E, Custom Command™ and TDC Series, AC and DC Decoders

Sensors & Accessories: TWRS Wireless RainSensor™ Series (receiver and transmitter), Smart Connect®, EVO-WS, EVO-AR, EVO-HH, SMRT-T.

SENTINEL® SERIES PRODUCT WARRANTY

All Sentinel Centrals, with the exception of centrals covered by the Toro National Support Network (NSN®), and Sentinel hand-held remotes are covered by this warranty for a period of two years from date of installation. All Sentinel Series satellites are covered by this warranty for a period of five years from date of installation.

LANDSCAPE DRIP WARRANTY

Warranty period from date of delivery:

DL2000™ Series Dripline
- Emitters – 2 years
- Hose – 5 years (prorated)
- Rootguard – 7 years

Drip In® Series Dripline
- Emitters – 2 years
- Hose – 5 years (prorated)

Blue Stripe® Hose
- All – 7 years (prorated)

Fittings
- All – 1 year

Emission Devices
- All (except NGE) – 1 year
- NGE® Emitter and Drip Bubblers – 2 years

Filters and Components
- All – 1 year

Other Accessories
- All – 1 year

GROUNDING

The Toro Warranty for Irrigation Controllers is void if controller is not properly grounded per instruction manual. A good ground source is a mandatory component of overall surge protection for Toro Irrigation Control Systems. Grounding electrode(s) should be placed at each automatic controller or controller group locations. The resistance to the grounding electrode should not exceed 10 Ohms when measured with a Megger Earth Resistance Testing instrument or equivalent. It is the responsibility of the installer to connect all electronic irrigation equipment for which he is responsible to earth ground in accordance with Article 250 of the National Electrical Code (NEC). Even with optimum grounding, neither Toro nor Toro Warranty Company are liable for product failures due to acts of God (i.e., lightning, flooding, etc.), and these failures are not covered by warranty.