

# FORMULAS AND CONVERSION FACTORS

## PRECIPITATION RATES

U.S. (SPACING IN FEET)	METRIC (SPACING IN METERS)
<b>Equilateral Triangular Spacing</b> P.R.= $\frac{\text{GPM of 360} \times 96.25}{(\text{in/hr}) (\text{Head Spacing})^2 \times .866}$	P.R.= $\frac{\text{m}^3/\text{hr of 360} \times 1000}{(\text{mm/hr}) (\text{Head Spacing})^2 \times .866}$
<b>Square/Rectangular Spacing</b> P.R.= $\frac{\text{GPM of 360} \times 96.25}{(\text{in/hr}) \text{Head Spacing} \times \text{Row Spacing}}$	P.R.= $\frac{\text{m}^3/\text{hr of 360} \times 1000}{(\text{mm/hr}) \text{Head Spacing} \times \text{Row Spacing}}$
<b>Square/Rectangular Spacing for Specific Arc</b> P.R.= $\frac{34650 \times \text{GPM (for any arc)}}{(\text{in/hr}) \text{Degrees of Arc} \times \text{Head Spacing} \times \text{Row Spacing}}$	P.R.= $\frac{\text{m}^3/\text{hr (for any arc)} \times 1000}{(\text{mm/hr}) \text{Degrees of Arc} \times \text{Head Spacing} \times \text{Row Spacing}}$
<b>HORSEPOWER</b> H.P. = $\frac{\text{GPM} \times \text{Ft of Head}}{3,960 \times \text{Pump Efficiency (expressed as a decimal)}}$	H.P. = $\frac{\text{LPM} \times \text{Meters of Head}}{3,433 \times \text{Pump Efficiency (expressed as a decimal)}}$
<b>STATION RUN TIME</b> S.R.T. = $\frac{\text{Total Weekly Req'd (inch/wk)} \times 60 (\text{min/hr})}{(\text{min/wk}) \text{Precipitation Rate (in/hr)}}$	S.R.T. = $\frac{\text{Total Weekly Req'd (mm/wk)} \times 60 (\text{min/hr})}{(\text{min/wk}) \text{Precipitation Rate (mm/hr)}}$
<b>PIPE VELOCITY</b> V= $\frac{0.4085 \times \text{Flow (GPM)}}{(\text{ft/sec}) (\text{Inside Pipe Diameter in Inches})^2}$	V= $\frac{1273.24 \times \text{Flow (l/sec)}}{(\text{m/sec}) (\text{Inside Pipe Diameter in Millimeters})^2}$
<b>SLOPE</b> S = $\frac{\text{Rise (Measure of Length)}}{\text{Run (Measure of Length)}}$	

TO CONVERT	FROM	TO	MULTIPLY BY
Area	acres	feet <sup>2</sup>	43,560
	acres	meters <sup>2</sup>	4046.8
	meters <sup>2</sup>	feet <sup>2</sup>	10.764
	feet <sup>2</sup>	inches <sup>2</sup>	144
	inches <sup>2</sup>	centimeters <sup>2</sup>	6.452
	hectares	meters <sup>2</sup>	10,000
	hectares	acres	2.471
Power	kilowatts	horsepower	1.3410
Flow	feet <sup>3</sup> /minutes	meters <sup>3</sup> /second	0.00047
	feet <sup>3</sup> /second	meters <sup>3</sup> /second	0.02832
	yards <sup>3</sup> /minute	meters <sup>3</sup> /second	0.01274
	gallons/minute	meters <sup>3</sup> /hour	0.22716
	gallons/minute	liters/minute	3.7854
	gallons/minute	liters/second	0.06309
	meters <sup>3</sup> /hour	liters/minute	16.645
	meters <sup>3</sup> /hour	liters/second	0.2774
	liters/minute	liters/second	60
Length	feet	inches	12
	inches	centimeters	2.540
	feet	meters	0.30481
	kilometers	miles	0.6214
	miles	feet	5,280
	miles	meters	1609.34
	millimeters	inch	0.03937

TO CONVERT	FROM	TO	MULTIPLY BY
Pressure	psi	kilopascals	6.89476
	psi	bars	.06895
	bars	kilopascals	100
	psi	feet of head	2.31
Velocity	feet/second	meters/second	.3048
Volume	feet <sup>3</sup>	gallons	7.481
	feet <sup>3</sup>	liters	28.32
	meters <sup>3</sup>	feet <sup>3</sup>	35.31
	meters <sup>3</sup>	yard <sup>3</sup>	1.3087
	yards <sup>3</sup>	feet <sup>3</sup>	27
	yards <sup>3</sup>	gallons	202
	acres/feet	feet <sup>3</sup>	43,560
	gallons	meters <sup>3</sup>	.003785
gallons	liters	3.785	
imperial gallons	gallons	1.833	

# DRIP EQUATIONS

## NUMBER OF EMITTERS PER PLANT

$$\text{Emitters per tree} = \frac{\text{canopy area (sq.ft.)} \times 0.75}{\text{wetted area per emitter (sq.ft.)}}$$

Soil Type	WETTED AREA	
	Diameter (ft.)	Area (sq. ft.)
Sand	2 – 3	3 – 7
Sandy Loam	3 – 4.5	7 – 16
Loam	3 – 5	7 – 20
Clay- Loam	4 – 6	13 – 28
Clay	5 – 7	20 – 38

## FLOW PER ZONE

$$\text{Flow per zone (gpm)} = \frac{\text{Total number of drippers} \times \text{dripper flow rate (gph)}}{\text{"60 (minutes)"}}$$

## PRECIPITATION RATE FOR EVENLY SPACED LATERALS AND EMITTERS

PRECIPITATION RATE FOR DRIP LATERALS (INCHES/HOUR)							
Emitter Flow	Emitter Spacing	Spacing Between Drip Laterals					
		6 in.	12 in.	18 in.	24 in.	30 in.	36 in.
0.53 gph	12 in.	1.62	0.81	0.54	0.40	0.32	0.27
0.53 gph	18 in.	1.08	0.54	0.36	0.27	0.22	0.18
0.53 gph	24 in.	0.81	0.40	0.27	0.20	0.16	0.13
1.02 gph	12 in.	3.11	1.56	1.04	0.78	0.62	0.52
1.02 gph	18 in.	2.07	1.04	0.69	0.52	0.41	0.35
1.02 gph	24 in.	1.56	0.78	0.52	0.39	0.31	0.26

## PRECIPITATION RATE FORMULA:

$$\text{Precipitation Rate (in/hr.)} = \frac{231.1 \times \text{Emitter Flow (gph)}}{\text{Lateral Spacing ("in.")} \times \text{Emitter Spacing (in.)}}$$

*Note: This formula applies to evenly spaced drip irrigation laterals and emitters.*

## PRECIPITATION RATE FOR A SINGLE LATERAL

PRECIPITATION RATE (IN/HR) OF A SINGLE ROW OF DRIPLINE IN A CONTAINED LANDSCAPE						
Emitter Flow	Emitter Spacing	Width of Contained Landscape				
		1 ft.	2 ft.	3 ft.	4 ft.	5 ft.
0.53 gph	12 in.	0.81	0.40	0.27	0.20	0.16
0.53 gph	18 in.	0.54	0.27	0.18	0.13	0.11
0.53 gph	24 in.	0.40	0.20	0.13	0.10	0.08
1.02 gph	12 in.	1.56	0.78	0.52	0.39	0.31
1.02 gph	18 in.	1.04	0.52	0.35	0.26	0.21
1.02 gph	24 in.	0.78	0.39	0.26	0.19	0.16

## THERMAL EFFECTS ON DRIP HOSE AND DRIPLINE

For recurring, ambient temperatures above 73°F (23°C), multiply PSI rating of selected tubing by the appropriate FACTOR from the table to the right. Result will be the temp-corrected maximum PSI rating for the tubing selected. For temperatures not shown, but between 73°F & 140°F (23°C & 60°C), interpolate to obtain the temp-corrected maximum PSI rating for the tubing selected. Use this information to select the appropriate pressure regulator to assure tubing life expectancy and warranty coverage.

°F	°C	FACTOR
73°	23°	1.00
80°	27°	0.92
90°	32°	0.81
100°	38°	0.70
110°	43°	0.60
120°	49°	0.45
130°	54°	0.32
140°	60°	0.18

## BELOW GRADE DRIP HOSE & DRIPLINE INSTALLATIONS

When installing Blue Stripe® drip hose below grade, consult ANSI/ASAE S376.2: Design, Installation and Performance of Underground, Thermoplastic Irrigation Pipelines for installation protocols regarding trench conditions, water packing of the drip hose prior to backfill and the quality of backfill material. Failure to follow these installation protocols will shorten the life of the tubing and may void the warranty.

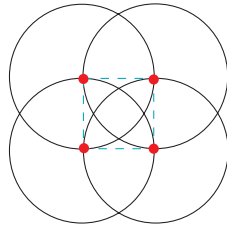
# SPRINKLER SPACING & WINTERIZATION SPECIFICATIONS

The Toro Company does not recommend designing for 0 mph wind conditions. Design in consideration of the worst wind conditions.

## PRECIPITATION RATE FORMULAS

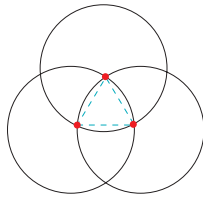
### Square-spaced sprinklers in pattern:

$$\frac{96.3 \times \text{gpm applied to irrigated area}}{(\text{Spacing between sprinklers})^2}$$



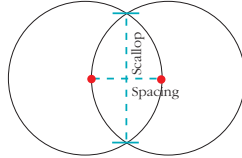
### Triangular-spaced sprinklers in pattern:

$$\frac{\text{gpm of full circle} \times 96.3}{(\text{Spacing between sprinklers})^2 \times 0.866}$$



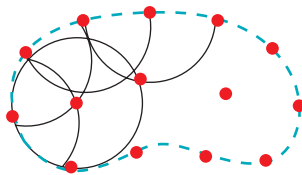
### Single row:

$$\frac{\text{gpm of full circle} \times 96.3}{(\text{Spacing}) (\text{Scallop})}$$



### Area and flow:

$$\frac{\text{Total gpm of zone} \times 96.3}{\text{Total irrigated square feet of zone}}$$



## WINTERIZATION SPECIFICATIONS

In freezing climates, sprinklers and valves should be properly winterized to prevent freeze-related damage.

## FRICTION LOSS FORMULAS

### Hazen-Williams Equation:

$$H_f = (0.2083) (100 / C)^{1.852} (Q^{1.852} / D^{4.866})$$

(The result is multiplied by .433 to give psi loss for 100 feet of pipe)

### The Velocity Values were Derived Using the Following:

$$V = (0.408 \times Q_{\text{gpm}}) / d^2$$

(The average inside diameter of OD controlled pipe was based upon subtracting two times the minimum wall thickness plus one-half of the wall thickness tolerance from the outside diameter.)

- Pressure ratings for plastic pipes are based on 23° C or 73.4° F
- Head loss decreases (increases) approximately 1% for every 3 degrees F above (below) the reference temperature (73.4° F)

# FRICTION LOSS CHARACTERISTICS

## LOSSES IN PSI PER 100 FEET OF HOSE (PSI/100 FT.) FOR HOSE SIZES: .509" ID THROUGH .627" ID

Part No.		EHD1335		EHD1348		EHD1350		EHD1443		EHD1554		EHD1635		EHD1642		EHD1645	
Nom. ID		0.509"		0.510"		0.520"		0.550"		0.572"		0.616"		0.627"		0.616"	
Min. ID		0.506"		0.510"		0.516"		0.547"		0.569"		0.613"		0.624"		0.613"	
Min. Wall		0.035"		0.048"		0.050"		0.043"		0.054"		0.035"		0.042"		0.045"	
Flow		Velocity		Loss		Velocity		Loss		Velocity		Loss		Velocity		Loss	
gpm	gph	fps	psi	fps	psi	fps	psi	fps	psi	fps	psi	fps	psi	fps	psi	fps	psi
0.5	30	0.80	0.37	0.79	0.35	0.77	0.34	0.68	0.25	0.63	0.21	0.54	0.14	0.52	0.13	0.54	0.14
1.0	60	1.60	1.33	1.57	1.28	1.53	1.21	1.37	0.91	1.26	0.75	1.09	0.52	1.05	0.48	1.09	0.52
1.5	90	2.39	2.82	2.36	2.71	2.30	2.56	2.05	1.93	1.89	1.59	1.63	1.11	1.57	1.02	1.63	1.11
2.0	120	3.19	4.80	3.14	4.62	3.07	4.37	2.73	3.29	2.52	2.71	2.17	1.89	2.10	1.73	2.17	1.89
2.5	150	3.99	7.26	3.93	6.99	3.84	6.60	3.41	4.97	3.15	4.10	2.72	2.85	2.62	2.62	2.72	2.85
3.0	180	4.79	10.18	4.71	9.80	4.60	9.26	4.10	6.97	3.79	5.75	3.26	4.00	3.15	3.67	3.26	4.00
3.5	210	5.58	13.55	5.50	13.04	5.37	12.31	4.78	9.27	4.42	7.65	3.80	5.32	3.67	4.88	3.80	5.32
4.0	240	6.38	17.35	6.28	16.69	6.14	15.77	5.46	11.87	5.05	9.79	4.35	6.81	4.20	6.25	4.35	6.81
4.5	270	7.18	21.57	7.07	20.76	6.90	19.61	6.14	14.76	5.68	12.18	4.89	8.48	4.72	7.77	4.89	8.48
5.0	300	7.98	26.22	7.85	25.24	7.67	23.84	6.83	17.94	6.31	14.81	5.44	10.30	5.25	9.45	5.44	10.30
6.0	360	9.57	36.75	9.42	35.37	9.21	33.41	8.19	25.15	7.57	20.75	6.52	14.44	6.29	13.24	6.52	14.44
7.0	420	11.17	48.90	10.99	47.06	10.74	44.45	9.56	33.46	8.83	27.61	7.61	19.21	7.34	17.62	7.61	19.21
8.0	480			12.56	60.26	12.27	56.92	10.92	42.85	10.09	35.36	8.70	24.60	8.39	22.56	8.70	24.60
9.0	540			14.13	74.95	13.81	70.80	12.29	53.29	11.36	43.98	9.78	30.60	9.44	28.06	9.78	30.60
10.0	600							13.65	64.77	12.62	53.45	10.87	37.19	10.49	34.11	10.87	37.19
11.0	660									13.88	63.77	11.96	44.37	11.54	40.69	11.96	44.37
ID120	720									15.14	74.93			12.59	47.81	13.05	52.13

## LOSSES IN PSI PER 100 FEET OF HOSE (PSI/100 FT.) FOR HOSE SIZES: .509" ID THROUGH .627" ID

Part No.		EHD1845		EHD1847		EHD1850		EHD2052		EHD2057		EHD2662		EHD2667		EHD3580	
Nom. ID		0.710"		0.729"		0.729"		0.807"		0.807"		1.060"		1.060"		1.365"	
Min. ID		0.707"		0.726"		0.726"		0.804"		0.804"		1.056"		1.056"		1.360"	
Min. Wall		0.045"		0.047"		0.050"		0.052"		0.057"		0.062"		0.067"		0.084"	
Flow		Velocity		Loss		Velocity		Loss		Velocity		Loss		Velocity		Loss	
gpm	gph	fps	psi	fps	psi	fps	psi	fps	psi	fps	psi	fps	psi	fps	psi	fps	psi
1	60	0.82	0.26	0.78	0.23	0.78	0.23	0.63	0.14	0.63	0.14	0.37	0.04	0.37	0.04	0.22	0.01
2	120	1.63	0.94	1.55	0.83	1.55	0.83	1.26	0.50	1.26	0.50	0.73	0.13	0.73	0.13	0.44	0.04
3	180	2.45	2.00	2.33	1.75	2.33	1.75	1.90	1.07	1.90	1.07	1.10	0.28	1.10	0.28	0.66	0.08
4	240	3.27	3.40	3.10	2.99	3.10	2.99	2.53	1.82	2.53	1.82	1.47	0.48	1.47	0.48	0.88	0.14
5	300	4.09	5.14	3.88	4.52	3.88	4.52	3.16	2.75	3.16	2.75	1.83	0.73	1.83	0.73	1.10	0.21
6	360	4.90	7.21	4.65	6.34	4.65	6.34	3.79	3.85	3.79	3.85	2.20	1.02	2.20	1.02	1.33	0.30
7	420	5.72	9.59	5.43	8.43	5.43	8.43	4.42	5.13	4.42	5.13	2.56	1.36	2.56	1.36	1.55	0.40
8	480	6.54	12.28	6.20	10.79	6.20	10.79	5.06	6.57	5.06	6.57	2.93	1.74	2.93	1.74	1.77	0.51
9	540	7.36	15.27	6.98	13.42	6.98	13.42	5.69	8.17	5.69	8.17	3.30	2.16	3.30	2.16	1.99	0.63
10	600	8.17	18.57	7.75	16.32	7.75	16.32	6.32	9.93	6.32	9.93	3.66	2.63	3.66	2.63	2.21	0.77
11	660	8.99	22.15	8.53	19.47	8.53	19.47	6.95	11.84	6.95	11.84	4.03	3.14	4.03	3.14	2.43	0.92
12	720	9.81	26.02	9.30	22.87	9.30	22.87	7.58	13.91	7.58	13.91	4.40	3.69	4.40	3.69	2.65	1.08
13	780	10.62	30.18	10.08	26.52	10.08	26.52	8.22	16.14	8.22	16.14	4.76	4.28	4.76	4.28	2.87	1.25
14	858	11.69	36.04	11.09	31.68	11.09	31.68	9.04	19.27	9.04	19.27	5.24	5.11	5.24	5.11	3.16	1.49
15	920	12.54	41.01	11.89	36.04	11.98	36.04	9.69	21.93	9.69	21.93	5.62	5.81	5.62	5.81	3.39	1.70
16	982	13.38	46.27	12.69	40.66	12.69	40.66	10.35	24.74	10.35	24.74	6.00	6.56	6.00	6.56	3.62	1.91
17	1,044	14.23	51.82	13.49	45.54	13.49	45.54	11.00	27.71	11.00	27.71	6.38	7.34	6.38	7.34	3.84	2.14
18	1,080			13.95	48.46	13.95	48.46	11.38	29.48	11.38	29.48	6.59	7.81	6.59	7.81	3.98	2.28
19	1,140			14.73	53.56	14.73	53.56	12.01	32.59	12.01	32.59	6.96	8.64	6.96	8.64	4.20	2.52
20	1,200							12.64	35.83	12.64	35.83	7.33	9.50	7.33	9.50	4.42	2.77
22	1,320							13.90	42.75	13.90	42.75	8.06	11.33	8.06	11.33	4.86	3.31
24	1,440							15.17	50.23	15.17	50.23	8.79	13.31	8.79	13.31	5.30	3.88
26	1,560							16.43	58.25	16.43	58.25	9.52	15.44	9.52	15.44	5.74	4.50
28	1,680							17.69	66.82	17.69	66.82	10.26	17.71	10.26	17.71	6.18	5.17
30	1,800							18.96	75.93	18.96	75.93	10.99	20.13	10.99	20.13	6.63	5.87
32	1,920									20.22	85.57	11.72	22.68	11.72	22.68	7.07	6.62
34	2,040											12.45	25.38	12.45	25.38	7.51	7.40
36	2,160											13.19	28.21	13.19	28.21	7.95	8.23
38	2,280											13.92	31.18	13.92	31.18	8.39	9.10
40	2,400											14.65	34.29	14.65	34.29	8.83	10.00
45	2,700											16.48	42.65	16.48	42.65	9.94	12.44
50	3,000											18.32	51.84	18.32	51.84	11.04	15.12
55	3,300											20.15	61.84	20.15	61.84	12.15	18.04
60	3,600											21.98	72.66	21.98	72.66	13.25	21.19
65	3,900													23.81	84.27	14.36	24.58
70	4,200															15.46	28.19
75	4,500															16.56	32.04
80	4,800															17.67	36.11
85	5,100															18.77	40.40
90	5,400															19.88	44.91
95	5,700															20.98	49.64

Friction losses are calculated using Hazen-Williams equation (C = 140) and minimum inside diameter. See page 194 for friction loss formulas.

# FRICITION LOSS CHARACTERISTICS

## LOSSES IN PSI PER 100 FEET OF HOSE (PSI/100 FT.) FOR HOSE SIZES: .596" (16MM) ID THROUGH .870" (22MM) ID

Part No.		EHO1650		EHO2055		EHO2060		HDO2255	
Nom. ID		0.600"		0.830"		0.820"		0.870"	
Min. ID		0.596"		0.821"		0.811"		0.870"	
Nom. Wall		0.050"		0.055"		0.060"		0.055"	
Flow		Velocity	Loss	Velocity	Loss	Velocity	Loss	Velocity	Loss
GPM	GPH	FPS	PSI	FPS	PSI	FPS	PSI	FPS	PSI
0.5	30	0.58	0.17	0.30	0.03	0.31	0.04	0.27	0.03
1.0	60	1.15	0.60	0.61	0.13	0.62	0.13	0.54	0.10
1.5	90	1.73	1.27	0.91	0.27	0.93	0.28	0.81	0.20
2.0	120	2.30	2.16	1.21	0.46	1.24	0.48	1.08	0.34
2.5	150	2.88	3.27	1.52	0.69	1.55	0.73	1.35	0.52
3.0	180	3.45	4.59	1.82	0.96	1.86	1.02	1.62	0.73
3.5	210	4.03	6.10	2.12	1.28	2.17	1.36	1.89	0.97
4.0	240	4.60	7.82	2.42	1.64	2.48	1.74	2.16	1.24
4.5	270	5.18	9.72	2.73	2.04	2.79	2.17	2.43	1.54
5.0	300	5.75	11.81	3.03	2.48	3.11	2.64	2.70	1.87
6.0	360	6.90	16.56	3.64	3.48	3.73	3.69	3.24	2.62
7.0	420	8.05	22.03	4.24	4.63	4.35	4.92	3.78	3.49
8.0	480	9.20	28.21	4.85	5.93	4.97	6.29	4.32	4.47
9.0	540	10.35	35.09	5.45	7.38	5.59	7.83	4.86	5.56
10.0	600	11.50	42.65	6.06	8.96	6.21	9.52	5.40	6.76
11.0	660	12.65	50.89	6.67	10.70	6.83	11.35	5.94	8.06
12.0	720	13.80	59.78	7.27	12.57	7.45	13.34	6.48	9.47
13.0	780			7.88	14.57	8.07	15.47	7.02	10.99
14.0	840			8.48	16.72	8.70	17.75	7.56	12.61
15.0	900			9.09	19.00	9.32	20.16	8.10	14.32
16.0	960			9.70	21.41	9.94	22.72	8.64	16.14
17.0	1,020			10.30	23.95	10.56	25.42	9.17	18.06
18.0	1,080			10.91	26.63	11.18	28.26	9.71	20.08
19.0	1,140			11.51	29.43	11.80	31.24	10.25	22.19
20.0	1,200			12.12	32.36	12.42	34.35	10.79	24.40
22.0	1,320			13.33	38.61	13.66	40.98	11.87	29.11
24.0	1,440			14.55	45.36	14.91	48.15	12.95	34.20
26.0	1,560			15.76	52.61	16.15	55.84	14.03	39.67
28.0	1,680			16.97	60.35			15.11	45.51
30.0	1,800							16.19	51.71
32.0	1,920							17.27	58.27

Friction losses are calculated using Hazen-Williams equation (C = 140) and minimum inside diameter. See page 194 for friction loss formulas.

# FRICITION LOSS CHARACTERISTICS

## POLYETHYLENE (PE) PLASTIC PIPE ID CONTROLLED

Size: 1/2" thru 4"      Flow: 1 thru 500GPM

PE 3408 ASTM D-2239 C=140      PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

Size	1/2"		3/4"		1"		1 1/4"		1 1/2"		2"		2 1/2"		3"		4"	
Avg ID	0.622		0.824		1.049		1.380		1.610		2.067		2.469		3.068		4.026	
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
1	1.05	0.49	0.60	0.12	0.37	0.04	0.21	0.01	0.16	0.00								
2	2.11	1.76	1.20	0.45	0.74	0.14	0.43	0.04	0.31	0.02	0.19	0.01						
3	3.16	3.73	1.80	0.95	1.11	0.29	0.64	0.08	0.47	0.04	0.29	0.01						
4	4.22	6.35	2.40	1.62	1.48	0.50	0.86	0.13	0.63	0.06	0.38	0.02	0.27	0.01				
5	5.27	9.60	3.00	2.44	1.85	0.76	1.07	0.20	0.79	0.09	0.48	0.03	0.33	0.01				
6	6.33	13.46	3.61	3.43	2.22	1.06	1.29	0.28	0.94	0.13	0.57	0.04	0.40	0.02	0.26	0.01		
7	7.38	17.91	4.21	4.56	2.60	1.41	1.50	0.37	1.10	0.18	0.67	0.05	0.47	0.02	0.30	0.01		
8	8.44	22.93	4.81	5.84	2.97	1.80	1.71	0.47	1.26	0.22	0.76	0.07	0.54	0.03	0.35	0.01		
9	9.49	28.52	5.41	7.26	3.34	2.24	1.93	0.59	1.42	0.28	0.86	0.08	0.60	0.03	0.39	0.01		
10	10.55	34.67	6.01	8.82	3.71	2.73	2.14	0.72	1.57	0.34	0.95	0.10	0.67	0.04	0.43	0.01		
12			7.21	12.37	4.45	3.82	2.57	1.01	1.89	0.48	1.15	0.14	0.80	0.06	0.52	0.02		
14			8.41	16.45	5.19	5.08	3.00	1.34	2.20	0.63	1.34	0.19	0.94	0.08	0.61	0.03		
16			9.61	21.07	5.93	6.51	3.43	1.71	2.52	0.81	1.53	0.24	1.07	0.10	0.69	0.04	0.40	0.01
18			10.82	26.21	6.67	8.10	3.86	2.13	2.83	1.01	1.72	0.30	1.20	0.13	0.78	0.04	0.45	0.01
20			12.02	31.85	7.42	9.84	4.28	2.59	3.15	1.22	1.91	0.36	1.34	0.15	0.87	0.05	0.50	0.01
22					8.16	11.74	4.71	3.09	3.46	1.46	2.10	0.43	1.47	0.18	0.95	0.06	0.55	0.02
24					8.90	13.79	5.14	3.63	3.78	1.72	2.29	0.51	1.61	0.21	1.04	0.07	0.60	0.02
26					9.64	16.00	5.57	4.21	4.09	1.99	2.48	0.59	1.74	0.25	1.13	0.09	0.65	0.02
28					10.38	18.35	6.00	4.83	4.41	2.28	2.67	0.68	1.87	0.28	1.21	0.10	0.70	0.03
30					11.12	20.85	6.43	5.49	4.72	2.59	2.86	0.77	2.01	0.32	1.30	0.11	0.76	0.03
32					11.86	23.50	6.86	6.19	5.04	2.92	3.06	0.87	2.14	0.36	1.39	0.13	0.81	0.03
34					12.61	26.29	7.28	6.92	5.35	3.27	3.25	0.97	2.28	0.41	1.47	0.14	0.86	0.04
36							7.71	7.69	5.67	3.63	3.44	1.08	2.41	0.45	1.56	0.16	0.91	0.04
38							8.14	8.50	5.98	4.02	3.63	1.19	2.54	0.50	1.65	0.17	0.96	0.05
40							8.57	9.35	6.30	4.42	3.82	1.31	2.68	0.55	1.73	0.19	1.01	0.05
42							9.00	10.24	6.61	4.83	4.01	1.43	2.81	0.60	1.82	0.21	1.06	0.06
44							9.43	11.16	6.93	5.27	4.20	1.56	2.94	0.66	1.91	0.23	1.11	0.06
46							9.86	12.12	7.24	5.72	4.39	1.70	3.08	0.71	1.99	0.25	1.16	0.07
48							10.28	13.11	7.56	6.19	4.58	1.84	3.21	0.77	2.08	0.27	1.21	0.07
50							10.71	14.14	7.87	6.68	4.77	1.98	3.35	0.83	2.17	0.29	1.26	0.08
55							11.78	16.87	8.66	7.97	5.25	2.36	3.68	0.99	2.38	0.35	1.38	0.09
60							12.85	19.82	9.44	9.36	5.73	2.77	4.02	1.17	2.60	0.41	1.51	0.11
65									10.23	10.86	6.21	3.22	4.35	1.36	2.82	0.47	1.64	0.13
70									11.02	12.45	6.68	3.69	4.69	1.55	3.03	0.54	1.76	0.14
75									11.81	14.15	7.16	4.19	5.02	1.77	3.25	0.61	1.89	0.16
80									12.59	15.95	7.64	4.73	5.35	1.99	3.47	0.69	2.01	0.18
85									13.38	17.84	8.12	5.29	5.69	2.23	3.68	0.77	2.14	0.21
90											8.59	5.88	6.02	2.48	3.90	0.86	2.27	0.23
95											9.07	6.50	6.36	2.74	4.12	0.95	2.39	0.25
100											9.55	7.15	6.69	3.01	4.33	1.05	2.52	0.28
110											10.50	8.53	7.36	3.59	4.77	1.25	2.77	0.33
120											11.46	10.02	8.03	4.22	5.20	1.47	3.02	0.39
130											12.41	11.62	8.70	4.89	5.63	1.70	3.27	0.45
140											13.37	13.33	9.37	5.61	6.07	1.95	3.52	0.52
150													10.04	6.38	6.50	2.22	3.78	0.59
160													10.71	7.19	6.94	2.50	4.03	0.67
170													11.38	8.04	7.37	2.79	4.28	0.74
180													12.05	8.94	7.80	3.11	4.53	0.83
190													12.72	9.88	8.24	3.43	4.78	0.92
200													13.39	10.87	8.67	3.78	5.03	1.01
220															9.54	4.50	5.54	1.20
240															10.40	5.29	6.04	1.41
260															11.27	6.14	6.54	1.64
280															12.14	7.04	7.05	1.88
300															13.00	8.00	7.55	2.13
320															13.87	9.02	8.05	2.40
340																	8.56	2.69
360																	9.06	2.99
380																	9.57	3.30
400																	10.07	3.63
420																	10.57	3.98
440																	11.08	4.33
460																	11.58	4.71
480																	12.08	5.09
500																	12.59	5.49

See page 194 for friction loss formulas.

# FRICITION LOSS CHARACTERISTICS

## PVC CLASS 160 IPS PLASTIC PIPE

Size: ½" thru 6" Flow: 1 thru 500GPM

ASTM D-2241 (1120, 1220) SDR 26 C=150 PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	1"		1¼"		1½"		2"		2½"		3"		4"		6"	
Avg.ID	1.175		1.512		1.734		2.173		2.635		3.210		4.134		6.084	
Pipe OD	1.315		1.660		1.900		2.375		2.875		3.500		4.500		6.625	
Avg Wall	0.070		0.074		0.083		0.101		0.120		0.145		0.183		0.271	
MinWall	0.060		0.064		0.073		0.091		0.110		0.135		0.173		0.255	
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
1	0.30	0.02	0.18	0.01	0.14	0.00										
2	0.59	0.07	0.36	0.02	0.27	0.01	0.17	0.00								
3	0.89	0.15	0.54	0.04	0.41	0.02	0.26	0.01								
4	1.18	0.25	0.71	0.07	0.54	0.04	0.35	0.01	0.24	0.00						
5	1.48	0.38	0.89	0.11	0.68	0.06	0.43	0.02	0.29	0.01						
6	1.77	0.54	1.07	0.16	0.81	0.08	0.52	0.03	0.35	0.01	0.24	0.00				
7	2.07	0.71	1.25	0.21	0.95	0.11	0.60	0.04	0.41	0.01	0.28	0.01				
8	2.36	0.91	1.43	0.27	1.09	0.14	0.69	0.05	0.47	0.02	0.32	0.01				
9	2.66	1.14	1.61	0.33	1.22	0.17	0.78	0.06	0.53	0.02	0.36	0.01				
10	2.96	1.38	1.78	0.40	1.36	0.21	0.86	0.07	0.59	0.03	0.40	0.01				
12	3.55	1.94	2.14	0.57	1.63	0.29	1.04	0.10	0.71	0.04	0.48	0.01				
14	4.14	2.58	2.50	0.76	1.90	0.39	1.21	0.13	0.82	0.05	0.55	0.02				
16	4.73	3.30	2.86	0.97	2.17	0.50	1.38	0.17	0.94	0.06	0.63	0.02	0.38	0.01		
18	5.32	4.10	3.21	1.20	2.44	0.62	1.56	0.21	1.06	0.08	0.71	0.03	0.43	0.01		
20	5.91	4.99	3.57	1.46	2.71	0.75	1.73	0.25	1.18	0.10	0.79	0.04	0.48	0.01		
22	6.50	5.95	3.93	1.74	2.99	0.90	1.90	0.30	1.29	0.12	0.87	0.04	0.53	0.01		
24	7.09	6.99	4.28	2.05	3.26	1.05	2.07	0.35	1.41	0.14	0.95	0.05	0.57	0.02		
26	7.68	8.11	4.64	2.38	3.53	1.22	2.25	0.41	1.53	0.16	1.03	0.06	0.62	0.02		
28	8.27	9.30	5.00	2.73	3.80	1.40	2.42	0.47	1.65	0.18	1.11	0.07	0.67	0.02		
30	8.87	10.57	5.35	3.10	4.07	1.59	2.59	0.53	1.76	0.21	1.19	0.08	0.72	0.02		
32	9.46	11.91	5.71	3.49	4.34	1.79	2.76	0.60	1.88	0.23	1.27	0.09	0.76	0.03	0.35	0.00
34	10.05	13.32	6.07	3.91	4.61	2.01	2.94	0.67	2.00	0.26	1.35	0.10	0.81	0.03	0.37	0.00
36	10.64	14.81	6.42	4.34	4.88	2.23	3.11	0.74	2.12	0.29	1.43	0.11	0.86	0.03	0.40	0.00
38	11.23	16.37	6.78	4.80	5.16	2.46	3.28	0.82	2.23	0.32	1.50	0.12	0.91	0.04	0.42	0.01
40	11.82	18.00	7.14	5.28	5.43	2.71	3.46	0.90	2.35	0.35	1.58	0.14	0.95	0.04	0.44	0.01
42	12.41	19.70	7.50	5.78	5.70	2.97	3.63	0.99	2.47	0.39	1.66	0.15	1.00	0.04	0.46	0.01
44	13.00	21.47	7.85	6.30	5.97	3.23	3.80	1.08	2.59	0.42	1.74	0.16	1.05	0.05	0.48	0.01
46	13.59	23.32	8.21	6.84	6.24	3.51	3.97	1.17	2.70	0.46	1.82	0.18	1.10	0.05	0.51	0.01
48	14.18	25.23	8.57	7.40	6.51	3.80	4.15	1.27	2.82	0.50	1.90	0.19	1.15	0.06	0.53	0.01
50	14.78	27.21	8.92	7.98	6.78	4.10	4.32	1.37	2.94	0.53	1.98	0.20	1.19	0.06	0.55	0.01
55			9.82	9.52	7.46	4.89	4.75	1.63	3.23	0.64	2.18	0.24	1.31	0.07	0.61	0.01
60			10.71	11.18	8.14	5.74	5.18	1.91	3.53	0.75	2.38	0.29	1.43	0.08	0.66	0.01
65			11.60	12.97	8.82	6.66	5.62	2.22	3.82	0.87	2.57	0.33	1.55	0.10	0.72	0.01
70			12.49	14.88	9.50	7.64	6.05	2.55	4.11	1.00	2.77	0.38	1.67	0.11	0.77	0.02
75			13.38	16.90	10.18	8.68	6.48	2.89	4.41	1.13	2.97	0.43	1.79	0.13	0.83	0.02
80			14.28	19.05	10.86	9.78	6.91	3.26	4.70	1.28	3.17	0.49	1.91	0.14	0.88	0.02
85					11.53	10.94	7.34	3.65	4.99	1.43	3.37	0.55	2.03	0.16	0.94	0.02
90					12.21	12.16	7.78	4.06	5.29	1.59	3.56	0.61	2.15	0.18	0.99	0.03
95					12.89	13.45	8.21	4.48	5.58	1.76	3.76	0.67	2.27	0.20	1.05	0.03
100					13.57	14.79	8.64	4.93	5.88	1.93	3.96	0.74	2.39	0.22	1.10	0.03
110					14.93	17.64	9.50	5.88	6.46	2.30	4.36	0.88	2.63	0.26	1.21	0.04
120							10.37	6.91	7.05	2.71	4.75	1.04	2.86	0.30	1.32	0.05
130							11.23	8.02	7.64	3.14	5.15	1.20	3.10	0.35	1.43	0.05
140							12.10	9.20	8.23	3.60	5.54	1.38	3.34	0.40	1.54	0.06
150							12.96	10.45	8.81	4.09	5.94	1.57	3.58	0.46	1.65	0.07
160							13.82	11.77	9.40	4.61	6.34	1.76	3.82	0.52	1.76	0.08
170							14.69	13.17	9.99	5.16	6.73	1.97	4.06	0.58	1.87	0.09
180									10.58	5.73	7.13	2.19	4.30	0.64	1.98	0.10
190									11.16	6.34	7.52	2.42	4.54	0.71	2.09	0.11
200									11.75	6.97	7.92	2.67	4.77	0.78	2.20	0.12
220									12.93	8.31	8.71	3.18	5.25	0.93	2.42	0.14
240									14.10	9.77	9.50	3.74	5.73	1.09	2.65	0.17
260											10.29	4.33	6.21	1.27	2.87	0.19
280											11.09	4.97	6.68	1.45	3.09	0.22
300											11.88	5.65	7.16	1.65	3.31	0.25
320											12.67	6.37	7.64	1.86	3.53	0.28
340											13.46	7.12	8.12	2.08	3.75	0.32
360											14.25	7.92	8.59	2.31	3.97	0.35
380													9.07	2.56	4.19	0.39
400													9.55	2.81	4.41	0.43
420													10.30	3.08	4.63	0.47
440													10.50	3.35	4.85	0.51
460													10.98	3.64	5.07	0.56
480													11.46	3.94	5.29	0.60
500													11.94	4.25	5.51	0.65

See page 194 for friction loss formulas.









# FRICION LOSS CHARACTERISTICS

## SCHEDULE 40 PVC IPS PLASTIC PIPE

Size: 4" thru 12" Flow: 10 thru 3000GPM

ASTM D1785 C=150 PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	4"		6"		8"		10"		12"	
Avg.ID	3.998		6.031		7.942		9.976		11.889	
Pipe OD	4.500		6.625		8.625		10.750		12.750	
Avg Wall	0.251		0.297		0.342		0.387		0.431	
Min Wall	0.237		0.280		0.322		0.365		0.406	
Flow GPM	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss
10	0.26	0.00	0.11	0.00	0.06	0.00	0.04	0.00	0.03	0.00
20	0.51	0.01	0.22	0.00	0.13	0.00	0.08	0.00	0.06	0.00
30	0.77	0.03	0.34	0.00	0.19	0.00	0.12	0.00	0.09	0.00
40	1.02	0.05	0.45	0.01	0.26	0.00	0.16	0.00	0.12	0.00
50	1.28	0.07	0.56	0.01	0.32	0.00	0.20	0.00	0.14	0.00
60	1.53	0.10	0.67	0.01	0.39	0.00	0.25	0.00	0.17	0.00
70	1.79	0.13	0.79	0.02	0.45	0.00	0.29	0.00	0.20	0.00
80	2.04	0.17	0.90	0.02	0.52	0.01	0.33	0.00	0.23	0.00
90	2.30	0.21	1.01	0.03	0.58	0.01	0.37	0.00	0.26	0.00
100	2.55	0.25	1.12	0.03	0.65	0.01	0.41	0.00	0.29	0.00
120	3.06	0.36	1.35	0.05	0.78	0.01	0.49	0.00	0.35	0.00
140	3.57	0.47	1.57	0.06	0.91	0.02	0.57	0.01	0.40	0.00
160	4.08	0.61	1.79	0.08	1.03	0.02	0.66	0.01	0.46	0.00
180	4.59	0.75	2.02	0.10	1.16	0.03	0.74	0.01	0.52	0.00
200	5.11	0.92	2.24	0.12	1.29	0.03	0.82	0.01	0.58	0.00
225	5.74	1.14	2.52	0.15	1.46	0.04	0.92	0.01	0.65	0.01
250	6.38	1.39	2.80	0.19	1.62	0.05	1.02	0.02	0.72	0.01
275	7.02	1.65	3.08	0.22	1.78	0.06	1.13	0.02	0.79	0.01
300	7.66	1.94	3.37	0.26	1.94	0.07	1.23	0.02	0.87	0.01
325	8.30	2.25	3.65	0.30	2.10	0.08	1.33	0.03	0.94	0.01
350	8.93	2.58	3.93	0.35	2.26	0.09	1.43	0.03	1.01	0.01
375			4.21	0.40	2.43	0.10	1.54	0.03	1.08	0.01
400			4.49	0.45	2.59	0.12	1.64	0.04	1.15	0.02
425			4.77	0.50	2.75	0.13	1.74	0.04	1.23	0.02
450			5.05	0.56	2.91	0.15	1.84	0.05	1.30	0.02
475			5.33	0.62	3.07	0.16	1.95	0.05	1.37	0.02
500			5.61	0.68	3.23	0.18	2.05	0.06	1.44	0.02
550			6.17	0.81	3.56	0.21	2.25	0.07	1.59	0.03
600			6.73	0.95	3.88	0.25	2.46	0.08	1.73	0.03
650			7.29	1.10	4.20	0.29	2.66	0.09	1.88	0.04
700			7.85	1.26	4.53	0.33	2.87	0.11	2.02	0.05
750					4.85	0.38	3.07	0.12	2.16	0.05
800					5.17	0.42	3.28	0.14	2.31	0.06
850					5.50	0.47	3.48	0.16	2.45	0.07
900					5.82	0.53	3.69	0.17	2.60	0.07
950					6.15	0.58	3.89	0.19	2.74	0.08
1000					6.47	0.64	4.10	0.21	2.89	0.09
1050					6.79	0.70	4.30	0.23	3.03	0.10
1150					7.44	0.83	4.71	0.27	3.32	0.12
1200					7.76	0.90	4.92	0.30	3.46	0.13
1250							5.12	0.32	3.61	0.14
1300							5.33	0.34	3.75	0.15
1350							5.53	0.37	3.90	0.16
1400							5.74	0.39	4.04	0.17
1500							6.15	0.45	4.33	0.19
1550							6.35	0.47	4.47	0.20
1600							6.56	0.50	4.62	0.21
1650							6.76	0.53	4.76	0.23
1700							6.97	0.56	4.91	0.24
1750							7.17	0.59	5.05	0.25
1800									5.20	0.27
1850									5.34	0.28
1900									5.48	0.29
1950									5.63	0.31
2000									5.77	0.32
2100									6.06	0.35
2200									6.35	0.39
2300									6.64	0.42
2400									6.93	0.45
2500									7.22	0.49
2600										
2700										
2800										
2900										
3000										

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

See page 194 for friction loss formulas.



# FRICION LOSS CHARACTERISTICS

## SCHEDULE 80 PVC IPS PLASTIC PIPE

Size: 4" thru 12" Flow: 10 thru 3000GPM

ASTM D1785 C=150 PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	4"		6"		8"		10"		12"	
Avg.ID	3.786		5.709		7.565		9.493		11.294	
Pipe OD	4.500		6.625		8.625		10.750		12.750	
Avg Wall	0.357		0.458		0.530		0.629		0.728	
Min Wall	0.337		0.432		0.500		0.593		0.687	
Flow GPM	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss
10	0.28	0.00	0.13	0.00	0.07	0.00	0.05	0.00	0.03	0.00
20	0.57	0.02	0.25	0.00	0.14	0.00	0.09	0.00	0.06	0.00
30	0.85	0.04	0.38	0.00	0.21	0.00	0.14	0.00	0.10	0.00
40	1.14	0.06	0.50	0.01	0.29	0.00	0.18	0.00	0.13	0.00
50	1.42	0.09	0.63	0.01	0.36	0.00	0.23	0.00	0.16	0.00
60	1.71	0.13	0.75	0.02	0.43	0.00	0.27	0.00	0.19	0.00
70	1.99	0.17	0.88	0.02	0.50	0.01	0.32	0.00	0.22	0.00
80	2.28	0.22	1.00	0.03	0.57	0.01	0.36	0.00	0.26	0.00
90	2.56	0.27	1.13	0.04	0.64	0.01	0.41	0.00	0.29	0.00
100	2.85	0.33	1.25	0.04	0.71	0.01	0.45	0.00	0.32	0.00
120	3.42	0.46	1.50	0.06	0.86	0.02	0.54	0.01	0.38	0.00
140	3.98	0.62	1.75	0.08	1.00	0.02	0.63	0.01	0.45	0.00
160	4.55	0.79	2.00	0.11	1.14	0.03	0.72	0.01	0.51	0.00
180	5.12	0.98	2.25	0.13	1.28	0.03	0.81	0.01	0.58	0.00
200	5.69	1.19	2.50	0.16	1.43	0.04	0.91	0.01	0.64	0.01
225	6.40	1.49	2.82	0.20	1.60	0.05	1.02	0.02	0.72	0.01
250	7.12	1.81	3.13	0.24	1.78	0.06	1.13	0.02	0.80	0.01
275	7.83	2.15	3.44	0.29	1.96	0.07	1.25	0.02	0.88	0.01
300	8.54	2.53	3.76	0.34	2.14	0.09	1.36	0.03	0.96	0.01
325	9.25	2.94	4.07	0.40	2.32	0.10	1.47	0.03	1.04	0.01
350	9.96	3.37	4.38	0.46	2.50	0.12	1.58	0.04	1.12	0.02
375			4.69	0.52	2.67	0.13	1.70	0.04	1.20	0.02
400			5.01	0.58	2.85	0.15	1.81	0.05	1.28	0.02
425			5.32	0.65	3.03	0.17	1.92	0.06	1.36	0.02
450			5.63	0.73	3.21	0.18	2.04	0.06	1.44	0.03
475			5.95	0.80	3.39	0.20	2.15	0.07	1.52	0.03
500			6.26	0.88	3.56	0.22	2.26	0.07	1.60	0.03
550			6.88	1.05	3.92	0.27	2.49	0.09	1.76	0.04
600			7.51	1.24	4.28	0.31	2.72	0.10	1.92	0.04
650			8.14	1.44	4.63	0.36	2.94	0.12	2.08	0.05
700			8.76	1.65	4.99	0.42	3.17	0.14	2.24	0.06
750					5.35	0.48	3.40	0.16	2.40	0.07
800					5.70	0.54	3.62	0.18	2.56	0.08
850					6.06	0.60	3.85	0.20	2.72	0.09
900					6.42	0.67	4.07	0.22	2.88	0.09
950					6.77	0.74	4.30	0.24	3.04	0.10
1000					7.13	0.81	4.53	0.27	3.20	0.12
1050					7.49	0.89	4.75	0.29	3.36	0.13
1150					8.20	1.05	5.21	0.35	3.68	0.15
1200					8.56	1.14	5.43	0.38	3.84	0.16
1250							5.66	0.41	4.00	0.17
1300							5.89	0.44	4.16	0.19
1350							6.11	0.47	4.32	0.20
1400							6.34	0.50	4.48	0.22
1500							6.79	0.57	4.80	0.24
1550							7.02	0.60	4.96	0.26
1600							7.24	0.64	5.12	0.28
1650							7.47	0.68	5.28	0.29
1700							7.70	0.72	5.44	0.31
1750							7.92	0.76	5.60	0.33
1800									5.76	0.34
1850									5.92	0.36
1900									6.08	0.38
1950									6.24	0.40
2000									6.40	0.42
2100									6.72	0.46
2200									7.04	0.50
2300									7.36	0.54
2400									7.68	0.58
2500									8.00	0.63
2600										
2700										
2800										
2900										
3000										

See page 194 for friction loss formulas.

# FRICITION LOSS CHARACTERISTICS

## TYPE 'K' COPPER TUBING

Size: 1/2" thru 3"      Flow: 1 thru 600 GPM  
 ASTM B 88 C=140    PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	1/2"		5/8"		3/4"		1"		1 1/4"		1 1/2"		2"		2 1/2"		3"					
Avg ID	0.527		0.652		0.745		0.995		1.245		1.481		1.959		2.435		2.907					
Pipe OD	0.625		0.750		0.875		1.125		1.375		1.625		2.125		2.625		3.125					
Avg Wall	0.049		0.049		0.065		0.065		0.065		0.072		0.083		0.095		0.109					
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				
1	1.47	1.09	0.96	0.39	0.74	0.20	0.41	0.05	0.26	0.02												
2	2.94	3.94	1.92	1.40	1.47	0.73	0.82	0.18	0.53	0.06												
3	4.41	8.35	2.88	2.97	2.21	1.55	1.24	0.38	0.79	0.13												
4	5.88	14.23	3.84	5.05	2.94	2.64	1.65	0.65	1.05	0.22												
5	7.35	21.51	4.80	7.64	3.68	3.99	2.06	0.98	1.32	0.33												
6	8.81	30.15	5.76	10.70	4.41	5.59	2.47	1.37	1.58	0.46	1.12	0.20										
7	10.28	40.12	6.72	14.24	5.15	7.44	2.88	1.82	1.84	0.61	1.30	0.26										
8	11.75	51.37	7.68	18.24	5.88	9.53	3.30	2.33	2.11	0.78	1.49	0.34										
9	13.22	63.90	8.64	22.68	6.62	11.85	3.71	2.90	2.37	0.97	1.67	0.42										
10	14.69	77.66	9.60	27.57	7.35	14.41	4.12	3.52	2.63	1.18	1.86	0.51										
12			11.52	38.64	8.82	20.20	4.95	4.94	3.16	1.66	2.23	0.71	1.28	0.18								
14			13.44	51.41	10.29	26.87	5.77	6.57	3.69	2.21	2.60	0.95	1.49	0.24								
16			15.36	65.83	11.76	34.41	6.59	8.42	4.21	2.83	2.98	1.22	1.70	0.31								
18			17.28	81.88	13.23	42.80	7.42	10.47	4.74	3.52	3.35	1.51	1.91	0.39								
20					14.70	52.02	8.24	12.72	5.26	4.28	3.72	1.84	2.13	0.47								
22					16.17	62.06	9.07	15.18	5.79	5.10	4.09	2.19	2.34	0.56	1.51	0.19	1.06	0.08				
24					17.64	72.91	9.89	17.84	6.32	5.99	4.46	2.58	2.55	0.66	1.65	0.23	1.16	0.10				
26							10.71	20.69	6.84	6.95	4.84	2.99	2.76	0.77	1.79	0.27	1.26	0.11				
28							11.54	23.73	7.37	7.97	5.21	3.43	2.98	0.88	1.93	0.30	1.35	0.13				
30							12.36	26.96	7.90	9.06	5.58	3.89	3.19	1.00	2.06	0.35	1.45	0.15				
32							13.19	30.39	8.42	10.21	5.95	4.39	3.40	1.12	2.20	0.39	1.54	0.16				
34							14.01	34.00	8.95	11.42	6.32	4.91	3.61	1.26	2.34	0.44	1.64	0.18				
36							14.84	37.79	9.48	12.70	6.70	5.46	3.83	1.40	2.48	0.49	1.74	0.20				
38							15.66	41.77	10.00	14.04	7.07	6.03	4.04	1.55	2.61	0.54	1.83	0.23				
40							16.48	45.94	10.53	15.43	7.44	6.63	4.25	1.70	2.75	0.59	1.93	0.25				
42							17.31	50.28	11.06	16.89	7.81	7.26	4.47	1.86	2.89	0.65	2.03	0.27				
44									11.58	18.41	8.18	7.91	4.68	2.03	3.03	0.70	2.12	0.30				
46									12.11	19.99	8.56	8.59	4.89	2.20	3.17	0.76	2.22	0.32				
48									12.63	21.63	8.93	9.30	5.10	2.38	3.30	0.83	2.32	0.35				
50									13.16	23.33	9.30	10.03	5.32	2.57	3.44	0.89	2.41	0.38				
55									14.48	27.84	10.23	11.96	5.85	3.07	3.78	1.06	2.66	0.45				
60									15.79	32.70	11.16	14.05	6.38	3.60	4.13	1.25	2.90	0.53				
65									17.11	37.93	12.09	16.30	6.91	4.18	4.47	1.45	3.14	0.61				
70									18.43	43.51	13.02	18.70	7.44	4.79	4.82	1.66	3.38	0.70				
75											13.95	21.24	7.97	5.45	5.16	1.89	3.62	0.80				
80									14.88	23.94	8.51	6.14	5.50	2.13	5.50	2.13	3.86	0.90				
85									15.81	26.79	9.04	6.87	5.85	2.38	4.10	1.01	4.10	1.01				
90									16.74	29.78	9.57	7.63	6.19	2.65	4.35	1.12	4.35	1.12				
95									17.67	32.91	10.10	8.44	6.54	2.93	4.59	1.24	4.59	1.24				
100									18.60	36.19	10.63	9.28	6.88	3.22	4.83	1.36	4.83	1.36				
110			Shaded area represents velocities over 7 fps. Use with caution, where water hammer is a concern.										11.69	11.07	7.57	3.84	5.31	1.62				
120																12.76	13.01	8.26	4.51	5.79	1.91	
130																13.82	15.08	8.95	5.23	6.28	2.21	
140																14.88	17.30	9.63	6.00	6.76	2.54	
150																15.95	19.66	10.32	6.82	7.24	2.88	
160											17.01	22.16	11.01	7.69	7.72	3.25						
170											18.07	24.79	11.70	8.60	8.21	3.63						
180													12.39	9.56	8.69	4.04						
190													13.07	10.57	9.17	4.46						
200													13.76	11.62	9.66	4.91						
220													15.14	13.87	10.62	5.86						
240													16.51	16.29	11.59	6.88						
260													17.89	18.90	12.55	7.98						
280													19.27	21.68	13.52	9.15						
300															14.48	10.40						
320																15.45	11.72					
340																16.42	13.11					
360																17.38	14.58					
380																18.35	16.11					
400																						
420																						
440																						
460																						
480																						
500																						

See page 194 for friction loss formulas.

# FRICITION LOSS CHARACTERISTICS

## TYPE 'L' COPPER TUBING

Size: 1/2" thru 3"      Flow: 1 thru 500GPM  
 C=140 PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	1/2"		5/8"		3/4"		1"		1"		1 1/2"		2"		2 1/2"		3"	
Avg.ID	0.545		0.666		0.785		1.025		1.265		1.505		1.985		2.465		2.945	
Pipe OD	0.625		0.750		0.875		1.125		1.375		1.625		2.125		2.625		3.125	
Avg Wall	0.040		0.042		0.045		0.050		0.055		0.060		0.070		0.080		0.090	
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
1	1.37	0.93	0.92	0.35	0.66	0.16	0.39	0.04	0.25	0.02								
2	2.75	3.35	1.84	1.26	1.32	0.57	0.78	0.15	0.51	0.06								
3	4.12	7.09	2.76	2.67	1.99	1.20	1.17	0.33	0.76	0.12								
4	5.49	12.09	3.68	4.56	2.65	2.05	1.55	0.56	1.02	0.20								
5	6.87	18.27	4.60	6.89	3.31	3.09	1.94	0.85	1.27	0.30								
6	8.24	25.61	5.52	9.65	3.97	4.34	2.33	1.18	1.53	0.43	1.08	0.18						
7	9.62	34.07	6.44	12.84	4.63	5.77	2.72	1.58	1.78	0.57	1.26	0.24						
8	10.99	43.63	7.36	16.45	5.30	7.39	3.11	2.02	2.04	0.72	1.44	0.31						
9	12.36	54.26	8.28	20.45	5.96	9.19	3.50	2.51	2.29	0.90	1.62	0.39						
10	13.74	65.95	9.20	24.86	6.62	11.17	3.88	3.05	2.55	1.10	1.80	0.47						
12			11.04	34.85	7.95	15.66	4.66	4.28	3.06	1.54	2.16	0.66	1.24	0.17				
14			12.88	46.36	9.27	20.83	5.44	5.69	3.57	2.04	2.52	0.88	1.45	0.23				
16			14.72	59.37	10.59	26.68	6.21	7.28	4.08	2.62	2.88	1.12	1.66	0.29				
18			16.56	73.84	11.92	33.18	6.99	9.06	4.59	3.25	3.24	1.40	1.86	0.36				
20					13.24	40.33	7.77	11.01	5.10	3.96	3.60	1.70	2.07	0.44				
22					14.57	48.11	8.54	13.14	5.61	4.72	3.96	2.03	2.28	0.53	1.48	0.18	1.03	0.08
24					15.89	56.53	9.32	15.44	6.12	5.55	4.32	2.38	2.49	0.62	1.61	0.22	1.13	0.09
26							10.10	17.90	6.63	6.43	4.68	2.76	2.69	0.72	1.75	0.25	1.22	0.11
28							10.87	20.54	7.14	7.38	5.04	3.17	2.90	0.82	1.88	0.29	1.32	0.12
30							11.65	23.33	7.65	8.38	5.40	3.60	3.11	0.94	2.01	0.33	1.41	0.14
32							12.43	26.30	8.16	9.45	5.76	4.06	3.31	1.05	2.15	0.37	1.51	0.15
34							13.20	29.42	8.67	10.57	6.12	4.54	3.52	1.18	2.28	0.41	1.60	0.17
36							13.98	32.71	9.18	11.75	6.48	5.05	3.73	1.31	2.42	0.46	1.69	0.19
38							14.76	36.15	9.69	12.99	6.84	5.58	3.93	1.45	2.55	0.51	1.79	0.21
40							15.53	39.75	10.20	14.28	7.21	6.13	4.14	1.59	2.69	0.56	1.88	0.23
42							16.31	43.51	10.71	15.63	7.57	6.71	4.35	1.75	2.82	0.61	1.98	0.26
44									11.22	17.04	7.93	7.32	4.56	1.90	2.95	0.66	2.07	0.28
46									11.73	18.50	8.29	7.94	4.76	2.07	3.09	0.72	2.16	0.30
48									12.24	20.02	8.65	8.60	4.97	2.24	3.22	0.78	2.26	0.33
50									12.75	21.59	9.01	9.27	5.18	2.41	3.36	0.84	2.35	0.35
55									14.02	25.76	9.91	11.06	5.70	2.88	3.69	1.00	2.59	0.42
60									15.30	30.26	10.81	13.00	6.21	3.38	4.03	1.18	2.82	0.50
65									16.57	35.10	11.71	15.07	6.73	3.92	4.36	1.37	3.06	0.57
70									17.85	40.26	12.61	17.29	7.25	4.50	4.70	1.57	3.29	0.66
75											13.51	19.65	7.77	5.11	5.04	1.78	3.53	0.75
80											14.41	22.14	8.28	5.76	5.37	2.01	3.76	0.84
85											15.31	24.77	8.80	6.44	5.71	2.25	4.00	0.94
90											16.21	27.54	9.32	7.16	6.04	2.50	4.23	1.05
95											17.11	30.44	9.84	7.91	6.38	2.76	4.47	1.16
100											18.01	33.47	10.35	8.70	6.71	3.03	4.70	1.28
110													11.39	10.38	7.39	3.62	5.17	1.52
120													12.43	12.20	8.06	4.25	5.65	1.79
130													13.46	14.15	8.73	4.93	6.12	2.07
140													14.50	16.23	9.40	5.66	6.59	2.38
150													15.53	18.44	10.07	6.43	7.06	2.70
160													16.57	20.78	10.74	7.24	7.53	3.05
170													17.60	23.25	11.41	8.11	8.00	3.41
180															12.09	9.01	8.47	3.79
190															12.76	9.96	8.94	4.19
200															13.43	10.95	9.41	4.61
220															14.77	13.07	10.35	5.50
240															16.12	15.35	11.29	6.46
260															17.46	17.80	12.23	7.49
280															18.80	20.42	13.17	8.59
300																	14.11	9.76
320																	15.05	11.00
340																	15.99	12.31
360																	16.94	13.69
380																	17.88	15.13
400																		
420																		
440																		
460																		
480																		
500																		

Shaded area represents velocities over 7 fps.  
 Use with caution, where water hammer is a concern.



# FRICITION LOSS CHARACTERISTICS

## TYPE 'M' COPPER TUBING

Size: 1/2" thru 3"      Flow: 1 thru 500GPM  
 C=140    PSI LOSS PER 100 FEET OF PIPE (PSI/100 FT)

size	1/2"		5/8"		3/4"		1"		1 1/4"		1 1/2"		2"		2 1/2"		3"	
Avg.ID	0.569		0.690		0.811		1.055		1.291		1.527		2.009		2.495		2.981	
Pipe OD	0.625		0.750		0.875		1.125		1.375		1.625		2.125		2.625		3.125	
Avg Wall	0.028		0.030		0.032		0.035		0.042		0.049		0.058		0.065		0.072	
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
1	1.26	0.75	0.86	0.29	0.62	0.13	0.37	0.04	0.24	0.01								
2	2.52	2.71	1.71	1.06	1.24	0.48	0.73	0.13	0.49	0.05								
3	3.78	5.75	2.57	2.25	1.86	1.03	1.10	0.29	0.73	0.11								
4	5.04	9.80	3.43	3.83	2.48	1.75	1.47	0.49	0.98	0.18								
5	6.30	14.81	4.28	5.80	3.10	2.64	1.83	0.73	1.22	0.27								
6	7.56	20.76	5.14	8.13	3.72	3.70	2.20	1.03	1.47	0.39	1.05	0.17						
7	8.82	27.62	6.00	10.81	4.34	4.92	2.57	1.37	1.71	0.51	1.22	0.23						
8	10.08	35.37	6.86	13.84	4.96	6.31	2.93	1.75	1.96	0.66	1.40	0.29						
9	11.34	44.00	7.71	17.22	5.58	7.84	3.30	2.18	2.20	0.82	1.57	0.36						
10	12.60	53.48	8.57	20.93	6.20	9.53	3.67	2.65	2.45	0.99	1.75	0.44						
12			10.28	29.33	7.44	13.36	4.40	3.72	2.94	1.39	2.10	0.61	1.21	0.16				
14			12.00	39.02	8.68	17.78	5.13	4.94	3.43	1.85	2.45	0.82	1.42	0.22				
16			13.71	49.97	9.93	22.77	5.87	6.33	3.92	2.37	2.80	1.05	1.62	0.28				
18			15.43	62.15	11.17	28.32	6.60	7.87	4.41	2.95	3.15	1.30	1.82	0.34				
20			17.14	75.55	12.41	34.42	7.33	9.57	4.90	3.58	3.50	1.58	2.02	0.42				
22					13.65	41.06	8.06	11.42	5.39	4.28	3.85	1.89	2.22	0.50	1.44	0.17	1.01	0.07
24					14.89	48.24	8.80	13.41	5.88	5.02	4.20	2.22	2.43	0.58	1.57	0.20	1.10	0.09
26							9.53	15.56	6.36	5.83	4.55	2.57	2.63	0.68	1.70	0.24	1.19	0.10
28							10.26	17.85	6.85	6.68	4.90	2.95	2.83	0.78	1.84	0.27	1.29	0.11
30							11.00	20.28	7.34	7.59	5.25	3.35	3.03	0.88	1.97	0.31	1.38	0.13
32							11.73	22.85	7.83	8.56	5.60	3.78	3.23	0.99	2.10	0.35	1.47	0.15
34							12.46	25.57	8.32	9.57	5.95	4.23	3.44	1.11	2.23	0.39	1.56	0.16
36							13.20	28.42	8.81	10.64	6.30	4.70	3.64	1.24	2.36	0.43	1.65	0.18
38							13.93	31.42	9.30	11.76	6.65	5.20	3.84	1.37	2.49	0.48	1.74	0.20
40							14.66	34.55	9.79	12.94	7.00	5.71	4.04	1.50	2.62	0.52	1.84	0.22
42							15.40	37.81	10.28	14.16	7.35	6.26	4.25	1.65	2.75	0.57	1.93	0.24
44									10.77	15.43	7.70	6.82	4.45	1.79	2.88	0.63	2.02	0.26
46									11.26	16.76	8.05	7.40	4.65	1.95	3.01	0.68	2.11	0.29
48									11.75	18.13	8.40	8.01	4.85	2.11	3.15	0.73	2.20	0.31
50									12.24	19.56	8.75	8.64	5.05	2.27	3.28	0.79	2.30	0.33
55									13.46	23.33	9.62	10.31	5.56	2.71	3.60	0.95	2.53	0.40
60									14.69	27.41	10.50	12.11	6.07	3.19	3.93	1.11	2.75	0.47
65									15.91	31.79	11.37	14.04	6.57	3.70	4.26	1.29	2.98	0.54
70									17.14	36.47	12.25	16.11	7.08	4.24	4.59	1.48	3.21	0.62
75											13.12	18.31	7.58	4.82	4.92	1.68	3.44	0.71
80											14.00	20.63	8.09	5.43	5.24	1.89	3.67	0.80
85											14.87	23.08	8.59	6.07	5.57	2.12	3.90	0.89
90											15.75	25.66	9.10	6.75	5.90	2.35	4.13	0.99
95											16.62	28.36	9.60	7.46	6.23	2.60	4.36	1.09
100											17.50	31.19	10.11	8.21	6.55	2.86	4.59	1.20
110													11.12	9.79	7.21	3.41	5.05	1.44
120													12.13	11.51	7.87	4.01	5.51	1.69
130													13.14	13.34	8.52	4.65	5.97	1.96
140													14.15	15.31	9.18	5.33	6.43	2.24
150													15.16	17.39	9.83	6.06	6.89	2.55
160													16.17	19.60	10.49	6.83	7.35	2.87
170													17.18	21.93	11.14	7.64	7.81	3.21
180															11.80	8.50	8.26	3.57
190															12.45	9.39	8.72	3.95
200															13.11	10.33	9.18	4.34
220															14.42	12.32	10.10	5.18
240															15.73	14.47	11.02	6.09
260															17.04	16.79	11.94	7.06
280															18.35	19.25	12.86	8.10
300																	13.77	9.20
320																	14.69	10.37
340																	15.61	11.60
360																	16.53	12.90
380																	17.45	14.26
400																		
420																		
440																		
460																		
480																		
500																		

Shaded area represents velocities over 7 fps.  
 Use with caution, where water hammer is a concern.



# FRICITION LOSS CHARACTERISTICS

## HDPE DR 7 265 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	2.440		3.136		4.589		6.013		7.494		8.890		9.760		11.156		12.550	
Pipe OD	3.500		4.500		6.625		8.625		10.750		12.750		14.000		16.000		18.000	
Avg Wall	0.530		0.682		1.018		1.306		1.628		1.930		2.120		2.422		2.725	
Min Wall	0.500		0.643		0.946		1.232		1.536		1.821		2.000		2.286		2.571	
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	3.43	0.78	2.07	0.23	0.97	0.04	0.56	0.01	0.36	0.00	0.26	0.00	0.21	0.00	0.16	0.00	0.13	0.00
60	4.11	1.09	2.49	0.32	1.16	0.05	0.68	0.01	0.44	0.00	0.31	0.00	0.26	0.00	0.20	0.00	0.16	0.00
70	4.80	1.45	2.90	0.43	1.36	0.07	0.79	0.02	0.51	0.01	0.36	0.00	0.30	0.00	0.23	0.00	0.18	0.00
80	5.48	1.86	3.32	0.55	1.55	0.09	0.90	0.02	0.58	0.01	0.41	0.00	0.34	0.00	0.26	0.00	0.21	0.00
90	6.17	2.31	3.73	0.68	1.74	0.11	1.02	0.03	0.65	0.01	0.46	0.00	0.39	0.00	0.30	0.00	0.23	0.00
100	6.85	2.81	4.15	0.83	1.94	0.13	1.13	0.03	0.73	0.01	0.52	0.01	0.43	0.00	0.33	0.00	0.26	0.00
120	8.22	3.93	4.98	1.16	2.32	0.18	1.35	0.05	0.87	0.02	0.62	0.01	0.51	0.00	0.39	0.00	0.31	0.00
140	9.59	5.23	5.81	1.54	2.71	0.24	1.58	0.06	1.02	0.02	0.72	0.01	0.60	0.01	0.46	0.00	0.36	0.00
160	10.96	6.70	6.64	1.98	3.10	0.31	1.81	0.08	1.16	0.03	0.83	0.01	0.69	0.01	0.52	0.00	0.41	0.00
180			7.47	2.46	3.49	0.39	2.03	0.10	1.31	0.04	0.93	0.02	0.77	0.01	0.59	0.01	0.47	0.00
200			8.30	2.99	3.87	0.47	2.26	0.13	1.45	0.04	1.03	0.02	0.86	0.01	0.66	0.01	0.52	0.00
220			9.13	3.56	4.26	0.56	2.48	0.15	1.60	0.05	1.14	0.02	0.94	0.01	0.72	0.01	0.57	0.00
240			9.96	4.19	4.65	0.66	2.71	0.18	1.74	0.06	1.24	0.03	1.03	0.02	0.79	0.01	0.62	0.00
260			10.79	4.86	5.04	0.76	2.93	0.20	1.89	0.07	1.34	0.03	1.11	0.02	0.85	0.01	0.67	0.01
280			11.62	5.57	5.42	0.87	3.16	0.23	2.03	0.08	1.45	0.03	1.20	0.02	0.92	0.01	0.73	0.01
300					5.81	0.99	3.39	0.27	2.18	0.09	1.55	0.04	1.28	0.03	0.98	0.01	0.78	0.01
320					6.20	1.12	3.61	0.30	2.32	0.10	1.65	0.04	1.37	0.03	1.05	0.01	0.83	0.01
340					6.59	1.25	3.84	0.34	2.47	0.12	1.76	0.05	1.46	0.03	1.11	0.02	0.88	0.01
360					6.97	1.39	4.06	0.37	2.62	0.13	1.86	0.06	1.54	0.04	1.18	0.02	0.93	0.01
380					7.36	1.54	4.29	0.41	2.76	0.14	1.96	0.06	1.63	0.04	1.25	0.02	0.98	0.01
400					7.75	1.69	4.51	0.45	2.91	0.16	2.06	0.07	1.71	0.04	1.31	0.02	1.04	0.01
450					8.72	2.10	5.08	0.56	3.27	0.19	2.32	0.08	1.93	0.05	1.48	0.03	1.17	0.02
500					9.69	2.56	5.64	0.69	3.63	0.24	2.58	0.10	2.14	0.06	1.64	0.03	1.30	0.02
550					10.66	3.05	6.21	0.82	4.00	0.28	2.84	0.12	2.36	0.08	1.80	0.04	1.42	0.02
600					11.62	3.58	6.77	0.96	4.36	0.33	3.10	0.14	2.57	0.09	1.97	0.05	1.55	0.03
650							7.33	1.12	4.72	0.38	3.36	0.17	2.78	0.11	2.13	0.06	1.68	0.03
700							7.90	1.28	5.09	0.44	3.61	0.19	3.00	0.12	2.29	0.06	1.81	0.04
750							8.46	1.45	5.45	0.50	3.87	0.22	3.21	0.14	2.46	0.07	1.94	0.04
800							9.03	1.64	5.81	0.56	4.13	0.24	3.43	0.16	2.62	0.08	2.07	0.05
850							9.59	1.83	6.18	0.63	4.39	0.27	3.64	0.17	2.79	0.09	2.20	0.05
900							10.16	2.04	6.54	0.70	4.65	0.30	3.85	0.19	2.95	0.10	2.33	0.06
950							10.72	2.25	6.90	0.77	4.90	0.34	4.07	0.21	3.11	0.11	2.46	0.06
1000							11.28	2.48	7.26	0.85	5.16	0.37	4.28	0.23	3.28	0.12	2.59	0.07
1050							11.85	2.71	7.63	0.93	5.42	0.40	4.50	0.26	3.44	0.13	2.72	0.08
1100									7.99	1.01	5.68	0.44	4.71	0.28	3.61	0.15	2.85	0.08
1150									8.35	1.10	5.94	0.48	4.93	0.30	3.77	0.16	2.98	0.09
1200									8.72	1.19	6.19	0.52	5.14	0.33	3.93	0.17	3.11	0.10
1250									9.08	1.28	6.45	0.56	5.35	0.35	4.10	0.19	3.24	0.10
1300									9.44	1.38	6.71	0.60	5.57	0.38	4.26	0.20	3.37	0.11
1350									9.81	1.48	6.97	0.64	5.78	0.41	4.43	0.21	3.50	0.12
1400									10.17	1.58	7.23	0.69	6.00	0.44	4.59	0.23	3.63	0.13
1450									10.53	1.69	7.49	0.74	6.21	0.47	4.75	0.24	3.76	0.14
1500									10.90	1.80	7.74	0.78	6.42	0.50	4.92	0.26	3.89	0.15
1550									11.26	1.91	8.00	0.83	6.64	0.53	5.08	0.28	4.02	0.16
1600									11.62	2.03	8.26	0.88	6.85	0.56	5.25	0.29	4.14	0.16
1650											8.52	0.93	7.07	0.59	5.41	0.31	4.27	0.17
1700											8.78	0.99	7.28	0.63	5.57	0.33	4.40	0.18
1750											9.03	1.04	7.50	0.66	5.74	0.35	4.53	0.19
1800											9.29	1.10	7.71	0.70	5.90	0.36	4.66	0.21
1900											9.81	1.21	8.14	0.77	6.23	0.40	4.92	0.23
2000											10.32	1.33	8.57	0.85	6.56	0.44	5.18	0.25
2100											10.84	1.46	8.99	0.93	6.88	0.48	5.44	0.27
2200											11.36	1.59	9.42	1.01	7.21	0.53	5.70	0.30
2300											11.87	1.73	9.85	1.10	7.54	0.57	5.96	0.32
2400													10.28	1.19	7.87	0.62	6.22	0.35
2500													10.71	1.28	8.20	0.67	6.48	0.38
2600													11.14	1.38	8.52	0.72	6.74	0.41
2700													11.56	1.48	8.85	0.77	6.99	0.43
2800													11.99	1.58	9.18	0.82	7.25	0.46
2900															9.51	0.88	7.51	0.50
3000															9.83	0.94	7.77	0.53
3300															10.82	1.12	8.55	0.63
3600															11.80	1.31	9.33	0.74
3900																	10.10	0.86
4000																	10.36	0.90

See page 194 for friction loss formulas.

# FRICITION 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

See page 194 for friction loss formulas.

# FRICITION 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

See page 194 for friction loss formulas.

# FRICITION 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.

# FRICITION 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			Shaded area represents velocities over 5 fps. Use with caution.								
3900											
4000											
4200											
4400											
4600											
4800											
5000											
5500											
6000											
6500											
7000											
7500											
8000											
8500											

# FRICITION 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										
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.

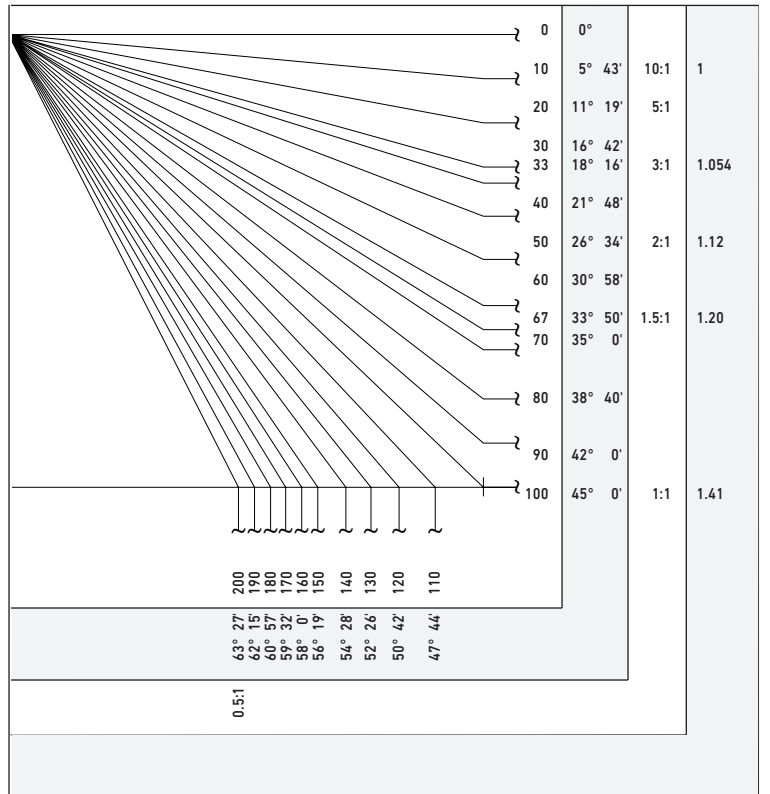
See page 194 for friction loss formulas.

# 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

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

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) †

Ground Wire	Valve Wire Sizing						
	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 Vac 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

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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.