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Friction Loss in Pipe

Losses Due to Friction

As water moves through the pumping system, pressure losses occur due to water contact with pipes, valves, and fittings. The four factors that determine friction losses in pipe are:

1. The velocity of the water: Water velocity is measured in feet per second. As velocity increases, pressure losses increase. Velocity is directly related to flow rate. An increase or decrease in flow rate will result in a corresponding increase or decrease in velocity.

2. The size (inside diameter) of the pipe: Smaller pipe causes a greater proportion of the water to be in contact with the pipe, which creates friction. Pipe size also affects velocity. Given a constant flow rate, decreasing pipe size increases the water's velocity, which increases friction.

3. The roughness of the inside of the pipe: Pipe inside wall roughness is rated by a "C" factor, which is provided by the manufacturer. The lower the C value, the rougher the inside and the more pressure loss due to friction.

4. The length of the pipe: The friction losses are cumulative as the water travels through the length of pipe. The greater the distance, the greater the friction losses will be.

Losses Due to Elevation Change

Water pressure can be expressed as either "psi" (pounds of pressure per square inch) or "feet of head." A column of water 1 foot high exerts 0.433 psi at the bottom and therefore 1 psi is equivalent to 2.31 feet of head. This means that for every foot of elevation change from the pump to the discharge point, the corresponding change in pressure will be 0.433 psi.

Fresh Water	Salt Water
1 foot of head = 0.433 psi	1 foot of head = 0.444 psi
1.0 psi = 2.31 feet of head	1.0 psi = 2.25 feet of head

Friction Loss Table

Head Loss / 100 Feet Pipe Due to Friction (C = 150)														
C = 150 for High Density Polyethylene Pipe (HDPE)														
Flow (GPM)	Pipe Diameter (Inch)													
	½"	¾"	1"	1-¼"	1-½"	2"	2-½"	3"	4"	5"	6"	8"	10"	12"
0.5	0.8	0.1												
1	2.9	0.4	0.1											
2	10.5	1.5	0.4	0.1										
3	22.2	3.1	0.8	0.3	0.1									
4	37.9	5.3	1.3	0.4	0.2									
5	57.2	7.9	2.0	0.7	0.3	0.1								
10		28.6	7.1	2.4	1.0	0.2	0.1							
15		60.6	14.9	5.0	2.1	0.5	0.2	0.1						
20			25.4	8.6	3.5	0.9	0.3	0.1						
30			53.8	18.2	7.5	1.8	0.6	0.3	0.1					
40			91.7	30.9	12.7	3.1	1.1	0.4	0.1					
50				46.7	19.2	4.7	1.6	0.7	0.2	0.1				
60				65.5	26.9	6.6	2.2	0.9	0.2	0.1				
70				87.1	35.8	8.8	3.0	1.2	0.3	0.1				
80					45.9	11.3	3.8	1.6	0.4	0.1	0.1			
90					57.0	14.1	4.7	2.0	0.5	0.2	0.1			
100					69.3	17.1	5.8	2.4	0.6	0.2	0.1			
150						36.1	12.2	5.0	1.2	0.4	0.2			
200						61.6	20.8	8.5	2.1	0.7	0.3	0.1		
250						93.0	31.4	12.9	3.2	1.1	0.4	0.1		
300							44.0	18.1	4.5	1.5	0.6	0.2	0.1	
400							74.8	30.8	7.6	2.6	1.1	0.3	0.1	
500								46.5	11.5	3.9	1.6	0.4	0.1	0.1
600								65.2	16.1	5.4	2.2	0.5	0.2	0.1
700								86.7	21.4	7.2	3.0	0.7	0.2	0.1
800									27.4	9.2	3.8	0.9	0.3	0.1
900									34.0	11.5	4.7	1.2	0.4	0.2
1000									41.3	13.9	5.7	1.4	0.5	0.2
1200									57.9	19.5	8.0	2.0	0.7	0.3
1500									87.5	29.5	12.1	3.0	1.0	0.4
2000										50.3	20.7	5.1	1.7	0.7
3000											43.8	10.8	3.6	1.5
4000											74.6	18.4	6.2	2.6
5000												27.8	9.4	3.9

Notes:

1. Values shown above are used in the Hazen-Williams Equation for flow in pipes.
   Feet of head loss values shown in the tables were developed using the
   Hazen-Williams equation.
2. Feet of head loss values are subject to the following conditions:
   a) Pipes carrying clear water at approximately 60° F (15.6° C).
   b) Pipes are flowing full.
   c) Velocities of water are generally less than 10 feet per second.

Note: HDPE is commonly sized by outside diameter. If in doubt, use the next smaller pipe size.

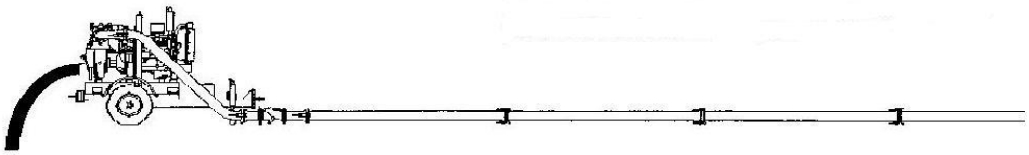
Friction Loss in Pipe Fittings

Steel/Copper	Equivalent feet of pipe caused by joint @ diam. Inch						
Fitting	**½**	**¾**	**1**	**1-¼**	**1-½**	**2**	**2-½**
90° Std Elbow	1.6	2.1	2.6	3.5	4.0	5.5	6.2
90° Long Elbow	1.0	1.4	1.7	2.3	2.7	4.3	5.1
90° Street Elbow	3.0	3.4	4.4	5.8	6.7	8.6	10.3
45° Std Elbow	0.8	1.1	1.4	1.8	2.1	2.8	3.3
45° Street Elbow	1.0	1.8	2.3	3.0	3.5	4.5	5.4
Square Elbow	3.0	3.9	5.0	6.5	7.6	9.8	11.7
Std T Flow Run	1.0	1.4	1.7	2.3	2.7	4.3	5.1
Std T Flow Branch	4.0	5.1	6.0	6.9	8.1	12.0	14.3
Gate Valve - Open	0.7	0.9	1.1	1.5	1.7	2.2	2.7

Plastic	Equivalent feet of pipe caused by joint @ diam. Inch						
Fitting	**½**	**¾**	**1**	**1-¼**	**1-½**	**2**	**2-½**
90° Std Elbow	4	5	6	7	8	9	10
Std T Flow Run	4	4	4	5	6	7	8
Std T Flow Branch	7	8	9	12	13	17	20

Friction Loss Estimates based on Pipe Lengths

Note: Determine total run of hose/pipe in pumping system and calculate friction loss at a given flow rate. Add Friction Loss in head feet to vertical elevation from suction point to discharge point to determine **total dynamic head**.



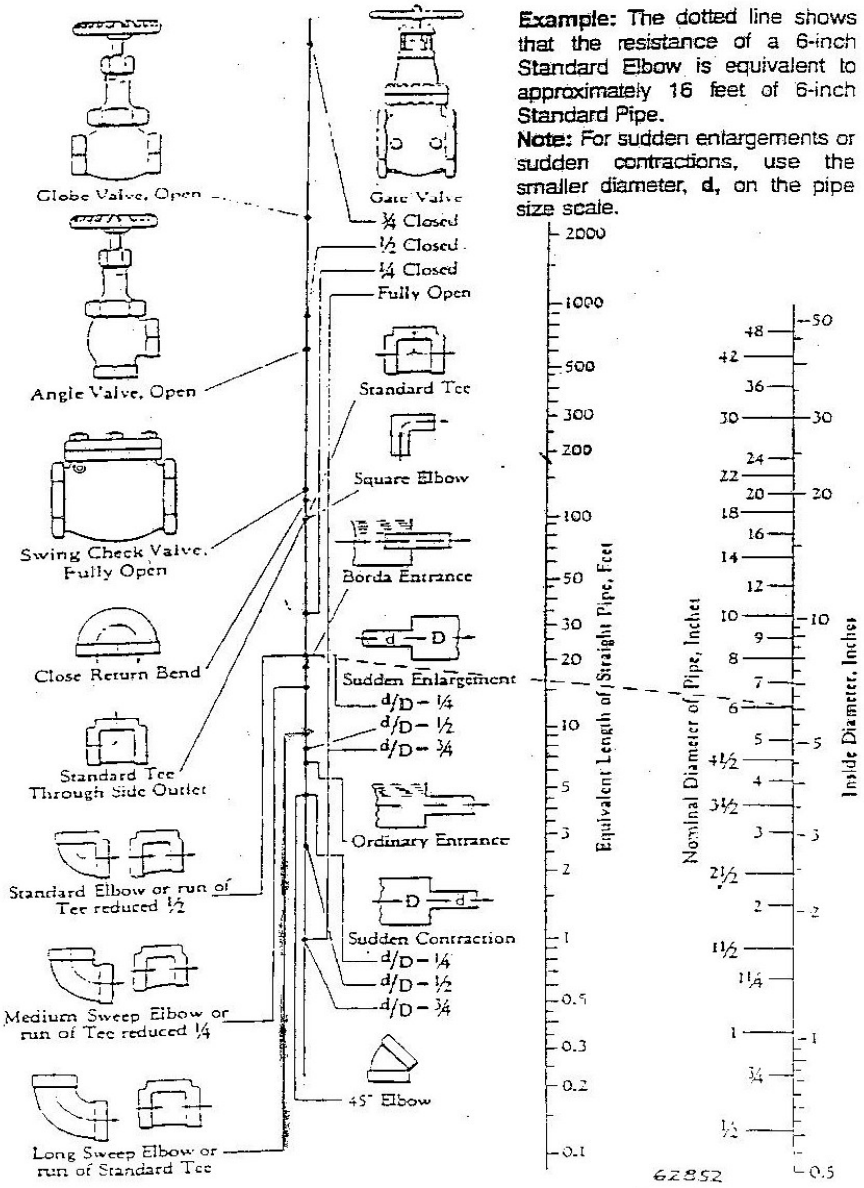
Flow	Hose Size	Velocity	100'	500'	1000'	1500'	2000'
100	4"	2.5' / sec	0.8'	4'	8'	12'	16'
200	4"	5.0' / sec	2.9'	14.5'	29'	43.5'	58'
300	4"	7.6' / sec	6.1'	30.5'	61'	91.5'	***122'***
400	4"	10.1' / sec	10.4'	52'	***104'***	***156'***	***208'***
400	6"	4.4' / sec	1.4'		14'	21'	28'
500	6"	5.6' / sec	2.2'	11'	22'	33'	44'
600	6"	6.7' / sec	3.1'	15.5'	31'	46.5'	62'
700	6"	7.8' / sec	4.1'	20.5'	41'	61.5'	82'
800	6"	8.9' / sec	5.2'	26'	52'	78'	***104'***
800	8"	5.1' / sec	1.3'				26'
900	6"	10.0' / sec	6.6'	33'	66'	99'	***132'***
900	8"	5.8' / sec	1.6'				32'
1000	6"	11.1' / sec	7.8'	39'	78'	***117'***	***156'***
1000	8"	6.4' / sec	2.0'			30'	40'
1100	8"	7.0' / sec	2.3'	11.5'	23'	34.5'	46'
1200	8"	7.7' / sec	2.7'	13.5'	27'	40.5'	54'
1300	8"	8.3' / sec	3.1'	15.5'	31'	46.5'	62'
1400	8"	9.0' / sec	3.6'	18'	36'	54'	72'
1500	8"	9.6' / sec	4.1'	20.5'	41'	61.5'	82'
1600	8"	10.3' / sec	4.7'	23.5'	47'	70.5'	94'
1800	8"	11.5' / sec	5.6'	28'	56'	84'	***112'***
1800	12"	5.1' / sec	0.8'				16'
2000	8"	12.8' / sec	7.0'	35'	70'	105'	***140'***
2000	12"	5.7' / sec	0.9'			13.5'	18'
2500	12"	7.1' / sec	1.5'	7.5'	15'	22.5'	30'
3000	12"	8.5' / sec	2.1'	10.5'	21'	31.5'	42'
3500	12"	9.9' / sec	2.7'	13.5'	27'	40.5'	54'
4000	12"	11.4' / sec	3.5'	17.5'	35'	52.5'	70'

Note:
Numbers in **bold** and ***italics*** represent dynamic head levels that exceed pump pump capabilities at that flow.

FRICTION-WATER-PIPE FITTINGS

Friction of Water *(Continued)*

Resistance of Valves and Fittings to Flow of Fluids in Equivalent Length of Pipe



Example: The dotted line shows that the resistance of a 6-inch Standard Elbow is equivalent to approximately 16 feet of 6-inch Standard Pipe.

Note: For sudden enlargements or sudden contractions, use the smaller diameter, **d**, on the pipe size scale.

From Crane Co. Technical Paper No. 409. Data based on the above chart are satisfactory for most applications; for more detailed data and information refer to pages 3-110 to page 3-120 which are based on Crane Co. Technical Paper No. 410.