Sizing The Water Supply System

Department of Safety & Professional Services
Division of Safety & Buildings

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Sizing The Water Supply System

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Introduction

One of the basic principles of governing plumbing regulations and installations is to supply a safe and adequate quantity of water to all plumbing fixtures. To accomplish this, water supply piping for every building must be properly sized to conduct the supply of water to all points of use.

Five reasons are given for proper water pipe sizing:

1. Protection of human health. Health is protected by adequate sizing of water pipes so that it is less likely for there to be a backflow or back siphonage of contaminants due to the lack of pressure in water distribution systems.

2. Providing proper pressure. Proper pressure must be provided to all plumbing fixtures and appliances so that the fixtures and equipment connected to the water supply system will function appropriately. Many valves and pieces of equipment are extremely pressure sensitive.

3. Providing sufficient quantities of water to all fixtures. Sufficient quantities of water must be provided for cleansing of fixtures which receive waste, or cooling of appliances connected to the water supply system. Consumers should not be inconvenienced by having to wait a long time for fixtures to reach the proper operating level of water.

4. Avoiding pipe failure. Improper sizing can lead to failure (or early failure) of a water supply system due to erosion or scale build up. Pipe failure can also occur due to the relation of the rate of pipe erosion to excessive velocities in a piping system.

5. Providing a quiet operating system. High velocities will cause noise and increase the danger of water hammer in a piping system. Consumers demand that a water supply system operates in a quiet manner.

Wisconsin Administrative Code

SPS 382.10(1)(b):
Plumbing fixtures, appliances and appurtenances, whether existing or to be installed, shall be supplied with water in sufficient volume and at pressures adequate to enable them to function properly and efficiently at all times and without undue noise under normal conditions of use. Plumbing systems shall be designed and adjusted to use the minimum quantity of water consistent with proper performance and cleaning.

The five reasons are interrelated in one manner or another. There is an impact on the health of the user in providing enough water to clean fixtures such as water closets and urinals and in safely carrying away the waste deposited in them. There is also an impact on flow in having sufficient pressure to operate flush valves or to provide for proper long-term operation of temperature pressure balancing valves. Ensuring that velocities are not excessive affects the flow in the piping systems as well as providing a quiet system which is free from the danger of early failure.

SPS 381.01(284)
"Water supply system" means the piping of a private water main, water service and water distribution system, fixture supply connectors, fittings, valves, and appurtenances through which water is conveyed to points of usage such as plumbing fixtures, plumbing appliances, water using equipment or other piping systems to be served.

The term "water supply system" has had several different meanings over the years. The water supply system as defined in the Wisconsin Administrative Code is the piping system from the connection with the municipal main or private water supply pressure tank to the point of use. The water supply system is further broken down into:

1. The water service piping;
2. The water distribution system; and
3. The fixture supply connector.

SPS 381.01(282)
"Water service" means that portion of a water supply system from the water main or private water supply to the building control valve.

Water service is the piping that runs from the municipal main, private water main, or external private water system supply pressure tank to the building control valve.

SPS 381.01(280)
"Water distribution system' means that portion of a water supply system from the building control valve to the connection of a fixture supply connector, plumbing fixture, plumbing appliance, water using equipment or other piping systems to be served.

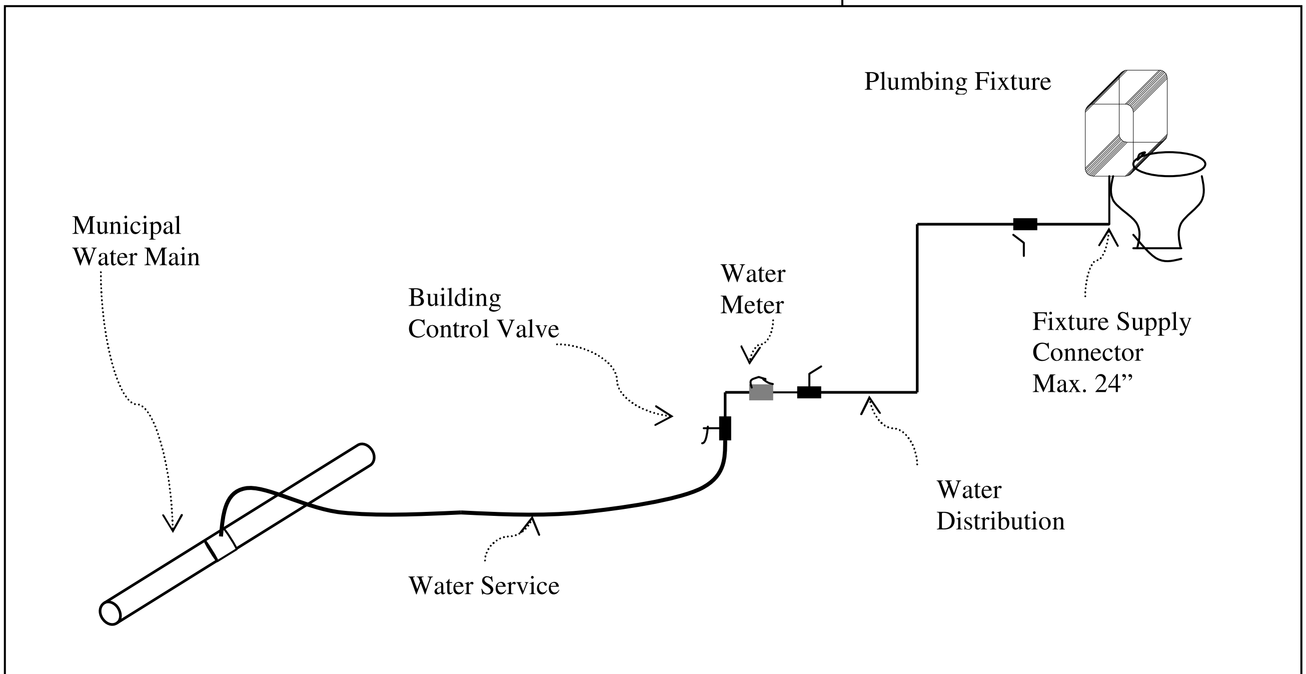
The water distribution system is the piping from the building control valve to, but not including, the fixture supply connectors.

SPS 381.01(98)
"Fixture supply connector" means that portion of water supply piping which connects a plumbing fixture, appliance or piece of equipment to the water distribution system.

Water fixture supply connectors are limited by administrative rule to a maximum length of 24" from the fixture connection. Plumbing appliances may have a 10-foot maximum fixture supply connector.

These terms are important to remember because the code's 8-feet-per-second velocity limit applies only to the water distribution system. That velocity limit may be exceeded in water services and fixture supply connectors with manufacturer's specification approval.

Figure 1



There are essentially two major steps that must be taken to properly size a water supply system:

1. Select a water service size; and

2. Determine how much pressure is available to operate the water distribution system which is then used to find the pressure available for uniform loss.

SPS 382.40(7)(h)
Maximum lengths for fixture supply connectors.

1.a. Except as provided in subd. 1.b.c., fixture supply connectors may not exceed more than 24” in developed length upstream from a plumbing fixture or the body of a faucet.

b. A fixture supply connector located downstream of a water cooler, water treatment device or water heater which individually services a faucet or outlet may not exceed more than 10 feet in developed length.

c. A fixture supply connector located upstream of a water treatment device serving no more than 2 fixtures or outlets may not exceed 10 feet in developed length.

Sizing the water service

Chapter 1

To size a water service, five items must be determined:

1. The gallons-per-minute (gpm) demand for the building;

2. The piping material used for the water service,

3. The difference in elevation between the main in the street and the building control valve;

4. The length of the water service piping from the water main connection to the building control valve.

5. The maximum and minimum pressure at the point of water service connection to the water main or other supply source.

In sizing a water service, you are not limited to the 8 feet per second requirement in the code as you are for water distribution systems. This is because the water service piping, for all practical purposes, is a straight length of pipe without numerous fittings, bends, or turns. Velocity erosion therefore is not as much of a problem in water service systems as in water distribution systems. However always check with the manufacturer's specifications for any pipe material limitations.

Water supply fixture units (wsfu's) are listed in Tables 382.40-1b and 382.40-2 in the Wisconsin Administrative Code (Figures 2, and 3, pages 8 and 9). Table 382.40-1b is labeled water supply fixture units for nonpublic use fixtures. In other words, fixtures where the public cannot normally enter and use the fixture at will, such as in a residence, hotel unit, or private office.

Table 382.40-2 is used for determining the proper water supply fixture units for public use fixtures, such as fixtures in schools, office buildings, places of employment, shopping malls churches, or sports facilities.

SPS 382.40(7)(e) Maximum velocity. A water distribution system shall be designed so that the flow velocity does not exceed 8 feet per second.

SPS 382.40(7)(a) Methodology. The determination of minimum pipe sizes shall take into account the pressure losses which occur throughout the entire water supply system and the flow velocities within the water distribution system. Calculations for sizing a water distribution system shall include:

1. The load factor in water supply fixture units or gallons per minute on the piping:

2. The minimum pressure available from the water main or pressure tank;

3. The pressure loss due to differences in elevation from the:
a. Water main or pressure tank to the building control valve; and
b. Building control valve to the controlling fixture;

4. The pressure losses due to flow friction through water heaters, water treatment devices, water meters and backflow preventers.

5. The minimum flow pressure needed at the controlling plumbing fixture; and

Building Demand

To determine the building demand in gallons per minute, first find the total water supply fixture unit load. To do this, list all of the plumbing fixtures, appliances, or devices which will be installed in the building in question. Refer to the appropriate table of public or nonpublic use. For fixtures supplied with both hot and cold water, use the fixture unit value listed under the column headed "total".

After reviewing the blueprints or proposed drawings of the building and determining the total fixture unit value for that building, use Table 382.40-3 (Figure 4, page 10) to convert the fixture units to gallons per minute.

As higher and higher fixture value loads are read off this table, the corresponding gallons-per-minute demand does not increase proportionately to the fixture unit values. This is because the table has built into it the probability of simultaneous use of all fixtures in a building. As the total number of fixtures in a building increases, the probability decreases that all, half, or a quarter of the fixtures will be used at any given time.

Low pressure of source

After determining the demand in gallons per minute, the next task is to determine what the low pressure of the water source would be. If connecting to the municipal water main, contact should be made with the local municipality in charge of the water supply system. Normally they will have information on what the low pressure is for that water main. For pressure tanks, contact the installer for the pressure tank to determine what the low pressure setting will be for that installation. The design examples used in this manual will be based on a municipal supply. See Chapter 6 for information on how pressure tanks affect system sizing.

Elevation difference

The next information needed is the elevation difference between the water main (or an external pressure tank) and the building control valve. This information is necessary because there will be a pressure loss if the water main is below the level of the building control valve, which is the usual case. For every foot in elevation that water is lifted against the force of gravity, .434 psi of pressure is lost. For a 10 foot difference in elevation from the main to a building control valve, 4.34 psi pressure is lost. This pressure loss is due to the energy needed to lift water against the pull of gravity. If the water main or outside pressure tank is higher in elevation, an increase in pressure will occur due to the force of gravity pulling the water down.

6. The pressure losses due to flow friction through piping, fittings, valves, and other plumbing appurtenances. This pressure loss may be calculated in terms of equivalent lengths of piping. The equivalent lengths of piping to a controlling plumbing fixture, including fittings, valves and other appurtenances, may be obtained by multiplying the developed length by 1.5.

SPS 382.40(7)(b) Private water mains and water services.

Private water mains and water services shall be designed to supply water to the water distribution systems to maintain the minimum flow pressures specified in par. (d), but shall not be less than ¾" in diameter.

SPS 382.40(7)(c) Maximum loading.
The calculated load on any portion of the water distribution system may not exceed the limits specified in Tables 382.40-4 to 382.40-9

Figure 2

Table 382.40–1b
Water Supply Fixture Units for Nonpublic Use Fixtures

Type of Fixture[a]	Water Supply Fixture Units (wsfu) Hot	Cold	Total
Automatic Clothes Washer	1.0	1.0	1.5
Bar Sink	0.5	0.5	1.0
Bathtub, with or without Shower Head	1.5	1.5	2.0
Bidet	1.0	1.0	1.5
Dishwashing Machine	1.0		1.0
Glass Filler		0.5	0.5
Hose Bibb:			
1/2″ diameter		3.0	3.0
3/4″ diameter		4.0	4.0
Kitchen Sink	1.0	1.0	1.5
Laundry Tray, 1 or 2 Compartment	1.0	1.0	1.5
Lavatory	0.5	0.5	1.0
Manufactured Home	—	15	15
Shower, Per Head	1.0	1.0	1.5
Water Closet, Flushometer Type		6.0	6.0
Water Closet, Gravity Type Flush Tank		2.0	2.0
Bathroom Groups:			
Bathtub, Lavatory and Water Closet–FM[b]	2.0	7.5	8.0
Bathtub, Lavatory and Water Closet–FT[c]	2.0	3.5	4.0
Shower Stall, Lavatory and Water Closet–FM	1.5	7.0	7.5
Shower Stall, Lavatory and Water Closet–FT	1.5	3.0	3.5

[a] For fixtures not listed, factors may be assumed by comparing the fixture to a listed fixture which uses water in similar quantities and at similar rates.
[b] FM means flushometer type.
[c] FT means flush tank type.

Table 382.40–1a
Distribution and Service

Supply	Tag and Band Color	Tag Shape	Tag Size	Tag Legend[a]
Potable	Green	Round	3″ diameter	Safe Water
Nonpotable	Yellow	Triangle	4″ sides	Nonpotable Water or Not Safe for Drinking
Reuse (Nonpotable)	Purple	Triangle	4″ sides	Nonpotable Water or Not Safe for Drinking or Specific Use[b]
Device Specific[c]	Gray	Triangle	4″ sides	Specific Use[b]

[a] All nonpotable water outlets shall be identified at the point of use for each outlet with the following legends or as otherwise approved by the department.
[b] Tag should reflect the intended use.
[c] Serving an individual or similar plumbing fixtures or appliances.

Note: Table 382.40-1a, Distribution and Service, shall be reviewed in Chapter 5, 382.40(3)(d) Identification of non-potable water distribution piping is addressed.

Figure 3

Table 382.40–2
Water Supply Fixture Units for Public Use Fixtures

Type of Fixture[a]	Water Supply Fixture Units (wsfu)		
	Hot	Cold	Total
Automatic Clothes Washer, Individual	2.0	2.0	3.0
Automatic Clothes Washer, Large Capacity	b	b	b
Autopsy Table	2.0	2.0	3.0
Bathtub, With or Without Shower Head	2.0	2.0	3.0
Coffeemaker		0.5	0.5
Dishwasher, Commercial	b	b	b
Drink Dispenser		0.5	0.5
Drinking Fountain		0.25	0.25
Glass Filler		0.5	0.5
Health Care Fixtures:			
Clinic sink	2.0	7.0	7.0
Exam/treatment sink	0.5	0.5	1.0
Sitz bath	1.5	1.5	2.0
Surgeon washup	1.5	1.5	2.0
Hose Bibb:			
1/2″ diameter		3.0	3.0
3/4″ diameter		4.0	4.0
Icemaker		0.5	0.5
Lavatory	0.5	0.5	1.0
Shower, Per Head	2.0	2.0	3.0
Sinks:			
Bar and Fountain	1.5	1.5	2.0
Barber and Shampoo	1.5	1.5	2.0
Cup		0.5	0.5
Flushing Rim		7.0	7.0
Kitchen and Food Preparation per faucet	2.0	2.0	3.0
Laboratory	1.0	1.0	1.5
Service sink	2.0	2.0	3.0
Urinal:			
Syphon Jet		4.0	4.0
Washdown		2.0	2.0
Wall Hydrant, Hot and Cold Mix:			
1/2″ diameter	2.0	2.0	3.0
3/4″ diameter	3.0	3.0	4.0
Wash Fountain:			
Semicircular	1.5	1.5	2.0
Circular	2.0	2.0	3.0
Water Closet:			
Flushometer		6.5	6.5
Gravity Type Flush Tank		3.0	3.0

[a] For fixtures not listed, factors may be assumed by comparing the fixture to a listed fixture which uses water in similar quantities and at similar rates.
[b] Load factors in gallons per minute, gpm, based on manufacturer's requirements.

a. For fixtures not listed, factors may be assumed by comparing the fixture to a listed fixture which uses water in similar quantities and at similar rates.

b. Load factors in gallons per minute (gpm) based on manufacturer's requirements.

Figure 4

Table 382.40–3
Conversion of Water Supply Fixture Units to Gallons Per Minute

Water Supply Fixture Units	Gallons per Minute	
	Predominately Flush-ometer Type Water Closets or Syphon Jet Urinals	Predominately Flush Tank Type Water Closets or Washdown Urinals
1	—	1
2	—	2
3	—	3
4	10	4
5	15	4.5
6	18	5
7	21	6
8	24	6.5
9	26	7
10	27	8
20	35	14
30	40	20
40	46	24
50	51	28
60	54	32
70	58	35
80	62	38
90	65	41
100	68	42
120	73	48
140	78	53
160	83	57
180	87	61
200	92	65
250	101	75
300	110	85
400	126	105
500	142	125
600	157	143
700	170	161
800	183	178
900	197	195
1000	208	208
1250	240	240
1500	267	267
1750	294	294
2000	321	321
2250	348	348
2500	375	375
2750	402	402
3000	432	432
4000	525	525
5000	593	593

Note: Values not specified in the table may be calculated by interpolation.

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Table 382.40–3e
Conversion of Water Supply Fixture Units to Gallons Per Minute for Water Treatment Devices[a] Serving an Individual Dwelling[b]

Water Supply Fixture Units (WSFUs)	Gallons Per Minute (GPM)
1	1
2	2
3	3
4	4
5	4.5
6	5
7	6
8	6.5
25	7
35	8
40	9

[a] Treatment devices providing treatment for compliance with Table 382.70–1 shall use Table 382.40–3 for conversion.

[b] Table shall not be used for converting hose bibb, high flow fixture or hydrant wsfu.

Note: Table 382.40 – 3e Conversion of Water Supply Fixture Units to Gallons Per Minute for Water Treatment Devices Serving an Individual Dwelling, Shall be reviewed in Chapter 5.

Length of Service
Probably the easiest information to obtain is the length of the water service. This is done by measuring from the water main to the proposed location of the building control valve. The building control valve must be placed within 3 feet of where the water service first enters the building.

After determining the length of the water service, it is necessary to calculate the friction loss that will occur in the water service when there is peak water demand.

Any time water moves through a pipe, there is a loss in pressure over the length of the pipe due to friction. The amount of pressure loss will vary with the relative roughness of a pipe wall. The rougher the surface of a pipe, the more friction loss created. Friction loss varies for different types of piping material. Additionally, as the water moves more rapidly through a pipe, the friction increases and creates greater pressure losses.
To determine the amount of friction loss incurred in a water service, select a size for the water service by trial and error and use the graphs found at the end of the Appendix to Chapter SPS 82, also provided in this manual.

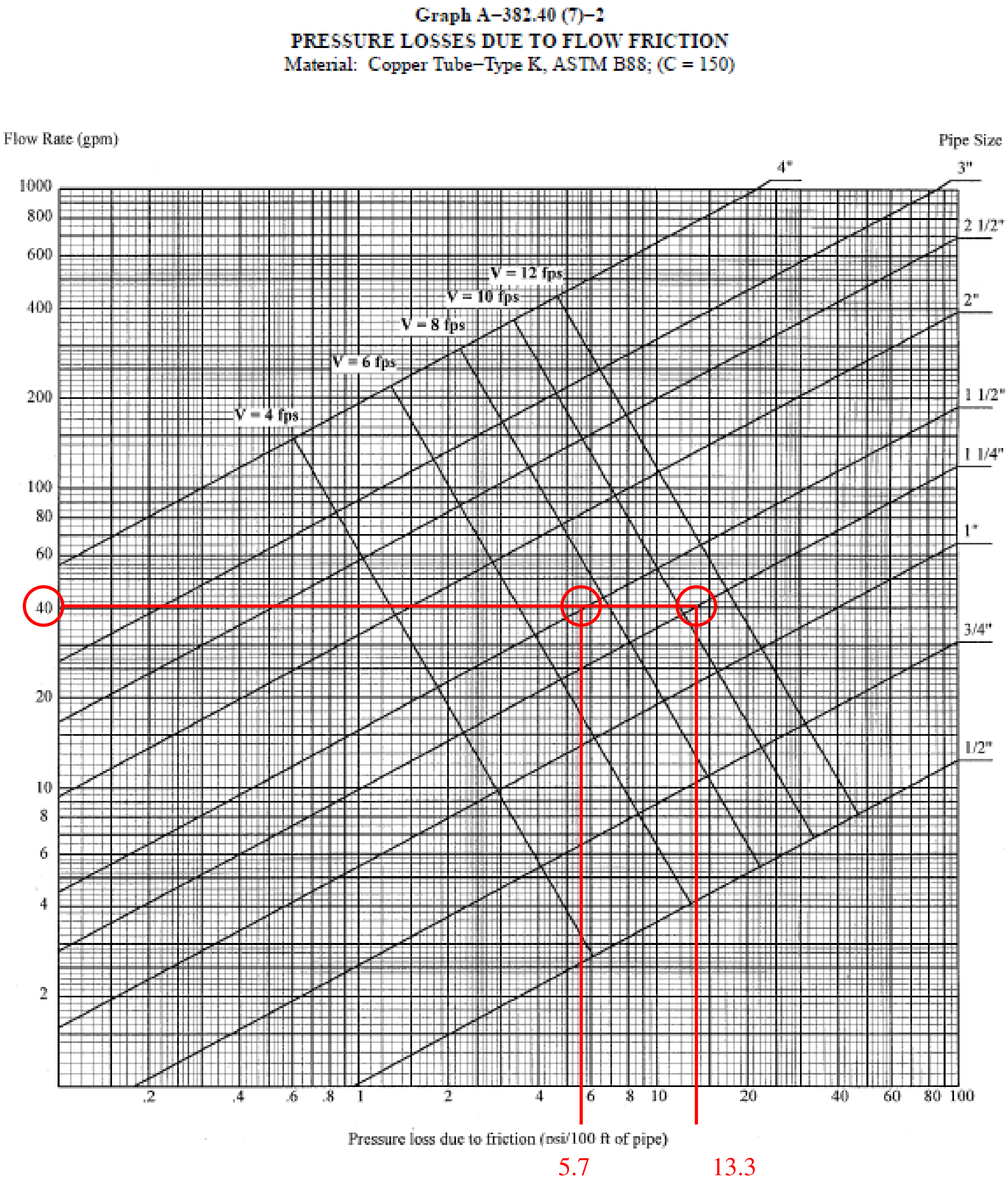
For example, using the chart for Type K copper tubing (Figure 5, page 12), presume a flow rate of 40 gallons per minute as the building demand. For a flow of 40 gallons per minute through a 1 ½" inch diameter pipe, the friction loss is 5.7 pounds per square inch loss per 100 feet of water service pipe. With an 1 ¼" inch pipe, there would be a higher velocity in the pipe, since the same gallons per minute are moved through a smaller pipe. This would lead to a friction loss of 13.3 pounds per square inch per 100 feet of pipe. The smaller the pipe for any given flow rate, the higher the friction loss in a service.

Since there is no rule of thumb or right or wrong answer for how much pressure loss is acceptable in a water service, the designer must determine whether the friction loss is too high and thus would require a larger size water service. After selecting the water service size, subtract the pressure available at the source of supply both the pressure loss due to elevation (main to building control valve) and the pressure loss due to friction through the water service. This determines the pressure available at the water meter of building control valve.

The frictional loss pressure through the water meter must also be calculated and subtracted from available pressure. The pressure available after the building control valve is then used in the next set of calculations to determine the pressure that is available when operating the water distribution system.

Note: The procedure for sizing private water mains is similar except the total gallons-per-minute demand of each building served is used to determine the size (always total the water supply fixture units, wsfu's, and then convert to gallons per minute).

Figure 5


Graph A−382.40 (7)−2
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Copper Tube−Type K, ASTM B88; (C = 150)
Flow Rate (gpm)
Pipe Size
4"
3"
2 1/2"
2"
1 1/2"
1 1/4"
1"
3/4"
1/2"
V = 12 fps
V = 10 fps
V = 8 fps
V = 6 fps
V = 4 fps
1000
800
600
400
200
100
80
60
40
20
10
8
6
4
2
.2
.4
.6
.8
1
2
4
6
8
10
20
40
60
80
100
Pressure loss due to friction (psi/100 ft of pipe)
5.7
13.3

WATER DISTRIBUTION SYSTEM SIZING

Chapter 2

In Wisconsin, the administrative rule directs sizing the water distribution system based on either:

1. The uniform pressure loss principle; or

2. Segmented loss calculations; or

3. Other engineering methods acceptable to the department.

To design a system using the segmented loss method, the friction loss through each length of pipe at the full demand load is calculated based on the water supply fixture units served by that length of water pipe.

This manual, however, will stress the uniform pressure loss method. This is based on the concept that when a system is in operation, friction will be lost uniformly throughout the length of the pipe.

For the uniform pressure loss calculations, knowledge is needed of:

1. The pressure available after the building control valve or the low pressure at the internal pressure tank;

2. The pressure required at the controlling fixture;

3. The difference in the elevation between the building control valve and controlling fixture;

4. The pressure loss due to treatment devices such as water softeners and iron filters, and other losses through backflow protection devices and instantaneous hot water heaters.

5. The length of piping from the building control valve to the controlling fixture; and

6. The load factor in water supply fixture units or gpm on the piping.

SPS 382.40(7) Sizing of Water Supply Piping. The sizing of the water supply system shall be based on the empirical method and limitations outlined in this subsection or on a detailed engineering analysis acceptable to the department.
(a) Methodology. The determination of minimum pipe sizes shall take into account the pressure losses which occur throughout the entire water supply system and the flow velocities within the water distribution system. Calculations for sizing a water distribution system shall include:

1. The load factor in water supply fixture units or gallon per minute on the piping;

2. The minimum pressure available from the water main or pressure tank;

3. The pressure loss due to the differences in elevation from the:

a. Water main or pressure tank to the building control valve; and
b. Building control valve to the controlling plumbing fixture;

4. The pressure losses due to flow through water heaters, water treatment devices, water meters and backflow preventers.

5. The minimum flow pressure needed at the controlling plumbing fixture; and

6. The pressure losses due to flow friction through piping, fittings, valves and other plumbing appurtenances.

Sample calculation #1.

The project is an eight-unit apartment building. The controlling fixture in this case is a shower on the second floor, which is 18 feet higher in elevation than the building control valve in the basement. Available pressure after the building control valve is 45 pounds per square inch (psi). The pressure balance shower valve has a required pressure of 20 psi. The length of piping from the building control valve to the shower is 78 feet. There are no water treatment devices. Pipe material is Type M copper.

Find the pressure available for uniform loss (psi / 100' of pipe). This will be the final result, "A" on the water calculation worksheet.

B. The available pressure after the bldg. control valve. B = 44.3 psi., or 45 as you round up.

C. The pressure loss through the water meter. In this case it is 0 as there is no water meter.
D. The pressure needed at the controlling fixture is 20 psi.

E. The difference in elevation of 18 feet amounts to 7.8 psi loss (18 X .434psi/ft. = 7.8 psi).

F. There is no loss due to water treatment devices or backflow preventers that serve the controlling fixture.

G. There is no loss due to tankless water heaters, combination boiler/ hot water heaters, or heat exchangers.

H. The length from the meter to the controlling fixture is 78 feet. Multiply 78 times 1.5 to get the developed length = 117 feet.

The subtotal 16.5 divided by 117 = 0.141 psi.

0.147 psi times 100 = 14.7 psi ("A"). The uniform pressure is always rounded up, so "A" is 15 psi available for uniform loss.

Using Table 382.40-6 (Figure 7, page 17) for pipe material Type M copper, the line for 15 psi offers various pipe sizes according to the demand in gallons per minute or the water supply fixture unit count. Note that the WSFU column is sub-divided, indicating "FM", predominately flushometer, and "FT", predominately flush tank type of water supply fixture units.

On the chart there is a limit identified by the letters "NP", which stands for "not-permitted." This point is the flow limit through a particular pipe size that is equivalent to an 8 ft. per second velocity.

Figure 6

WATER CALCULATION WORKSHEET FOR Sample Calculation #1
NAME/ADDRESS OF PROJECT

INFORMATION REQUIRED TO CALCULATE WATER SERVICE SIZE

1.	Demand of building in gallons per minute. WSFU's 104	1.a.	= (GPM)	43.2
2.	Difference in elevation from main to extermal pressure tank or to building control valve.		(feet)	4.0
3.	Size of the water meter. (when applicable) 5/8 ___ 3/4 ___ 1 ___ 1.5 ___ Inch; 2 ___ 3 ___ 4 ___ 6 ___ Inch			
4.	Developed length from main or external pressure tank to building control valve.		(feet)	60
5.	Low pressure at main in street or external pressure tank.		(psig)	50.0

CALCULATE WATER SERVICE PRESSURE LOSS

6.	Low pressure at main in street or external pressure tank. (value of #5 above)		50.0
7.	Water service diameter is 1.5 Material is Type K Copper, ASTM B88		
	Pressure loss per 100 ft. = 6.59 p.s.i. X 0.6 .		4.0
	(decimal equivalent of service length, i.e. 65ft = 0.65) (Subtract line 7. From line 6.)	subtotal	46.0
8.	Determine pressure gain or loss due to elevation. (multiply the value of #2 above by 0.434)	value of "8"	1.7
9.	Available pressure after the bldg. Conrol valve. (subtract or add line 8. Enter in "B".)	**subtotal**	44.3

CALCULATE THE PRESSURE AVAILABLE FOR UNIFORM LOSS (VALUE OF "A")

B.	Available pressure after the building control valve. (from "9" above)	value of "B"	44.3
C.	Pressure loss of water meter. (when meter is required or installed)	value of "C"	0.0
	(subtract line C. From B.)	**subtotal**	44.3
D.	Pressure at controlling fixture.	value of "D"	20.0
	(controlling fixture is Pressure bal. shower valve)		
	(subtract the value of D.)	**subtotal**	24.3
E.	Difference in elevation between the building control valve and the controlling fixture in feet 18 X 0.434 psi/ft.	value of "E"	7.8
	(subtract the value of E.)	**subtotal**	16.5
F.	Pressure loss due to water treatment devices, and backflow preventers which serve the controlling fixture.		
	Pressure loss due to 0 (subtract the value of F)		
	F1. WSFU's downstream of Water Treatment Device: ___		
	F2. Convert wsfu's to GPM using **Table 382.40-3** ___		
	OR		
	F3. Convert wsfu's to GPM using **Table 382.40-3e** ___		
	F4. Refer to manufacturer's graph to obtain pressure loss:	value of "F4"	0.0
	(If no water treatment device enter "0")	**subtotal**	16.5
G.	Pressure loss through tankless water heaters, combination boiler / hot water heaters, heat exchangers;		
	Hot water WSFU's; 0 convert to; GPM = ___ (Table 82.40-3)		
	Refer to manufacturer's pressure loss graph to determine loss at required GPM: 0 pressure loss.		
	(If no pressure loss through hot water appliance enter "0")	value of "G"	0.0
		subtotal	16.5

(Page 1 of 3)

Figure 6, continued.

(Page 2 of 3)

Water Calc Worksheet Sample Calculatlon #1

G.	Continued from page 1;		**subtotal**	16.5
H.	Developed length from building control valve to controlling fixture in feet X 78 1.5 Divide by		value of "H"	117
		(divide by the value of G.)	**subtotal**	0.141
		(multiply by 100)		100
A.	Pressure available for uniform loss		**"A" =**	**14.1**

Water distribution piping material is: Copper Type M Tubing

*Note: The "A" value obtained by usinç **382.40-3e** ɔan only be used for sizing the water treatment device (water softeners, etc) when no hose bibbs, hydrants, or high flow fixtures are being served by the water treatment device.

Note: High flow fixtures are defined as fixtures that exceed a flow rate of 4 gpm @ 80 psi.

Comments

"A" value may be rounded up to 15.

Pressure losses due to flow friction through piping may be calculated in terms of equivalent lengths of piping. The equivalent length of piping to a controlling fixture including fittings, valves and appurtenances, may be obtained by multiplying the developed length by 1.5.

Figure 7

Table 382.40–6
MAXIMUM ALLOWABLE LOAD FOR COPPER TUBING–TYPE M, ASTM B88; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches) 1/2"			3/4"			1"			1 1/4"			1 1/2"		
	GPM	WSFU FM	WSFU FT	GPM	WSFU FM	WSFU FT	GPM	WSFU FM	WSFU FT	GPM	WSFU FM	WSFU FT	GPM	WSFU FM	WSFU FT
0.5	0.5	–	0.5	2.0	–	2.0	4.0	–	4.0	7.0	–	9.0	11.5	4.0	15.5
1	1.0	–	1.0	3.0	–	3.0	6.0	–	7.0	10.5	4.0	14.0	16.5	5.5	24.0
2	1.5	–	1.5	4.5	–	5.0	9.0	–	11.5	15.5	5.0	22.5	24.0	8.0	40.0
3	2.0	–	2.0	5.5	–	6.5	11.5	4.0	15.5	19.5	6.5	29.0	30.0	13.5	55.0
4	2.5	–	2.5	6.5	–	8.0	13.0	4.5	18.0	22.0	7.0	35.0	35.0	20.0	70.0
5	2.5	–	2.5	7.5	–	9.5	15.0	5.0	21.5	25.0	8.5	42.0	40.0	30.0	86.0
6	3.0	–	3.0	8.0	–	10.0	16.5	5.5	24.0	28.0	11.0	50.0	44.0	36.0	106
7	3.5	–	3.5	9.0	–	11.5	18.0	6.0	26.5	30.0	13.5	55.0	45.0	39.0	112
8	3.5	–	3.5	9.5	–	12.5	19.5	6.5	29.0	32.0	17.0	62.0	NP		
9	4.0	–	4.0	10.0	4.0	13.0	20.5	6.5	31.0	NP					
10	4.0	–	4.0	11.0	4.0	15.0	21.5	7.0	34.0						
11	4.5	–	5.0	11.5	4.0	15.5	NP								
12	4.5	–	5.0	12.0	4.0	16.5									
13	5.0	–	6.0	12.5	4.5	17.5									
14	5.0	–	6.0	12.5	4.5	18.0									
15	5.0	–	6.0	NP											
16	5.5	–	6.5												
17	5.5	–	6.5												
18	5.5	–	6.5												
19	6.0	–	7.0												
20	6.0	–	7.0												
21	6.0	–	7.5												
	NP														

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches) 2"			2 1/2"			3"			4"		
	GPM	WSFU FM	WSFU FT	GPM	WSFU FM	WSFU FT	GPM	WSFU FM	WSFU FT	GPM	WSFU FM	WSFU FT
0.5	23.0	7.5	37.0	42.0	33.0	100	67.0	96.0	210	139	481	577
1	34.0	18.5	66.0	61.0	77.0	180	97.0	227	360	202	945	953
2	50.0	48.0	128	88.0	184	315	141	493	588	294	1750	1750
3	62.0	80.0	185	110	300	425	174	731	776	303	1835	1835
4	73.0	120	240	121	374	484	NP			NP		
5	79.0	144	270	NP								
6	NP											

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

Determine the Controlling Fixture

The controlling fixture is the fixture which requires the highest pressure and / or flow requirement.

Pressure required at the controlling fixture is based on the requirements of s.SPS 382.40(7) and is discussed in more detail in Chapter 10.

The minimum amount of pressure that must be supplied at any plumbing fixture in Wisconsin is 8 pounds per square inch flow pressure at the outlet of the fixture supply (i.e., sinks, wash basins, hose bibbs, standard mixing valves and standard flush tank type water closets).

There are fixtures which have a higher pressure requirement. These are divided up into four categories. The controlling fixture pressures for these different categories are:

1. Fixtures requiring 15 psi; i.e., siphonic type urinals, washdown type urinals and water closets, and siphonic type flushometer water closets;

2. Fixtures requiring 20 psi; i.e., one-piece tank type water closets, pressure balanced mixing valves, and thermostatic mixing valves;

3. Fixtues requiring 25 psi, i.e., blowout type urinals and water closets;

4. Fixtures requiring more than 25 psi at the fixture supply; i.e., emergency fixtures and other fixtures with pressures as required by the manufacturer.

Note: Flow rates and pressure loss through a fixture served by a water softener or water treatment device or instantaneous tankless water heaters must also be taken into consideration. When this type of hot water heater is specified, always refer to the manufacturer's specifications pressure loss graph. A faucet with a 8 psi minimum pressure requirement with a tankless hot water heater upstream with a 20 psi pressure loss on the hot water side may be a higher pressure requirement than a 15 psi requirement on a flushometer water closet.

SPS 382.40(7)(c) Maximum loading. The calculated load on any portion of the water distribution system may not exceed the limits specified in Tables 382.40-4 to 382.40-9.

SPS 382.40(7)(d) Pressure. 1. Except as provided in subd. 1.a. to c., water supply systems shall be designed to provide at least 8 psi of flow pressure at the outlets of all fixture supplies.

SPS 382.40(7)(d)1.a. The flow pressure at the outlets of the fixture supplies serving siphonic type urinals, washdown type urinals, and washdown type water closets, siphonic type flushometer water closets and campsite water supply hose connections shall be at least 15 psig.

SPS 382.40(7)(d)1.b. The flow pressure at the outlets of the fixture supplies serving one piece tank type water closets, pressure balancing mixing valves, manufactured homes, and thermostatic mixing valves shall be at least 20 psig.

SPS 382.40(7)(d)1.c. The flow pressure at the outlets of the fixture supplies serving blowout type urinals and blowout type water closets shall be at least 25 psig.

Totaling Water Supply Fixture Units

Chapter 3

To properly size the water supply system, it is necessary to know the volume of water required to serve all the fixtures and equipment in the building. To know the volume, or demand, it is necessary to add up the number of water supply fixture units for the fixtures on the system.

The majority of fixtures requiring a supply of water within a plumbing system are shown in Tables SPS 382.40-1b and 382.40-2 (pages 8 and 9 figures 2 and 3). The difference between these tables is that Table 382.40-1b is for nonpublic use fixtures, while Table 382.40-2 is for public use fixtures. Therefore, to determine the demand of a building, the proper category of use for the fixtures needs to be considered. The process of adding up water supply fixture units is the same regardless of the type of fixture or building.

The plumbing code defines a nonpublic use fixture as "Those fixtures in residences, apartments, living units of hotels and motels, and other places where the fixtures are intended for use by the family or an individual to the exclusion of all others." Public use fixtures are "Those fixtures which are available for use by the public or employees."

Some buildings will contain both public and nonpublic fixtures. In a hotel, the bathroom fixtures in a individual hotel room are nonpublic fixtures. The fixtures in hotel restrooms, (such as lobbies, bars and restaurant areas, swimming pool areas, etc.) are public use fixtures. In office buildings, the public and employee restroom areas are public use fixtures. In office buildings, the public and employee restroom areas are public fixtures, while the bar sink, lavatory and water closet in a private office are nonpublic.

Generally speaking, if a person can walk in off the street and use a fixture, then it is a public use fixture.

In Tables 382.40-1b and 382.40-2, the left side of the table indicates the fixture names. To the right there are three columns with the water supply fixture unit values. The "total" column is the total fixture unit value of that fixture. If the fixture requires both hot and cold water, the value for the individual hot line going to the fixture would be under the "hot' column. The value for the individual cold piping would be under the column marked "cold".

SPS 381.01(162) "Nonpublic" means, in the classification of plumbing fixtures, those fixtures in residences, apartments, living units of hotels and motels, and other places where the fixtures are intended for the sue by a family or an individual to the exclusion of all others.

SPS 381.01(196) "Public" means, in the classification of plumbing fixtures, those fixtures which are available for use by the public or employees.

SPS 382.40(6)(a) Intermittent flow fixtures. The load factor for intermittent flow fixtures on water supply piping shall be computed in terms of water supply fixture units as specified in Tables 382.40-1 and 382.40-2 for the corresponding fixture and use. Water supply fixture units may be converted to gallons per minute in accordance with Tables 382.40-3 or 382.40-3e.

SPS 382.40(6)(b) Continuous flow devices. The load factor for equipment which demand a continuous flow of water shall be computed on the basis of anticipated flow rate in terms of gallons per minute.

The fixture unit values given in Tables 382.40-1b and 382.40-2 are for intermittent flow fixtures only. These are fixtures such as showers, lavatories, bathtubs, etc., or fixtures which do not require a continuous flow of water. For a continuous-flow fixture such as water-cooled equipment, chillers, etc., the demand would be determined on the basis of its anticipated flow rate in gallons per minute.

When the building contains a bathroom group (water closet, lavatory, bathtub and / or shower), use the fixture unit values for a bathroom group as shown. Adding the individual fixture unit values of the water closet, lavatory, and bathtub/ shower would exceed the value as shown for the bathroom group. The smaller fixture unit value given for the nonpublic bathroom group is because of the improbability of simultaneous use. There is no value given for a bathroom group for public use fixtures.

The process of adding water supply fixture units is identical regardless of the type of building. The most important factor when adding the fixture units is to determine if the fixtures are of a public or nonpublic usage.

Once the number of water supply fixture units have been determined on the water service, it is necessary to add the water supply fixture unit values on the lines within the building. To add water supply fixture units values, use the following process;

1. Determine the total number of water supply fixture unit values within the entire building. This total count will serve as a "check" after adding the fixture unit values on piping within the building. If the total for the building and the total for the piping are not the same, there is an error and the numbers should be re-added.

2. Add together the fixture units on the hot water piping. To do this, go the end of any of the hot water piping within the building and follow it back toward the heater, adding up the hot water supply fixture unit values. The individual "hot" values are found in the first column of either Table 382.40-1 or 382.40-2.

Whatever the fixture unit value is on the hot piping leaving the heater, it will be identical for the cold line entering the heater for tank type hot water heaters. The water heater does not change fixture units, it just heats water.

3. The next step is to add the fixture unit values on the cold lines. Beginning at the furthermost fixture served with cold water, work back towards the water meter or building control valve. Continue to add the cold water supply fixture units until reaching the point where the cold water line serves the water heater. Keep in mind exactly what this line serves. First of all, it serves all the hot water in the building plus the cold to any fixtures downstream of the distribution pipe serving the water heater. In essence, it serves the total fixture unit value of any fixture downstream of the distribution line serving the water heater.

So, to determine the fixture unit load on the piping serving the heater (as shown as point A in Figure 9,page 21), add together the total fixture unit values of all fixtures downstream of the distribution piping serving the water heater and the rest of the hot fixture unit values in the building.

Figure 8

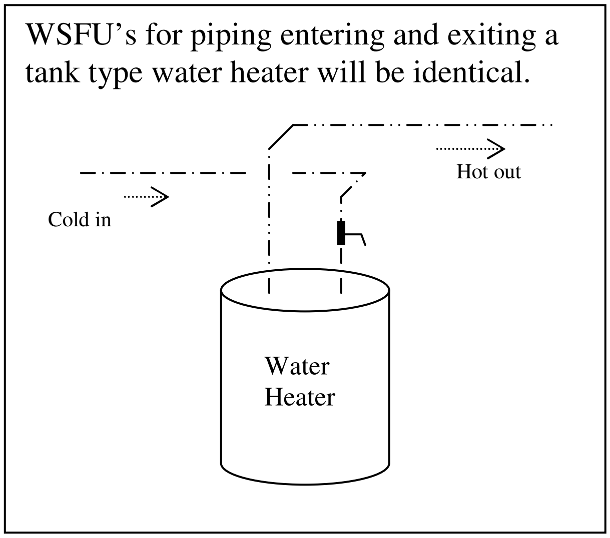
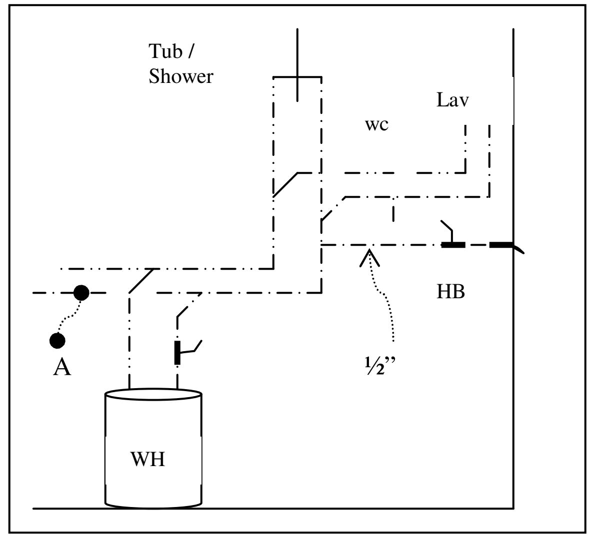


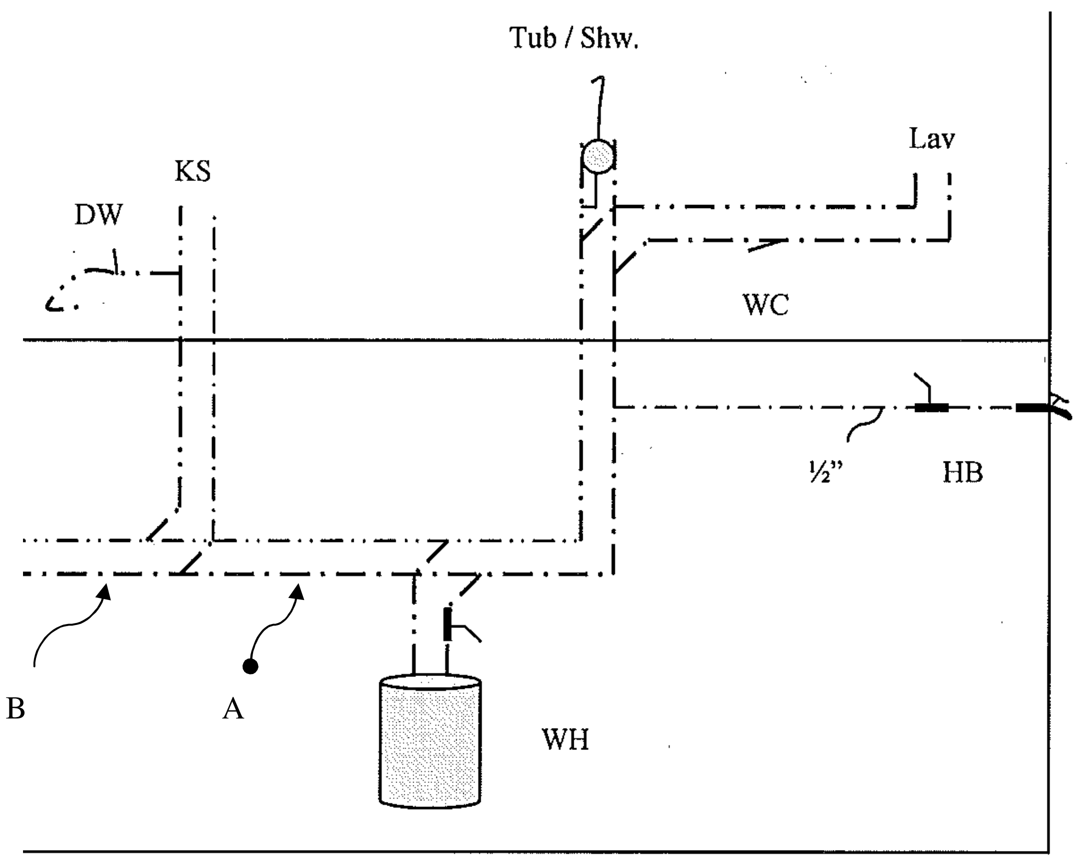
Figure 9



Continuing upstream along the cold water line towards the meter (as shown in Point B in Figure 10), the method to calculate the fixture units would be;

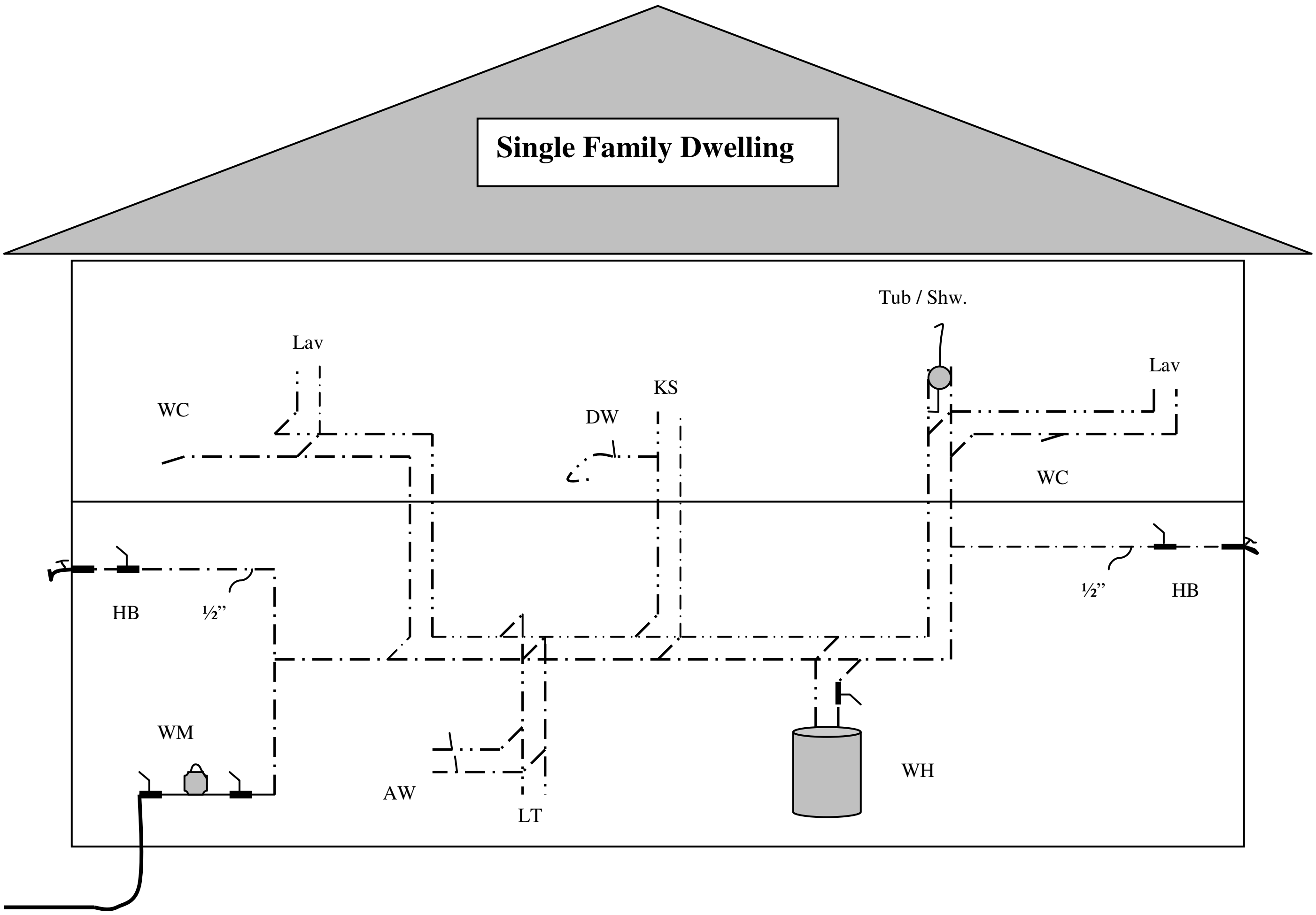
1. Determine the total fixture unit value of the fixture shown as "ks" in the following sketch.
2. Subtract the hot fixture unit value of the fixture from its total value.
3. Add this remainder to the value of letter "A".

Figure 10



Test Yourself! What would be the total fixture unit value on each line of Figure 11? (For the answer, see page 78, Figure 38.)

Figure 11



Symbols

Cold Water Piping		Lavatory	Lav	Hose Bibb	HB
Hot Water Piping		Water Closet	WC	Water Meter	WM
Water Heater	WH	Dishwasher	DW	Clothes Washer	AW
Tub & Shower	Tub/Shw.	Kitchen Sink	KS	Laundry Tray	LT

Is The System Flushometer-Type or Flush Tank – Type??

<u>Chapter 4</u>

To convert water supply fixture units to gallons per minute, it is necessary to determine if the system or water pipe in question is serving predominately flushometer or flush tank – type fixtures.

Flushometer (flush valve) fixtures are flush valve type water closets, flushing rim sinks or a flush valve siphon jet urinal.

In essence, **all fixtures other than those listed above are flush tank – type fixtures.**

The total fixture unit count of the predominately flush tank type fixtures would also include the water supply fixture units for the shower, bathtub, lavatory, laundry tub, etc.

The flushvalve washdown urinal is included with the flush tank – type fixtures because of the smaller amount of water used to properly wash down the fixture.

To determine whether there is a predominately flushvalve or flush tank system, compare the gallons per minute load for the flush valve fixtures in a structure to the gallons per minute load of the flush tank fixtures.

1. Add up the total water supply fixture unit count of the <u>flush valve fixtures</u> and convert to gallons per minute using Table 382.40-3 (Figure 4, page 10).

2. Add up the total water supply fixture unit count of the <u>flush tank fixtures</u> and convert to gallons per minute using Table 382.40-3 (Figure 4, page 10).

3. Compare the gallons per minute demand of the flush tank type fixtures to the gallons per minute demand of the flush valve type fixtures.

Whichever is larger will be the "predominate' type for that particular pipe.

Three examples of how to determine if a system is predominately flushvalve or flush tank – type.

Example 1.
The total water supply fixture unit (WSFU) count of a building is 130; 60 are of the flush valve type, while the remaining 70 WSFUs are of the flush tank type.

60 flush valve fixture units = 54 gallons per minute (GPM).

70 flush tank fixture units = 35 GPM

54 GPM is greater than 35 GPM, so the building water service and a portion of the water distribution system is predominately flush valve.

Example 2.
The total water supply fixture unit (WSFU) count of a building is 180; 60 are the flush valve type, while the remaining 120 WSFUs are of the flush tank type.

60 flush valve fixture units = 54 GPM

120 flush tank fixture units = 48 GPM

54 GPM is greater than 48 GPM, so the building water service and a portion of the water distribution system is predominately flushvalve.

Example 3.
The total water supply fixture unit (WSFU) count of a building is 100 WSFUs; 20 are the flushvalve type, while the remaining 80 WSFUs are the flush tank type.

20 flush valve fixture units = 35 GPM

80 flush tank fixture units = 38 GPM

38 GPM is greater than 35 GPM, so the building water service and a portion of the water distribution system is predominately flush tank type. Individual branches with flush valves may be required to be sized again if they are predominate on a branch pipe.

The previous examples indicated that the water service was either predominately flush valve or flush tank. When a building contains both flush valve and flush tank fixtures, it will be necessary to examine the water distribution system.

For any piping within the distribution system which serves both flush valve and flush tank type fixtures, it's necessary to determine if it is predominately flush valve or flush tank in order to properly size it.

When using the water pipe sizes Tables 382.40-4 through 382.40-11, pages 80 - 92 to properly size pipes, there is a difference whether the piping is predominately flush valve or flush tank.

There are two columns under water supply fixture units (WSFU) on the sizing charts. Make sure that the correct column ("FM" for flushometer / flush valve lines or "FT" for flush tank lines) is used for determining pipe sizing.

Converting Water Supply Fixture Units To Gallons Per Minute

Chapter 5

Table 382.40-3 (Figure 4, page 10) is divided into three columns. The first is labeled "Water Supply Fixture Units" (WSFUs). The second and third columns represent the equivalent gallons per minute. They are labeled, respectively, "Predominately Flushometer –Type Water Closets or Syphon Jet Urinals" and "Predominately Flush Tank Type Water Closets or Washdown Urinals."

In the left column, the numbers represent the fixture unit values on any portion of the water supply system. (The process of adding fixture units is described in Chapter 3.)

Go horizontally to the right to determine the number of gallons per minute that the fixture units are equivalent to.

In order to determine the correct number of gallons per minute, it is necessary to know if the line is serving:

1. Predominately flushometer (flush valve) type water closets or siphon jet urinals; or

2. Predominately flush tank – type water closets or washdown urinals.

(Determining whether the system is predominately flush valve or predominately flush tank was described in Chapter 4.)

The following examples of reading the table assume the system is predominately flush valve type water closets or siphon jet urinals, using the second column.

Fixture units		Gallons per minute
5	=	15
10	=	27
50	=	51
80	=	62
200	=	92

These examples of reading the table assume the system is predominately flush tank type water closets or washdown urinals, using the third column.

Fixture units		Gallons per minute
5	=	4.5
10	=	8
50	=	28
80	=	38
200	=	65

Interpolate when the number of fixture units do not exactly match the numbers shown in the water supply fixture column.
For example; assume that the total wsfu count is 45 and the system is predominately flush tank.

50 wsfu's = 28 gpm,
-40 wsfu's = 24 gpm
10 wsfu's per 4 gpm

Dividing 10 wsfu's into 4 gpm will equal .4 gpm/wsfu (each wsfu equals .4 gpm between 40 and 50 wsfu's).

Multiplying the 5 wsfu's beyond 40 by .4 equals 2 gpm.

40 wsfu's are 24 gpm. Add the two additional gpms that the 5 wsfu's above represent. This equals 26 gpm.

Therefore, 45 wsfu's = 26 gpm.

This process is followed in any case where interpolation is required.

Table 382.40-3 will not only convert water supply fixture units to gallons per minute, but will also convert gallons per minute back to fixture units.

SPS 382.40(3)(d) Identification.

Plumbing water distribution systems include non-potable or specific use water distribution systems of varying degrees of hazard that serve plumbing fixtures, appliances, appurtenances, or are directly connected to the water supply or drain system. The need and value of capturing and re-using water is becoming more and more the choice of design engineering. SPS 382.70 Table 1 provides the guidelines on plumbing treatment standards for plumbing systems that supply water to outlets based on the intended use.

The plumbing water distribution system shall supply water that is of a quality that will protect the public health, the waters of the state, and suitable for its intended use.

Where buildings and facilities contain water supply systems with varying degrees of hazard, then labeling is required to identify the non-potable water distribution systems. Labeling the potable water distribution system and its corresponding valves and outlets is optional.

Above ground piping supplying water other than potable shall be labeled by tags or colored bands, according to Table 382.40-1a. Valves shall be identified by tags.

The tags or colored bands shall be placed at intervals of not more than 25 feet and where the pipe passes through a wall, floor, or roof, the tags or bands shall be placed on each side of the wall and within each compartment.

The colored bands shall be at least 3 inches wide and shall identify the water or the specific use in writing.

Tags used to identify water outlets, valves and piping shall be made with metal or plastic and of a shape specified in Table 382.40-1a. The lettering shall be at least ½ inch in height.

Hose bibbs that discharge any water not meeting drinking water quality as specified in SPS 382.70 shall be labeled non-potable or identified for the specific use or uses, and shall be equipped with removable handles.

Piping downstream of cross connection control assemblies as listed in Table 382.22-1 shall be labeled with bands or tags as specified in this subsection.

Any buildings that are served by two water distribution systems, one system supplied by a public water supply, and the other system supplied by a private well, each water distribution system shall be identified to indicate the supply source.

Figure 12

Table 382.40–1a
Distribution and Service

Supply	Tag and Band Color	Tag Shape	Tag Size	Tag Legend[a]
Potable	Green	Round	3″ diameter	Safe Water
Nonpotable	Yellow	Triangle	4″ sides	Nonpotable Water or Not Safe for Drinking
Reuse (Nonpotable)	Purple	Triangle	4″ sides	Nonpotable Water or Not Safe for Drinking or Specific Use[b]
Device Specific[c]	Gray	Triangle	4″ sides	Specific Use[b]

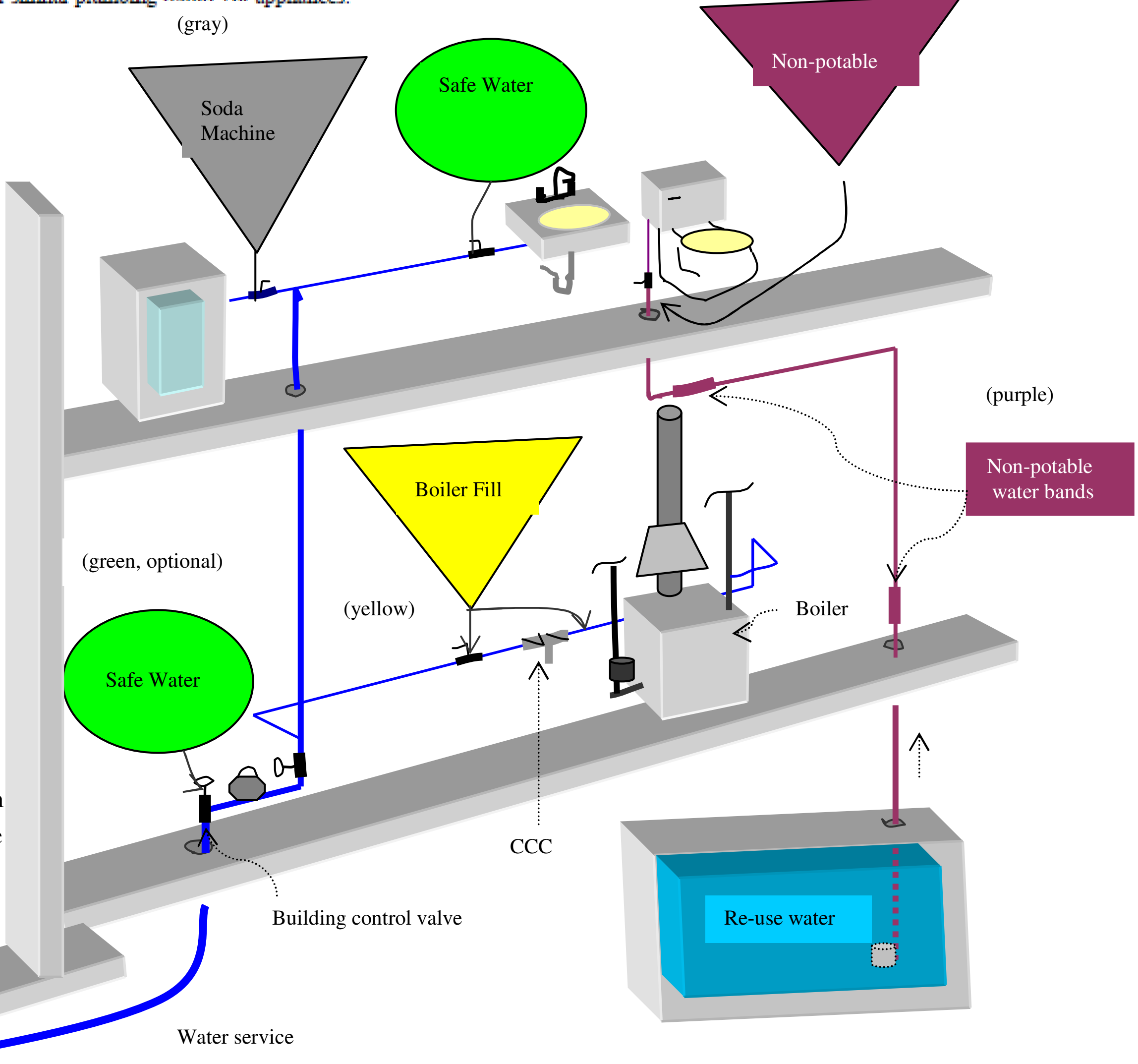
[a] All nonpotable water outlets shall be identified at the point of use for each outlet with the following legends or as otherwise approved by the department.
[b] Tag should reflect the intended use.
[c] Serving an individual or similar plumbing fixtures or appliances.

Figure 13

Water Distribution and Service.

Triangle Tags and Bands are required for Non-potable, Reuse, and Device Specific water supplies.

Round Tags are optional for potable water, unless there are two water distribution systems one supplied by a public water supply, and the other system supplied by a private well, then each system shall be identified.



Converting water supply fixture units to gallons per minute using Table 382.40-3e.

The most common type of water treatment device used on the water distribution system is the water softener. A device such as a softener or iron filter can anticipate lower gpm flow rate requirements than the actual total gpm building demand when certain stipulations are in effect. High flow fixtures, hose bibbs, or hydrants are not allowed downstream of the treatment device, and Table 382.40-3e can only be used when treatment devices serve an individual dwelling.

Table 382.40–3e
Conversion of Water Supply Fixture Units to Gallons Per Minute for Water Treatment Devices[a] Serving an Individual Dwelling[b]

Water Supply Fixture Units (WSFUs)	Gallons Per Minute (GPM)
1	1
2	2
3	3
4	4
5	4.5
6	5
7	6
8	6.5
25	7
35	8
40	9

[a] Treatment devices providing treatment for compliance with Table 382.70–1 shall use Table 382.40–3 for conversion.
[b] Table shall not be used for converting hose bibb, high flow fixture or hydrant wsfu.

For example, let's use a dwelling with a total building wsfu demand of 25 wsfu's, the conversion to gpm using Table 382.40-3 is 17 gpm, and we would like to install a water softener.

If we do not have any high flow fixtures such as a deck mount tub filler, and there are no hose bibbs downstream of the water treatment device, then we can use Table 382.40-3e to size our water treatment device (softener).

<u>Note that the table is used for sizing the water treatment device only,</u> not the water distribution system piping.

Converting 24 wsfu's to gpm using Table 382.40-3e will equal 7 gpm. The next step would be to check with the water softener manufacturer to determine the proper size of water softener with a flow rate demand of 7 gpm downstream of the device.

Final caution is Table 382.40-3e cannot be used to size water treatment devices providing treatment for compliance with Table 382.70-1.

Table 382.70–1
Plumbing Treatment Standards

Intended Use	Plumbing Treatment Standards [f]
1. Drinking, cooking, food processing, preparation and cleaning, pharma-ceutical processing and medical uses	NR 811 and 812 approved sources
2. Personal hygiene, bath-ing and showering	NR 811 and 812 approved sources
3. Automatic fire protec-tion systems	As acceptable by local author-ity
4. Swimming pool makeup water	NR 811 and 812 approved sources
5. Swimming pool fill water	DHS 172 requirements
6. Cooling water [b]	pH 6 – 9 [b] $\leq$ 50 mg/L BOD_5 $\leq$ 30 mg/L TSS Free chlorine residual 1.0 – 10.0 mg/L[b]
7. Subsurface infiltration and irrigation, using reuse as the source [c]	$\leq$ 15 mg/L oil and grease $\leq$ 30 mg/L BOD_5 $\leq$ 35 mg/L TSS < 200 fecal coliform cfu/100 mL [d]
8. Subsurface infiltration and irrigation, using stormwater as the source [c]	< 15 mg/L oil and grease < 60 mg/L TSS
9. Surface or spray irriga-tion using stormwater and clearwater as the source [c]	$\leq$ 10 mg/L BOD_5 $\leq$ 5 mg/L TSS
10. Surface irrigation except food crops, vehicle washing, clothes washing, air conditioning, soil com-paction, dust control, washing aggregate and making concrete [a, c]	pH 6 – 9 [b] $\leq$ 10 mg/L BOD_5 $\leq$ 5 mg/L TSS Free chlorine residual 1.0 – 10.0 mg/L[b]
11. Toilet and urinal flushing	pH 6 – 9 [b] 200 mg/L BOD_5 $\leq$ 5 mg/L TSS Free chlorine residual .1 mg/L – 4.0 mg/L [b]
12. Uses not specifically listed above	Contact department for stan-dards

Sizing for hot water demand.

SPS 382.40(5)(a) General. Water heating systems shall be sized to provide sufficient hot water to supply peak demand.

The master plumber or designer has a choice of tank type, instantaneous, and a combination of the two hot water heaters to choose from. Also there are the boiler side unit devices that draw heat through a heat exchanger coil, and heat exchanger units. In the past, proper sizing of the heater was provided by engineering calculations provided by the hot water manufacturers, or design estimates by the master plumber.

As of August 6, 2010, an alternate system of water sizing method has been approved to provide uniformity in hot water appliance or device sizing and to adjust to new technology and market demands.

The alternate is product file # 20090426, and is an alternate to SPS 382.40(6) Load Factors For Water Supply Systems, and is valid until the end of August 2013.

The alternate approval is contingent upon the following stipulations:

- Minimum flow rate of a water heater shall be obtained by multiplying the calculated hot water demand as determined by Table 382.40-1b and Table 382.40-3 by 0.65.
- This sizing method may only be utilized on 1 and 2 family residences, Townhouses, and apartments with individual water heaters.
- A tank type heater flow rate shall be based on a 10 minute draw time, 70% usable storage plus the recovery rate.
- A tank-less type heater shall be based on a temperature rise that will achieve 110 degrees at the terminal fitting or faucet.
- This alternate sizing may not be used for a water heater serving a high flow fixture, hose bibb, hydrant or a fixture that requires more than a ½" supply. For these specified types of outlets, the full demand, based upon the water sizing methods per SPS 382.40(7) shall be used.
- Note: High flow fixtures are defined as fixtures that exceed a flow rate of 4 gpm @ 80 psi, and water velocity not exceeding 8 ft. per second.

Let's use an example to show how to size the hot water heater. If we use our example on page 21, Chapter 3, Figure 11, the hot water demand downstream of the hot water heater is 6.5 wsfu's when converted to gpm in Table 382.40-3 we have 5.5 gpm demand downstream of the hot water heater. Multiplying the 5.5 gpm by .65 will give us the flow rate for the example.

6.5 wsfu's = 5.5 gpm X .65 = 3.575 or 3.6 gpm.

For instantaneous hot water heaters, the hot water demand of 3.6 would be used.

For tank type hot water heaters, the flow rate shall be based upon a 10 minute draw time. A 40 gallon hot water heater would be sized:

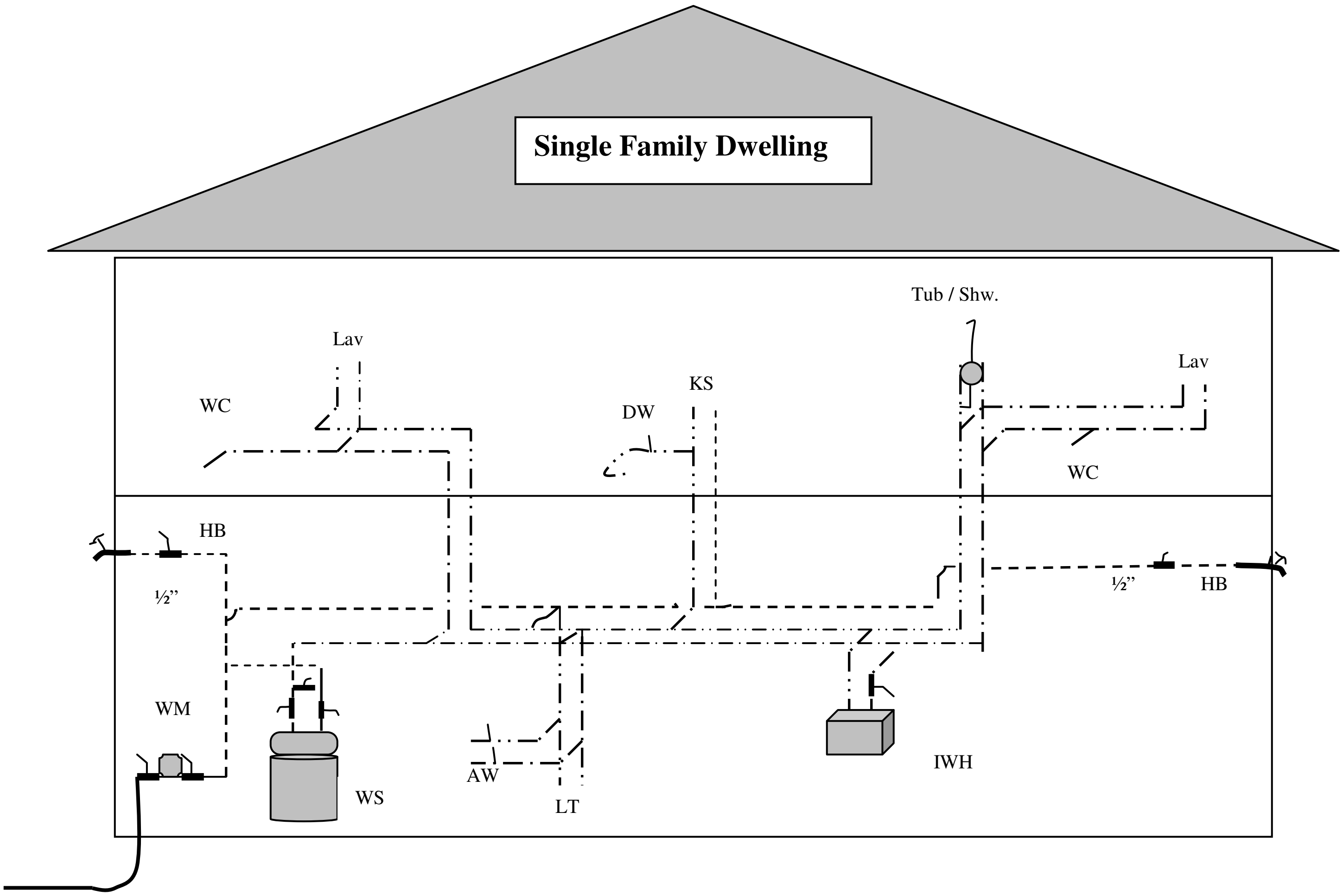
40 gal.W.H. X .70 usable gal./10 min.= 2.8gpm
70^0 rise @ 51.9 gph / 60 min. =<u>.87 gpm</u>
Providing a gpm flow rate of: 3.67 gpm

Instantaneous water heaters have been around for a long time, but recently have become more popular with new technology and an increased awareness to conserve energy. Because they are instantaneous, careful water calculations of anticipated fixture use should be made to insure hot water peak demand is met. Pressure loss through the heater is also very critical, for instance; a 5.5 gpm flow rate through one instantaneous hot water heater will create a 22 PSI pressure drop. This pressure loss, combined with the pressure requirement of a pressure balanced tub and shower valve of 20 psi will limit simultaneous fixture use.

Figure 12 shows the piping arrangement changes for our single family dwelling example when a water softener is specified and Table 382.40-3e is utilized. The water softener may not serve hose bibbs, wall hydrants, or high flow fixtures thereby requiring dedicated hard water piping to be installed and connected upstream of the water softener to serve the wall hydrants.

The kitchen cold water pipe is also connected to the hard water piping as a convenience for drinking water use.

Figure 14



Pipe segment WSFU load is shown in Figure 39, page 79.

Symbols

Cold Water Piping	— · — · —	Lavatory	Lav	Hose Bibb	HB
Hot Water Piping	— · · — · · —	Water Closet	WC	Water Meter	WM
Hard Water Piping	- - - - - - -	Dishwasher	DW	Clothes Washer	AW
Tub & Shower	Tub/Shw.	Kitchen Sink	KS	Laundry Tray	LT
Water Softener	WS	Instantaneous Water Heater		IWH	

Determining Low Pressure At The Water Supply Source

<u>Chapter 6</u>

To begin the water calculations, determine the low pressure at the source of the water supply system.

To determine the low pressure at the municipal main, contact the local water utility and ask what the low (residual) pressure is in the area of the project. It is also important to ask what the elevation or depth of the water main is at the building location.

When not connecting to a municipal water main, it is necessary to know the low pressure setting at the pressure tank. There are two locations for pressure tanks – internal and external. When designing for a building which has an internal pressure tank, do not complete the top two portions of the water calc worksheet, but go directly to the last section; **Calculate The Pressure Available For Uniform Loss** (Value of "A").

Item B in this section calls for the available pressure after building control valve or <u>low pressure at internal pressure tank.</u> This is obtained either by checking the low pressure setting on the pressure tank, if it is existing, or by asking the well installer.

Then calculate the pressure available for uniform loss using the formula on the water calculation worksheet.

For plumbing systems that will be served by an external pressure tank, check with the well installer. Piping after or downstream of an external pressure tank is, by the plumbing code definition, water service piping. So the low pressure setting on the external tank will have an impact on the water service and water distribution system sizing.

For remodeling or additions where changes to the water distribution system are anticipated, it's necessary to recalculate the pressure available for uniform loss to determine if there is still sufficient pressure after the water service to operate the system.

If the flow rate increases dramatically through a water service,(such as when doubling the number of fixtures on a water service) the loss due to friction in the water service will also be much higher. In cases where the friction loss in an existing water service is excessive, it may be necessary to:

1. Install a replacement service
2. Add a second water service to serve the addition
3. Install a hydro pneumatic pressure booster system
4. Install larger distribution mains and branches.

In other cases, such as large multistory buildings (e.g., hospitals, apartments, schools, office buildings, etc.) the project may call for removing more fixtures than are being added. In these cases, the gauge pressure point at the point of connection or near the point of connection can be measured and used in sizing. Then the supply source is existing distribution piping.

Figures 15 and 15a. on the following page provide two examples of pressure tank locations. The pressure available at the internal pressure tank does not have to take into account the pressure losses through the water service because an adequate supply of water is stored and available at the building control valve.

The water supply available at the external pressure tank, (whether it is buried or above ground) must pass through the water service to reach the building control valve. Therefore, the pressure loss through the water service must be calculated on the water calculation worksheet.

Figure 15

WELL W / INTERNAL PRESSURE TANK
Low pressure set at 40 psi.
Initiate water calculations at point 'B.' on the Water Calculation Worksheet

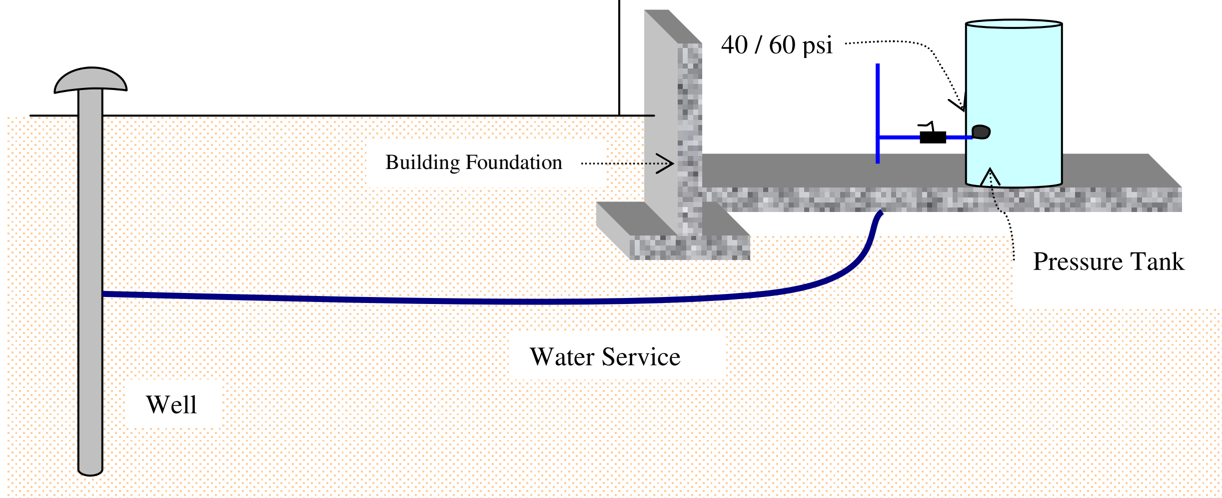
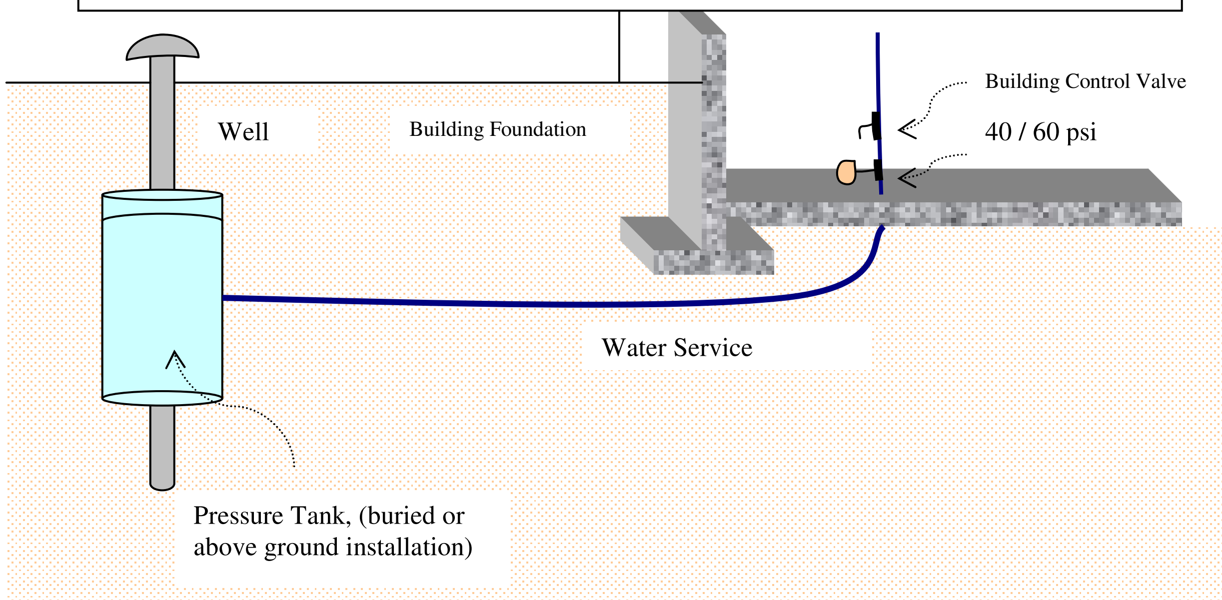


Figure 15a.

WELL W/ EXTERNAL PRESSURE TANK
Low pressure set at 40 psi.
Initiate water calculations at point '6.' on the Water Calculation Worksheet
Pressure loss through the water service must be calculated.



Determining Water Service Friction Loss

Chapter 7

Anytime water moves through a pipe, there is a loss in pressure over the length of the pipe. This is due to friction. To determine friction loss, it is necessary to know:

1. The piping material being used for the water service;

2. The size of the water service;

3. The length of the water service; and

4. The maximum flow rate through the water service pipe in gallons per minute, which is based on building demand.

5. The difference in elevation between the main in the street and the building control valve (which is covered in the next chapter as a elevation loss not necessarily a friction loss).

Any object or liquid that is moving has a frictional force working against it, trying to slow it down. As the speed of an object or liquid gets faster, the frictional force increases.

In pipes, frictional force is due to the liquid being in contact with the sides of the pipe. This contact force varies with the roughness of the inner surface of the pipe, and the rate of speed (velocity) of the water moving through the pipe.

For any given flow rate, as the diameter of a pipe gets smaller, the friction loss will go up. Therefore the velocity of water must increase as the piping gets smaller, in order to maintain the same gallons-per-minute flow rate.

The friction loss in the water service results in lowering the pressure available at the end of the water service or discharge point. This pressure loss is determined from a chart which is labeled in pounds of pressure lost per 100- foot length of pipe.

After determining the pressure loss that will occur in a water service in pounds per square inch per 100- foot length of pipe, either:

1. Multiply it by the number of 100- foot lengths of pipe: (i.e. 75 ft. = .75 multiplier) or

2. Cross multiply to obtain the friction loss in the service.

For example, if a water service is 50 feet long, this is a .5 hundred – foot length of pipe. If the water service was 120 feet long, this would be 1.2 hundred- foot length of pipe.

To determine the friction loss in a water service, we take the estimated demand for the building in gallons per minute and refer to the monographs in Figures 50 – 60 (pages 92 - 102 of this manual). There are different charts for different types of materials since the inside diameter and coefficient of friction (how rough the pipe surface is) changes for different materials.

There are also materials which require more than one chart for the same material, copper requires three charts, one each for Type K, L, and M copper (M copper is not allowed for water services). In comparing the charts between Type K and L, note that for the same size pipe, more gallons per minute will flow through the Type L. This is due to the difference in wall thickness of the different types of copper pipe.

See Figures 16 and 17.

Water Services may be installed with multiple pipe sizes. Each pipe size segment of the water service would have its own corresponding friction loss.

Figure 16

Graph A–382.40 (7)–2
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Copper Tube–Type K, ASTM B88; (C = 150)

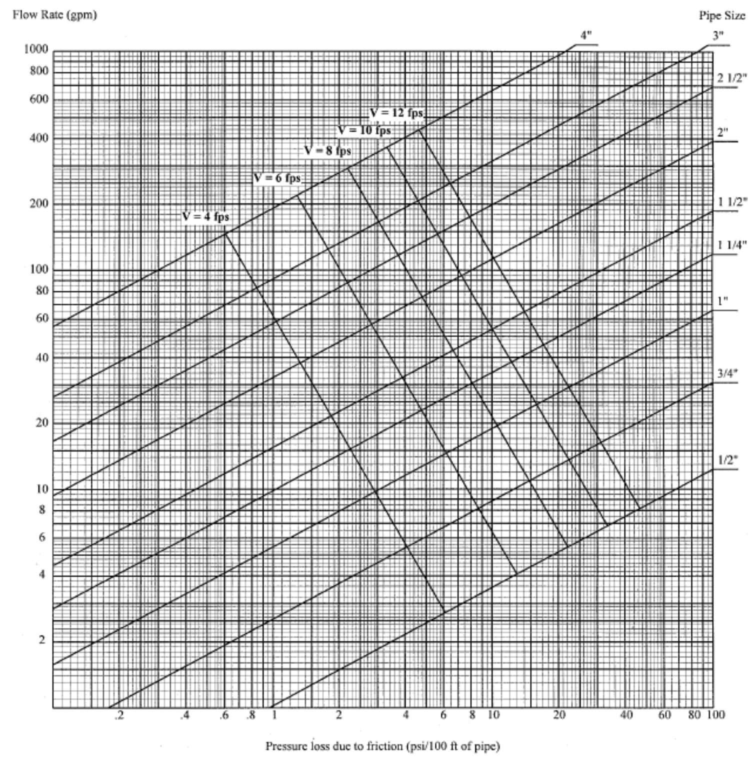
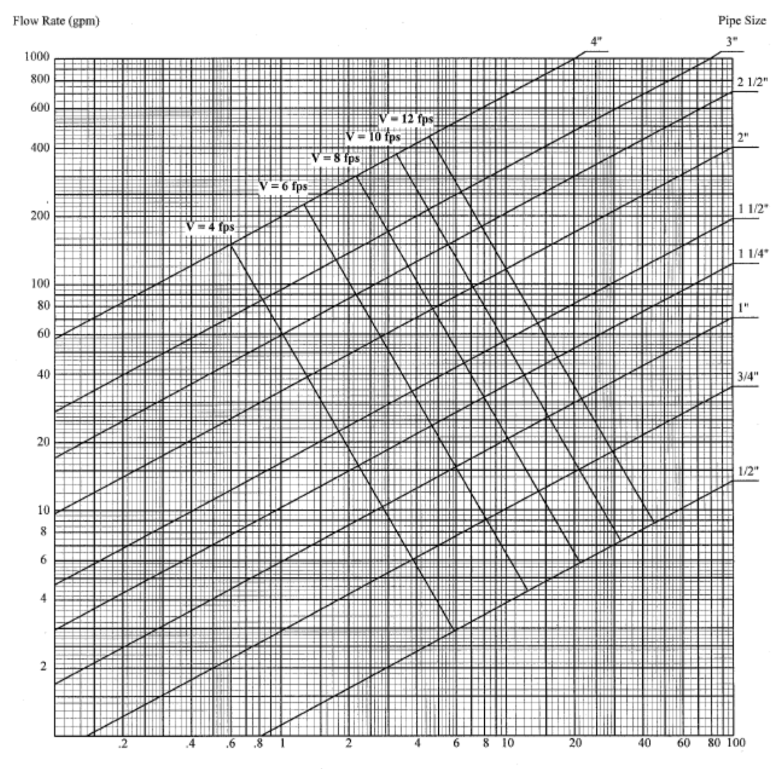


Figure 17

Graph A–382.40 (7)–3
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Copper Tube–Type L, ASTM B88; (C = 150)

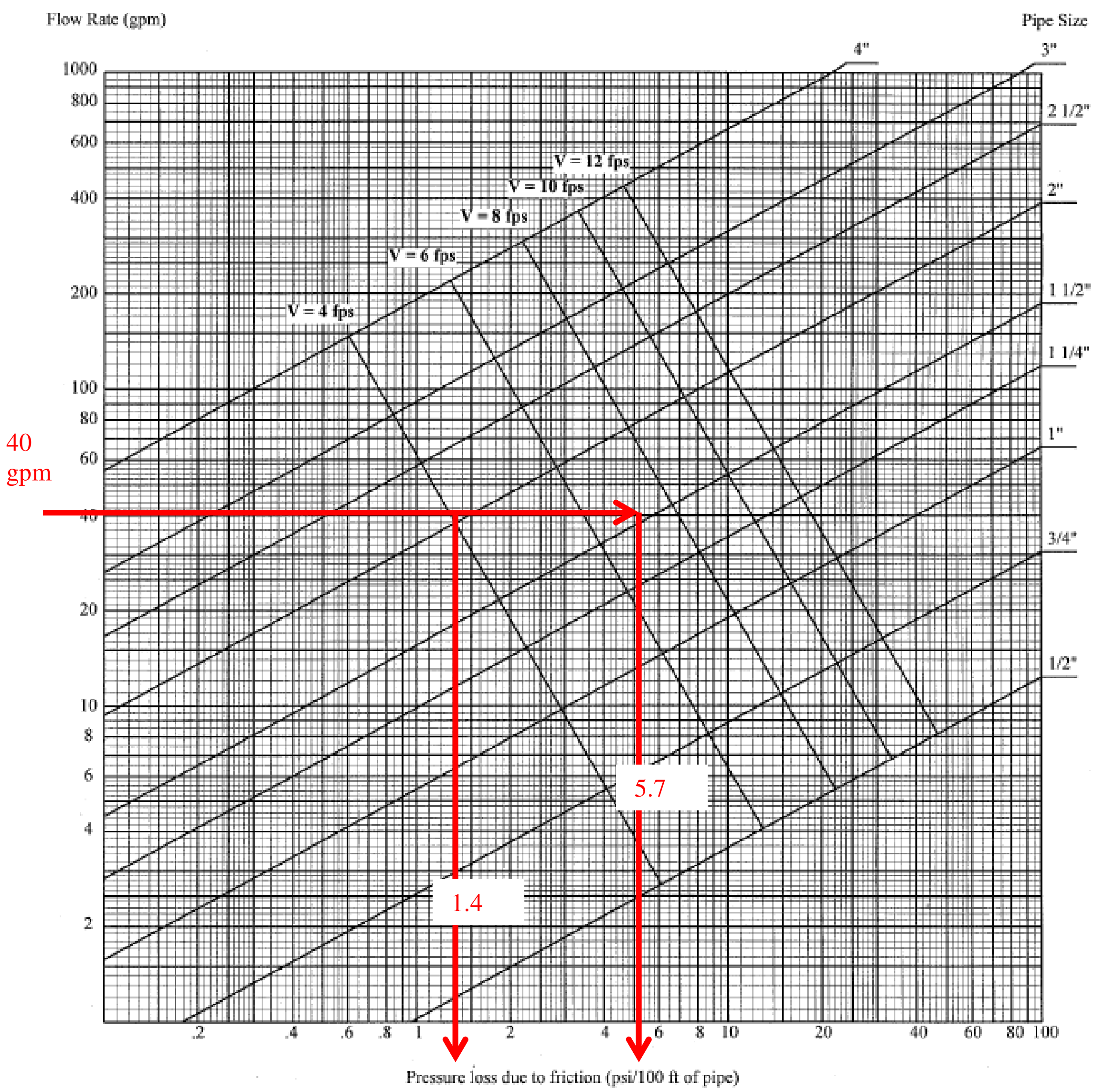


Dissect one of the charts and learn how it works. Figure 16 is the chart for Type K Copper tubing and the horizontal lines indicate the flow rate in gallons per minute (GPM). The left side is labeled GPM, beginning with 2 GPM at the bottom and progressing to 1000 GPM at the top. The vertical lines on the chart represent pounds-per-square-inch loss due to friction in 100 feet of pipe. The numbers for the vertical lines start at the bottom left, increasing from .2 to 100. This, in essence, is a scale like the horizontal lines.

Diagonal lines represent pipe sizes from ½ inch to 4 inches. The plotted lines provide us the information needed to find pressure losses in water service piping. Remember, there is not a limitation by rule of a maximum velocity of 8 feet per second within the service. The velocity diagonal lines are shown for reference only, not as code limits.

Figure 18

Graph A–382.40 (7)–2
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Copper Tube–Type K, ASTM B88; (C = 150)



With the flow rate determined from calculating building demand, use the chart for Type K copper (Figure 18) to determine the friction loss for a service being installed. The water service will have a flow rate of 40 gallons per minute. Find the correct line on the left side of the graph. Follow the 40 gallons- per – minute flow rate line horizontally across the chart to the right until it intersects the size of water service anticipated. An 1 ½" water service with a 40 gpm flow rate will result in 5.7 psi per 100 feet of pipe. If the water service is 130 feet long then multiply; 5.7 psi per 100' X 1.3 equivalent 100' lengths, and the answer would be 7.4 psi pressure loss in 130 feet of Type K Copper.

Increasing the water service size to 2" will give us a friction loss of 1.4 psi per 100' of pipe.
In the example, the friction loss in 130 feet of pipe would be:

1.4 psi per 100' pipe X 1.3 equivalent 100' lengths = 1.9 psi pressure loss.

There is no rule concerning how much friction loss is too much in a water service. Instead, one of the functions of the plumbing designer is to balance pipe size (and thus cost on installation) with the amount of pressure loss that can be allowed in the water service. The 8 feet per second maximum velocity in the water distribution system piping does not need to be observed for water service piping, unless manufacturers specifications have velocity limitations.

However, ensure that velocities are not totally out of line, so erosion of the piping system does not become a concern. The manufacturer of each individual piping material should be consulted to determine what water service maximum velocity should be.

Determining Pressure Loss Due To Elevation

Chapter 8

A difference in elevation between the source of the water supply and the outlet of the water will cause either an increase or decrease in system pressure.

After determining the pressure available at the point of supply, calculate the difference in elevation and determine how much pressure will be either lost or gained. Pressure is gained or lost because the force of gravity is acting on the water in the piping system. If the water main in the street is lower in elevation that the fixtures served, there will be a loss in pressure due to the amount of energy it takes to lift the water upwards against the force of gravity.

For every foot of elevation that the water if lifted against the force of gravity, .434 psi of pressure is lost.

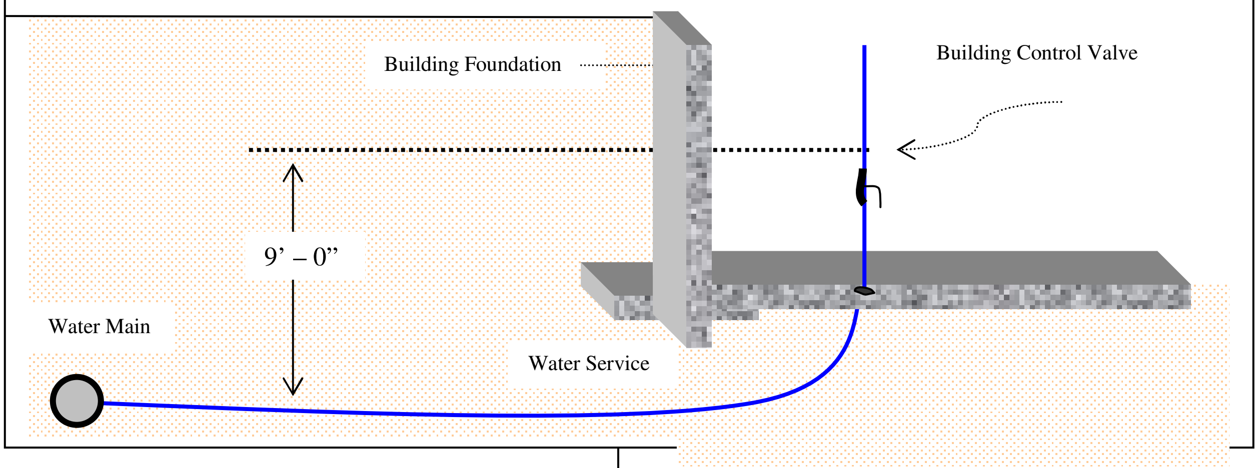
For example, as shown in Figure 19, the water main is 9 feet lower than the building control valve. To find the pressure loss due to elevation in the service, multiply the 9 foot elevation difference by .434.

9 ft. X .434 psi ft. = 3.9 or 4 psi pressure loss

If the low pressure at the main was 50 psi, subtract the 4 psi elevation loss.

50 psi at the main – 4 psi = 46 psi at the building control valve and of course minus the pipe friction loss.

Figure 19



In the next example, Figure 20, there is a pressure gain because the water main is higher than the building control valve.

If the water main is 7 feet higher than the building control valve the pressure gain is:

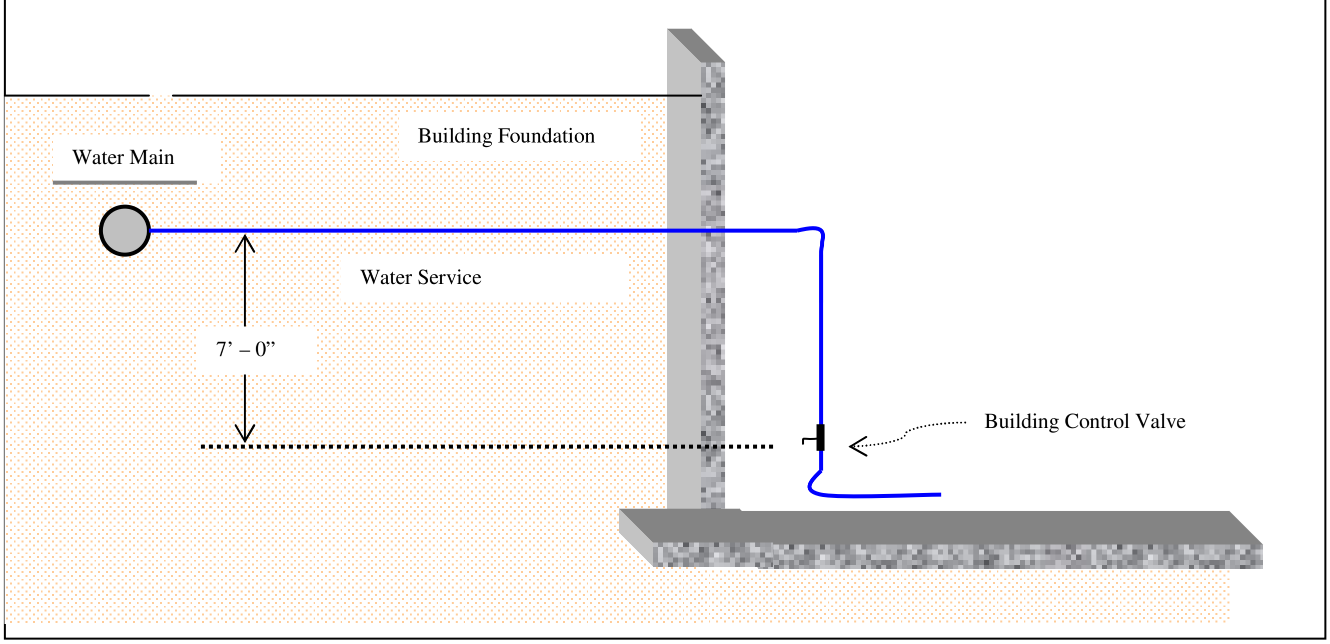
7 ft. X .434 psi/ft. = 3 psi gain

These last two examples demonstrate how to find the pressure loss or gain due to elevation in a water service.

Later in the calculations, the difference in elevation from the building control valve to the controlling fixture will have to be determined. The calculations will be exactly the same.

Where the controlling fixture is higher in elevation than the building control valve, subtract pressure due to the need to lift water against the force of gravity; .434 psi per foot based on the amount of pressure that is exerted by one foot of water in a standing pipe or column.

Figure 20



One more example: You have been contacted to install the water service piping from a water main installed at an elevation of 103 feet to a slab constructed building with a building control valve at an elevation of 117 feet. The building control valve is higher in elevation than the water service is. There will be a pressure loss through the water service piping due to this elevation difference.

The pressure loss will be:

117 ft. minus 103 ft = 14 ft. of elevation difference

14 ft. X .434 psi / ft = 6.1 psi loss

6.1 pounds of pressure are lost as the water is lifted from the water main to the building control valve.

Determining Pressure Loss Due To Water Meters

<u>Chapter 9</u>

Much of the loss in pressure within a water meter is a frictional loss just like the loss incurred in water service piping. In some water meters, there is an additional loss due to the energy needed to turn the disc or vane in the meter. Other meters record water usage by other means and have very little friction loss.

To determine the pressure loss in water meters:

1. Contact the manufacturer of the meter and ask for a pressure loss chart; or

2. Use the graph Figure 21, page 40.

This graph shows the pressure loss for flow rates in gallons-per-minute, and different sized meters ranging from 5/8" to 6 inches.

Use the building demand in gallons per minute, which has been previously calculated, and match it with the flow rates located at the bottom of the chart.

Assume, for example, use of a 1 ½ meter for a 40 gallons per minute flow rate. Locate 40 gpm along the bottom line of the chart.

Move vertically up the 40 gallons per minute flow rate line until intersecting the line that is labeled "pressure loss, psi." A pressure loss of 3.1 psi would be incurred going through a 1 ½ meter at a flow rate of 40 gallons per minute.

Substitute a 1-inch meter at a 40 gallons per minute flow rate. The loss in pressure would be 9.3 psi.

Figure 21

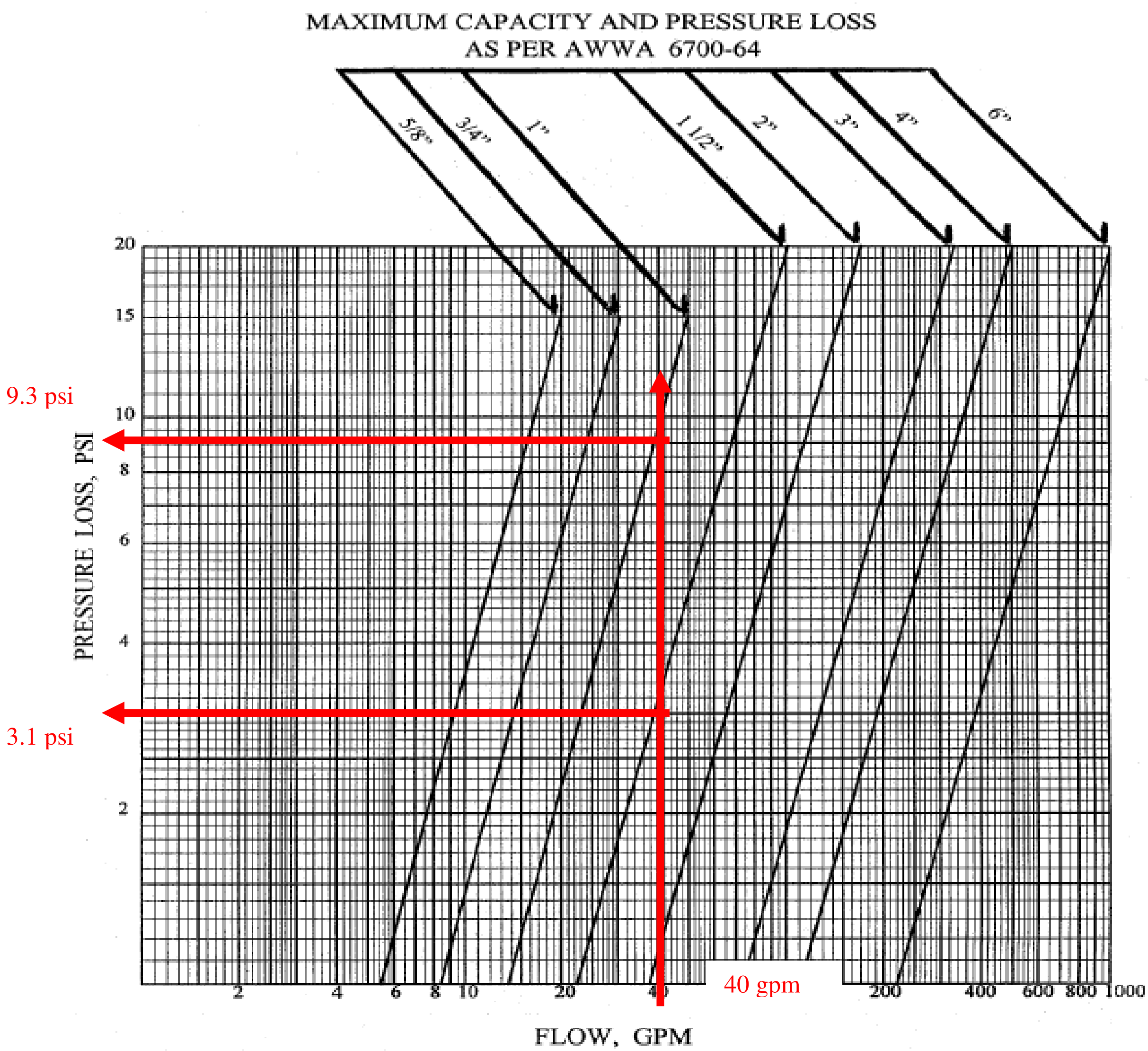
A–382.40 (7) (a) METHODOLOGY.

Where equipment such as an instantaneous or tankless water heater, water treatment device, water meter, and backflow preventer is provided in the design, the friction loss in such equipment, corresponding to the GPM demand, should be determined from the manufacturer or other reliable source.

Where a direct fired pressurized tank type water heater is provided in the design, the friction loss for such equipment can be assumed as part of the pressure losses due to flow through piping, fittings, valves and other plumbing appurtenances when the developed length of piping is multiplied by 1.5.

The pressure losses due to flow friction through displacement type cold–water meters may be calculated from Graph A–382.40 (7)–1.

Graph A–382.40 (7)–1
PRESSURE LOSS IN COLD–WATER METERS, DISPLACEMENT TYPE



Determining The Controlling Fixture

Chapter 10

If all fixtures had the same pressure requirements, selecting the controlling fixture would be easy. The furthest fixture, highest in elevation, would be the controlling fixture. But not all fixtures have the same pressure requirements.

The minimum amount of pressure that must be supplied at any plumbing fixture in Wisconsin is 8 pounds-per-square-inch flowing pressure at the outlet of the fixture supply.

There are fixtures which have higher pressure requirements.

Fixtures requiring a <u>flow</u> pressure of **15** psi at the outlets of the fixture supplies are siphonic type urinals, washdown type urinals, washdown type water closets, siphonic type flushometer water closets and campsite water supply hose connections.

Fixtures requiring a <u>flow</u> pressure of **20** psi at the outlets of the fixture supplies are one piece tank type water closets, pressure balancing mixing valves, manufactured homes, and thermostatic mixing valves.

Fixtures requiring a <u>flow</u> pressure of 25 psi at the outlets of the fixture supplies are blow-out type urinals and blow-out type water closets.

Fixtures requiring a <u>flow</u> pressure greater than 25 psi at the outlets of the fixture supplies are emergency showers and washdown fixtures, emergency eye wash, and other fixtures with pressure requirements by the manufacturer.

Higher flow pressures are required for flushometer fixtures to properly operate those fixtures and to provide an adequate flow of water on instantaneous demand, which is how the valves work. A flushometer valve will have trouble both being actuated and in closing down if there is no adequate pressure supplied.

A pressure balancing mixing valve is designed to respond to changes in pressure on the hot and cold supplies. As the pressure drops on the cold side, a plunger or cylinder is actuated to equalize the pressure in relation to the supply pressure on the hot side. Inadequate pressure to a mixing valve can cause the valve to fail and raises the risk of scalding.

Blowout type fixtures will not properly cleanse itself without proper water flow and pressure to meet the demand. Water must be provided on a instantaneous basis and at the proper pressure to actuate and close the valves.

SPS 382.40(7)(d) Pressure.
1. Except as provided in subd. 1.a. to c., water supply systems shall be designed to provide at least 8 psig of flow pressure at the outlets of all fixture supplies.

a. The flow pressure at the outlets of the fixture supplies serving siphonic type urinals, washdown type urinals, washdown type water closets, siphonic type flushometer water closets and campsite water supply hose connections shall be at least 15 psig.

b. The flow pressure at the outlets of the fixture supplies serving one piece tank type water closests, pressure balancing mixing valves, manufactured homes (mobile homes), and thermostatic mixing valves shall be at least 20 psig.

c. The flow pressure at the outlets of the fixture supplies serving blowout type urinals, and blowout type water closets shall be at least 25 psig.

Note that the code uses the verbiage “at least”. There are many fixtures, faucets, and flush valves that are designed either with backflow prevention built into the faucet, or designed with a minimum water flow requirement that require flow pressures greater than the minimum specified by code. For instance;

A kitchen sink faucet used in a residential kitchen almost always performed adequately with the minimum 8 psi flow pressure at the outlet. Today, many kitchen sink faucets demand a higher flow pressure of 15 or 20 psi in order to operate properly due to pressure loss through the spout when the spout is of the pull out type on a hose. The backflow protection required for this type of faucet creates greater pressure losses and the plumber must be careful to have proper pipe sizing for this type of faucet.

New flush valves for urinals and water closets use less water but require a higher pressure to operate properly. Always check with the manufacturer to confirm the pressure requirements, they may be a higher requirement than the minimum required by code.

To determine the controlling fixture, select the fixture that has the highest demand in volume of water and pressure, factor in elevation pressure losses, and friction pressure losses due to length of pipe from the fixture to the building control valve, and water treatment devices.

If a building or dwelling has a Multipurpose Piping System, where fire sprinklers and plumbing fixtures are served by a water distribution system, it has to be determined which has the greater demand requirement, a plumbing fixture or a sprinkler(s).

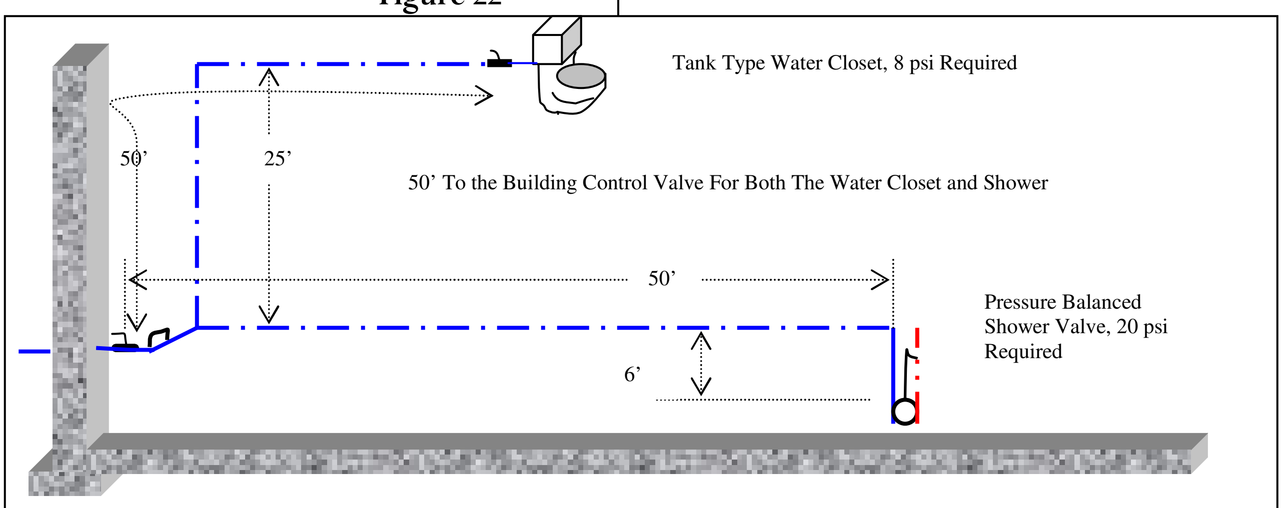
There will be cases when the furthest fixture will not be the controlling fixture. For example, there may be a building where the furthest fixture is a water cooler with a minimum gpm requirement, which is 100 feet from our water meter. There also are three pressure balanced shower valves 80 feet from the meter. The showers have a higher demand for water, and a higher pressure requirement, and are the controlling fixtures.

In another case, there might be a shower 6 feet lower in elevation than the building control valve and 50 feet in length from the building control valve. It has a pressure requirement of 20 psi. There also is a tank type water closet on the third floor, 25 feet higher in elevation than the building control valve and 50 feet in length from the building control valve. See Figure 22.

	Shower	Water Closet
Operating Press.	20 psi	8.0 psi
Elevation Diff.	(.434 x 6 ft.) -2.6 psi	(.434 x 25 ft.) +10.8 psi
Total pressure Required to Serve Fixture	17.4 psi	18.8 psi

The tank type water closet will require more pressure than the pressure balanced shower valve.

Figure 22



Calculating The Pressure Available For Uniform Loss

Chapter 11

The uniform pressure loss method of sizing the water distribution system is a method of calculation using the Hazen and Williams formula. The calculation provides an amount of pressure which can be lost over a 100 foot length of pipe, while still supplying adequate pressure at the controlling fixture. The number is expressed in pounds per square inch per 100 feet of pipe.

In other chapters it has been shown how to:

1. Determine the pressure available after the building control valve;

2. Determine the building demand in GPM or WSFU;

3. Determine the controlling fixture and the pressure needed to properly operate it; and

4. Determine the elevation difference between the building control valve and the controlling fixture.

Two items have not yet been determined:
1. The developed length of the water distribution system (length from the building control valve to the controlling fixture); and

2. The pressure loss that would occur due to other equipment, appliances, or devices that water would flow through on its way to the controlling fixture. This pressure loss may be calculated in terms of equivalent lengths of piping. The equivalent length of piping to a controlling plumbing fixture, including fittings, valves and other appurtenances may be obtained by multiplying the developed length by 1.5 (SPS 382.40(7)(a) 1. – 6.)

The "developed length" is the piping from the building control valve to the controlling fixture. It is not the total length of all piping in the building and does not include the water service piping, or all of the mains and branches in the building (In some cases, the hot water piping may have a greater length) This length is the distance along the main and any branch directly to the controlling fixture. If the most demanding fixture with the greatest pressure and gpm load is satisfied, then it can be assumed all of the other fixtures with a lesser load demand will be satisfied also.
The distance to the controlling fixture through the piping is multiplied by 1.5 to account for additional pressure losses in fittings and valves in the water distribution system.

Item F on the water calculation worksheet represents pressure losses due to other types of equipment. These are pressure losses that would occur through water treatment devices such as filters, softeners or other types of water treatment equipment.

Always consult the manufacturer's specifications or ask the manufacturer what the pressure loss will be through the unit at the demand flow rate.

Item G on the water calculation worksheet represents pressure losses due to tankless water heaters (instantaneous), combination boiler / hot water heaters, and heat exchangers.
Tank type water heaters do not have any pressure loss through the unit unless the manufacturer of the water heater says a loss will occur.

Instantaneous water heaters have pressure losses through the unit and are the primary reason for their gpm flow limitations. Always refer to the manufacturers specifications and pressure loss graphs to determine proper pressure losses in the calculations. In some models, a 5.5 gpm demand downstream of the instantaneous water heater can create a 22 psi pressure loss through the heater.

When determining the controlling fixture, always consider the hot side of a fixture when an instantaneous water heater, combination water heater / boiler, or heat exchanger is specified. Because of the high pressure losses of these fixtures, the piping from the building control valve to the controlling fixture such as a shower valve, will experience the greater load.

A pressure loss should only be subtracted if the water goes through the device, appliance, or equipment serving the controlling fixture.

As an example, the controlling fixture is isolated with a backflow preventer. Every backflow preventer has a given pressure loss which is determined by the demand in GPM through the device. The manufacturers' flow charts will determine the actual pressure loss for any model specified. This pressure loss figure is entered into our equation on line F of the water calculation worksheet.

This information will be used in the calculations:

"B" = Available pressure after the building control valve (Chapter 8).

"C" = Pressure loss through the water meter when a water meter is installed (Chapter 9).

"D" = Pressure at the controlling fixture (Chapter 10).

"E" = Difference in elevation between the building control valve and the controlling fixture in feet ___. x .434 psi / ft. (Chapter 8).

"F" = Pressure loss due to water treatment devices, and backflow preventers which serve the controlling fixture.

"G" = Pressure loss through tankless water heaters, combination boiler / hot water heaters, heat exchangers, which serve the controlling fixture.

"H" = Developed length from the building control valve to the controlling fixture in feet ___. x 1.5.

"A" = Pressure available for uniform loss (psi / 100 ft of pipe), **the answer and number you are calculating for.**

After assembling all of this information, as represented by the letters in the calculations, subtract each from the available pressure "B". Start by subtracting the value of "C" from "B" , then subtract "D" from the pressure left and continue until the remaining pressure after "E".

In order to find the pressure loss due to water treatment devices under "F", it must be determined which Table is going to be used to calculate and convert wsfu's to gpm using Table 382.40-3 or Table 382.40-3e. The Table 382.40-3e is used to find the gpm load or demand on a water treatment device such as a water softener on individual dwelling water distribution systems . When using this table, there can be no high flow fixtures, hose bibbs, or hydrants downstream of the water treatment device. Once you convert to gpm's , a person must refer to the manufacturer's graph to obtain the pressure loss.

Enter the pressure loss through the tankless water heater, combination boiler / water heater, or heat exchanger under "G". If no pressure loss, enter "0".

The remaining pressure will be divided by "H" which is the developed length from the building control valve to the controlling fixture in feet multiplied by 1.5.
The subtotal or remaining pressure will now be multiplied by 100 to convert the pressure to the units of psi per 100 feet of pipe, which is the answer to "A". Round the result up to the next whole number.

See the following examples in Chapter 12.

Chapter 12

WATER CALCULATION WORKSHEET FOR Example 1
NAME/ADDRESS OF PROJECT

INFORMATION REQUIRED TO CALCULATE WATER SERVICE SIZE

1. Demand of building in gallons per minute. WSFU's 22.5 1.a. = (GPM) 15.5
2. Difference in elevation from main to extermal pressure tank or to building control valve. (feet) 7.0
3. Size of the water meter. (when applicable) 5/8 ___ 3/4 ___ 1 ___ 1.5 ___ Inch
   2 ___ 3 ___ 4 ___ 6 ___ Inch
4. Developed length from main or external pressure tank to building control valve. (feet) 50
5. Low pressure at main in street or external pressure tank. (psig) 40.0

CALCULATE WATER SERVICE PRESSURE LOSS

6. Low pressure at main in street or external pressure tank. (value of #5 above) 40.0
7. Water service diameter is 1.25 Material is PE (Polyethylene Tubing), Copper Tube Size, ASTM D2737
   Pressure loss per 100 ft. = 4.83 p.s.i. X 0.5 . 2.4
   (decimal equivalent of service length, i.e. 65ft = 0.65) (Subtract line 7. From line 6.) subtotal 37.6
8. Determine pressure gain or loss due to elevation. (multiply the value of #2 above by 0.434) value of "8" 3.0
9. Available pressure after the bldg. Conrol valve. (subtract or add line 8. Enter in "B".) **subtotal** 34.5

CALCULATE THE PRESSURE AVAILABLE FOR UNIFORM LOSS (VALUE OF "A")

B. Available pressure after the building control valve. (from "9" above) value of "B" 34.5

C. Pressure loss of water meter. (when meter is required or installed) value of "C" 0.0
   (subtract line C. From B.) **subtotal** 34.5

D. Pressure at controlling fixture. value of "D" 20.0
   (controlling fixture is PressureBalanced Tub/Shower Valve)
   (subtract the value of D.) **subtotal** 14.5

E. Difference in elevation between the building control valve
   and the controlling fixture in feet 12 X 0.434 psi/ft. value of "E" 5.2
   (subtract the value of E.) **subtotal** 9.3

F. Pressure loss due to water treatment devices, and backflow preventers which serve the controlling fixture.
   Pressure loss due to water softener, hot water only (subtract the value of F)

   F1. WSFU's downstream of Water Treatment Device: 8.5
   F2. Convert wsfu's to GPM using **Table 382.40-3** ______
   OR
   F3. Convert wsfu's to GPM using **Table 382.40-3e** 6.7
   F4. Refer to manufacturer's graph to obtain pressure loss: value of "F4" 6.0
   (If no water treatment device enter "0") **subtotal** 3.3

G. Pressure loss through tankless water heaters, combination boiler / hot water heaters, heat exchangers;

   Hot water WSFU's; ______ convert to; GPM = ______ (**(Table 82.40-3)**
   Refer to manufacturer's pressure loss graph to determine loss at required GPM: 0 pressure loss.
   (If no pressure loss through hot water appliance enter "0") value of "G" 0.0
   subtotal 3.3

Continued on next page

Water Calc Worksheet Example 1

G.	Continued from page 1;		**subtotal**	3.3
H.	Developed length from building control valve to controlling fixture in feet X	48 1.5 Divide by	value of "H"	72
		(divide by the value of G.)	**subtotal**	0.046
		(multiply by 100)		100
A.	Pressure available for uniform loss		**"A" =**	**4.6**

Water distribution piping material is: CPVC tubing

Note: High flow fixtures are defined as fixtures that exceed a flow rate of 4 gpm @ 80 psi.

Comments

A 2 ½ bath home will be served by an external pressure tank that is buried 7 feet lower than the building control valve. Within the home is two bathrooms, a laundry tray, a clothes washer, a kitchen sink, a dishwasher and two ½ inch hose bibbs. The water softener being installed will serve the hot water distribution system only. The water supply fixture unit load is:

2 Bathroom groups @ 4 wsfu's each = 8
(bathtub, lavatory, and water closet)
1 Flush tank water closet...............................= 2
1 Lavatory... = 1
1 Clothes Washer...................................... = 1.5
1 Laundry Tray.................................. ... = 1.5
1 Kitchen Sink...................................... ....= 1.5
1 Dishwasher...= 1
2 ½" Hose Bibbs....................... ....= 6

Total WSFU's...22.5

A fixture load of 22.5 WSFU's is converted to 15.5 GPM using Table 382.40-3

1.On point 1. of the water calculation worksheet enter the WSFU's 22.5 and the GPM 15.5.

2. Difference in elevation from the main or external pressure tank to the building control valve; 7 feet.

Example 1, continued…
3. point. There is no water meter.

4. point. Developed length from main or external pressure tank to building control valve; 50 feet.

5. point. Low pressure at the external pressure tank is; 40 psi.

Calculate Water Service Pressure Loss

6. point. Low pressure at the main in the street or external pressure tank (value of #5 above); 40 psi.

7. point. A 1 ¼" polyethylene tubing water service is specified. The friction loss (Graph A-382.40(7)-7) is 4.8 psi / 100 ft. with a 15.5 gpm demand. A friction loss in the 50 foot water service of:

4.83 psi / 100 ft. X .5 equivalent 100 ft. lengths = 2.4 psi.

Subtract 7 point. from 6 point: 37.6.

8 point. The elevation of the external pressure tank is 7 feet lower than the building control valve. The loss due to elevation is calculated as:

7 ft. X .434 psi/ft. = 3 psi.

9. point. .Available pressure after the building control valve.   Subtract 8 point from 7 point: 34.5.

Calculate The Pressure Available For Uniform Loss (Value of 'A")

B. point. Available pressure after the building control valve (from "9." Above):   34.5.

C. point. There is no water meter therefore no pressure loss of water meter……………………34.5.

D. point. The pressure at the controlling fixture which is a pressure balanced tub shower valve: 20 psi.

Subtract D point from C point: 14.5 psi.

E point. The difference in elevation between the building control valve and the controlling fixture (tub shower head is 12 feet. Multiplying 12 ft. X .434 psi/ft. = 5.2 psi loss due to elevation. Subtract E point from D point and the subtotal is; 9.3.

F. point. The pressure loss due to a water softener that is to be installed is found by converting 8.5 wsfu's , which is the hot load on the water distribution system downstream of the hot water heater to 6.7 gpm using Table 382.40-3e. The pressure loss through the water softener is determined by the manufacturer's pressure loss graph and using a maximum demand load of 6.7 gpm. In this case there is a pressure loss of 6 psi. Subtract F point (6 psi) from E point subtotal (14.5 psi) and the subtotal is: 3.3 psi.

G. point. Pressure loss through tankless water heaters, combination boiler / hot water heaters, heat exchangers does not apply in this example. The hot water heater will be a tank type hot water heater and there is no pressure loss through the heater. The subtotal remains: 3.3 psi.

Example 1, continued..

H. point. The developed length from the building control valve to the controlling fixture is 48 ft.. Multiplying 48 X 1.5 = 72 and dividing 72 into the subtotal of 3.3 = 0.046. Final step is multiplying the 0.046 by 100 and the answer is: 4.6.

A. point. Pressure available for uniform loss is 4.6. Always round up to obtain a whole number, and in this case we would have an A value of 5.0.

For the type of material of the water distribution piping, the example is using CPVC pipe. The maximum loads on the distribution pipe segments are found by locating the 5 psi/ 100 ft on Table 382.40-8 and follow it across. See pages 47, and 48.

Pipe Size	CPVC WSFU's Flush Tank Column
1/2 in.	2
3/4 in.	6
1.0 in.	14
1 ¼"	25.5

The minimum diameter pipe segment required including the building control valve will be 1 ¼" .

Figure 23 Example 1

Graph A-382.40(7)-7

PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Polyethylene Tubing, Copper Tube Size, ASTM D2737; (C = 150)

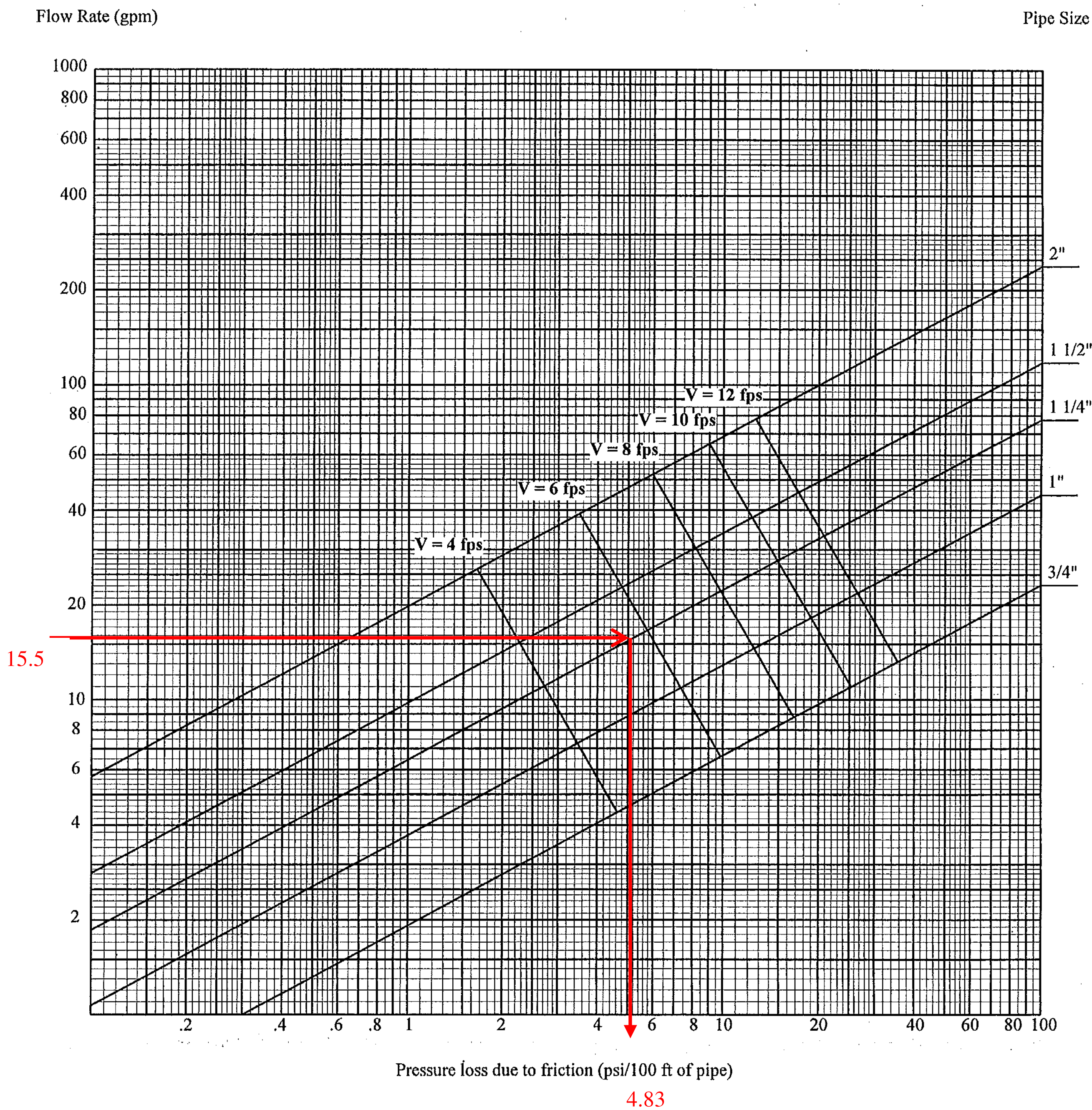


Figure 24 Example 1

Table 382.40–8
CHLORINATED POLYVINYL CHLORIDE TUBING, ASTM D2846 and F442, SDR 11; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																	
	1/2"			3/4"			1"			1 1/4"			1 1/2"			2"		
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	1.5	–	1.5	3.0	–	3.0	5.0	–	6.0	8.0	–	10.0	16.0	5.0	23.0
1	0.5	–	0.5	2.0	–	2.0	4.0	–	4.0	7.5	–	9.5	11.5	4.0	15.5	23.0	7.5	37.0
2	1.0	–	1.0	3.0	–	3.0	6.0	–	7.0	10.5	4.0	14.0	16.5	5.5	24.0	34.0	18.5	66.0
3	1.5	–	1.5	4.0	–	4.0	8.0	–	10.0	13.5	4.5	19.0	21.0	7.0	32.0	42.0	33.0	100
4	1.5	–	1.5	4.5	–	5.0	9.0	–	11.5	15.5	5.0	22.5	24.0	8.0	40.0	50.0	48.0	128
5	2.0	–	2.0	5.0	–	6.0	10.5	4.0	14.0	17.5	5.5	25.5	27.0	10.0	47.0	56.0	65.0	155
6	2.0	–	2.0	6.0	–	7.0	11.5	4.0	15.5	19.5	6.5	29.0	30.0	13.5	55.0	59.0	73.0	171
7	2.0	–	2.0	6.5	–	8.0	12.5	4.5	17.5	21.5	7.0	33.0	33.0	17.5	63.0		NP	
8	2.5	–	2.5	7.0	–	9.0	13.5	4.5	19.0	23.0	7.5	37.0	34.0	19.0	68.0			
9	2.5	–	2.5	7.0	–	9.0	14.5	4.5	20.5	24.0	8.0	40.0		NP				
10	2.5	–	2.5	7.5	–	9.5	15.0	5.0	21.5	24.0	8.0	41.0						
11	3.0	–	3.0	8.0	–	10.0	16.0	5.0	23.0		NP							
12	3.0	–	3.0	8.5	–	10.5	16.5	5.5	24.0									
13	3.0	–	3.0	9.0	–	11.5		NP										
14	3.0	–	3.0	9.5	–	12.5												
15	3.5	–	3.5	9.5	–	12.5												
16	3.5	–	3.5	10.0	4.0	13.0												
17	3.5	–	3.5		NP													
18	4.0	–	4.0															
19	4.0	–	4.0															
20	4.0	–	4.0															
21	4.0	–	4.0															
22	4.0	–	4.0															
23	4.5	–	5.0															
		NP																

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

WATER CALCULATION WORKSHEET FOR Example 2
NAME/ADDRESS OF PROJECT

INFORMATION REQUIRED TO CALCULATE WATER SERVICE SIZE

1. Demand of building in gallons per minute. WSFU's 110 1.a. = (GPM) 45.0
2. Difference in elevation from main to extermal pressure tank or to building control valve. (feet) N/A
3. Size of the water meter. (when applicable) 5/8 ___ 3/4 ___ 1 ___ 1.5 ___ Inch
   2 ___ 3 ___ 4 ___ 6 ___ Inch
4. Developed length from main or external pressure tank to building control valve. (feet) N/A
5. Low pressure at main in street or external pressure tank. (psig) 40.0

CALCULATE WATER SERVICE PRESSURE LOSS

6. Low pressure at main in street or external pressure tank. (value of #5 above) 40.0
7. Water service diameter is ______ Material is ______
   Pressure loss per 100 ft. = 0 p.s.i. X 100 .
   (decimal equivalent of service length, i.e. 65ft = 0.65) (Subtract line 7. From line 6.) subtotal #VALUE!
8. Determine pressure gain or loss due to elevation. (multiply the value of #2 above by 0.434) value of "8" ______
9. Available pressure after the bldg. Conrol valve. (subtract or add line 8. Enter in "B".) **subtotal** ______

CALCULATE THE PRESSURE AVAILABLE FOR UNIFORM LOSS (VALUE OF "A")

B. Available pressure after the building control valve. (from "9" above) value of "B" 40.0

C. Pressure loss of water meter. (when meter is required or installed) value of "C" 0.0
(subtract line C. From B.) **subtotal** 40.0

D. Pressure at controlling fixture. value of "D" 20.0
(controlling fixture is Pressure Balance Tub Valve)
(subtract the value of D.) **subtotal** 20.0

E. Difference in elevation between the building control valve
and the controlling fixture in feet 14 X 0.434 psi/ft. value of "E" 6.1
(subtract the value of E.) **subtotal** 13.9

F. Pressure loss due to water treatment devices, and backflow preventers which serve the controlling fixture.
Pressure loss due to Water Softener (subtract the value of F)

F1. WSFU's downstream of Water Treatment Device: 98
F2. Convert wsfu's to GPM using **Table 382.40-3** 41.8
OR
F3. Convert wsfu's to GPM using **Table 382.40-3e** ______
F4. Refer to manufacturer's graph to obtain pressure loss: value of "F4" 10.0
(If no water treatment device enter "0") **subtotal** 3.9

G. Pressure loss through tankless water heaters, combination boiler / hot water heaters, heat exchangers;

Hot water WSFU's; ______ convert to; GPM = ______ **Table 382.40-3**
Refer to manufacturer's pressure loss graph to determine loss at required GPM: 0 pressure loss.
(If no pressure loss through hot water appliance enter "0") value of "G" 0.0
subtotal 3.9

Continued on page 52.

Water Calc Worksheet Example 2

G.	Continued from page 1;		**subtotal**	3.9
H.	Developed length from building control valve to controlling fixture in feet X	70 1.5 Divide by	value of "H"	105
		(divide by the value of G.)	**subtotal**	0.037
		(multiply by 100)		100
A.	Pressure available for uniform loss		**"A" =**	**3.7**

Water distribution piping material is: Type L Copper

Note: High flow fixtures are defined as fixtures that exceed a flow rate of 4 gpm @ 80 psi.

Comments

Each unit of a 10- unit apartment building has 1 ½ baths, 1 kitchen sink, and 1 dishwasher. There are 4 automatic clothes washers and 3 hose bibbs, ½".

The fixture count for each unit is:

1 bathroom group (bathtub, lavatory and water closet)	= 4
1 flush tank water closet	= 2
1 lavatory	= 1
1 kitchen sink	= 1.5
1 dishwasher	= 1
Total wsfu's for 1 apartment	= 9.5

9.5 wsfu's X 10 apt. units = 95 wsfu's
4 automatic washers = 4 X 1.5 wsfu's = 6 wsfu's
3, ½ inch hose bibbs = 3 X 3 wsfu's = 9 wsfu's
95 + 6 + 9 = 110 wsfu's

110 WSFU's in a predominately flush tank system converts to a demand of 45 gallons per minute.

This facility is served by its own well and internal pressure tank. There is no need to calculate a pressure loss due to the water service.

Example 2 continued..
1. point   Enter the WSFUs 110 and the GPM 45.

5. point. The low pressure setting at the internal pressure tank is 40 psi. This is found on the limit switch for the private water supply.

6. point. The low pressure from point 5 above; 40 psi.

7. point. There is no water service, in the sense that the pressure tank is located within the building. Therefore, no loss, subtotal 40 psi.

8. point. There is no pressure gain or loss calculated for the water service, subtotal 40 psi.

9 point. Available pressure after the building control valve; 40 psi.

Calculate The Pressure Available For Uniform Loss (Value of "A")

B. point Available pressure after the building control valve (from "9" above), 40

C point. There is no water meter therefore no pressure loss of water meter, subtotal is 40.

D point. The controlling fixture is a pressure balanced tub and shower valve. The pressure at the controlling fixture is 20. Subtract from "C" and the subtotal is 20.

E. point. The difference in elevation between the internal pressure tank and the controlling fixture (shower head) is 14 feet. 14 ft. X .434 psi/ft = 6.1 psi loss due to elevation. Subtract from "D" and the subtotal is : 13.9.

F. point. The pressure loss due to a water softener being installed. The manufacturer's specifications indicate a loss of 10 psi, with a 41.8 gpm load downstream. Subtract 10 psi from the value of "E" and the subtotal is 3.9.

G. point. Pressure loss through a standard tank hot water heater is 0. Subtotal is still 3.9.

H. point. Developed length from the building control valve to the controlling fixture in feet 70 X 1.5 =105. Divide 105 into "G', (3.9) and there is a subtotal of 0.037. Multiply by 100 = 3.7.

A. point. Pressure available for uniform loss "A" = 3.7. Round up to 4 psi / 100 ft.

Use the 4 psi row on the far left hand side of the Table 382.40-5 Type L copper tubing. The following shows the maximum flush tank WSFU loads and the corresponding pipe size.

Pipe Size	Maximum WSFU's
1/2 inch	2
3/4 inch	7
1 inch	16.5
1 ¼ inch	33
1 ½ inch	66
2 inch	225

Minimum diameter piping including building control valve will be 2 inches in diameter.

Figure 25 Example 2

Table 382.40–5
MAXIMUM ALLOWABLE LOAD FOR COPPER TUBING–TYPE L, ASTM B88; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																										
	1/2"			3/4"			1"			1 1/4"			1 1/2"			2"			2 1/2"			3"			4"		
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	2.0	–	2.0	4.0	–	4.0	7.0	–	9.0	11.0	4.0	15.0	23.0	7.5	37.0	40.0	30.0	86.0	65.0	90.0	200	136	462	561
1	1.0	–	1.0	2.5	–	2.5	5.5	–	6.5	10.0	4.0	13.0	16.0	5.0	23.0	33.0	17.5	63.0	59.0	72.0	170	94.0	211	345	198	909	923
2	1.5	–	1.5	4.0	–	4.0	8.5	–	10.5	14.5	4.5	20.5	23.0	7.5	37.0	48.0	44.0	120	86.0	175	305	137	468	566	288	1694	1694
3	2.0	–	2.0	5.0	–	6.0	10.5	4.0	14.0	18.5	6.0	27.5	29.0	12.5	52.0	60.0	75.0	175	107	283	410	169	698	752	298	1792	1792
4	2.0	–	2.0	6.0	–	7.0	12.0	4.0	16.5	21.5	7.0	33.0	34.0	18.5	66.0	70.0	108	225	119	356	469		NP			NP	
5	2.5	–	2.5	6.5	–	8.0	14.0	4.5	20.0	24.0	8.0	40.0	38.0	26.0	80.0	77.0	136	260		NP							
6	2.5	–	2.5	7.5	–	9.5	15.5	5.0	22.5	26.0	9.0	45.0	42.0	33.0	100		NP										
7	3.0	–	3.0	8.0	–	10.0	16.5	5.5	24.0	29.0	12.5	52.0	44.0	37.0	107												
8	3.0	–	3.0	8.5	–	10.5	18.0	6.0	26.5	31.0	15.0	58.0		NP													
9	3.5	–	3.5	9.5	–	12.5	19.0	6.0	28.0		NP																
10	3.5	–	3.5	10.0	4.0	13.0	20.0	6.5	30.0																		
11	4.0	–	4.0	10.5	4.0	14.0	20.5	6.5	31.0																		
12	4.0	–	4.0	11.0	4.0	15.0		NP																			
13	4.0	–	4.0	11.5	4.0	15.5																					
14	4.5	–	5.0	12.0	4.0	16.5																					
15	4.5	–	5.0		NP																						
16	5.0	–	6.0																								
17	5.0	–	6.0																								
18	5.0	–	6.0																								
19	5.0	–	6.0																								
20	5.5	–	6.5																								
		NP																									

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

WATER CALCULATION WORKSHEET FOR Example 3

NAME/ADDRESS OF PROJECT

INFORMATION REQUIRED TO CALCULATE WATER SERVICE SIZE

1. Demand of building in gallons per minute. WSFU's 160 — 1.a. = (GPM) 83.0
2. Difference in elevation from main to extermal pressure tank or to building control valve. (feet) 7.0
3. Size of the water meter. (when applicable) 5/8 __ 3/4 __ 1 __ 1.5 __ Inch; 2 X 3 __ 4 __ 6 __ Inch
4. Developed length from main or external pressure tank to building control valve. (feet) 62
5. Low pressure at main in street or external pressure tank. (psig) 65.0

CALCULATE WATER SERVICE PRESSURE LOSS

6. Low pressure at main in street or external pressure tank. (value of #5 above) 65.0
7. Water service diameter is 2 Material is PVC Pipe - Schedule 40; ASTM D1785: ASTM D2672
   Pressure loss per 100 ft. = 4.4 p.s.i. X 0.62 . 2.7
   (decimal equivalent of service length, i.e. 65ft = 0.65) (Subtract line 7. From line 6.) subtotal 62.3
8. Determine pressure gain or loss due to elevation. (multiply the value of #2 above by 0.434) value of "8" 3.0
9. Available pressure after the bldg. Conrol valve. (subtract or add line 8. Enter in "B".) **subtotal** 59.2

CALCULATE THE PRESSURE AVAILABLE FOR UNIFORM LOSS (VALUE OF "A")

B. Available pressure after the building control valve. (from "9" above) value of "B" 59.2

C. Pressure loss of water meter. (when meter is required or installed) value of "C" 5.0
(subtract line C. From B.) **subtotal** 54.2

D. Pressure at controlling fixture. value of "D" 15.0
(controlling fixture is Flushometer water closet)
(subtract the value of D.) **subtotal** 39.2

E. Difference in elevation between the building control valve and the controlling fixture in feet 23 X 0.434 psi/ft. value of "E" 10.0
(subtract the value of E.) **subtotal** 29.3

F. Pressure loss due to water treatment devices, and backflow preventers which serve the controlling fixture.
Pressure loss due to Water Softener (subtract the value of F)

F1. WSFU's downstream of Water Treatment Device: 148
F2. Convert wsfu's to GPM using **Table 382.40-3** 80
OR
F3. Convert wsfu's to GPM using **Table 382.40-3e** ____
F4. Refer to manufacturer's graph to obtain pressure loss: value of "F4" 12.0
(If no water treatment device enter "0") **subtotal** 17.3

G. Pressure loss through tankless water heaters, combination boiler / hot water heaters, heat exchangers;

Hot water WSFU's; ____ convert to; GPM = ____ **(Table 382.40-3)**
Refer to manufacturer's pressure loss graph to determine loss at required GPM: 0 pressure loss.
(If no pressure loss through hot water appliance enter "0") value of "G" 0.0
subtotal 17.3

Continued on page 56.

Water Calc Worksheet Example 3

G.	Continued from page 1;		**subtotal**	17.3
H.	Developed length from building control valve to controlling fixture in feet X	90 1.5 Divide by	value of "H"	135
		(divide by the value of G.)	**subtotal**	0.128
		(multiply by 100)		100
A.	Pressure available for uniform loss		**"A" =**	**12.8**

Water distribution piping material is: Type M Copper

Note: High flow fixtures are defined as fixtures that exceed a flow rate of 4 gpm @ 80 psi.

Comments

In this example a building with a predominately flushometer valve system has a building demand with a total of 160 water supply fixture units (wsfu's).

70 wsfu's are of the flush tank-type and
90 wsfu's are of the flushometer valve type.
70 wsfu's Tank Type = 35 Gallons Per Minute (GPM)
90 wsfu's Flushometer Type = 65 GPM
65 GPM is larger than 35 GPM,
End result; the water distribution system is predominately flushometer type.

Convert the 160 wsfu's to gpm using the predominately flushometer column of Table 382.40-3.

160 wsfu's total = 83 gpm.

1. point Enter the demand of the building; 160 wsfu's = 83 gpm.

2. point. There is a 7 foot difference in elevation from the main to the building control valve.

3. point. The water meter will be 2 inches in size.

4. point. The water service length from the municipal main to the building control valve will be 62 feet.

5. point. The low pressure at the municipal main is 65 psi.

Calculate Water Service Pressure Loss

Example 3 continued;
6. point. The low pressure from line 5 above; 65.

Start the calculations by selecting 2 inch Schedule 40 PVC piping as the material and size for the water service. From the friction loss chart for Sch. 40 PVC, determine that the friction loss will be 4.4 psi / 100 feet of pipe. Find the water friction loss for the 62 foot water service by multiplying 4.5 psi / 100 ft. X .62 100 ft equivalent lengths of pipe to be installed.

4.5 psi 100 ft. X .62 = 2.8 psi lost in the water service due to friction

7. point. The water service is 2 inch diameter. The water service piping material is Schedule 40 PVC.
Subtract the value of "7" (2.8). Subtotal is 62.3.

8. point. Determine the pressure loss due to elevation. There is a 7 foot difference in elevation between the water main and the water meter, which is multiplied by .434 psi / ft.

7 ft. X .434 psi/ ft. = 3 psi loss

Add or subtract the value of "8"; 3 psi.

9. point. Available pressure after the building control valve: 59.2.

Calculate The Pressure Available For Uniform Loss (Value of "A")

B. point. Available pressure after the building control valve (from "9" above); 59.2.

C. point. Pressure loss of water meter is 5 psi. Subtract from "B", subtotal is 54.2.

D. point. The pressure at the controlling fixture which is a flushometer water closet is 15 psi. Subtract from 'C", subtotal is 39.2.

E. point. Pressure loss due to a difference of 23 feet from the building control valve to the controlling fixture. 23 X .434 psi/ ft. = 10 psi loss due to elevation. Subtract from "D" and the subtotal is then 29.3. (Note, the decimal point is being rounded off, so at times the calculation may vary a tenth of a decimal point.)

F. point. The pressure loss is due to a water softener being installed. The manufacturer's specifications indicate a loss of 12 psi. F.1 is the wsfu's downstream of the softener which is 148, minus the hose bibbs. Converting to gpm the maximum flow rate through the water softener is 80 gpm. Subtract the value of "F" 12 psi, from "E" 29.3, the subtotal is 17.3.

G. point. No pressure loss through tank water heaters. Subtotal remains at 17.3.

The pipe length to the controlling flushometer is 90 feet. Multiply the length by 1.5 to account for additional pressure losses due to fittings and valves.

90 ft. X 1.5 = 135 ft.

H. point. Developed length from building control valve to controlling fixture in feet 90 feet X 1.5 and divide 17.3 by 135 , which will give you a subtotal of 0.128. Multiply by 100.

A. point. Pressure available for uniform loss; "A" = 12.8 and round up to 13 psi / 100 ft.

The water distribution material for this example is Type M Copper, refer to Table 382.40-6. In the far left hand column find the row that corresponds to a 13 psi/100 feet pressure loss due to friction. Follow this row horizontally to the right to find the maximum allowable fixture unit load for each pipe size. Use the columns labeled FM, since this is a predominately flushometer valve system.
In this example the maximum WSFU's are:

Pipe Size	Flushometer wsfu's (FM)	Flush Tank wsfu's (FT)
1/2 inch	0	6
3/4 inch	4.5	17.5
1 inch	7	34
1 ¼ inch	17	62
1 ½ inch	39	112
2 inch	144	270
2 ½ inch	374	484

The minimum diameter pipe segment downstream of the water meter will be 2 ½ inches. This is because the demand of the building was 160 predominately flushometer fixture units.
Note: Piping ½ inch in diameter serving two or more plumbing fixtures may not have a load of more than two water supply fixture units.

Figure 26 Example 3

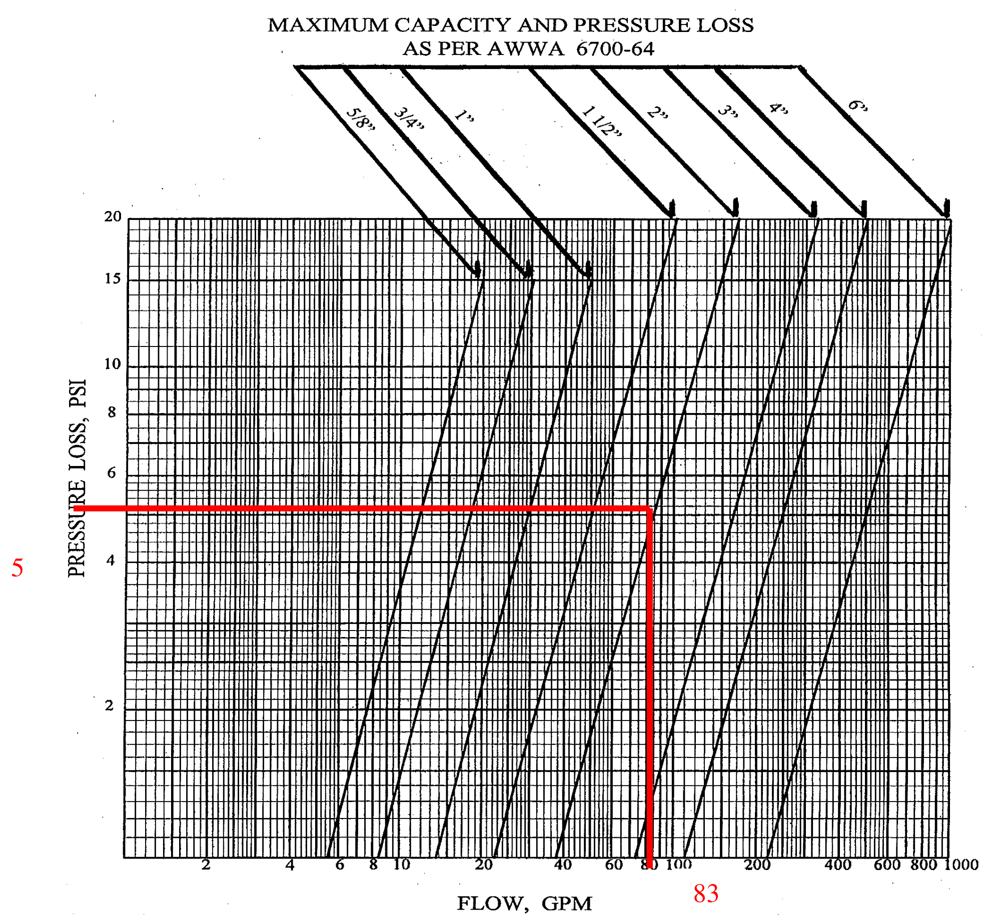


Figure 27 Example 3

Graph A-382.40-8

PRESSURE LOSSES DUE TO FLOW FRICTION
Material: ABS Pipe–Schedule 40; ASTM D1527; or
CPVC Pipe–Schedule 40; ASTM F441; or
PE Pipe–Schedule 40; ASTM D2104; ASTM D2447; or
PVC Pipe–Schedule 40; ASTM D1785; ASTM D2672; (C =150)

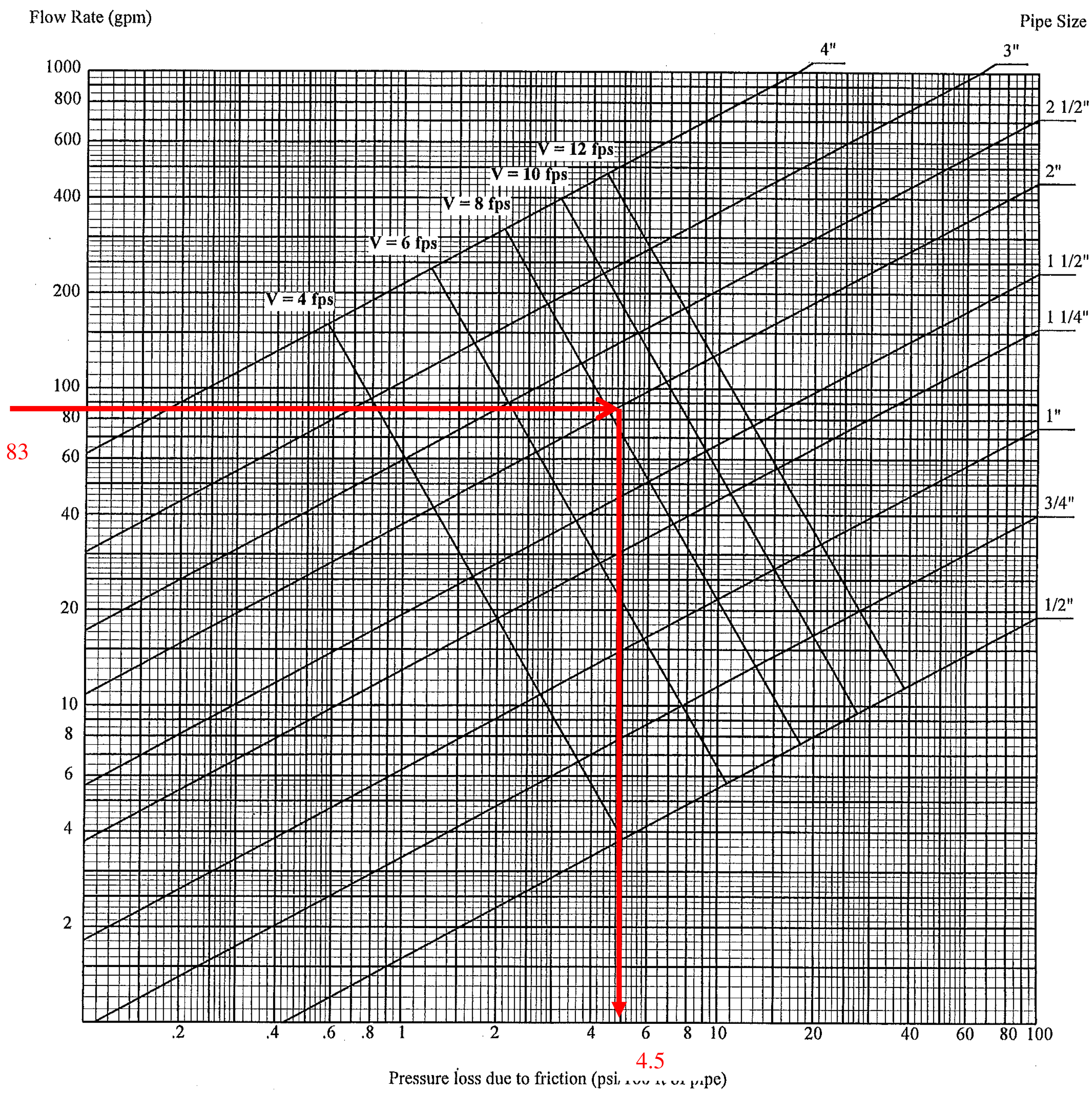


Figure 28 Example 3

Table 382.40–6
MAXIMUM ALLOWABLE LOAD FOR COPPER TUBING–TYPE M, ASTM B88; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																										
	1/2"			3/4"			1"			1 1/4"			1 1/2"			2"			2 1/2"			3"			4"		
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	2.0	–	2.0	4.0	–	4.0	7.0	–	9.0	11.5	4.0	15.5	23.0	7.5	37.0	42.0	33.0	100	67.0	96.0	210	139	481	577
1	1.0	–	1.0	3.0	–	3.0	6.0	–	7.0	10.5	4.0	14.0	16.5	5.5	24.0	34.0	18.5	66.0	61.0	77.0	180	97.0	227	360	202	945	953
2	1.5	–	1.5	4.5	–	5.0	9.0	–	11.5	15.5	5.0	22.5	24.0	8.0	40.0	50.0	48.0	128	88.0	184	315	141	493	588	294	1750	1750
3	2.0	–	2.0	5.5	–	6.5	11.5	4.0	15.5	19.5	6.5	29.0	30.0	13.5	55.0	62.0	80.0	185	110	300	425	174	731	776	303	1835	1835
4	2.5	–	2.5	6.5	–	8.0	13.0	4.5	18.0	22.0	7.0	35.0	35.0	20.0	70.0	73.0	120	240	121	374	484		NP			NP	
5	2.5	–	2.5	7.5	–	9.5	15.0	5.0	21.5	25.0	8.5	42.0	40.0	30.0	86.0	79.0	144	270		NP							
6	3.0	–	3.0	8.0	–	10.0	16.5	5.5	24.0	28.0	11.0	50.0	44.0	36.0	106		NP										
7	3.5	–	3.5	9.0	–	11.5	18.0	6.0	26.5	30.0	13.5	55.0	45.0	39.0	112												
8	3.5	–	3.5	9.5	–	12.5	19.5	6.5	29.0	32.0	17.0	62.0		NP													
9	4.0	–	4.0	10.0	4.0	13.0	20.5	6.5	31.0		NP																
10	4.0	–	4.0	11.0	4.0	15.0	21.5	7.0	34.0																		
11	4.5	–	5.0	11.5	4.0	15.5		NP																			
12	4.5	–	5.0	12.0	4.0	16.5																					
13	5.0	–	6.0	12.5	4.5	17.5																					
14	5.0	–	6.0	12.5	4.5	18.0																					
15	5.0	–	6.0		NP																						
16	5.5	–	6.5																								
17	5.5	–	6.5																								
18	5.5	–	6.5																								
19	6.0	–	7.0																								
20	6.0	–	7.0																								
21	6.0	–	7.5																								
		NP																									

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

WATER CALCULATION WORKSHEET FOR Example 4
NAME/ADDRESS OF PROJECT

INFORMATION REQUIRED TO CALCULATE WATER SERVICE SIZE

1. Demand of building in gallons per minute. WSFU's 90 1.a. = (GPM) 41.0
2. Difference in elevation from main to extermal pressure tank or to building control valve. (feet) 2.0
3. Size of the water meter. (when applicable) 5/8 ___ 3/4 ___ 1 X 1.5 ___ Inch
   2 ___ 3 ___ 4 ___ 6 ___ Inch
4. Developed length from main or external pressure tank to building control valve. (feet) 40
5. Low pressure at main in street or external pressure tank. (psig) 75.0

CALCULATE WATER SERVICE PRESSURE LOSS

6. Low pressure at main in street or external pressure tank. (value of #5 above) 75.0
7. Water service diameter is 1 Material is Type L Copper, ASTM B88
   Pressure loss per 100 ft. = 36 p.s.i. X 0.4 . 14.4
   (decimal equivalent of service length, i.e. 65ft = 0.65) (Subtract line 7. From line 6.) subtotal 60.6
8. Determine pressure gain or loss due to elevation. (multiply the value of #2 above by 0.434) value of "8" 0.9
9. Available pressure after the bldg. Conrol valve. (subtract or add line 8. Enter in "B".) **subtotal** 59.7

CALCULATE THE PRESSURE AVAILABLE FOR UNIFORM LOSS (VALUE OF "A")

B. Available pressure after the building control valve. (from "9" above) value of "B" 59.7

C. Pressure loss of water meter. (when meter is required or installed) value of "C" 10.0
(subtract line C. From B.) **subtotal** 49.7

D. Pressure at controlling fixture. value of "D" 20.0
(controlling fixture is Pressure Balanced Shower Valve)
(subtract the value of D.) **subtotal** 29.7

E. Difference in elevation between the building control valve
and the controlling fixture in feet 4.5 X 0.434 psi/ft. value of "E" 2.0
(subtract the value of E.) **subtotal** 27.8

F. Pressure loss due to water treatment devices, and backflow preventers which serve the controlling fixture.
Pressure loss due to None (subtract the value of F)

F1. WSFU's downstream of Water Treatment Device: ______
F2. Convert wsfu's to GPM using Table 382.40-3 ______
OR
F3. Convert wsfu's to GPM using Table 382.40-3e ______
F4. Refer to manufacturer's graph to obtain pressure loss: value of "F4" 0.0
(If no water treatment device enter "0") **subtotal** 27.8

G. Pressure loss through tankless water heaters, combination boiler / hot water heaters, heat exchangers;

Hot water WSFU's; 3@5.66 convert to; GPM = 4.75 **(Table 382.40-3)**
Refer to manufacturer's pressure loss graph to determine loss at required GPM: 17 pressure loss.
(If no pressure loss through hot water appliance enter "0") value of "G" 17.0
subtotal 10.8

Continued on page 62.

Water Calc Worksheet Example 4

G.	Continued from page 1;	**subtotal**	10.8
H.	Developed length from building control valve to controlling fixture in feet X 120 1.5 Divide by	value of "H"	180
	(divide by the value of G.)	**subtotal**	0.060
	(multiply by 100)		100
A.	Pressure available for uniform loss	**"A" =**	**6.0**

Water distribution piping material is: Type L Copper

Note: High flow fixtures are defined as fixtures that exceed a flow rate of 4 gpm @ 80 psi.

Comments

3 - Instantaneous, Tankless hot water heaters for new addition serving 8 b.g. units.

Eight units and a clothes washer are being added to an existing ten unit motel. The existing fixture unit count is 55 WSFU's from:

10 hotel units @ 4 WSFUs each = 40 wsfu's
(Each unit consists of a bathtub with shower, lavatory, and flush tank water closet)

2 Public Restrooms with;

2 flush tank water closets	= 6.0
2 lavatories	= 2.0
1 3/4 inch hose bibb	= 4.0
1 icemaker	= .5
1 coffee maker	= .5
1 public bar sink	= 2.0
	15.0 wsfu's

40 + 15 = 55 wsfu's

Add to this total the new fixtures:

8 units @ 4 WSFU's	= 32.0
1 clothes washer	= 3.0
	35.0 wsfu's

55 (existing) + 35 (new) = 90 wsfu's
90 wsfu's (tank type) = 41 gpm

Example 4 continued..

The low pressure at the main is 75 psi. When calculating the friction loss in the existing service, make sure the existing service will handle the additional load without creating too much friction loss.

1. point. Enter the WSFU's <u>90</u>, and the GPM <u>41.</u>

2. point. There is a <u>2 foot</u> difference in elevation between the main and the building control valve.

3. point. The water meter will be <u>1 inch</u> in size.

4. point. The water service is an existing Type L copper tubing, <u>1 inch</u> water service is <u>40 feet.</u>

5. point. The low residual pressure at the municipal main is <u>75 psi.</u>

6. point. Low pressure at the main in the street (value of #5 above) <u>75.</u>

From the Graph for type L copper tubing, the friction loss will be 36 psi / 100 feet.

36 psi/ 100 ft. X .4 equivalent 100ft lengths = 14.4 psi loss
due to friction in the type L copper water service.

7. point. Determine the pressure loss due to friction in a <u>1 inch</u> diameter water service.
Subtract value (7.) <u>14.4 psi</u> from (6.) <u>75</u> = <u>60.6</u>

8. point. Determine the pressure gain or loss due to elevation,
(multiply the value of #2. point above by .434) Add or subtract value of "8" = <u>0.9</u>

9. point. Available pressure after the bldg. control valve (enter in "B" below) subtotal = <u>59.7</u>

Calculate The Pressure Available For Uniform Loss (Value of "A")

B. point. Available pressure after the building control valve (from "9" above). <u>59.7</u>

C. point. Pressure loss of the water meter, see graph. Subtract value of "C"……… … <u>10.0</u>

Subtotal = <u>49.7</u>

D point. The controlling fixture is a pressure balanced shower valve. The pressure
At the controlling fixture is <u>20 psi.</u> Subtract value of "D"………….<u>20.0</u>

Subtotal = <u>29.7</u>

E. point.. The difference in elevation between the building control valve and the
Controlling fixture is <u>4.5 feet.</u> 4.5 feet X .434 psi/ft. = <u>2.0</u> psi loss due
to elevation. Subtract from "D" subtotal. Subtotal = <u>27.8</u>

F. point. There is no pressure loss due to water treatment devices, enter 0.

Example 4, continued.

G. point. Pressure loss through tankless water heaters. Three tankless instantaneous hot water heaters piped in parallel will serve the new 8 unit addition hot water distribution system. The hot water wsfu's for the new addition is 17 wsfu's (8 bathroom groups hot @ 2 wsfu's each, and 1 wsfu for the new clothes washer). Divide 17 by 3 (water heaters) = 5.66 wsfu's. Coverting the wsfu's to gpm from Table 382.40-3, each unit will have a maximum of

. 4.75 gpm,flowing through the units. Checking the manufacturer's specifications and pressure drop chart, there will be a <u>17 psi pressure loss</u> through each unit, see graph on page 69, Figure 33.

Subtract <u>17 psi</u> value of "G", from the subtotal of "E"(27.8)

Subtotal = <u>10.8</u>

H. point. Developed length from building control valve to the controlling fixture in feet; <u>120</u> X 1.5 = 180.

Divide by value of "G"; 180 into 10.8 Subtotal = <u>0.060.</u>

Multiply by 100: 0.060 X 100 = 6.0

A. point. Pressure available for uniform loss; **<u>"A" = 6.0</u>**

The water distribution system will consist of Type L Copper piping, see Table 382.40-5 on page 67, figure 31.

Pipe Size	WSFU's, (Tank Type)
1/2 inch	2.5
3/4 inch	9.5
1 inch	22.5
1 1/4	45
1 1/2	100

The minimum diameter pipe segment downstream of the building control valve will be 1 1/2 inches. This is because the demand of the building was 90 predominately flush tank fixture units.

Figure 29 Example 4

Graph A-382.40(7)-1

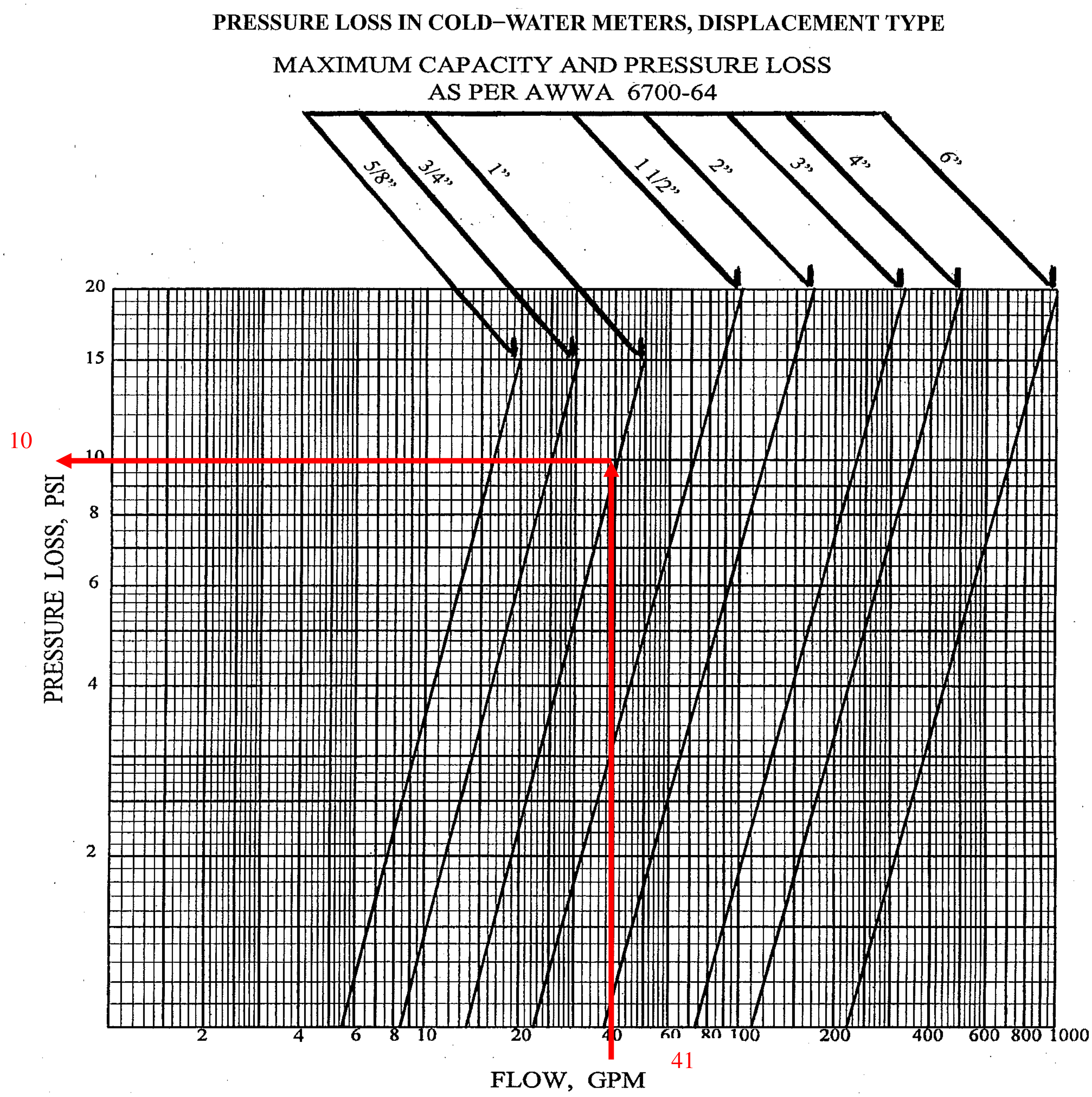


Figure 30 Example 4

Graph A-382.40(7)-3

PRESSURE LOSSES DUE TO FLOW FRICTION

Material: Copper Tube–Type L, ASTM B88; (C = 150)

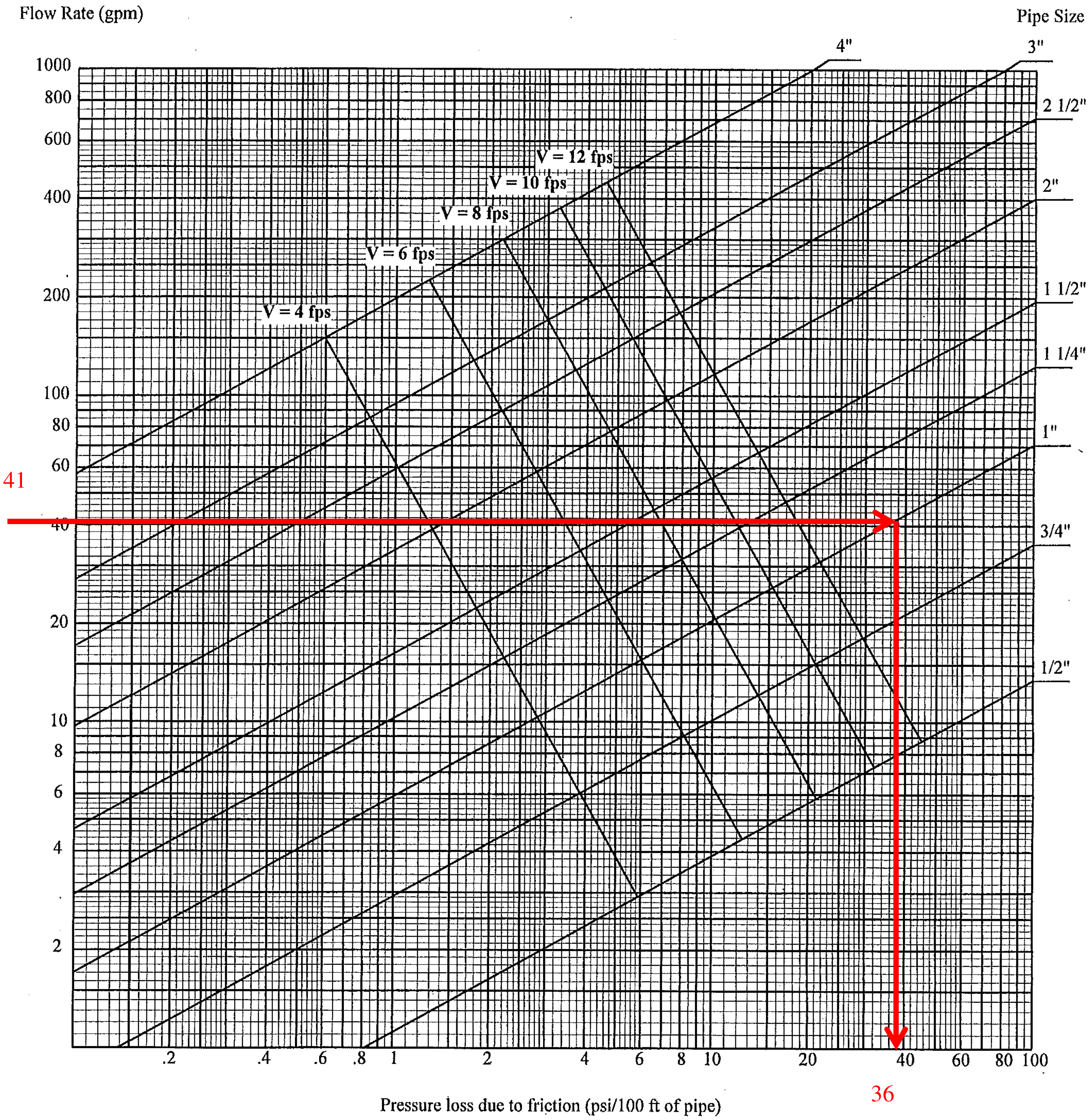


Figure 31 Example 4

Table 382.40–5
MAXIMUM ALLOWABLE LOAD FOR COPPER TUBING–TYPE L, ASTM B88; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																										
	1/2"			3/4"			1"			1 1/4"			1 1/2"			2"			2 1/2"			3"			4"		
	GPM	WSFU		GPM	WSFU		GPM	WSFU		GPM	WSFU		GPM	WSFU		GPM	WSFU		GPM	WSFU		GPM	WSFU		GPM	WSFU	
		FM	FT		FM	FT		FM	FT		FM	FT		FM	FT		FM	FT		FM	FT		FM	FT		FM	FT
0.5	0.5	–	0.5	2.0	–	2.0	4.0	–	4.0	7.0	–	9.0	11.0	4.0	15.0	23.0	7.5	37.0	40.0	30.0	86.0	65.0	90.0	200	136	462	561
1	1.0	–	1.0	2.5	–	2.5	5.5	–	6.5	10.0	4.0	13.0	16.0	5.0	23.0	33.0	17.5	63.0	59.0	72.0	170	94.0	211	345	198	909	923
2	1.5	–	1.5	4.0	–	4.0	8.5	–	10.5	14.5	4.5	20.5	23.0	7.5	37.0	48.0	44.0	120	86.0	175	305	137	468	566	288	1694	1694
3	2.0	–	2.0	5.0	–	6.0	10.5	4.0	14.0	18.5	6.0	27.5	29.0	12.5	52.0	60.0	75.0	175	107	283	410	169	698	752	298	1792	1792
4	2.0	–	2.0	6.0	–	7.0	12.0	4.0	16.5	21.5	7.0	33.0	34.0	18.5	66.0	70.0	108	225	119	356	469		NP			NP	
5	2.5	–	2.5	6.5	–	8.0	14.0	4.5	20.0	24.0	8.0	40.0	38.0	26.0	80.0	77.0	136	260		NP							
6	2.5	–	2.5	7.5	–	9.5	15.5	5.0	22.5	26.0	9.0	45.0	42.0	33.0	100		NP										
7	3.0	–	3.0	8.0	–	10.0	16.5	5.5	24.0	29.0	12.5	52.0	44.0	37.0	107												
8	3.0	–	3.0	8.5	–	10.5	18.0	6.0	26.5	31.0	15.0	58.0		NP													
9	3.5	–	3.5	9.5	–	12.5	19.0	6.0	28.0		NP																
10	3.5	–	3.5	10.0	4.0	13.0	20.0	6.5	30.0																		
11	4.0	–	4.0	10.5	4.0	14.0	20.5	6.5	31.0																		
12	4.0	–	4.0	11.0	4.0	15.0		NP																			
13	4.0	–	4.0	11.5	4.0	15.5																					
14	4.5	–	5.0	12.0	4.0	16.5																					
15	4.5	–	5.0		NP																						
16	5.0	–	6.0																								
17	5.0	–	6.0																								
18	5.0	–	6.0																								
19	5.0	–	6.0																								
20	5.5	–	6.5																								
		NP																									

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

Figure 32 Example 4

Flow Rates:

Flow Rate Specifications		
Output BTU (NG)	195,020	195,020
Combustion Efficiency (NG)	98%	98%
Input BTU (NG)	199,000	199,000
GPM @ 35°F Temperature Rise (70°F to 105°F for example) (theoretical value based on BTUs; may be subject to manufacturer's heat exchanger flow limits)	11.1	11.1
GPM @ 45°F Temperature Rise (60°F to 105°F for example) (theoretical value based on BTUs; may be subject to manufacturer's heat exchanger flow limits)	8.7	8.7
GPM @ 50°F Temperature Rise (70°F to 120°F for example)	7.8	7.8
GPM @ 55°F Temperature Rise (65°F to 120°F for example)	7.1	7.1
GPM @ 60°F Temperature Rise (60°F to 120°F for example)	6.5	6.5
GPM @ 65°F Temperature Rise (55°F to 120°F for example)	6.0	6.0
GPM @ 70°F Temperature Rise (50°F to 120°F for example)	5.6	5.6
GPM @ 75°F Temperature Rise (45°F to 120°F for example)	5.2	5.2
GPM @ 80°F Temperature Rise (40°F to 120°F for example)	4.9	4.9
# of Simultaneous Showers with 40°F Ground Water (2.5 GPM Heads)	2.4	2.4
# of Simultaneous Showers with 55°F Ground Water (2.5 GPM Heads)	3.2	3.2
# of Simultaneous Showers with 70°F Ground Water (2.5 GPM Heads)	4.6	4.6

Figure 30 is the manufacturer's specification sheet on two instantaneous tankless hot water heaters with an input of 199,000 BTU's

Note with an 80^0 F Temperature rise the maximum flow rate for both units is 4.9 gpm. This temperature rise is appropriate for the State of Wisconsin in representing the cold water temperature during the winter season. No more than two showers could be served with one heater.

Figure 33 Example 4

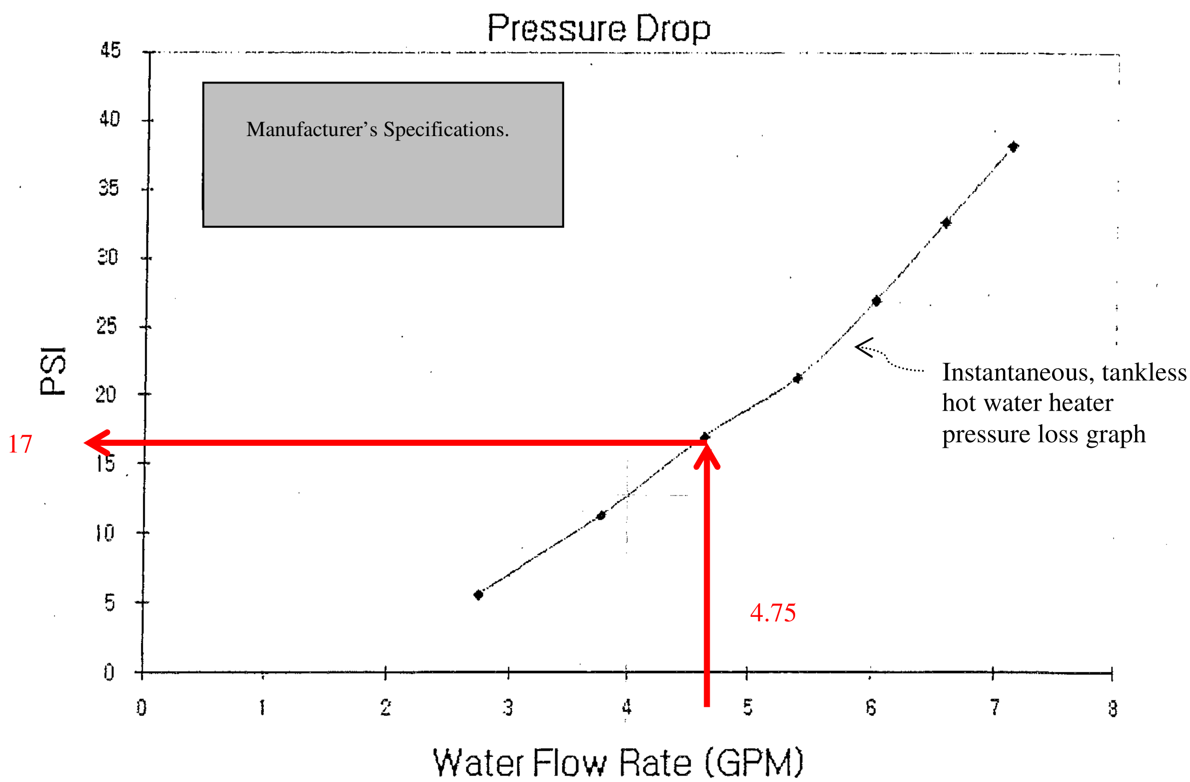


Figure 33 is a Pressure Loss Graph for the two instantaneous tankless hot water heaters and provided with the manufacturer's specifications.

Note with a water flow rate of 4.75 gpm, the pressure loss through one unit is approx. 17 psi. This pressure loss must be captured on the water calc worksheet under "G" if the controlling fixture has a hot water demand, such as a tub or shower valve.

Example 5.

WATER CALCULATION WORKSHEET FOR Example 5

NAME/ADDRESS OF PROJECT

INFORMATION REQUIRED TO CALCULATE WATER SERVICE SIZE

1. Demand of building in gallons per minute. WSFU's 36.25 1.a. = (GPM) 22.5
2. Difference in elevation from main to extermal pressure tank or to building control valve. (feet) 7.0
3. Size of the water meter. (when applicable) 5/8 ___ 3/4 X 1 ___ 1.5 ___ Inch
   2 ___ 3 ___ 4 ___ 6 ___ Inch
4. Developed length from main or external pressure tank to building control valve. (feet) 110
5. Low pressure at main in street or external pressure tank. (psig) 62.0

CALCULATE WATER SERVICE PRESSURE LOSS

6. Low pressure at main in street or external pressure tank. (value of #5 above) 62.0
7. Water service diameter is 4 Material is PVC Pipe - Schedule 40; ASTM D1785: ASTM D2672
   Pressure loss per 100 ft. = 0.04 p.s.i. X 1.1 . 0.0
   (decimal equivalent of service length, i.e. 65ft = 0.65) (Subtract line 7. From line 6.) subtotal 62.0
8. Determine pressure gain or loss due to elevation. (multiply the value of #2 above by 0.434) value of "8" 3.0
9. Available pressure after the bldg. Conrol valve. (subtract or add line 8. Enter in "B".) **subtotal** 58.9

CALCULATE THE PRESSURE AVAILABLE FOR UNIFORM LOSS (VALUE OF "A")

B. Available pressure after the building control valve. (from "9" above) value of "B" 58.9

C. Pressure loss of water meter. (when meter is required or installed) value of "C" 8.0
(subtract line C. From B.) **subtotal** 50.9

D. Pressure at controlling fixture. value of "D" 8.0
(controlling fixture is Service Sink, Hot Water)
(subtract the value of D.) **subtotal** 42.9

E. Difference in elevation between the building control valve
and the controlling fixture in feet 3 X 0.434 psi/ft. value of "E" 1.3
(subtract the value of E.) **subtotal** 41.6

F. Pressure loss due to water treatment devices, and backflow preventers which
serve the controlling fixture.
Pressure loss due to Iron Filter POE (subtract the value of F)

F1. WSFU's downstream of Water Treatment Device: 24.25
F2. Convert wsfu's to GPM using **Table** **382.40-3** 16.5
OR
F3. Convert wsfu's to GPM using **Table** **382.40-3e** ___
F4. Refer to manufacturer's graph to obtain pressure loss: value of "F4" 11.0
(If no water treatment device enter "0") **subtotal** 30.6

G. Pressure loss through tankless water heaters, combination boiler / hot water heaters, heat exchangers;

Hot water WSFU's; 6 convert to; GPM = 5 **(Table 382.40-3)**
Refer to manufacturer's pressure loss graph to determine loss at required GPM: 19 pressure loss.
(If no pressure loss through hot water appliance enter "0") value of "G" 19.0
subtotal 11.6

Continued on page 71.

Water Calc Worksheet Example 5

G.	Continued from page 1;		**subtotal**	11.6
H.	Developed length from building control valve to controlling fixture in feet X	45 1.5 Divide by	value of "H"	68
		(divide by the value of G.)	**subtotal**	0.172
		(multiply by 100)		100
A.	Pressure available for uniform loss		**"A" =**	**17.2**

Water distribution piping material is: Type M Copper

Note: High flow fixtures are defined as fixtures that exceed a flow rate of 4 gpm @ 80 psi.

Comments

Water service is a combination fire/ domestic service. 3 hose bibbs on hard water piping.

Example 5 is a service garage and therefore a public building. Refer to Table 382.40-2 to find the plumbing fixture load in Water Fixture Supply Units.

Fixtures	WSFU/Fixtures	Total WSFU's
4 - Tank type water closets	3	12.0
4 - lavatories	1	4.0
1 - urinal	2	2.0
3 – 3/4 inch hose bibbs	4	12.0
2 – Service sinks	3	6.0
1 – Drinking fountain	0.25	0.25
	Total:	36.25

Converting 36.25 wsfu's to gallons per minute from Table 382.40-3, the gpm building load is 22.5.

The proposal calls for use of a 4 – inch Schedule 40 PVC combination fire/ domestic water service 110 feet long. The water meter will be 3/4 inch. The use of Schedule 40 PVC is for example purposes only, water service pipe materials would have to be approved in accordance with the NFPA 13 Standard and the Plumbing Code.

The low residual pressure in the street is 62 psi.

Friction loss is basically 0 psi / 100 feet in the 4 inch water service with a demand of 22.5 GPM. The service is sized for fire flows, and at 22.5 gpm there is negligible velocity in the service, thus essentially only a fraction loss.

The loss from the difference in elevation is: 7 feet X .434 psi/ft = 3 psi. Subtract the 3 psi loss from the 62 psi in the main in the street. Subtotal is 58.9 or 59 psi

Available pressure after the building control valve is 59 psi.

Calculate The Pressure Available For Uniform Loss (Value of "A").

B. point. Available pressure after the building control valve (from "9" above); 59 psi.

C. point. Pressure loss through the water meter. Refer to manufacturer's pressure loss graph or the Appendix A – 382.40(7)-1 graph. The pressure loss is estimated to be 8 psi, subtract From the value of "B"; Subtotal is 50.9 or 51.

D. point. The pressure required at the controlling fixture, a service sink is: 8 psi. Subtract 8 psi from the subtotal of "C"; Subtotal 42.9

Note: The urinal has a higher pressure requirement of 15 psi than a service sink, but, the job specifies an instantaneous tankless hot water heater. The pressure loss will be greater through the tankless hot water heater, 19 psi and service sink 8 psi.

E. point. Difference in elevation, loss or gain, from the building control valve to the controlling fixture which is the service sink, 3 ft. X .434 psi/ ft. = 1.3 psi. Subtract from subtotal "D"; Subtotal 41.6

F. point. Pressure loss due to water treatment devices is a iron filter serving the water distribution system with the exception of the 3 hose bibbs. The wsfu load downstream of the iron filter is 24.25 , which converts to 16.5 gpm. Manufacturer's pressure loss graph specifies a 11 psi pressure loss with a 16.5 gpm flow rate. Subtract from "E" point subtotal. Subtotal 30.6

G. point. Pressure loss through a tankless instantaneous hot water heater. The hot water wsfu load Downstream of the water heater is 6 , and converts to 5 gpm in Table 382.40-3. Referring to the manufacturer's specifications graph to determine the pressure loss through the heater, 19 psi. is the loss incurred. Subtract from subtotal "F". Subtotal 11.6

H. point. The pressure loss due to friction in the developed length of pipe from the building Control valve to the controlling fixture (service sink) of 45 feet multiplied by 1.5 to Account for pressure loss due to fittings and valves. 45 X 1.5 = 67.5 Value of "H" 68

Divide the subtotal "G" 11.6 by 67.5 = 0.172. Subtotal 0.172

Multiply by 100.

A. point. Pressure available for uniform loss; "A" = 17.2

The pipe sizes are limited by the 8 feet / second velocity design limit. The maximum fixture unit values are shown on the sizing Table 382.40-6 Type M Copper.

Example 5

Pipe Size	WSFU's (Tank Type)
1/2 inch	6.5
3/4 inch	18
1 inch	34
1 ¼	62

The largest size pipe segment downstream of the water meter is 1 ¼" to serve a 36.25 wsfu load (predominately flush tank).

Figure 34 **Graph A-382.40(7)-1**

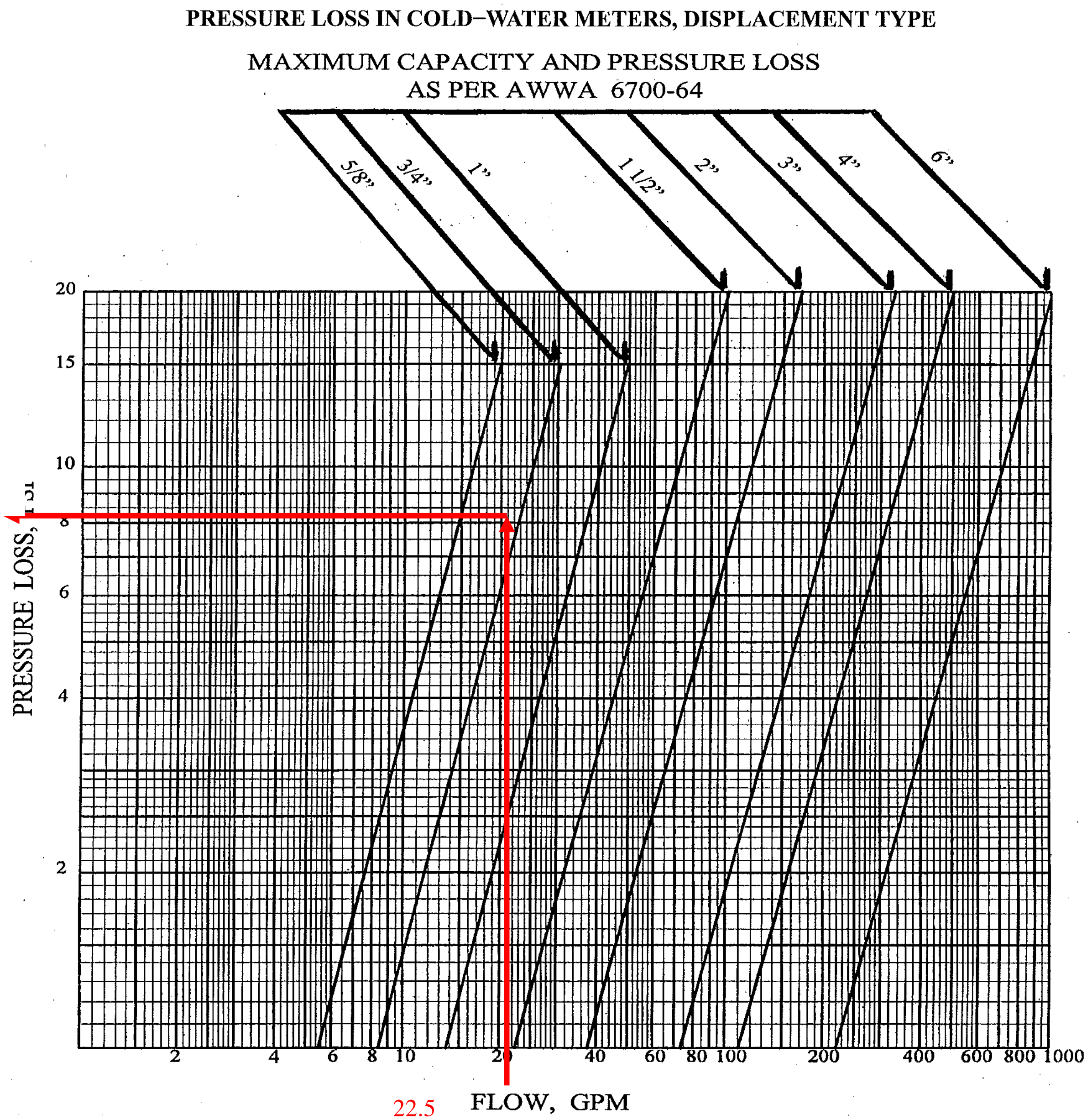
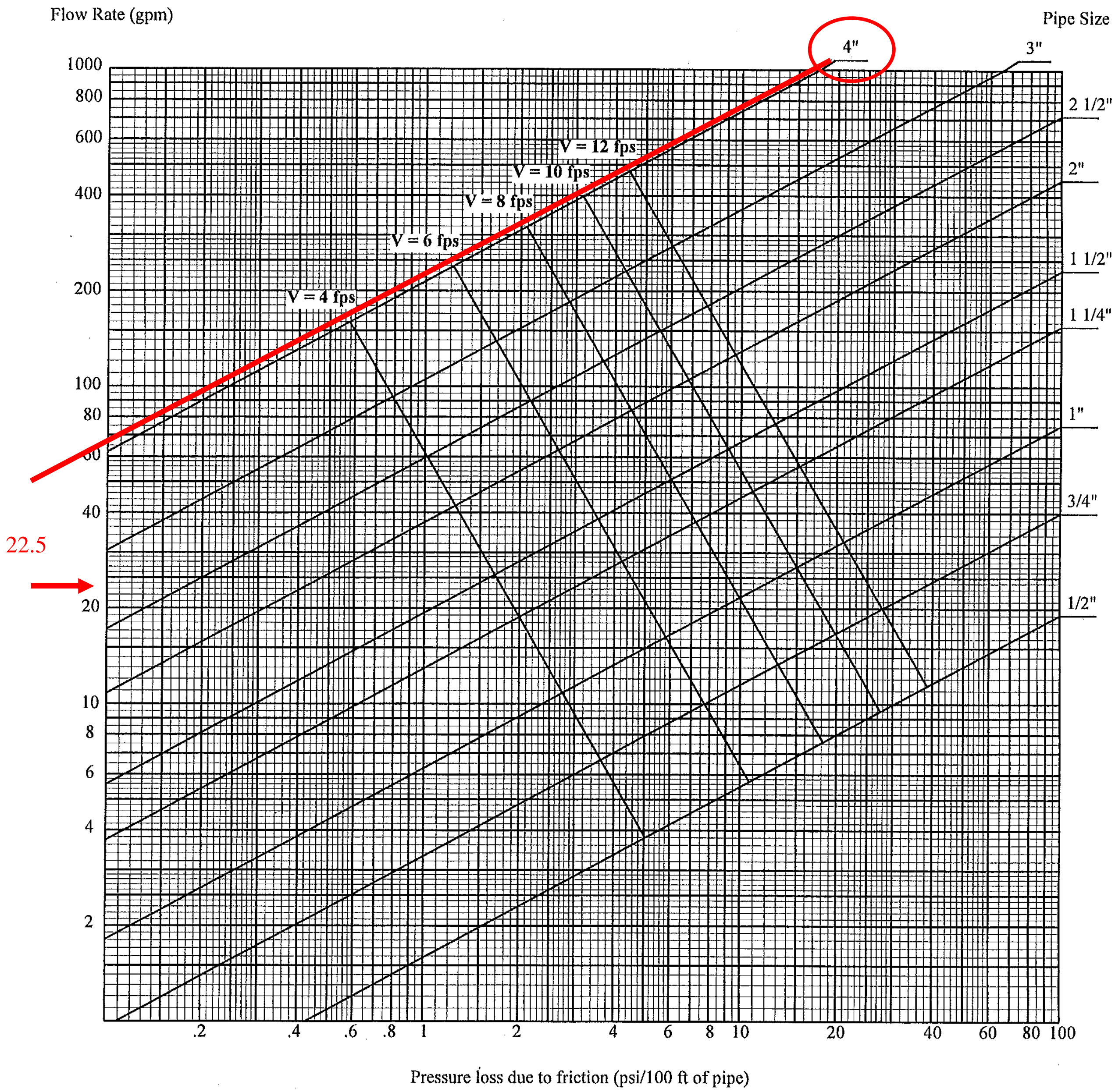


Figure 35 Example 5

Graph A-382.40(7)-8

PRESSURE LOSSES DUE TO FLOW FRICTION
Material: ABS Pipe–Schedule 40; ASTM D1527; or
CPVC Pipe–Schedule 40; ASTM F441; or
PE Pipe–Schedule 40; ASTM D2104; ASTM D2447; or
PVC Pipe–Schedule 40; ASTM D1785; ASTM D2672; (C =150)



Fractional friction loss on a 4 inch water service and a 22.5 domestic water building demand.

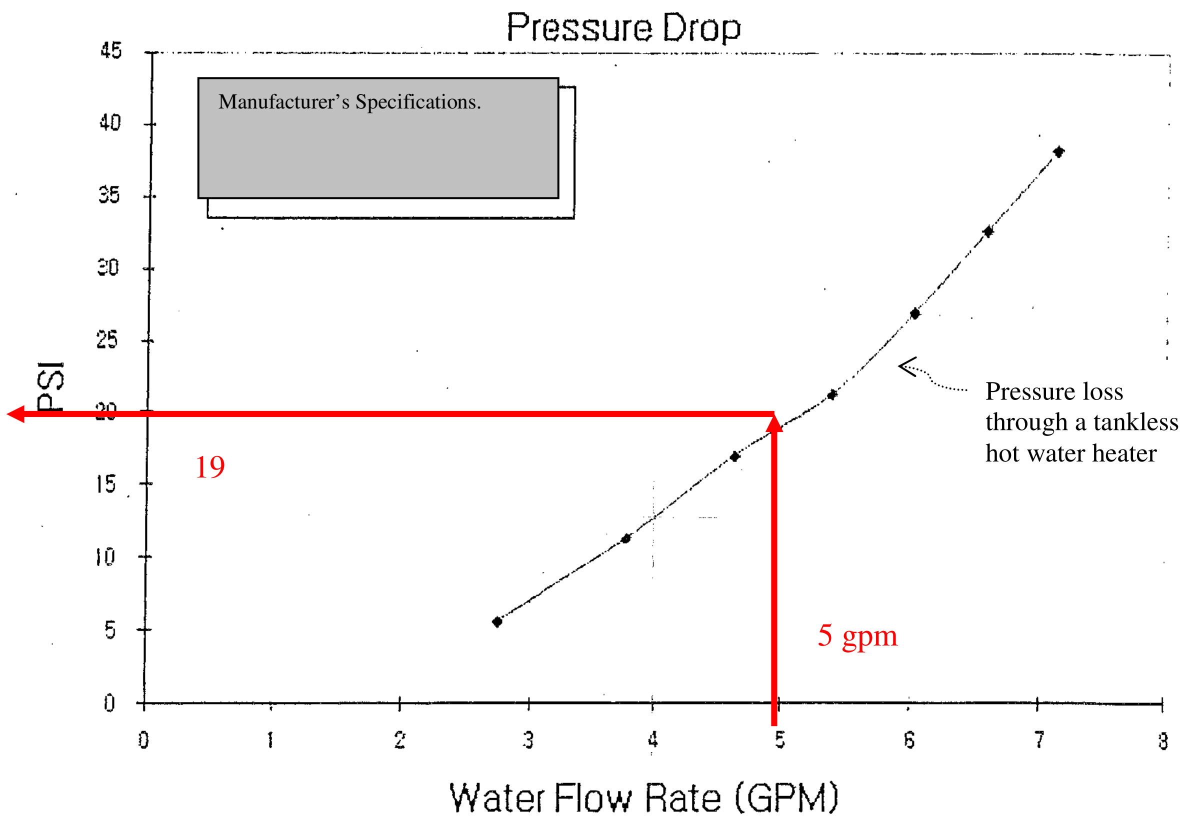
Figure 36. Example 5

Table 382.40–6
MAXIMUM ALLOWABLE LOAD FOR COPPER TUBING–TYPE M, ASTM B88; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																										
	1/2"			3/4"			1"			1 1/4"			1 1/2"			2"			2 1/2"			3"			4"		
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	2.0	–	2.0	4.0	–	4.0	7.0	–	9.0	11.5	4.0	15.5	23.0	7.5	37.0	42.0	33.0	100	67.0	96.0	210	139	481	577
1	1.0	–	1.0	3.0	–	3.0	6.0	–	7.0	10.5	4.0	14.0	16.5	5.5	24.0	34.0	18.5	66.0	61.0	77.0	180	97.0	227	360	202	945	953
2	1.5	–	1.5	4.5	–	5.0	9.0	–	11.5	15.5	5.0	22.5	24.0	8.0	40.0	50.0	48.0	128	88.0	184	315	141	493	588	294	1750	1750
3	2.0	–	2.0	5.5	–	6.5	11.5	4.0	15.5	19.5	6.5	29.0	30.0	13.5	55.0	62.0	80.0	185	110	300	425	174	731	776	303	1835	1835
4	2.5	–	2.5	6.5	–	8.0	13.0	4.5	18.0	22.0	7.0	35.0	35.0	20.0	70.0	73.0	120	240	121	374	484	NP			NP		
5	2.5	–	2.5	7.5	–	9.5	15.0	5.0	21.5	25.0	8.5	42.0	40.0	30.0	86.0	79.0	144	270	NP								
6	3.0	–	3.0	8.0	–	10.0	16.5	5.5	24.0	28.0	11.0	50.0	44.0	36.0	106	NP											
7	3.5	–	3.5	9.0	–	11.5	18.0	6.0	26.5	30.0	13.5	55.0	45.0	39.0	112												
8	3.5	–	3.5	9.5	–	12.5	19.5	6.5	29.0	32.0	17.0	62.0	NP														
9	4.0	–	4.0	10.0	4.0	13.0	20.5	6.5	31.0	NP																	
10	4.0	–	4.0	11.0	4.0	15.0	21.5	7.0	34.0																		
11	4.5	–	5.0	11.5	4.0	15.5	NP																				
12	4.5	–	5.0	12.0	4.0	16.5																					
13	5.0	–	6.0	12.5	4.5	17.5																					
14	5.0	–	6.0	12.5	4.5	18.0																					
15	5.0	–	6.0	NP																							
16	5.5	–	6.5																								
17	5.5	–	6.5																								
18	5.5	–	6.5																								
19	6.0	–	7.0																								
20	6.0	–	7.0																								
21	6.0	–	7.5																								
	NP																										

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

Figure 37 Example 10



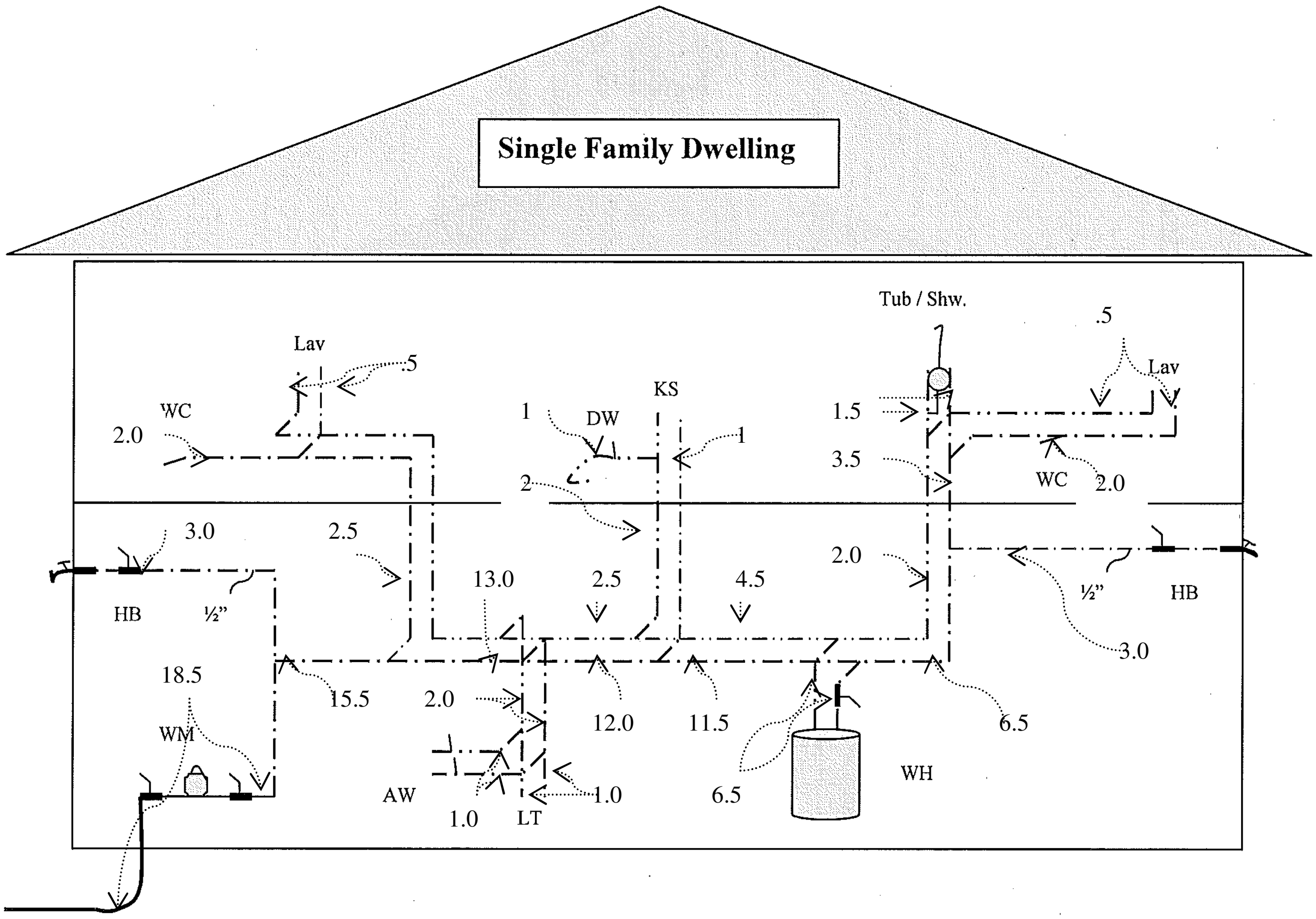
WSFU's downstream of the tankless, instantaneous hot water heater; 6 wsfu's.
Convert to GPM using Table 382.40-3; 5 gpm..

Five gpm flowing through the tankless heater will incur a 19 psi pressure loss.

APPENDIX

TABLES AND GRAPHS

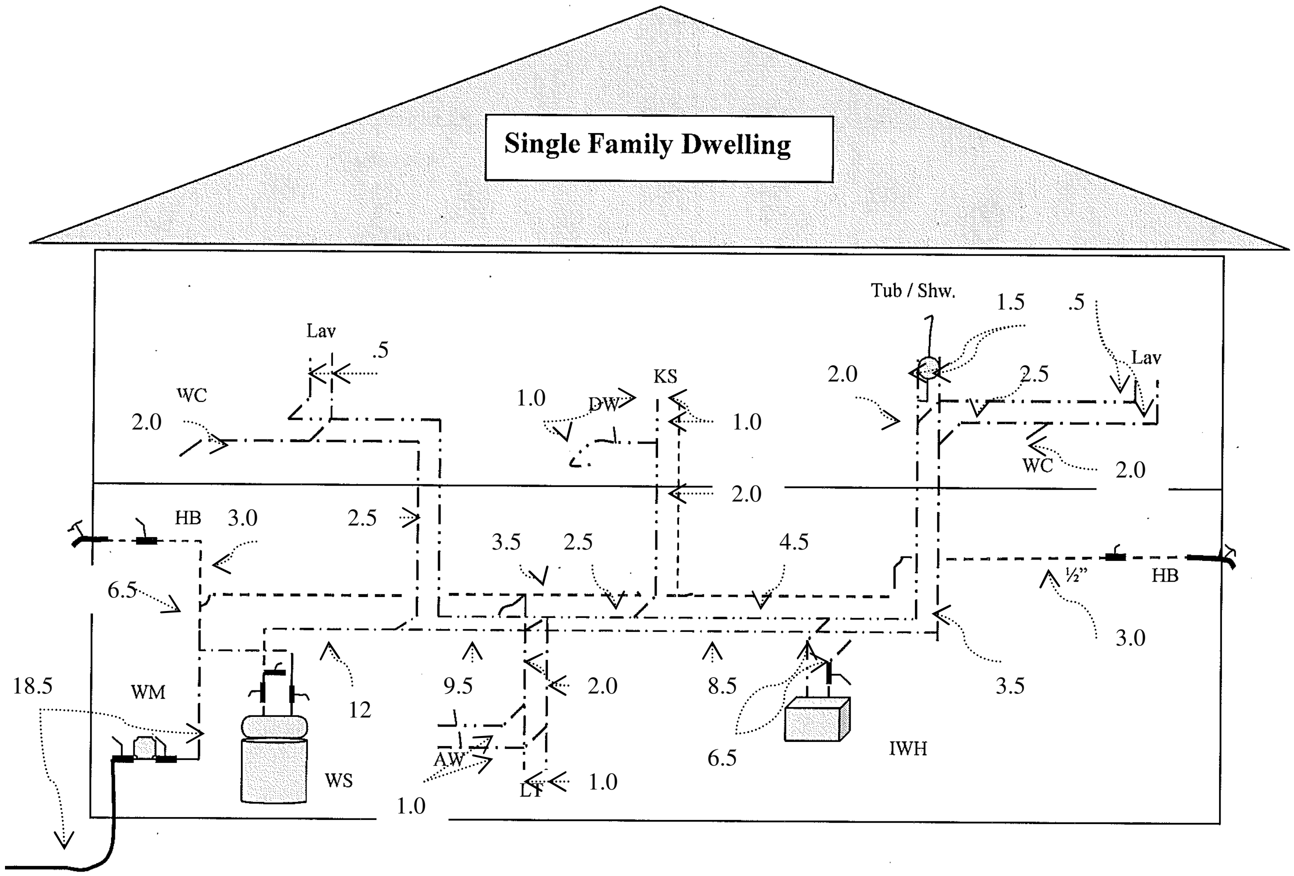
Figure 38



Symbols

Cold Water Piping	—·—·—·	Lavatory	Lav	Hose Bibb	HB
Hot Water Piping	—··—··—	Water Closet	WC	Water Meter	WM
Water Heater	WH	Dishwasher	DW	Clothes Washer	AW
Tub & Shower	Tub/Shw.	Kitchen Sink	KS	Laundry Tray	LT

Figure 39



Symbols

Cold Water Piping	—·—·—	Lavatory	Lav	Hose Bibb	HB
Hot Water Piping	—··—··—	Water Closet	WC	Water Meter	WM
Hard Water Piping	- - - - - - -	Dishwasher	DW	Clothes Washer	AW
Tub & Shower	Tub/Shw.	Kitchen Sink	KS	Laundry Tray	LT
Water Softener	WS	Instantaneous Water Heater	IWH		

Figure 40

Table 382.40–4

MAXIMUM ALLOWABLE LOAD FOR COPPER TUBING–TYPE K, ASTM B88; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																										
	1/2"			3/4"			1"			1 1/4"			1 1/2"			2"			2 1/2"			3"			4"		
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	1.5	–	1.5	3.5	–	3.5	6.5	–	8.0	10.5	4.0	14.0	22.0	7.0	35.0	39.0	28.0	83.0	62.0	80.0	185	132	437	538
1	1.0	–	1.0	2.5	–	2.5	5.0	–	6.0	9.5	–	12.5	15.5	5.0	22.5	32.0	16.0	60.0	57.0	67.0	160	91.0	196	330	192	864	882
2	1.0	–	1.0	3.5	–	3.5	7.5	–	9.5	14.0	4.5	20.0	22.0	7.0	35.0	47.0	42.0	116	83.0	160	290	132	437	538	279	1611	1611
3	1.5	–	1.5	4.5	–	5.0	9.5	–	12.5	17.5	5.5	25.5	28.0	11.0	50.0	58.0	70.0	165	103	261	390	165	661	723	291	1725	1725
4	2.0	–	2.0	5.0	–	6.0	11.5	4.0	15.5	20.5	6.5	31.0	32.0	16.0	60.0	68.0	100	215	116	338	455	165	665	726	NP		
5	2.0	–	2.0	6.0	–	7.0	13.0	4.5	18.0	23.0	7.5	37.0	36.0	22.0	73.0	75.0	128	250	NP			NP					
6	2.5	–	2.5	6.5	–	8.0	14.0	4.5	20.0	25.0	8.5	42.0	40.0	30.0	86.0	NP											
7	2.5	–	2.5	7.0	–	9.0	15.5	5.0	22.5	28.0	11.0	50.0	42.0	34.0	103												
8	3.0	–	3.0	7.5	–	9.5	16.5	5.5	24.0	30.0	13.5	55.0	NP														
9	3.0	–	3.0	8.0	–	10.0	17.5	5.5	25.5	NP																	
10	3.5	–	3.5	8.5	–	10.5	18.5	6.0	27.5																		
11	3.5	–	3.5	9.0	–	11.5	19.0	6.0	28.5																		
12	3.5	–	3.5	9.5	–	12.5	NP																				
13	4.0	–	4.0	10.0	4.0	13.0																					
14	4.0	–	4.0	10.5	4.0	14.0																					
15	4.0	–	4.0	10.5	4.0	14.5																					
16	4.5	–	5.0	NP																							
17	4.5	–	5.0																								
18	4.5	–	5.0																								
19	5.0	–	6.0																								
	NP																										

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

Figure 41

Table 382.40–5

MAXIMUM ALLOWABLE LOAD FOR COPPER TUBING–TYPE L, ASTM B88; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																										
	1/2"			3/4"			1"			1 1/4"			1 1/2"			2"			2 1/2"			3"			4"		
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	2.0	–	2.0	4.0	–	4.0	7.0	–	9.0	11.0	4.0	15.0	23.0	7.5	37.0	40.0	30.0	86.0	65.0	90.0	200	136	462	561
1	1.0	–	1.0	2.5	–	2.5	5.5	–	6.5	10.0	4.0	13.0	16.0	5.0	23.0	33.0	17.5	63.0	59.0	72.0	170	94.0	211	345	198	909	923
2	1.5	–	1.5	4.0	–	4.0	8.5	–	10.5	14.5	4.5	20.5	23.0	7.5	37.0	48.0	44.0	120	86.0	175	305	137	468	566	288	1694	1694
3	2.0	–	2.0	5.0	–	6.0	10.5	4.0	14.0	18.5	6.0	27.5	29.0	12.5	52.0	60.0	75.0	175	107	283	410	169	698	752	298	1792	1792
4	2.0	–	2.0	6.0	–	7.0	12.0	4.0	16.5	21.5	7.0	33.0	34.0	18.5	66.0	70.0	108	225	119	356	469	NP			NP		
5	2.5	–	2.5	6.5	–	8.0	14.0	4.5	20.0	24.0	8.0	40.0	38.0	26.0	80.0	77.0	136	260	NP								
6	2.5	–	2.5	7.5	–	9.5	15.5	5.0	22.5	26.0	9.0	45.0	42.0	33.0	100	NP											
7	3.0	–	3.0	8.0	–	10.0	16.5	5.5	24.0	29.0	12.5	52.0	44.0	37.0	107												
8	3.0	–	3.0	8.5	–	10.5	18.0	6.0	26.5	31.0	15.0	58.0	NP														
9	3.5	–	3.5	9.5	–	12.5	19.0	6.0	28.0	NP																	
10	3.5	–	3.5	10.0	4.0	13.0	20.0	6.5	30.0																		
11	4.0	–	4.0	10.5	4.0	14.0	20.5	6.5	31.0																		
12	4.0	–	4.0	11.0	4.0	15.0	NP																				
13	4.0	–	4.0	11.5	4.0	15.5																					
14	4.5	–	5.0	12.0	4.0	16.5																					
15	4.5	–	5.0	NP																							
16	5.0	–	6.0																								
17	5.0	–	6.0																								
18	5.0	–	6.0																								
19	5.0	–	6.0																								
20	5.5	–	6.5																								
	NP																										

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

Figure 42

Table 382.40–6
MAXIMUM ALLOWABLE LOAD FOR COPPER TUBING–TYPE M, ASTM B88; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																										
	1/2"			3/4"			1"			1 1/4"			1 1/2"			2"			2 1/2"			3"			4"		
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	2.0	–	2.0	4.0	–	4.0	7.0	–	9.0	11.5	4.0	15.5	23.0	7.5	37.0	42.0	33.0	100	67.0	96.0	210	139	481	577
1	1.0	–	1.0	3.0	–	3.0	6.0	–	7.0	10.5	4.0	14.0	16.5	5.5	24.0	34.0	18.5	66.0	61.0	77.0	180	97.0	227	360	202	945	953
2	1.5	–	1.5	4.5	–	5.0	9.0	–	11.5	15.5	5.0	22.5	24.0	8.0	40.0	50.0	48.0	128	88.0	184	315	141	493	588	294	1750	1750
3	2.0	–	2.0	5.5	–	6.5	11.5	4.0	15.5	19.5	6.5	29.0	30.0	13.5	55.0	62.0	80.0	185	110	300	425	174	731	776	303	1835	1835
4	2.5	–	2.5	6.5	–	8.0	13.0	4.5	18.0	22.0	7.0	35.0	35.0	20.0	70.0	73.0	120	240	121	374	484	NP			NP		
5	2.5	–	2.5	7.5	–	9.5	15.0	5.0	21.5	25.0	8.5	42.0	40.0	30.0	86.0	79.0	144	270	NP								
6	3.0	–	3.0	8.0	–	10.0	16.5	5.5	24.0	28.0	11.0	50.0	44.0	36.0	106	NP											
7	3.5	–	3.5	9.0	–	11.5	18.0	6.0	26.5	30.0	13.5	55.0	45.0	39.0	112												
8	3.5	–	3.5	9.5	–	12.5	19.5	6.5	29.0	32.0	17.0	62.0	NP														
9	4.0	–	4.0	10.0	4.0	13.0	20.5	6.5	31.0	NP																	
10	4.0	–	4.0	11.0	4.0	15.0	21.5	7.0	34.0																		
11	4.5	–	5.0	11.5	4.0	15.5	NP																				
12	4.5	–	5.0	12.0	4.0	16.5																					
13	5.0	–	6.0	12.5	4.5	17.5																					
14	5.0	–	6.0	12.5	4.5	18.0																					
15	5.0	–	6.0	NP																							
16	5.5	–	6.5																								
17	5.5	–	6.5																								
18	5.5	–	6.5																								
19	6.0	–	7.0																								
20	6.0	–	7.0																								
21	6.0	–	7.5																								
	NP																										

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

Figure 43

Table 382.40–7
MAXIMUM ALLOWABLE LOAD FOR GALVANIZED STEEL PIPE, SCHEDULE 40, ASTM A53; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																										
	1/2"			3/4"			1"			1 1/4"			1 1/2"			2"			2 1/2"			3"			4"		
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	1.5	–	1.5	3.5	–	3.5	7.0	–	9.0	11.0	4.0	15.0	21.0	7.0	32.0	34.0	18.5	66.0	60.0	75.0	175	123	381	490
1	1.0	–	1.0	2.5	–	2.5	5.0	–	6.0	10.5	4.0	14.0	16.0	5.0	23.0	31.0	15.0	57.0	49.0	46.0	124	87.0	180	310	179	769	805
2	1.5	–	1.5	4.0	–	4.0	7.5	–	9.5	15.5	5.0	22.5	23.0	7.5	37.0	45.0	38.0	110	72.0	116	235	127	406	511	260	1435	1435
3	2.0	–	2.0	5.0	–	6.0	9.0	–	11.5	19.0	6.0	28.0	29.0	12.5	52.0	56.0	65.0	155	89.0	188	320	158	607	683	317	1966	1966
4	2.5	–	2.5	5.5	–	6.5	11.0	4.0	15.0	22.0	7.0	35.0	34.0	18.5	66.0	65.0	90	200	104	266	395	184	809	837	NP		
5	3.0	–	3.0	6.5	–	8.0	12.0	4.0	16.5	25.0	8.5	42.0	38.0	26.0	80.0	74.0	124	245	118	350	465	NP					
6	3.0	–	3.0	7.0	–	9.0	13.5	4.5	19.0	28.0	11.0	50.0	42.0	33.0	100	81.0	152	280	119	358	471						
7	3.5	–	3.5	7.5	–	9.5	14.5	4.5	20.5	30.0	13.5	55.0	46.0	40.0	113	83.0	163	293	NP								
8	4.0	–	4.0	8.0	–	10.0	16.0	5.0	23.0	33.0	17.5	63.0	49.0	46.0	124	NP											
9	4.0	–	4.0	9.0	–	11.5	17.0	5.5	25.0	35.0	20.0	70.0	50.0	49.0	131												
10	4.5	–	5.0	9.5	–	12.5	18.0	6.0	26.5	37.0	24.0	76.0	NP														
11	4.5	–	5.0	10.0	4.0	13.0	19.0	6.0	28.0	37.0	24.0	77.0															
12	5.0	–	6.0	10.5	4.0	14.0	19.5	6.5	29.0	NP																	
13	5.0	–	6.0	11.0	4.0	15.0	20.5	6.5	31.0																		
14	5.0	–	6.0	11.0	4.0	15.0	21.5	7.0	33.0																		
15	5.5	–	6.5	11.5	4.0	15.5	NP																				
16	5.5	–	6.5	12.0	4.0	16.5																					
17	6.0	–	7.0	12.5	4.5	17.5																					
18	6.0	–	7.0	13.0	4.5	18.0																					
19	6.0	–	7.0	13.0	4.5	18.5																					
20	6.5	–	8.0	NP																							
21	6.5	–	8.0																								
22	7.0	–	9.0																								
23	7.0	–	9.0																								
24	7.0	–	9.0																								
25	7.5	–	9.5																								
	NP																										

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

Figure 44

Table 382.40–8
CHLORINATED POLYVINYL CHLORIDE TUBING, ASTM D2846 and F442, SDR 11; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																	
	1/2"			3/4"			1"			1 1/4"			1 1/2"			2"		
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	1.5	–	1.5	3.0	–	3.0	5.0	–	6.0	8.0	–	10.0	16.0	5.0	23.0
1	0.5	–	0.5	2.0	–	2.0	4.0	–	4.0	7.5	–	9.5	11.5	4.0	15.5	23.0	7.5	37.0
2	1.0	–	1.0	3.0	–	3.0	6.0	–	7.0	10.5	4.0	14.0	16.5	5.5	24.0	34.0	18.5	66.0
3	1.5	–	1.5	4.0	–	4.0	8.0	–	10.0	13.5	4.5	19.0	21.0	7.0	32.0	42.0	33.0	100
4	1.5	–	1.5	4.5	–	5.0	9.0	–	11.5	15.5	5.0	22.5	24.0	8.0	40.0	50.0	48.0	128
5	2.0	–	2.0	5.0	–	6.0	10.5	4.0	14.0	17.5	5.5	25.5	27.0	10.0	47.0	56.0	65.0	155
6	2.0	–	2.0	6.0	–	7.0	11.5	4.0	15.5	19.5	6.5	29.0	30.0	13.5	55.0	59.0	73.0	171
7	2.0	–	2.0	6.5	–	8.0	12.5	4.5	17.5	21.5	7.0	33.0	33.0	17.5	63.0		NP	
8	2.5	–	2.5	7.0	–	9.0	13.5	4.5	19.0	23.0	7.5	37.0	34.0	19.0	68.0			
9	2.5	–	2.5	7.0	–	9.0	14.5	4.5	20.5	24.0	8.0	40.0		NP				
10	2.5	–	2.5	7.5	–	9.5	15.0	5.0	21.5	24.0	8.0	41.0						
11	3.0	–	3.0	8.0	–	10.0	16.0	5.0	23.0		NP							
12	3.0	–	3.0	8.5	–	10.5	16.5	5.5	24.0									
13	3.0	–	3.0	9.0	–	11.5		NP										
14	3.0	–	3.0	9.5	–	12.5												
15	3.5	–	3.5	9.5	–	12.5												
16	3.5	–	3.5	10.0	4.0	13.0												
17	3.5	–	3.5		NP													
18	4.0	–	4.0															
19	4.0	–	4.0															
20	4.0	–	4.0															
21	4.0	–	4.0															
22	4.0	–	4.0															
23	4.5	–	5.0															
		NP																

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

Figure 45

Table 382.40–9
MAXIMUM ALLOWABLE LOAD FOR CROSSLINKED POLYETHYLENE (PEX) TUBING, ASTM F876 and F877; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																			
	1/2"			5/8"			3/4"			1"			1 1/4"			1 1/2"			2"	
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	0.5	–	0.5	1.0	–	1.0	2.5	–	2.5	4.0	–	4.0	6.5	–	8.0	13.5	4.5	19.0
1	0.5	–	0.5	1.0	–	1.0	1.5	–	1.5	3.5	–	3.5	6.0	–	7.0	9.5	–	12.5	19.5	6.5	29.0
2	1.0	–	1.0	1.5	–	1.5	2.5	–	2.5	5.0	–	6.0	9.0	–	11.5	14.0	4.5	20.0	28.0	11.0	50.0
3	1.0	–	1.0	2.0	–	2.0	3.0	–	3.0	6.5	–	8.0	11.0	4.0	15.0	17.5	5.5	25.5	36.0	22.0	73.0
4	1.5	–	1.5	2.5	–	2.5	4.0	–	4.0	7.5	–	9.5	13.0	4.5	18.0	20.5	6.5	31.0	42.0	33.0	100
5	1.5	–	1.5	3.0	–	3.0	4.5	–	5.0	8.5	–	10.5	15.0	5.0	21.5	23.0	7.5	37.0	47.0	42.0	116
6	2.0	–	2.0	3.0	–	3.0	5.0	–	6.0	9.5	–	12.5	16.5	5.5	24.0	25.0	8.5	42.0	51.0	53.0	135
7	2.0	–	2.0	3.5	–	3.5	5.5	–	6.5	10.5	4.0	14.0	18.0	6.0	26.5	28.0	11.0	50.0		NP	
8	2.0	–	2.0	3.5	–	3.5	5.5	–	6.5	11.0	4.0	15.0	19.0	6.0	28.0	30.0	13.5	55.0			
9	2.5	–	2.5	4.0	–	4.0	6.0	–	7.0	12.0	4.0	16.5	20.5	6.5	31.0		NP				
10	2.5	–	2.5	4.0	–	4.0	6.5	–	8.0	12.5	4.5	17.5	21.5	7.0	34.0						
11	2.5	–	2.5	4.5	–	5.0	7.0	–	9.0	13.5	4.5	19.0		NP							
12	2.5	–	2.5	4.5	–	5.0	7.0	–	9.0	14.0	4.5	20.0									
13	3.0	–	3.0	5.0	–	6.0	7.5	–	9.5	14.5	4.5	20.5									
14	3.0	–	3.0	5.0	–	6.0	8.0	–	10.0		NP										
15	3.0	–	3.0	5.5	–	6.5	8.0	–	10.0												
16	3.0	–	3.0	5.5	–	6.5	8.5	–	10.5												
17	3.5	–	3.5	5.5	–	6.5	8.5	–	11.0												
18	3.5	–	3.5	6.0	–	7.0		NP													
19	3.5	–	3.5	6.0	–	7.0															
20	3.5	–	3.5	6.0	–	7.5															
21	4.0	–	4.0		NP																
		NP																			

Note: WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means – not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

Figure 46

Table 382.40–10
MAXIMUM ALLOWABLE LOAD FOR CHLORINATED POLYVINYL CHLORIDE TUBING, ASTM F442, SDR 13.5; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)																				
	3/4"			1"			1 1/4"			1 1/2"			2"			2 1/2"			3"		
		WSFU			WSFU			WSFU			WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	2.5	–	2.5	4.5	–	5.0	9.0	–	11.5	13.0	4.5	18.0	23.0	7.5	37.0	38.0	26.0	80.0	65.0	90.0	200
1	3.5	–	3.5	7.0	–	9.0	13.0	4.5	18.0	18.5	6.0	27.5	34.0	18.5	66.0	56.0	65.0	155	94.0	211	345
2	5.5	–	6.5	10.0	4.0	13.0	19.0	6.0	28.0	27.0	10.0	47.0	49.0	46.0	124	82.0	156	285	138	475	572
3	7.0	–	9.0	12.5	4.5	17.5	23.0	7.5	37.0	34.0	18.5	66.0	62.0	80.0	185	102	255	385	170	703	755
4	8.0	–	10.0	15.0	5.0	21.5	27.0	10.0	47.0	40.0	30.0	86.0	72.0	116	235	114	331	449		NP	
5	9.0	–	11.5	16.5	5.5	24.0	31.0	15.0	57.0	45.0	38.0	110	78.0	142	267		NP				
6	10.0	4.0	13.0	18.5	6.0	27.5	34.0	18.5	66.0	49.0	46.0	124		NP							
7	11.0	4.0	15.0	20.0	6.5	30.0	37.0	24.0	76.0	50.0	48.0	128									
8	11.5	4.0	15.5	21.5	7.0	33.0	38.0	26.0	80.0		NP										
9	12.5	4.5	17.5	23.0	7.5	37.0		NP													
10	13.0	4.5	18.0	23.0	7.5	39.0															
11	14.0	4.5	20.0		NP																
12	14.5	4.5	20.5																		
13	14.5	5.0	21.5																		
		NP																			

Note:
WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.
Approved for cold water use only.
Intended use is for MPP systems.

Figure.47

Table 382.40–11
MAXIMUM ALLOWABLE LOAD FOR POLYETHYLENE ALUMINUM POLYETHYLENE TUBING (PexAlPex), ASTM F1281; (C=150)

Pressure Loss Due to Friction (in lbs. per 100 ft. of Length)	Pipe Diameter (in inches)											
	1/2"			5/8"			3/4"			1"		
		WSFU			WSFU			WSFU			WSFU	
	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT	GPM	FM	FT
0.5	0.5	–	0.5	1.0	–	1.0	2.0	–	2.0	4.0	–	4.0
1	0.5	–	0.5	1.5	–	1.5	3.0	–	3.0	6.0	–	7.0
2	1.0	–	1.0	2.0	–	2.0	4.5	–	5.0	8.5	–	10.5
3	1.5	–	1.5	3.0	–	3.0	5.5	–	6.5	10.5	4.0	14.0
4	1.5	–	1.5	3.5	–	3.5	6.5	–	8.0	12.5	4.5	17.5
5	2.0	–	2.0	4.0	–	4.0	7.0	–	9.0	14.0	4.5	20.0
6	2.0	–	2.0	4.0	–	4.0	8.0	–	10.0	15.5	5.0	22.5
7	2.5	–	2.5	4.5	–	5.0	8.5	–	10.5	17.0	5.5	25.0
8	2.5	–	2.5	5.0	–	6.0	9.5	–	12.5	18.0	6.0	26.5
9	2.5	–	2.5	5.5	–	6.5	10.0	4.0	13.0	19.5	6.5	29.0
10	3.0	–	3.0	5.5	–	6.5	10.5	4.0	14.0	20.5	6.5	31.0
11	3.0	–	3.0	6.0	–	7.0	11.0	4.0	15.0	20.5	6.5	32.0
12	3.0	–	3.0	6.0	–	7.0	11.5	4.0	15.5		NP	
13	3.5	–	3.5	6.5	–	8.0	12.5	4.5	17.5			
14	3.5	–	3.5	7.0	–	9.0		NP				
15	3.5	–	3.5	7.0	–	9.0						
16	3.5	–	3.5	7.5	–	9.5						
17	4.0	–	4.0		NP							
18	4.0	–	4.0									
19	4.0	–	4.0									
20	4.0	–	4.0									
21	4.5	–	5.0									
		NP										

Note:
WSFU means water supply fixture units.
GPM means gallons per minute.
FM means predominately flushometer type water closets or syphon jet urinals.
FT means predominately flush tank type water closets or wash down urinals.
NP means not permitted, velocities exceed 8 feet per second.
For using this table, round the calculated pressure loss due to friction to the next higher number shown.
SPS 382.40 (7) (f) and (g) specifies minimum sizes for water distribution piping.

Figure 48

Maximum Allowable Load For PVC Sched. 80, ASTM 1785, (½ to 2 inches)

Press. Loss due to friction A-value	½ inch				¾ inch				1 inch				1¼ inches				1½ inches				2 inches			
	GPM	Vel ft/sec	WSFU FM	WSFU FT	GPM	Vel ft/sec	WSFU FM	WSFU FT	GPM	Vel ft/sec	WSFU FM	WSFU FT	GPM	Vel ft/sec	WSFU FM	WSFU FT	GPM	Vel ft/sec	WSFU FM	WSFU FT	GPM	Vel. ft/sec	WSFU FM	WSFU FT
0.5	0.77	1	---	0.5	1.7	1.2	---	1.5	3.5	1.5	---	3.5	7	1.7	---	9	11	2	4	16	21.6	2.3	7	33
1	1.1	1.5	---	1	2.5	1.8	---	2.5	5	2.2	---	6	10.5	2.6	4	14	16	2.9	5	23	32	3.4	17	60
2	1.6	2.2	---	1.5	3.7	2.7	---	3.5	7.1	3.1	---	9	15.5	3.8	5	21	23.5	4.2	7	39	46	5	40	87
3	2	2.7	---	2	4.6	3.4	---	4.5	9	4	---	12	19	4.7	6	29	29.4	5.3	12	55	57	6.2	69	160
4	2.4	3.2	---	2	5.3	3.9	---	6	10.5	4.6	4	14	22.3	5.5	7	31	34.2	6.2	19	60	67	7.3	97	210
5	2.7	3.6	---	2.5	6	4.4	---	7	11.8	5.2	4	16	25.3	6.3	8	40	38.4	6.9	25	80	75.4	8	134	251
6	2.9	3.9	---	2.5	6.6	4.9	---	8	13	5.7	4	18	27.7	6.9	10	49	42.1	7.6	32	100				
7	3.2	4.3	---	3	7.2	5.3	---	9	14.1	6.2	4	20	30.1	7.5	12	55	45.8	8	39	112				
8	3.4	4.6	---	3	7.7	5.7	---	9	15	6.6	5	21	32.3	8	16	60								
9	3.7	5	---	3.5	8.2	6	---	10	16	7.1	5	22												
10	3.9	5.3	---	3.5	8.7	6.4	---	10	17	7.6	5	23												
11	4.1	5.6	---	4	9.2	6.8	---	12	17.9	8	5	26												
12	4.3	5.8	---	4	9.6	7.1	---	13																
13	4.5	6.1	---	4.5	10.1	7.5	4	14																
14	4.7	6.4	---	4.5	10.5	7.8	4	14																
15	4.8	6.5	---	4.5	10.8	8	4	15																
16	5	6.8	---	6																				
17	5.2	7.1	---	6																				
18	5.3	7.2	---	6																				
19	5.5	7.5	---	6.5																				
20	5.7	7.8	---	6.5																				
21	5.8	7.9	---	6.5																				
22	5.9	8	---	6.5																				
Per 100 feet of length																								

Maximum Allowable Load For PVC Sched. 80, ASTM 1785, (2½ to 6 inches)

Press. Loss due to friction A-value	2½ inches				3 inches				3 ½ inches				4 inches				5 inches				6 inches			
			WSFU				WSFU				WSFU				WSFU				WSFU				WSFU	
	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT
0.5	35	2.6	20	70	64	3.1	87	195	92	3.3	200	335	130	3.6	425	527	237	4	1,226	1,226	380	4.6	2,546	2,546
1	51	3.8	50	130	91	4.4	196	330	134	4.8	450	550	188	5.2	835	855	344	6	2,213	2,213	569	7	4,047	4,047
2	74	5.6	125	245	132	6.4	436	536	195	7	885	900	274	7.6	1,564	1,564								
3	92	6.9	200	330	164	8	654	717																
4	108	8	288	415																				
Per 100 feet of length																								

Figure 49

Maximum Allowable Load for Schedule 80 CPVC ASTM F 441 Pipe (⅜ to 2 inches)

Press. Loss due to Friction A-Value	⅜ inch				½ inch				¾ inch				1 inch				1¼ inch				1½ inches				2 inches			
			WSFU				WSFU				WSFU				WSFU				WSFU				WSFU				WSFU	
	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT	GPM	Vel. ft/sec	FM	FT
0.5	0.36	0.8	---	0.25	0.5	0.7	---	0.5	0.6	1.1	---	0.5	3.2	1.5	---	3	6.9	1.8	---	8	10.5	2	4	14	20.7	2.3	6	31
1	0.5	1.2	---	0.5	1	1.5	---	1	2.4	1.8	---	2	4.7	2.1	---	4.5	10	2.6	4	13	15.2	2.9	5	22	30.1	3.4	13	55
2	0.75	1.8	---	0.5	1.5	2.2	---	1.5	3.5	2.7	---	2.5	6.7	3.1	---	8	14.5	3.8	4	20	22.2	4.2	7	35	43.8	4.9	36	106
3	0.97	2.3	---	1	1.7	2.4	---	1.5	4.3	3.3	---	4	8.3	3.8	---	10	18.1	4.7	6	26	27.6	5.2	10	49	54.5	6.1	60	147
4	1.1	2.7	---	1	1.8	2.6	---	1.5	5	3.9	---	6	9.7	4.5	---	12	21.1	5.5	7	32	32.2	6	16	60	63.7	7.1	85	193
5	1.24	3	---	1	2.5	3.6	---	2.5	5.7	4.4	---	6.5	11	5.1	4	15	23.8	6.2	7	39	36.4	6.8	22	74	71.8	8	115	234
6	1.37	3.3	---	1	2.7	3.9	---	2.5	6.2	4.8	---	7	12.1	5.6	4	16	26.3	6.8	9	45	40.1	7.5	30	87				
7	1.5	3.7	---	1.5	2.95	4.3	---	3	6.7	5.2	---	8	13.1	6.1	4	18	28.5	7.4	11	51	42.7	8	34	102				
8	1.6	3.9	---	1.5	3.2	4.6	---	3	7.25	5.6	---	9	14.1	6.5	4.5	20	30.8	8	14	56								
9	1.7	4.1	---	1.5	3.4	4.9	---	3	7.75	6	---	9	15	7	5	21												
10	1.8	4.4	---	1.5	3.6	5.2	---	3.5	8.3	6.4	---	10	15.9	7.4	5	23												
11	1.9	4.6	---	1.5	3.7	5.4	---	3.5	8.7	6.7	---	11	16.8	7.8	5	24												
12	2	4.9	---	2	3.9	5.7	---	3.5	9	7	---	12	17.2	8	5	25												
13	2.08	5.1	---	2	4.1	6	---	4	9.4	7.3	---	12																
14	2.16	5.3	---	2	4.3	6.3	---	4	9.8	7.6	4	13																
15	2.24	5.5	---	2	4.4	6.4	---	4	10.2	8	4	13																
16	2.32	5.7	---	2	4.6	6.7	---	5																				
17	2.4	5.9	---	2	4.8	7	---	5																				
18	2.47	6	---	2	5	7.3	---	6																				
19	2.55	6.2	---	2.5	5.1	7.4	---	6																				
20	2.63	6.4	---	2.5	5.2	7.6	---	6																				
21	2.71	6.6	---	2.5	5.3	7.7	---	6																				
22	2.78	6.8	---	2.5	5.5	8	---	6.5																				
25	3	7.3	---	3																								
30	3.25	8	---	3																								
Per 100 feet of Length																												

Maximum Allowable Load for Schedule 80 CPVC ASTM F 441 Pipe (2½ to 10 inches)

Press. Loss due to Friction	2½ inches				3 inches				4 inches			
		Vel.	WSFU			Vel.	WSFU			Vel.	WSFU	
A-Value	GPM	ft/sec	FM	FT	GPM	ft/sec	FM	FT	GPM	ft/sec	FM	FT
0.5	33.2	2.6	17	64	59.8	3	74	174	125	3.5	393	500
1	48.3	3.8	44	121	87	4.3	180	310	181	5.2	784	817
2	70.2	5.5	108	226	126	6.3	400	505	281	8	1,629	1,629
3	87.4	6.8	181	312	157	7.8	600	677				
4	102	8	255	385								
Per 100 feet of Length												

Press. Loss due to Friction	6 inches				8 inches				10 inches			
		Vel.	WSFU			Vel.	WSFU			Vel.	WSFU	
A-Value	GPM	ft/sec	FM	FT	GPM	ft/sec	FM	FT	GPM	ft/sec	FM	FT
0.5	366	4.6	2,416	2,416	768	5.5	7,134	7,134	1,393	6.3	14,756	14,756
1	533	6.7	4,117	4,117	1,116	8	11,378	11,378				

Note: CPVC 3inches and larger only approved for cold water.

Figure 50

The pressure losses due to flow friction through displacement type cold–water meters may be calculated from Graph A–382.40 (7)–1.

Graph A–382.40 (7)–1
PRESSURE LOSS IN COLD–WATER METERS, DISPLACEMENT TYPE

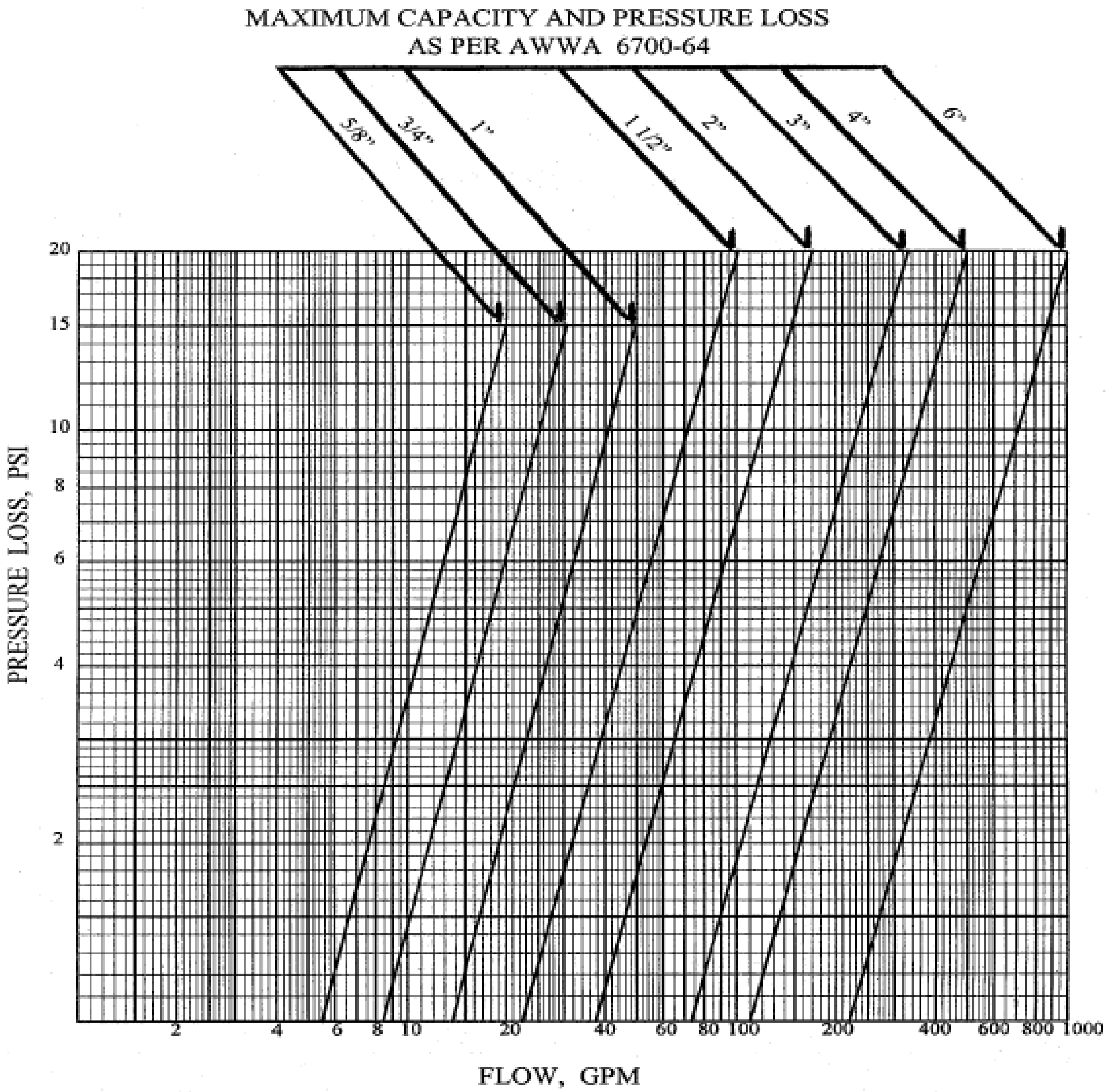


Figure 51

Graph A−382.40 (7)−2
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Copper Tube−Type K, ASTM B88; (C = 150)

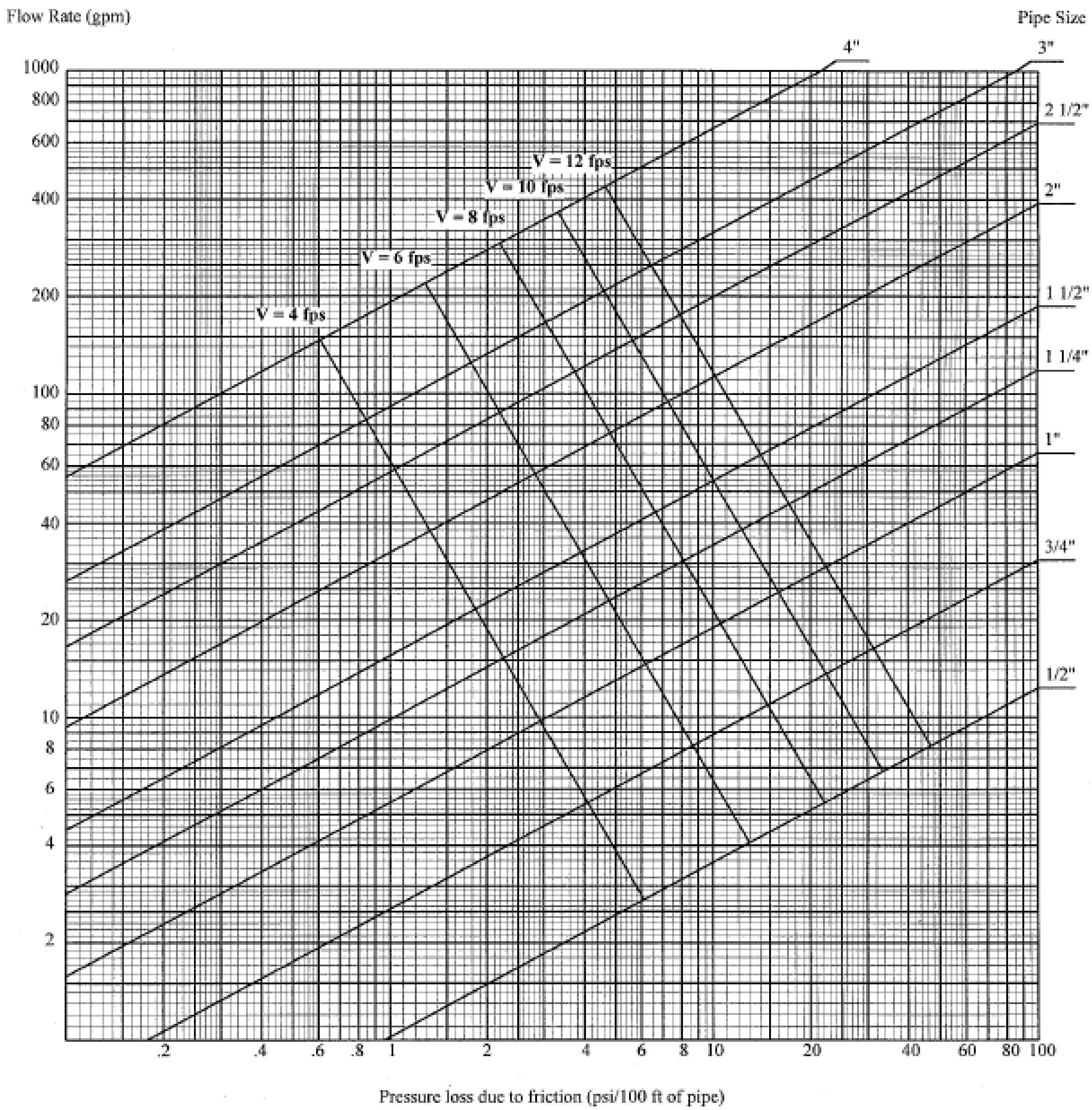


Figure 52

Graph A–382.40 (7)–3

PRESSURE LOSSES DUE TO FLOW FRICTION

Material: Copper Tube–Type L, ASTM B88; (C = 150)

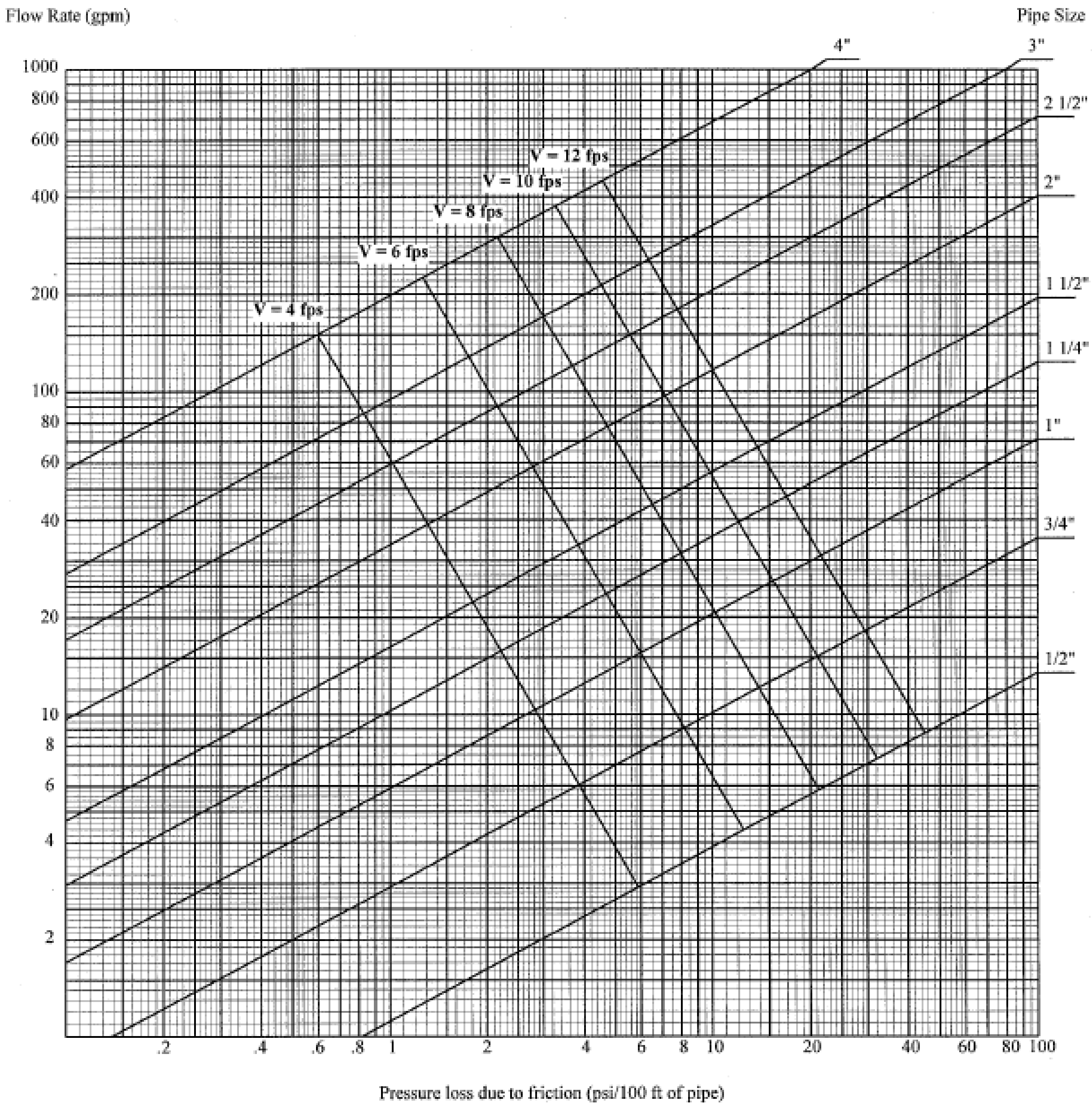


Figure 53

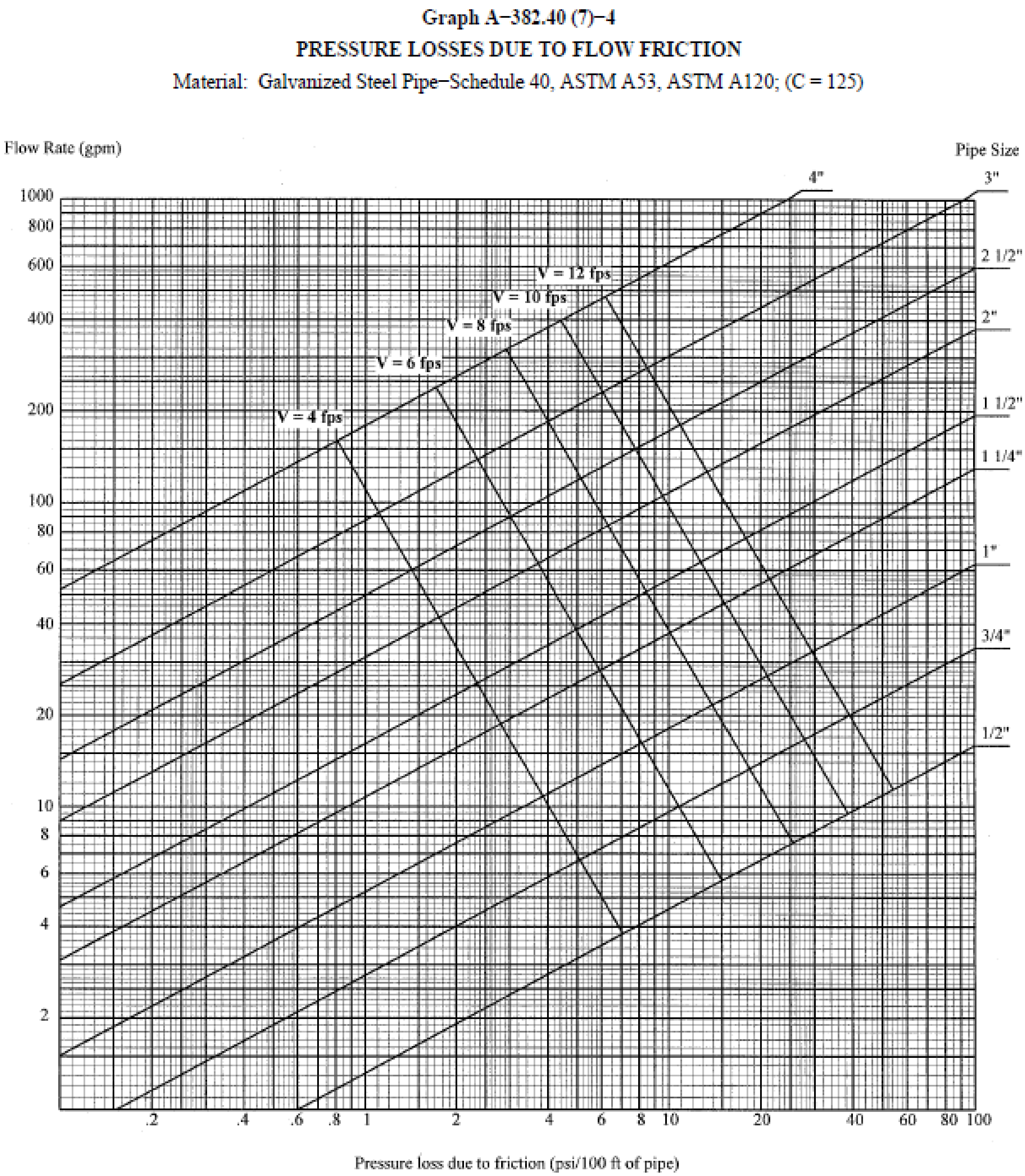
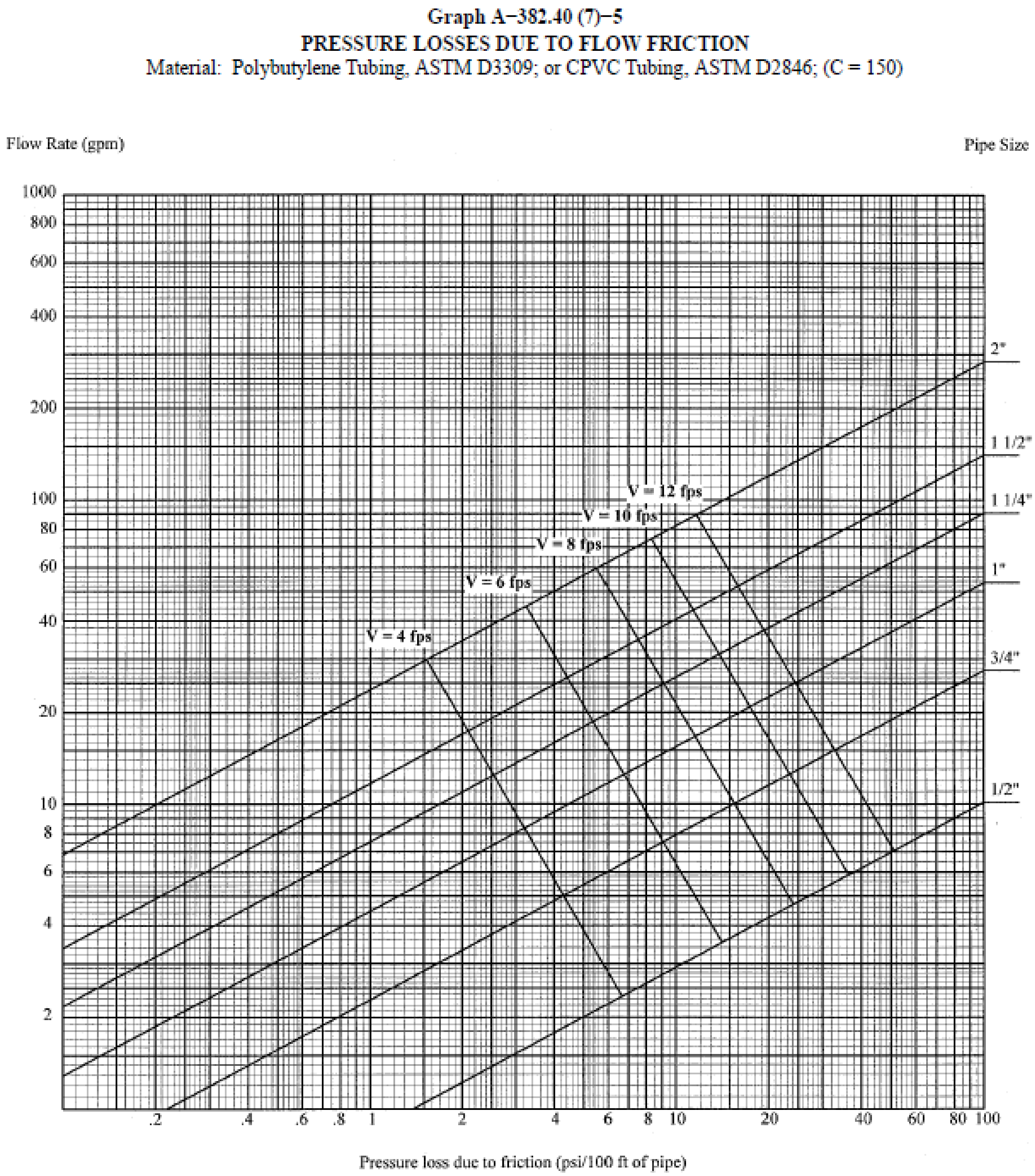

Graph A−382.40 (7)−4
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Galvanized Steel Pipe−Schedule 40, ASTM A53, ASTM A120; (C = 125)
Flow Rate (gpm)
Pipe Size
4"
3"
2 1/2"
2"
1 1/2"
1 1/4"
1"
3/4"
1/2"
V = 12 fps
V = 10 fps
V = 8 fps
V = 6 fps
V = 4 fps
1000
800
600
400
200
100
80
60
40
20
10
8
6
4
2
.2
.4
.6
.8
1
2
4
6
8
10
20
40
60
80
100
Pressure loss due to friction (psi/100 ft of pipe)

Figure 54



Graph A−382.40 (7)−5
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Polybutylene Tubing, ASTM D3309; or CPVC Tubing, ASTM D2846; (C = 150)
Flow Rate (gpm)
Pipe Size
1000
800
600
400
200
100
80
60
40
20
10
8
6
4
2
2"
1 1/2"
1 1/4"
1"
3/4"
1/2"
V = 12 fps
V = 10 fps
V = 8 fps
V = 6 fps
V = 4 fps
.2
.4
.6
.8
1
2
4
6
8
10
20
40
60
80
100
Pressure loss due to friction (psi/100 ft of pipe)

Figure 55

Graph A−382.40 (7)−6
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Crosslinked Polyethylene (PEX) Tubing, ASTM F876; (C = 150)

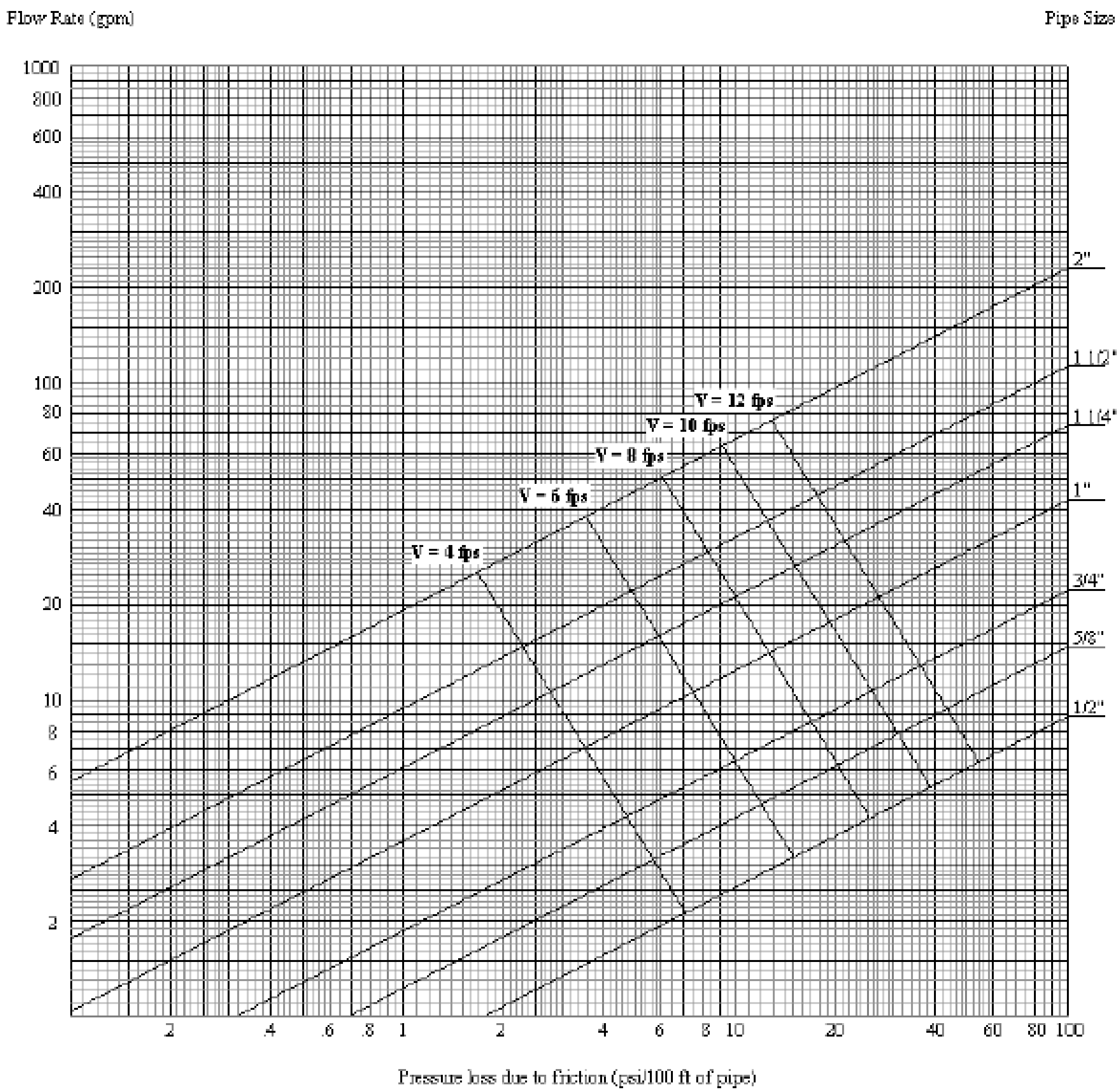
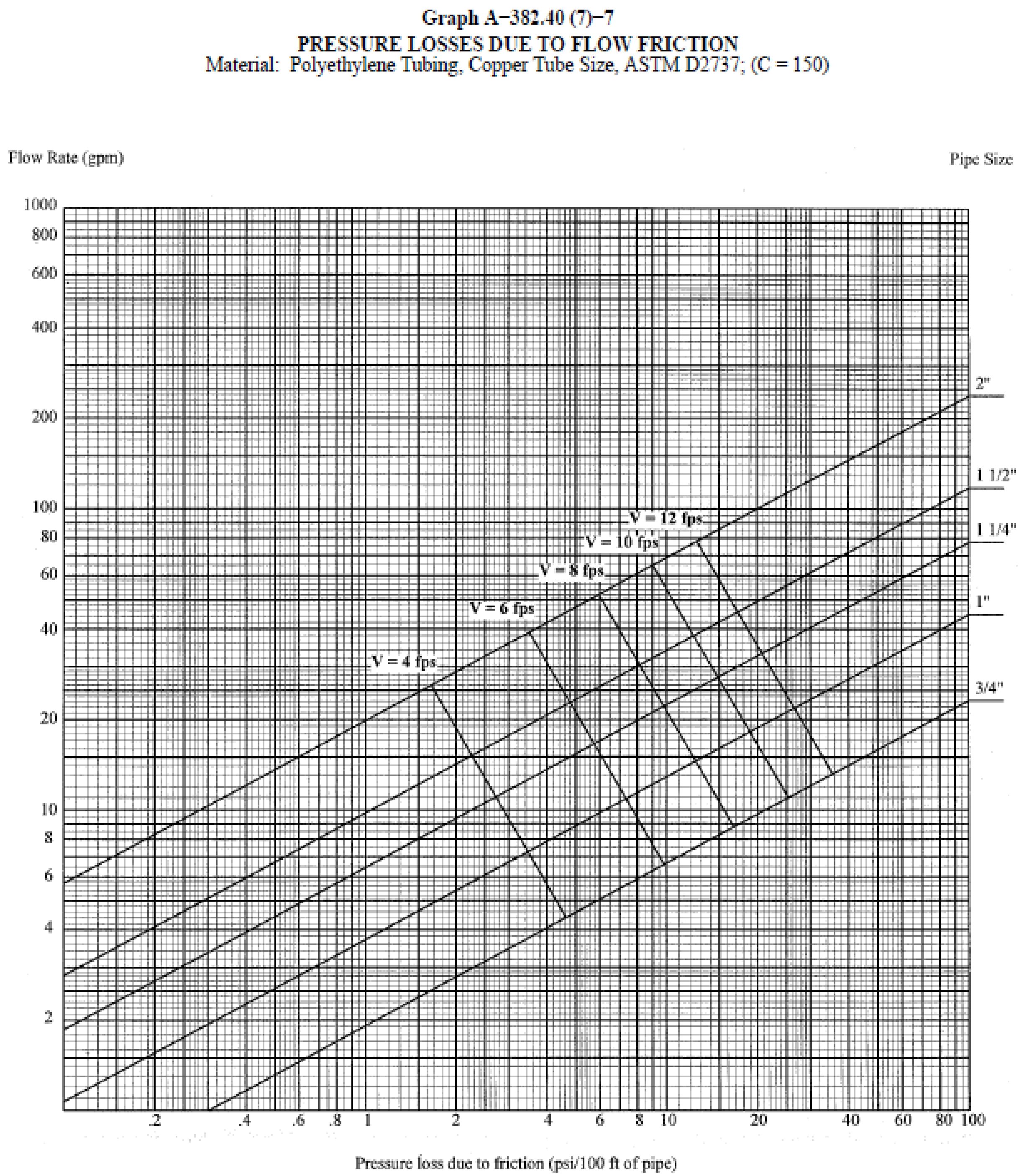


Figure 56



Graph A–382.40 (7)–7
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Polyethylene Tubing, Copper Tube Size, ASTM D2737; (C = 150)
Flow Rate (gpm)
Pipe Size
1000
800
600
400
200
100
80
60
40
20
10
8
6
4
2
2"
1 1/2"
1 1/4"
1"
3/4"
V = 12 fps
V = 10 fps
V = 8 fps
V = 6 fps
V = 4 fps
.2
.4
.6
.8
1
2
4
6
8
10
20
40
60
80
100
Pressure loss due to friction (psi/100 ft of pipe)

Figure 57

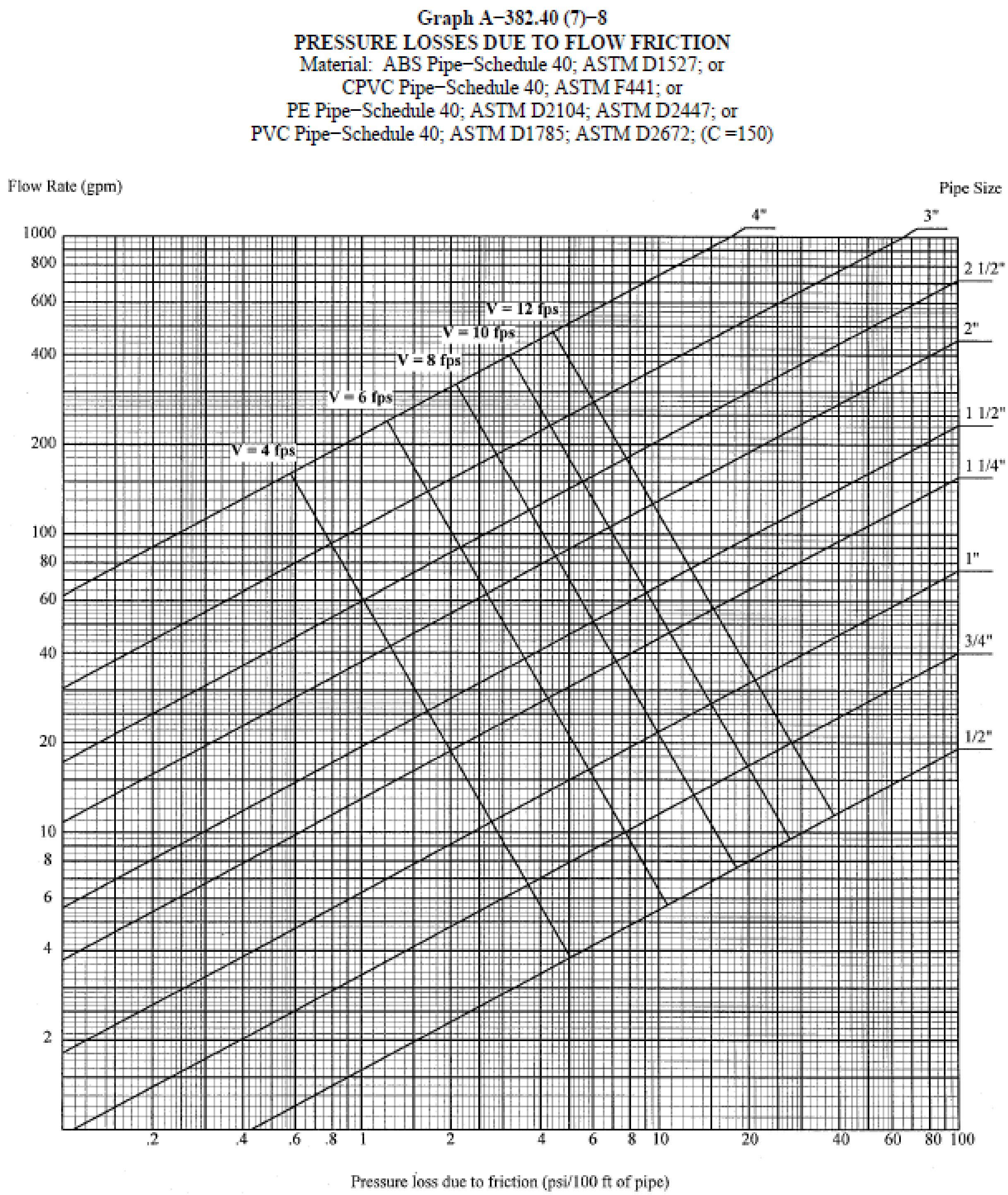

Graph A-382.40 (7)-8
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: ABS Pipe-Schedule 40; ASTM D1527; or
CPVC Pipe-Schedule 40; ASTM F441; or
PE Pipe-Schedule 40; ASTM D2104; ASTM D2447; or
PVC Pipe-Schedule 40; ASTM D1785; ASTM D2672; (C =150)
Flow Rate (gpm)
Pipe Size
4"
3"
2 1/2"
2"
1 1/2"
1 1/4"
1"
3/4"
1/2"
V = 12 fps
V = 10 fps
V = 8 fps
V = 6 fps
V = 4 fps
1000
800
600
400
200
100
80
60
40
20
10
8
6
4
2
.2
.4
.6
.8
1
2
4
6
8
10
20
40
60
80
100
Pressure loss due to friction (psi/100 ft of pipe)

Figure 58

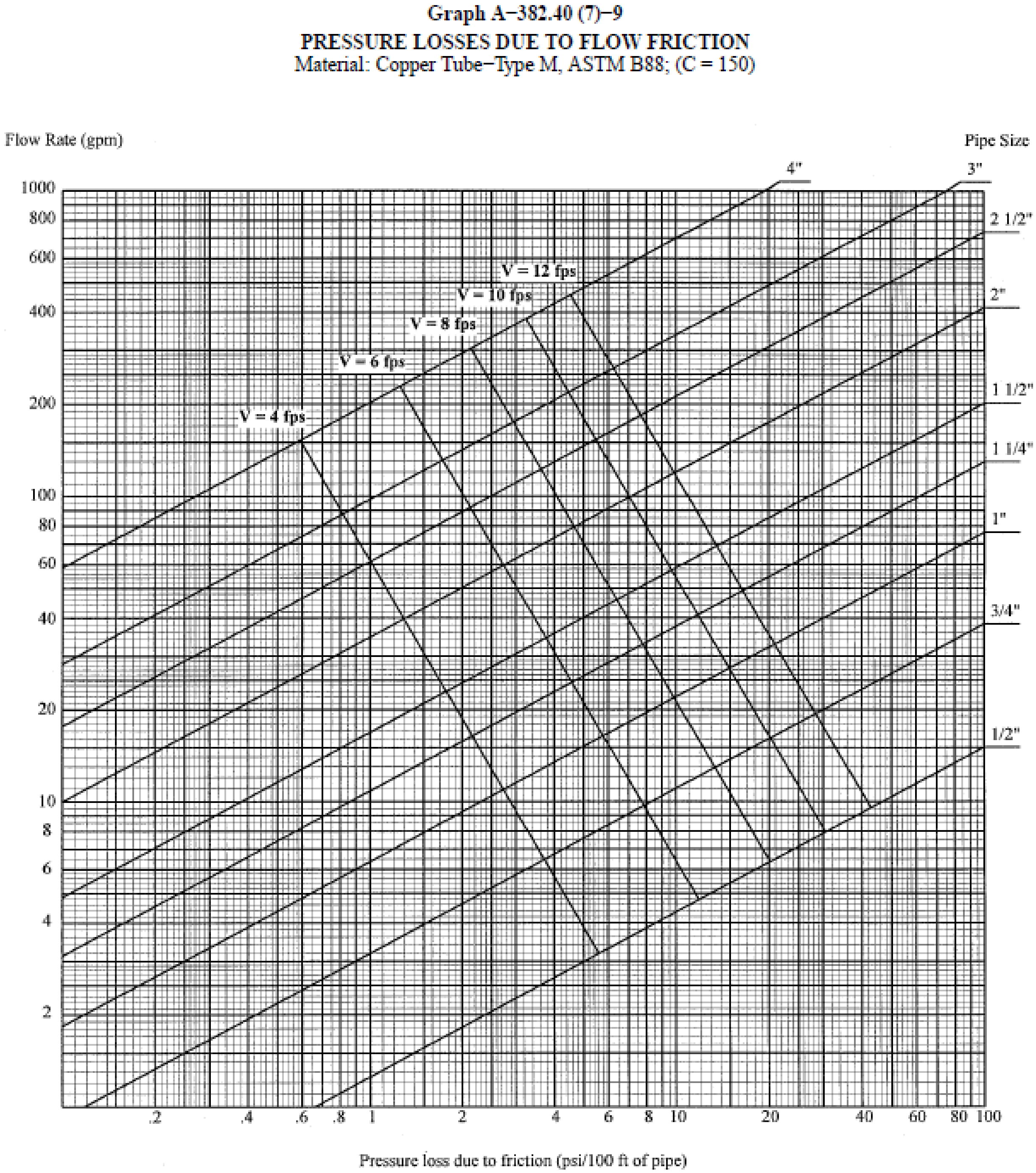

Graph A−382.40 (7)−9
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: Copper Tube−Type M, ASTM B88; (C = 150)
Flow Rate (gpm)
Pipe Size
1000
800
600
400
200
100
80
60
40
20
10
8
6
4
2
4"
3"
2 1/2"
2"
1 1/2"
1 1/4"
1"
3/4"
1/2"
V = 12 fps
V = 10 fps
V = 8 fps
V = 6 fps
V = 4 fps
.2
.4
.6
.8
1
2
4
6
8
10
20
40
60
80
100
Pressure loss due to friction (psi/100 ft of pipe)

Figure 59

Graph A-382.40 (7)-10

PRESSURE LOSSES DUE TO FLOW FRICTION

Material: Polyethylene Aluminum Polyethylene Tubing (PexAlPex), ASTM F1281; (C = 150)

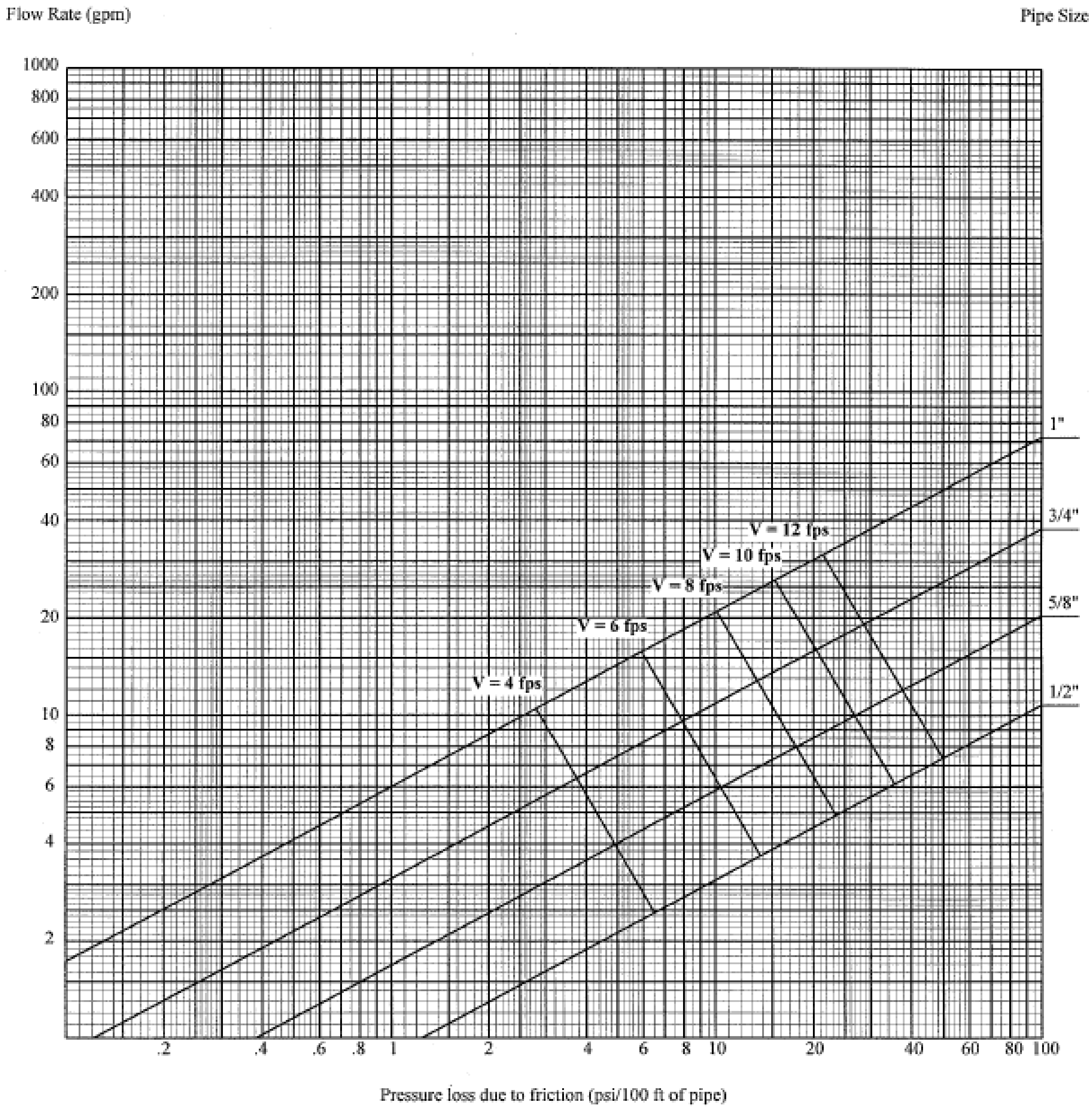
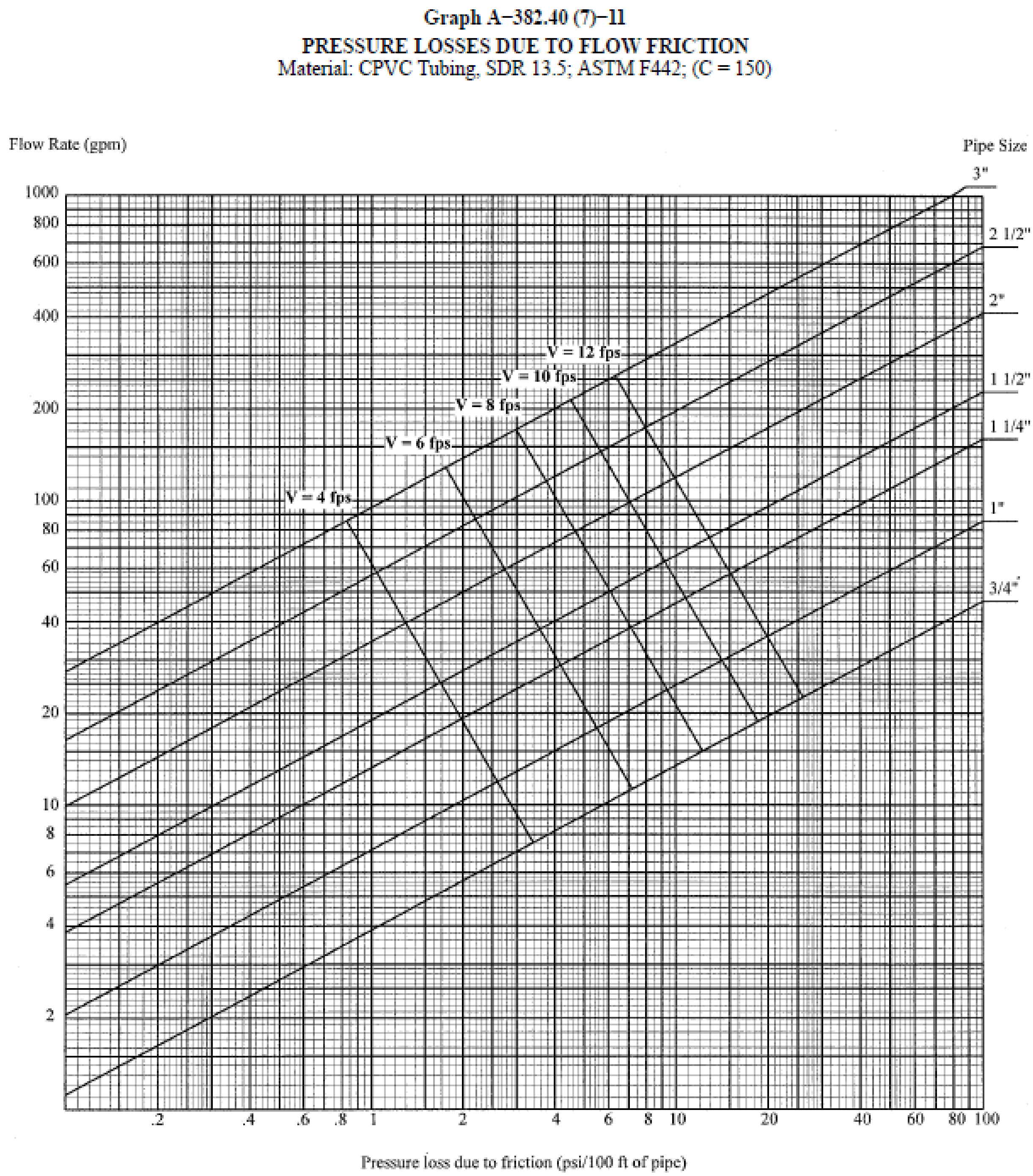


Figure 60


Graph A−382.40 (7)−11
PRESSURE LOSSES DUE TO FLOW FRICTION
Material: CPVC Tubing, SDR 13.5; ASTM F442; (C = 150)
Flow Rate (gpm)
Pipe Size
1000
800
600
400
200
100
80
60
40
20
10
8
6
4
2
3"
2 1/2"
2"
1 1/2"
1 1/4"
1"
3/4"
V = 12 fps
V = 10 fps
V = 8 fps
V = 6 fps
V = 4 fps
.2
.4
.6
.8
1
2
4
6
8
10
20
40
60
80
100
Pressure loss due to friction (psi/100 ft of pipe)

Water Calc. Worksheet ______________________________

Name of Project

INFORMATION REQUIRED TO SIZE WATER SERVICE AND WATER DISTRIBUTION:

1-	Demand of building in water supply fixture units (WSFU);	(WSFU) ________
1.a.	Demand of building in WSFU converted to Gallons Per Minute: (Table 82.40-3)	(GPM) ________
2-	Elevation difference from main or external pressure tank to building control valve; (feet)	________
3-	Size of water meter (when required) 5/8" ____ 3/4" ____ 1" ____ other ____	________
4-	Developed length from main or external pressure tank to building control valve;	(feet) ________
5-	Low pressure at main in street or external pressure tank.	(psi) ________

CALCULATE WATER SERVICE PRESSURE LOSS
(unnecessary for internal pressure tanks)

6- Low pressure at main in street or external pressure tank. (value of # 5 above) ________

7- Determine pressure loss due to friction in ________ inch diameter water service.

Water service piping material is ______________

Pressure loss per 100 ft. = ________ X ________ (decimal equivalent of service length, i.e. 65 ft = 0.65) **Subtract value of "7"** ________

Subtotal ________

8- Determine pressure loss or gain due to elevation, (multiply the value of # 2 above by .434) **Subtract value of "8"** ________

9- Available pressure after the bldg. control valve. Subtotal ________

CALCULATE THE PRESSURE AVAILABLE FOR UNIFORM LOSS (VALUE OF "A")

B. Available pressure after the bldg. control valve. (from "9" above) Value of "B" ________

C. Pressure loss of water meter (when meter is required) **Subtract value of "C"** ________

Subtotal ________

D. Pressure at controlling fixture*.

(Controlling fixture is: ____________________). **Subtract value of "D"** ________

(*Contolling fixture is the fixture with the most demanding pressure to operate properly which includes the following when determining fixture performance; loss due to instantaneous water heaters, water treatment devices, and backflow preventers which serve the controlling fixture.) Subtotal ________

E. Difference in elevation between building control valve and the controlling fixture in feet; ________ X .434 psi/ft. **Subtract value of "E"** ________

Subtotal ________

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Water Calc Worksheet ______________________________
Name of Project

F. Pressure loss due to water treatment devices and backflow preventers which serve the controlling fixture. (Water softeners, filters, etc.)

(Pressure loss due to; ______________________).

F1. WSFU Downstream of Water Treatment Device; ________

F2. Convert wsfu to GPM using **Table 382.40-3** ________

or

F3. Convert wsfu to GPM using **Table 382.40-3e** ________
(For individual dwellings only)

F4. Refer to manuf. graph to obtain pressure loss: ________
(If no water treatment device enter "0")

Subtract value of F4 ________

Subtotal ________

G. Pressure loss through tankless water heaters, combination boiler / hot water heaters, heat exchangers which serve the controlling fixture;

Hot water WSFU's; ________ convert to; GPM = ________ **Table 382.40-3**
Refer to manufacturer's pressure loss graph to determine loss at the required GPM;

________ pressure loss. **Subtract value of "G"** ________

Subtotal ________

H. Developed length from building control valve to controlling fixture in feet ________ X 1.5 **Divide by value "H"** ________

Subtotal ________

Multiply by: 100

A. Pressure available for uniform loss **"A" =** ________

Water distribution piping is: ______________________

*Note: The "A" value obtained by using **382.40-3e** can only be used for an individual dwelling when sizing the water treatment device (water softeners, etc) and no hose bibbs, hydrants, or high flow fixtures are being served by the water treatment device.

Note: High flow fixtures are defined as fixtures that exceed a flow rate of 4 gpm @ 80 psi, and water velocity not exceeding 8 ft. per second.

Water Calc. Worksheet ______________________________
Name of Project

INFORMATION REQUIRED TO SIZE WATER SERVICE AND WATER DISTRIBUTION:

1-	Demand of building in water supply fixture units (WSFU);	(WSFU) ________
1.a.	Demand of building in WSFU converted to Gallons Per Minute: (Table 82.40-3)	(GPM) ________
2-	Elevation difference from main or external pressure tank to building control valve; (feet)	________
3-	Size of water meter (when required) 5/8" ____ 3/4" ____ 1" ____ other ____	________
4-	Developed length from main or external pressure tank to building control valve;	(feet) ________
5-	Low pressure at main in street or external pressure tank.	(psi) ________

CALCULATE WATER SERVICE PRESSURE LOSS
(unnecessary for internal pressure tanks)

6- Low pressure at main in street or external pressure tank. (value of # 5 above) ________

7- Determine pressure loss due to friction in ________ inch diameter water service.
Water service piping material is ________________
Pressure loss per 100 ft. = ________ X ________ (decimal equivalent of service length, i.e. 65 ft = 0.65) **Subtract value of "7"** ________
Subtotal ________

8- Determine pressure loss or gain due to elevation, (multiply the value of # 2 above by .434) **Subtract value of "8"** ________

9- Available pressure after the bldg. control valve. Subtotal ________

CALCULATE THE PRESSURE AVAILABLE FOR UNIFORM LOSS (VALUE OF "A")

B. Available pressure after the bldg. control valve. (from "9" above) Value of "B" ________

C. Pressure loss of water meter (when meter is required) **Subtract value of "C"** ________
Subtotal ________

D. Pressure at controlling fixture*.
(Controlling fixture is: ____________________). **Subtract value of "D"** ________
(*Contolling fixture is the fixture with the most demanding pressure to operate properly which includes the following when determining fixture performance; loss due to instantaneous water heaters, water treatment devices, and backflow preventers which serve the controlling fixture.)
Subtotal ________

E. Difference in elevation between building control valve and the controlling fixture in feet; ________ X .434 psi/ft. **Subtract value of "E"** ________
Subtotal ________

Water Calc Worksheet ______________________________
Name of Project

F. Pressure loss due to water treatment devices and backflow preventers which serve the <u>controlling fixture</u>. (Water softeners, filters, etc.)

(Pressure loss due to; ____________________).

F1. WSFU Downstream of Water Treatment Device; ______

F2. Convert wsfu to GPM using **Table 382.40-3** ______

<u>or</u>

F3. Convert wsfu to GPM using **Table 382.40-3e** ______

(For individual dwellings only)

F4. Refer to manuf. graph to obtain pressure loss: ______
(If no water treatment device enter "0")

Subtract value of F4 ______

Subtotal ______

G. Pressure loss through tankless water heaters, combination boiler / hot water heaters, heat exchangers <u>which serve the controlling fixture</u>;

Hot water WSFU's; ______ convert to; GPM = ______ **(Table 382.40-3)**
Refer to manufacturer's pressure loss graph to determine loss at the required GPM;

______ pressure loss. **Subtract value of "G"** ______

Subtotal ______

H. Developed length from building control valve to <u>controlling fixture</u> in feet ______ X 1.5 **Divide by value "H"** ______

Subtotal ______

Multiply by: 100

A. Pressure available for uniform loss **"A" =** ______

Water distribution piping is: ____________________

*Note: The "A" value obtained by using **382.40-3e** e can only be used for an individual dwelling when sizing the water treatment device (water softeners, etc) and no hose bibbs, hydrants, or high flow fixtures are being served by the water treatment device.

Note: High flow fixtures are defined as fixtures that exceed a flow rate of 4 gpm @ 80 psi, and water velocity not exceeding 8 ft. per second.

Glossary

1. Building Control Valve The valve that separates the water service from the water distribution system. This valve must be located within 3 feet of the point where the water service penetrates the building wall or floor.

2. Controlling Fixture The plumbing fixture which has the highest pressure and / or flow requirement in a water distribution system.

3. Elevation Difference The vertical distance, measured in feet between two points in the water supply system, such as the difference in height between the water main and the building control valve.
4. Fixture Supply Connector The piping or tubing which connects a plumbing fixture or appliance to the distribution system. This pipe / tub is limited to 24 inches in length for fixtures such as faucets, and water closets, and may not exceed 10 feet in developed length located downstream of a water cooler, water treatment device, or water heater which individually serves a faucet or outlet.

5. External Pressure Tank A hydro pneumatic tank, in most cases, buried underground. These tanks are normally mounted directly on top of a well casing.

6. Flow Pressure The pressure in a pipe when water is moving in the pipe, i.e. residual pressure.

7. Friction Loss The loss in pressure that occurs when water is moving in a pipe that is due to the contact between the water in the pipe and the pipe wall.

8. Gallons Per Minute Demand A predicted building water requirement (load) is expressed in gallons of water per minute of use.

9. Nonpotable Water Means water not safe for drinking, personal or culinary use.

10. Nonpublic In the classification of plumbing fixtures, those fixtures in residences, apartments, living units of hotels and motels, and other places where the fixtures are intended for the use by a family or an individual to the exclusion of all others.

11. Peak Demand The maximum designed flow rate anticipated in a piping system.

12. Plumbing Fixture Is a receptacle or device which meets at least one of the following:
    a. Is either permanently or temporarily connected to the water supply system of the premises, and demands a supply of water from the system;
    b. Discharges wastewater or waste materials either directly or indirectly to the drain system of the premises.
    c. Requires both a water supply connection and a discharge to the drain system of the premises.

13. Potable Water Water that is both safe for drinking, personal or culinary use, and free from impurities present in amounts sufficient to cause disease or harmful physiological effects.

14. Pounds Per Square Inch A unit of measure for pressure. The atmosphere exerts a pressure at sea level equal to 14.7 pounds per square inch. The abbreviation in common use is; psi.

15. Predominately Flushometer (Flush Valve) This term is applied to water distribution piping which is carrying more gallons per minute to flushometer type fixtures than to non-flushometer fixtures.

16. Predominately Flush Tank This term is used to refer to water distribution piping that carries more gallons per minute to fixtures that do not use flushometer valves.

17. Pressure Available for Uniform Loss The pressure that can be lost as friction in the water distribution system and yet still ensure adequate pressure at all fixtures. This term is also a design limit used for sizing water distribution piping.

18. Pressure Balanced Mixing Valve A valve which automatically compensates for changes in hot and cold water supply line pressures. By compensating for these changes in pressure, shower temperatures are kept constant.

19. Pressure Loss Due to Friction Pressure lost when water moves through a pipe, usually expressed in psig or psi.

20. Pressure Tank A hydro pneumatic tank that pressurizes water in a reservoir maintaining a preset pressure range.

21. Private Water Supply System A well, pressure tank, and related piping owned and controlled privately.

22. Private Water Main Water main serving 2 or more buildings and not part of the municipal water system.

23. Public Water Main A publicly owned and managed pipe which carries water for use by citizens and businesses within a service area.

24. Public Water Supply The system of wells, pipes, reservoirs, and pumps owned and controlled by a public authority.

25. Residual Pressure The pressure in a water supply pipe at a faucet which is flowing open.

26. Segmented Loss A method of sizing water distribution piping where the friction loss through each segment of pipe is balanced against pipe size to ensure that adequate pressure is supplied to all fixtures.

27. Simultaneous Use The use of more than one fixture (connected to a water distribution system) at the same time.

28. Velocity The time rate of motion of an object. In water piping, the velocity of water is measured as feet per second.

29. Velocity Erosion The process of wearing of a pipe due to water movement through the pipe. The pipe material is worn down and carried away with the water.

30. Water Conditioner Is an appliance, appurtenance or device used for the purpose of ion exchange, demineralizing water or other methods of water treatment.

31. Water Distribution The water piping in a building from the building control valve to the fixture supply connector.

32. Water Heater Means any heating device with plumbing connections to the water supply system that is intended to supply hot water for domestic or commercial purposes other than space heating.

33. Water Service The water piping from the connection with a public or private water main or external pressure tank to the building control valve.

34. Water Supply Fixture Unit Demand The total of all water supply fixture units on a pipe, or within a building.

35. Water Supply System Means the piping of a private water main, water service and water distribution system, fixture supply connectors, fittings, valves, and appurtenances through which water is conveyed to points of usage such as plumbing fixtures, plumbing appliances, water using equipment or other piping systems to be served.

36. Water Treatment Device A device which:
    a. Renders inactive or removes microbiological, particulate, inorganic, or radioactive contaminants from water which passes through the device or the water supply system downstream of the device; or
    b. Injects in the water supply system gaseous, liquid or solid additives other than water, to render inactive microbiological, particulate, inorganic, organic, or radioactive contaminants.

The Plumber Protects The Health of The Nation.