Piping system in Building

by

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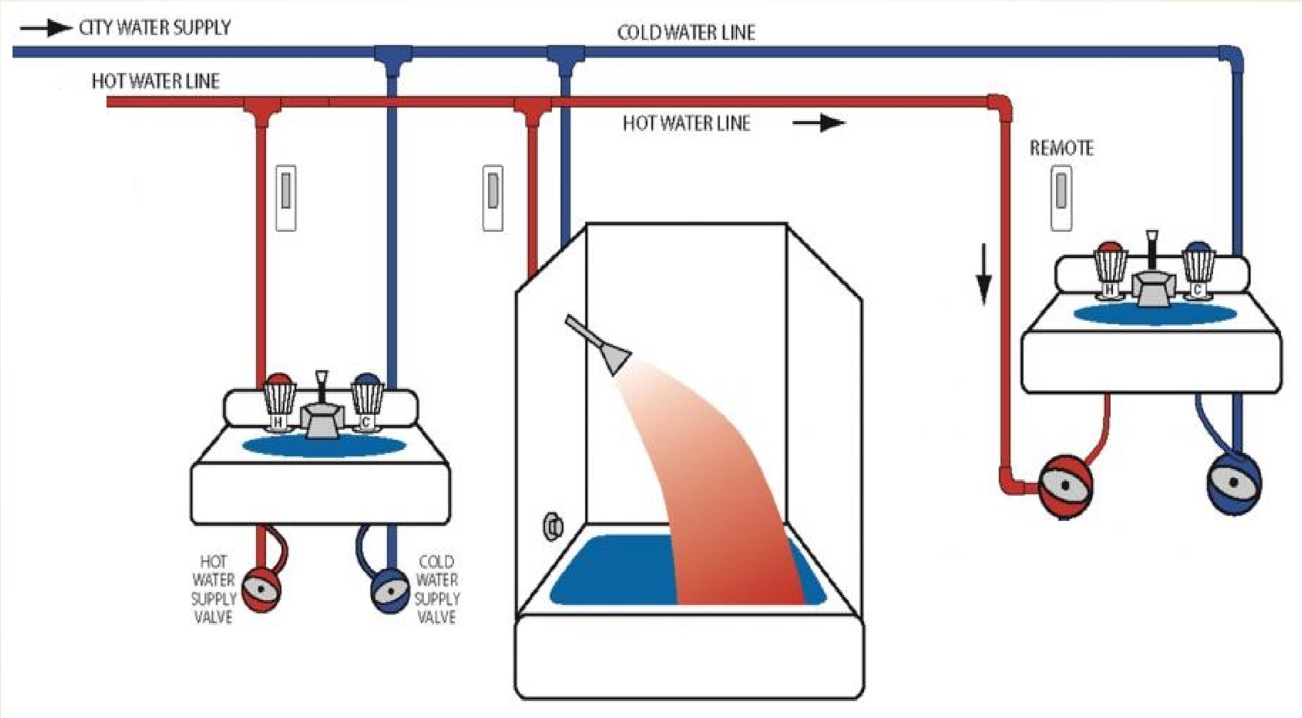
Building piping

Piping is a system of pipes used to convey fluids (liquids and gases) from one location to another. It includes pipe, fittings, valves, and other piping components



Water distribution

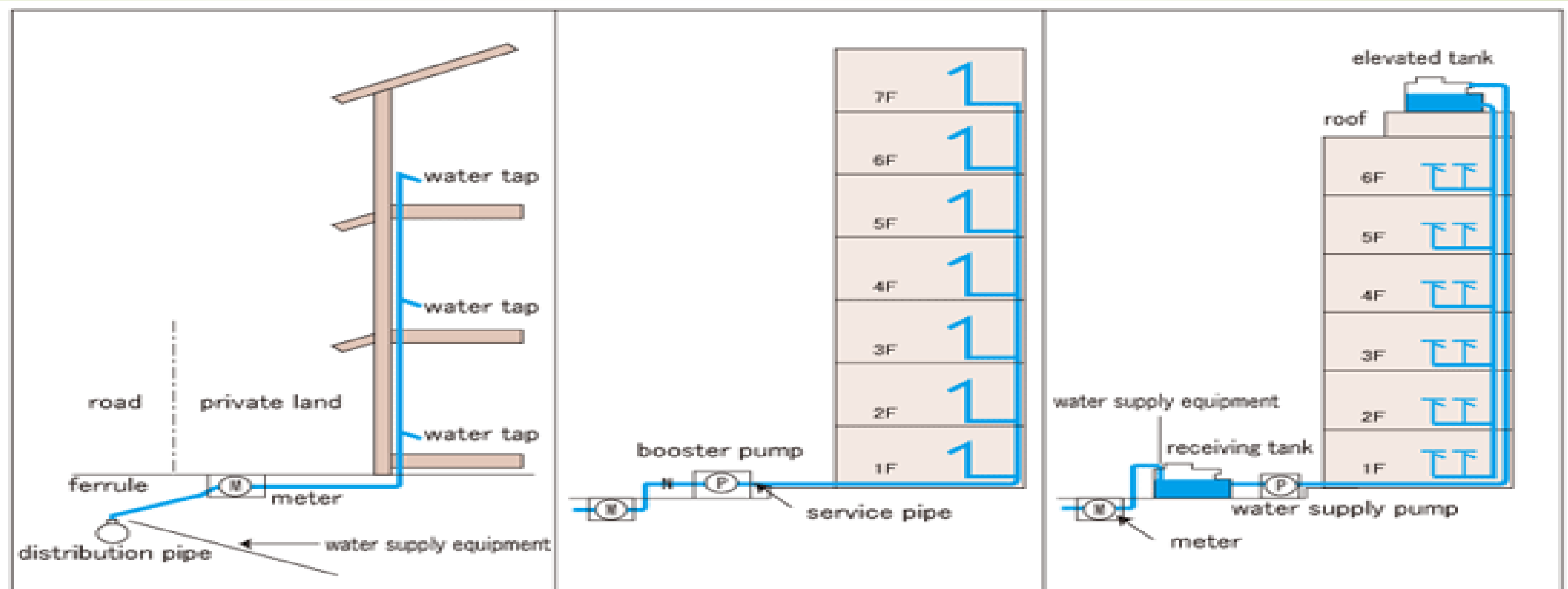
City water supply is distributed through municipal street mains. There are large pipes that usually run underground below the streets. The water flows under pressure that must be great enough to overcome the frictional resistance and static pressure of the distribution system.

Upfeed distribution

When water is fed to fixtures in a building by the incoming pressure of water , it is called upfeed distribution. For medium-size buildings, additional pumps have to be installed to increase pressure.

Downfeed distribution

Downfeed distribution systems may be designed for building more than six stories in height. Water is pumped to the roof of the building to storage tanks. The water from the storage tanks serves the floors below due to the force of gravity.



Upfeed distribution

Upfeed with pump

Downfeed distribution

Supply piping materials

Water pipes and fittings may be of brass, black steel, copper, galvanized steel, or plastic. However, the specific type of materials may be used for each particular piping system.

TABLE 24.5

Comparison of Different Pipe Materials for Water Supply

Material	*Major Advantages*	*Major Disadvantages*
Copper	Long lasting Easy to put together and dismantle Resists attacks by most acids Thin-walled Lightweight Low frictional resistance	Very expensive Requires soldering
Galvanized steel	Strong Relatively inexpensive Resistant to rough handling High pressure rating	Heavy Susceptible to corrosion High frictional resistance
Plastic	Inexpensive Lightweight Easy to install Very low frictional resistance Corrosion resistant	High thermal expansion Low strength Brittle when cold Easily scratched

Steel and Galvanized steel

Steel and Galvanized steel may used for supply when water is noncorrosive. It is made from mild carbon steel. In order to prevent rust and corrosion, the steel pipe is dipped in a hot bath of molten zinc. This process is known as galvanizing. *Nominal sizes** of galvanized steel pipe range from 1/8 inch to 12 inch, in several wall thicknesses.

Nominal size or trade size used for purposes of general identification; the actual size of a part will be approximately the same as the nominal size but need not be exactly the same.

The pipe wall thickness is usually described using terms **Schedule 40, for standard wall** and **Schedule 80, for extra strong wall**. Schedule 40 is normally used for plumbing applications.

Steel Pipe Data

SCHEDULE 40 & 80

Pipe Size	Schedule No.	O.D.	Wall Thickness	Wt. Per Foot (in lbs.)	
				Water	Pipe
3/8	40 80	.675	.091 .126	.083 .061	.567 .738
1/2	40 80	.840	.109 .147	.132 .101	.850 1.087
3/4	40 80	1.050	.113 .154	.230 .186	1.130 1.473
1	40 80	1.315	.133 .179	.374 .311	1.678 2.171
1 1/4	40 80	1.660	.140 .191	.647 .555	2.272 2.996
1 1/2	40 80	1.900	.145 .200	.882 .765	2.717 3.631
2	40 80	2.375	.154 .218	1.452 1.279	3.652 5.022
2 1/2	40 80	2.875	.203 .276	2.072 1.834	5.790 7.660
3	40 80	3.500	.216 .300	3.200 2.860	7.570 10.250
3 1/2	40 80	4.000	.226 .318	4.280 3.850	9.110 12.510
4	40 80	4.500	.237 .337	5.510 4.980	10.790 14.980

Pipe Size	Schedule No.	O.D.	Wall Thickness	Wt. Per Foot (in lbs.)	
				Water	Pipe
5	40 80	5.563	.258 .375	8.660 7.870	14.620 20.780
6	40 80	6.625	.280 .432	12.510 11.920	18.970 28.570
8	40 80	8.625	.322 .500	21.600 19.800	28.550 43.390
10	40 80	10.750	.365 .593	34.100 31.100	40.480 64.400
12	40 80	12.750	.406 .687	48.500 44.000	53.600 88.600
14	40 80	14.000	.437 .750	58.500 51.200	63.000 107.000
16	40 80	16.000	.500 .843	76.500 69.700	83.000 137.000
18	40 80	18.000	.563 .937	97.200 88.500	105.000 171.000
20	40 80	20.000	.593 1.031	120.400 109.400	123.000 209.000
24	40 80	24.000	.687 1.218	174.200 158.200	171.000 297.000
30 36	20 API	30.000 36.000	.500 .500	286.000 417.000	158.000 190.000

Plastic

Plastic pipes are produced from synthetic resins derived from fossil fuels. Four types of plastics are commonly used for plumbing pipes and fittings: (1) polyvinyl chloride (PVC), (2) chlorinated polyvinyl chloride (CPVC), (3) acrylonitrile butadiene styrene (ABS) and (4) polyethylene (PE).

Schedule 40 PVC Pipe Dimensions

Nom. Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./Ft.	Maximum W.P. PSI*
1/8	0.405	0.249	0.068	0.051	810
1/4	0.540	0.344	0.088	0.086	780
3/8	0.675	0.473	0.091	0.115	620
1/2	0.840	0.602	0.109	0.170	600
3/4	1.050	0.804	0.113	0.226	480
1	1.315	1.029	0.133	0.333	450
1-1/4	1.660	1.360	0.140	0.450	370
1-1/2	1.900	1.590	0.145	0.537	330
2	2.375	2.047	0.154	0.720	280
2-1/2	2.875	2.445	0.203	1.136	300
3	3.500	3.042	0.216	1.488	260
3-1/2	4.000	3.521	0.226	1.789	240
4	4.500	3.998	0.237	2.118	220
5	5.563	5.016	0.258	2.874	190
6	6.625	6.031	0.280	3.733	180
8	8.625	7.942	0.322	5.619	160
10	10.750	9.976	0.365	7.966	140
12	12.750	11.889	0.406	10.534	130
14	14.000	13.073	0.437	12.462	130
16	16.000	14.940	0.500	16.286	130
18	18.000	16.809	0.562	20.587	130
20	20.000	18.743	0.593	24.183	120
24	24.000	22.544	0.687	33.652	120

Schedule 80 PVC Pipe Dimensions

Nominal Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./ft.	Maximum W.P. PSI*
1/8	0.405	0.195	0.095	0.068	1230
1/4	0.540	0.282	0.119	0.115	1130
3/8	0.675	0.403	0.126	0.158	920
1/2	0.840	0.526	0.147	0.232	850
3/4	1.050	0.722	0.154	0.314	690
1	1.315	0.936	0.179	0.461	630
1-1/4	1.660	1.255	0.191	0.638	520
1-1/2	1.900	1.476	0.200	0.773	470
2	2.375	1.913	0.218	1.070	400
2-1/2	2.875	2.29	0.276	1.632	420
3	3.500	2.864	0.300	2.186	370
4	4.500	3.786	0.337	3.196	320
6	6.625	5.709	0.432	6.102	280
8	8.625	7.565	0.500	9.269	250
10	10.750	9.493	0.593	13.744	230
12	12.750	11.294	0.687	18.909	230
14	14.000	12.41	0.750	22.681	220
16	16.000	14.213	0.843	29.162	220
18	18.000	16.014	0.937	36.487	220
20	20.000	17.814	1.031	44.648	220
24	24.000	21.418	1.218	63.341	210

Working pressure (kgf/cm^2)

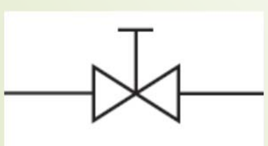
Unit : mm

ชื่อขนาด NOMINAL SIZE	เส้นผ่าศูนย์กลางภายนอก (OD)	ความหนา (THICKNESS)			ความยาวต่อท่อน (LENGTH)	น้ำหนักต่อท่อน-กิโลกรัม (WEIGHT PER LENGTH, Kg)		
		PVC 5	PVC 8.5	PVC 13.5		PVC 5	PVC 8.5	PVC 13.5
18 (1/2")	22±0.15	-	2.0±0.20	2.0±0.20	4,000 +30 -0	-	0.72	0.88
20 (3/4")	26±0.15	-	2.0±0.20	2.5±0.20		-	0.86	1.06
25 (1")	34±0.15	-	2.0±0.20	3.0±0.25		-	1.15	1.67
35 (1 1/4")	42±0.15	1.5±0.15	2.0±0.20	3.1±0.25		1.09	1.44	2.17
40 (1 1/2")	48±0.15	1.5±0.15	2.3±0.20	3.5±0.25		1.25	1.89	2.80
55 (2")	60±0.15	1.8±0.20	2.9±0.25	4.3±0.30		1.88	2.98	4.30
65 (2 1/2")	76±0.20	2.2±0.20	3.5±0.25	5.4±0.35		2.92	4.56	6.85
80 (3")	89±0.20	2.5±0.20	4.1±0.30	6.4±0.40		3.89	6.26	9.50
100 (4")	114±0.30	3.2±0.25	5.2±0.35	8.1±0.50		6.37	10.17	15.41
125 (5")	140±0.30	3.9±0.30	6.4±0.40	9.9±0.55		9.55	15.40	23.23
150 (6")	165±0.40	4.6±0.30	7.5±0.45	11.7±0.65		13.28	21.29	32.37
200 (8")	216±0.50	5.4±0.35	8.8±0.50	13.7±0.75		20.48	32.87	50.06
250 (10")	267±0.70	6.6±0.40	10.9±0.60	16.9±0.90		30.96	50.37	76.43
300 (12")	318±0.80	7.8±0.45	12.9±0.70	20.1±1.05		43.61	71.07	108.40
350 (14")	370±0.90	9.1±0.55	15.0±0.80	23.4±1.20		59.22	96.22	147.01
400 (16")	420±1.10	10.3±0.60	17.0±0.90	26.5±1.35		76.12	123.89	189.23
450 (18")	470±1.20	11.5±0.65	19.0±1.00	29.7±1.50		95.16	155.07	237.58
500 (20")	520±1.30	12.7±0.70	21.0±1.10	32.8±1.65		116.32	189.78	290.65
600 (24")	630±1.60	15.3±0.80	25.4±1.30	39.7±2.00		169.97	278.57	427.32

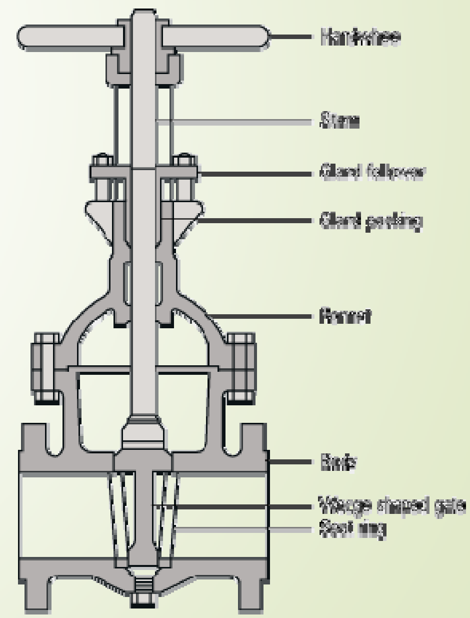
Water supply accessories and controls

Valve is a device used on a piping system to control the flow of fluid within that system. It is desirable to install a valve to control individual fixtures, branch supply lines and every riser (i.e., vertical supply line).

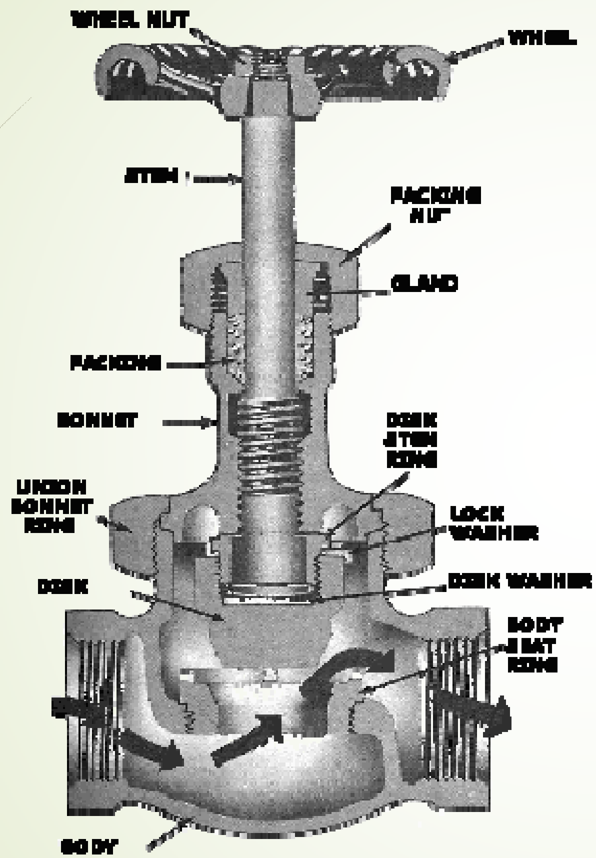
Gate valve is commonly used device that can obstruct the flow of water by means of a wedge disk fitted within the valve body. It mainly performs shut-off duty, not intended for flow regulations

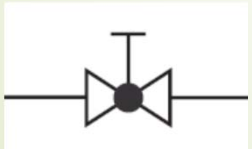


Gate valve symbol



Gate valve



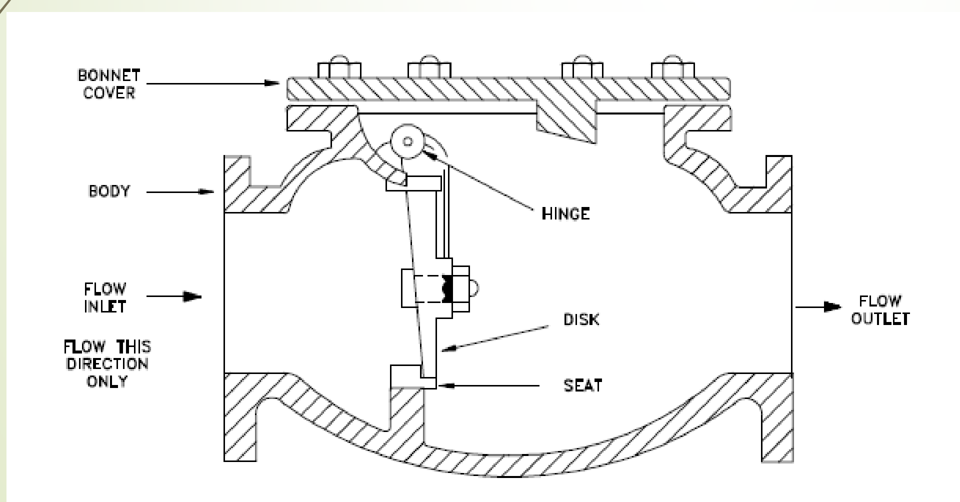


Globe valve symbol

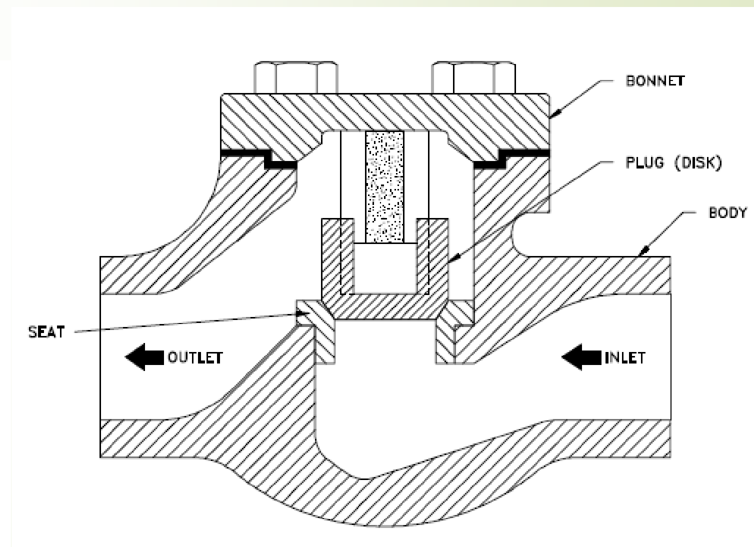
Globe valve is installed when it is necessary to regulate the flow of water. It is a compression-type valve that controls the flow of water by means of a circular disk in stalled within the valve body. The globe valve has small ports, an “S” flow pattern, and relatively high pressure drop.

Check valve is a device that prevents the flow of water in a direction reverse to the normal flow. It is used to direct the flow of water in only one direction. Any reversal flow closes the valve.

Check valve symbol



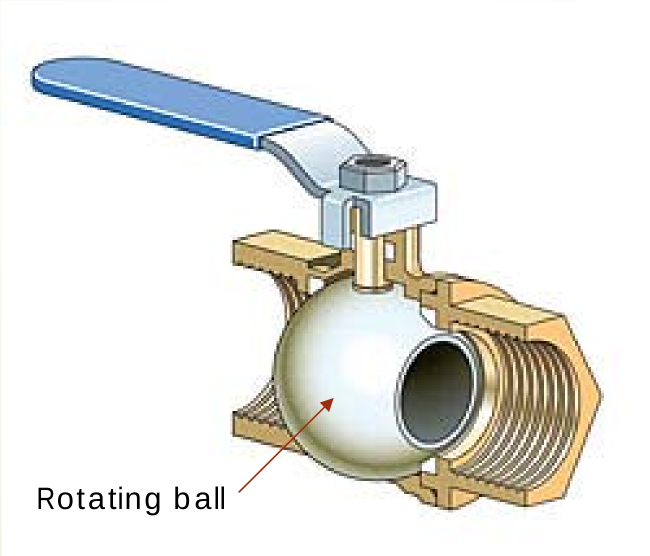
Swing-type



Lift-type

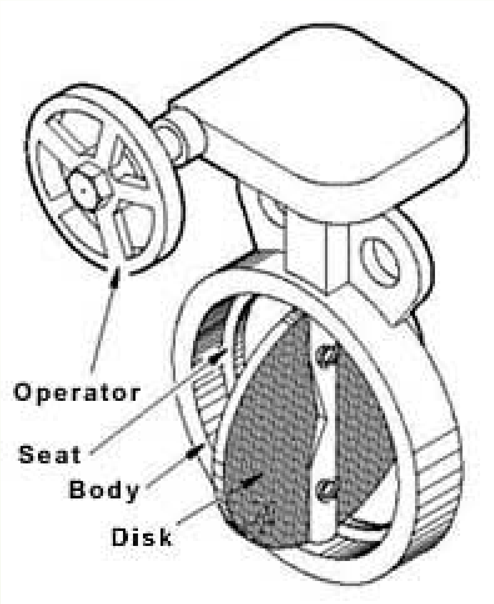
Ball valve controls the water by means of a rotating ball with a cylindrical hole through its center. When the hole is aligned with the water flow, the water flow freely through the valve. It is usually used in pipes smaller than 3 inches in size.

Ball valve symbol



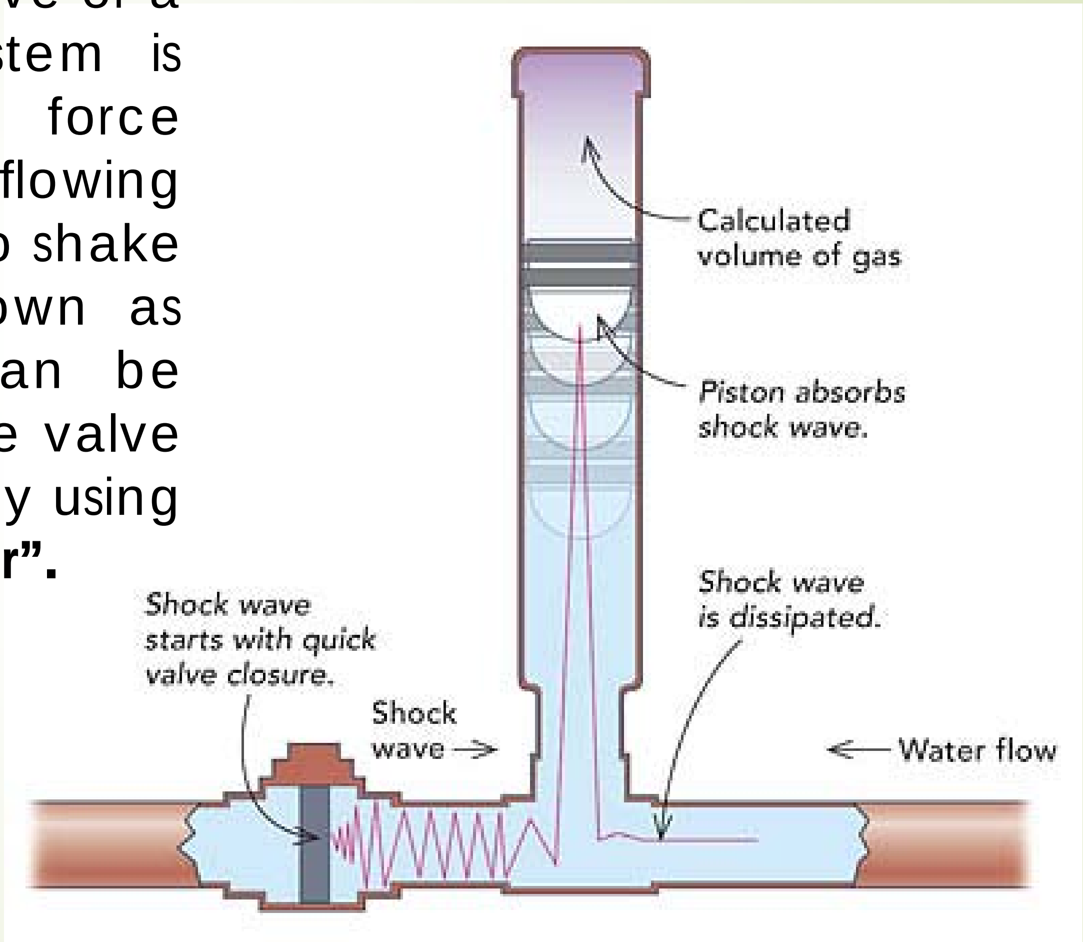
Butterfly valve has a rotating disk that controls the water flow. When fully open, the disk is aligned with the water flow. To close the disk is rotated at a right angle so that it fully blocks the flow. They are used mostly on pipes that are 3 inches or larger in size.

Butterfly valve symbol



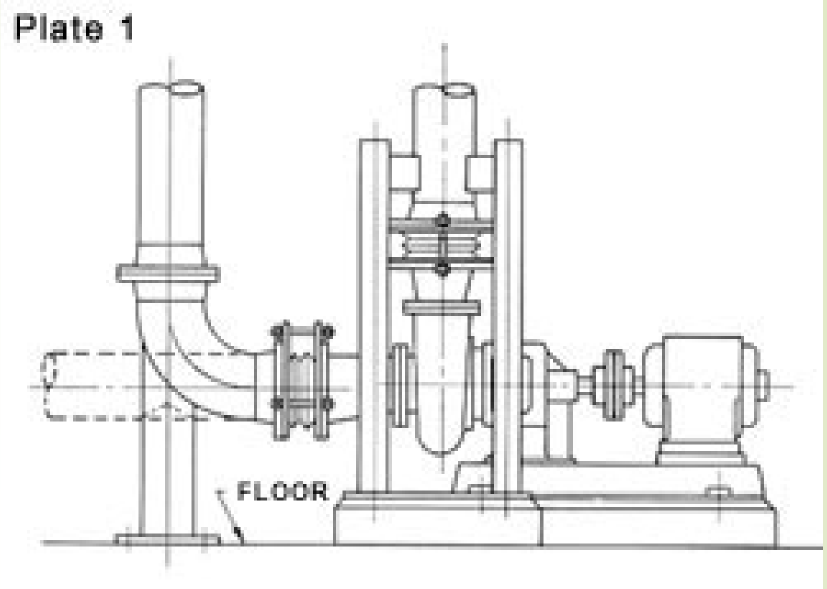
Water hammer arrestor

When a water supply valve or a fixture in a supply system is closed quickly, the force exerted by the fast flowing water causes the pipe to shake and rattle. This is known as water hammer. It can be prevented by closing the valve slowly or be controlled by using a **"water hammer arrestor".**



Pipe expansion joint

is an assembly designed to safely absorb the heat-induced expansion and contraction of construction materials, to absorb vibration, to hold parts together, or to allow movement.



Sizing of supply pipes

Total water demand

In order to determine the size of water supply main to a building and the subsequent branch sizes, it is necessary to determine the maximum load that the supply main should carry. This demand can be calculated form the total supply fixture units for all the plumbing fixtures installed in a building have been calculated, the total water demand can then be found out in terms of GPM

Water velocity

Water flowing through supply pipes tends to produce noise due to friction. The higher the velocity, the greater the noise and the pressure drop.

Water velocity (cont.)

To avoid excessive noise, generally accepted practice for commercial buildings is to limit water velocity to between 6 and 8 fps (2-2.5 m/s). For industrial projects, 10 fps (3 m/s) is acceptable in work areas where the noise is not noticeable.

Recommended velocity (1) Main: 8 m/s (2) Risers and Branches: 6 m/s

$$Q = AV = \frac{\pi}{4} D^2 V$$

$$\Delta P_{Major} = \gamma \left[f \frac{L}{D} \frac{V^2}{2g} \right]$$

$$D = f(Q, V)$$

$$\frac{\Delta P_{Major}}{L} = g(V, D, pipe\ material)$$

f = friction factor = f(surface roughness, flow type)

Friction factor, *f*

is a dimensionless quantity used to calculate friction losses in pipe flow.

$$f = f(e/D, \mathrm{Re})$$ → can be obtained from Moody diagram

$$\mathrm{Re} = \frac{\rho V D}{\mu}$$

where e = surface roughness
Re = Reynolds number
μ = fluid viscosity [water = 1.002 x 10^{-3} Pa-s (2.034 lb_f-s/ft^2)]

Moody diagram

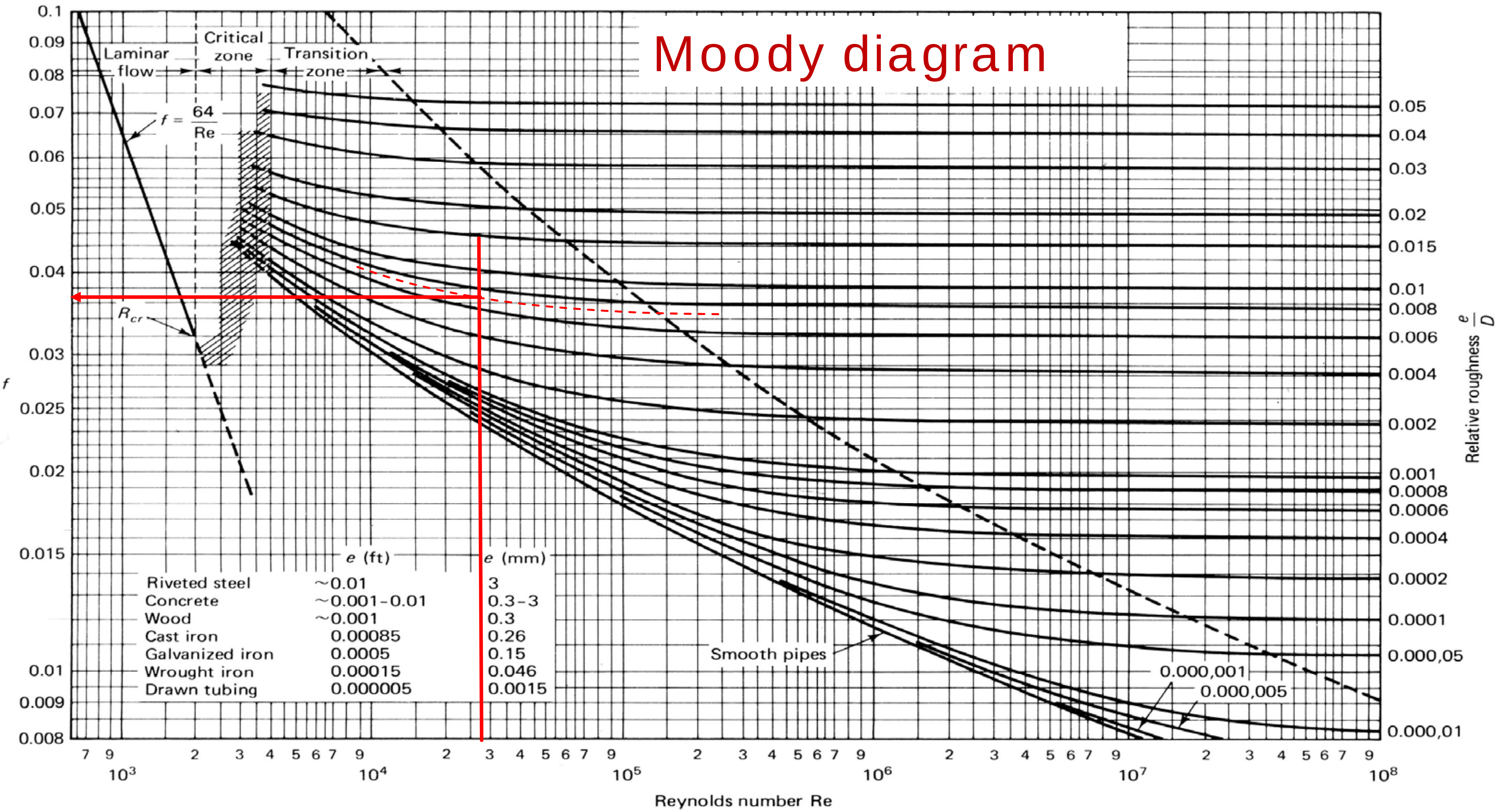


Figure 7.13 Moody diagram. (From L. F. Moody, *Trans. ASME*, Vol. 66, 1944.)

Example 1

¾” S40 PVC pipe delivers10 GPM of water. Calculate pressure drop per length of water flow.

$$D_{@D_{nominal}=3/4"} = 0.804"(0.0204m)$$

$$\dot{Q} = 10\,GPM\,(0.000631\,m^3/s)$$

$$A = \frac{\pi}{4}D^2 = 0.003519\ ft^2\ (0.0003269\,m^2)$$

$$V = \dot{Q}/A = 6.33\,f/s = (1.93m/s)$$

Unit conversion:
1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gpm = 3.785 L/m,
1 psi = 6.895 kPa, 1 foot per second = 0.305 m/s.

Example 1 (cont.)

$$Re = \frac{\rho V D}{\mu} \cong 39{,}200$$

$$e / D = \text{Smooth pipe}$$

$$f \cong 0.039$$

(from Moody diagram)

$$Re = \frac{\rho V D}{\mu} \begin{cases} < 2300 & \textit{Laminar} \\ 2300 < Re < 4000 & \textit{Transition} \\ > 4000 & \textit{Turbulent} \end{cases}$$

Moody diagram

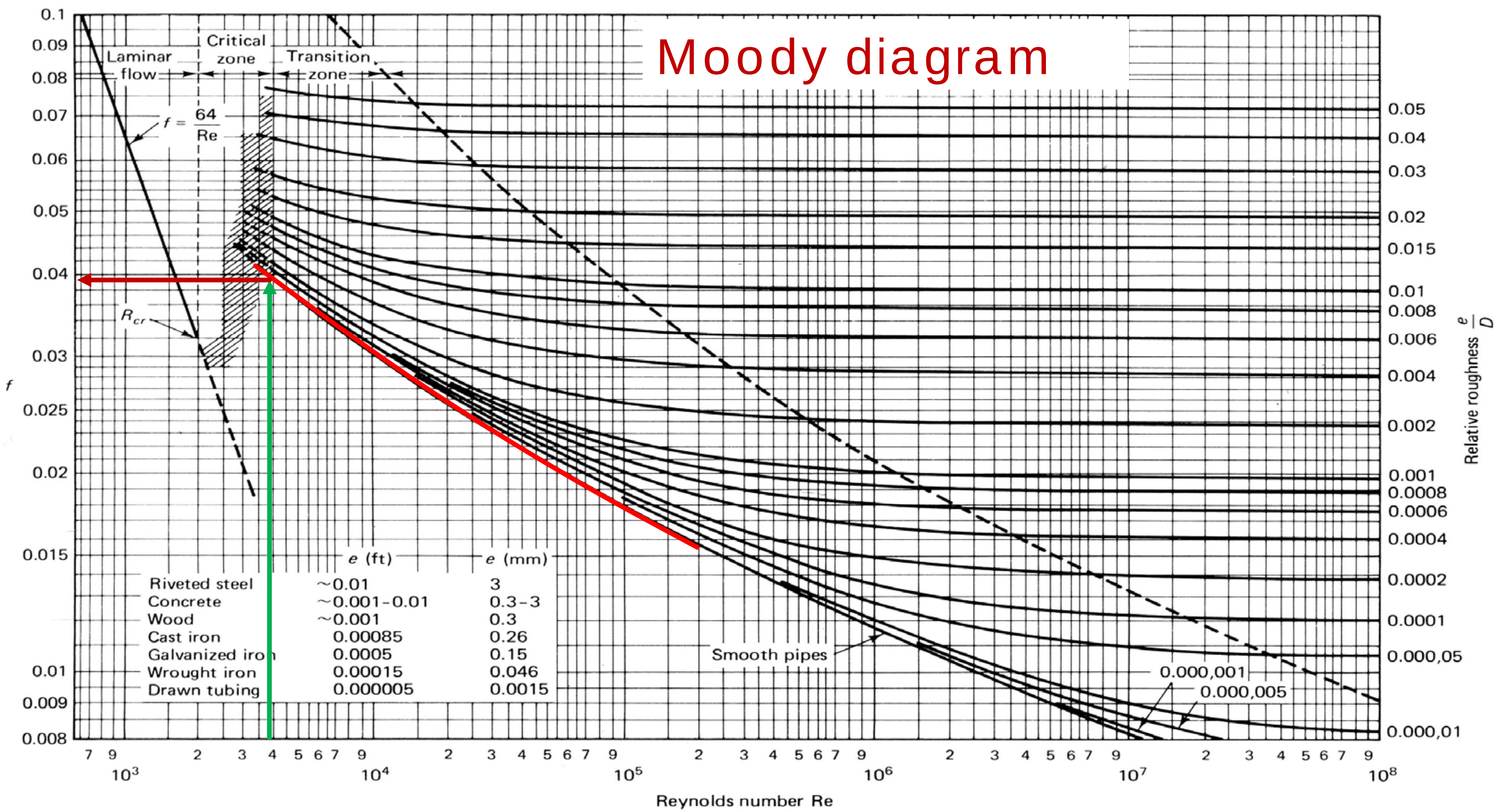
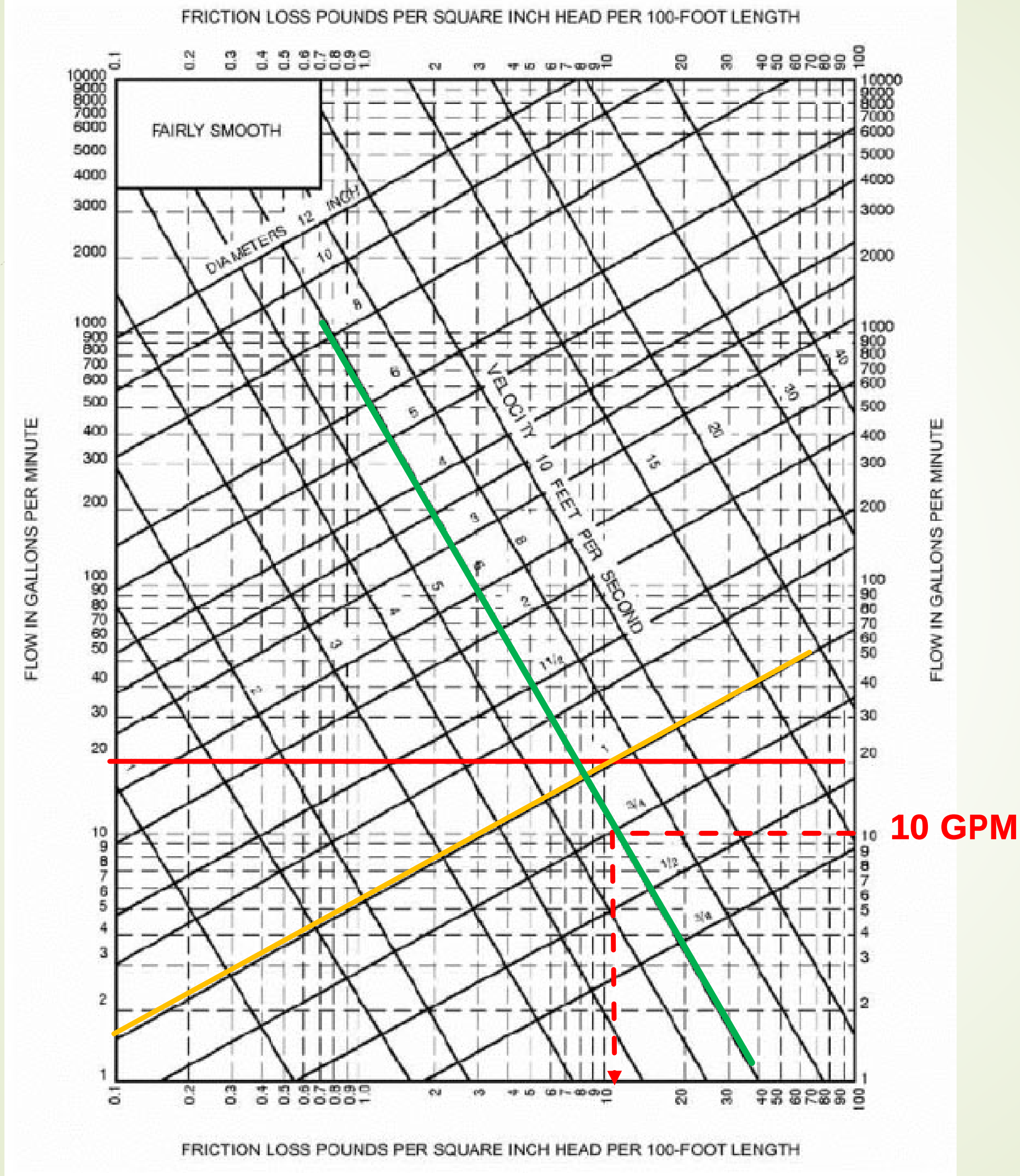


Figure 7.13 Moody diagram. (From L. F. Moody, *Trans. ASME*, Vol. 66, 1944.)

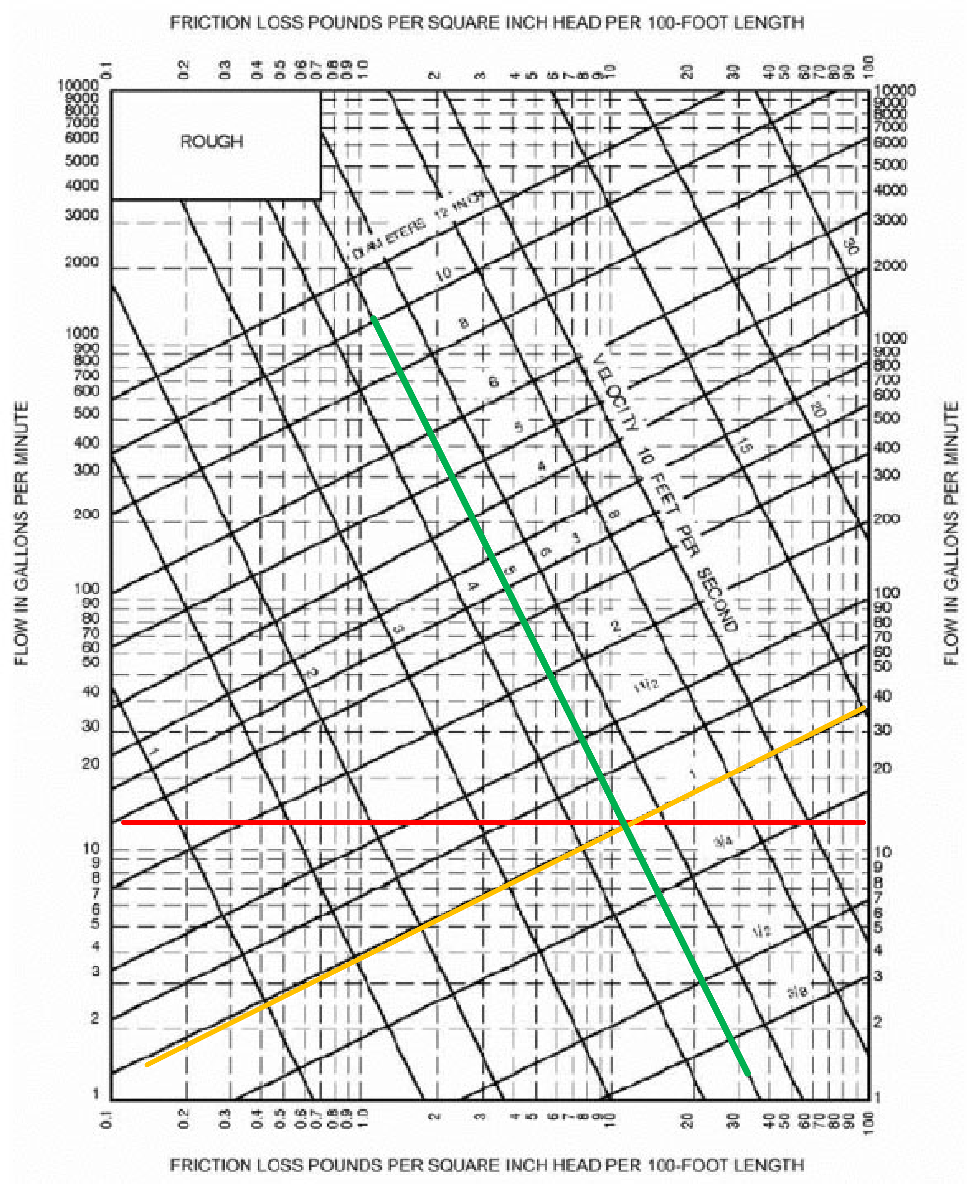
Example 1 (cont.)

$$\frac{\Delta P_{Major}}{L} = f\,\frac{\rho}{D}\frac{V^2}{2} \cong 0.039\,\frac{997}{0.0204}\,\frac{1.93^2}{2} = 3.55\,kPa/m$$

$$\frac{\Delta P_{Major}}{L} = 3.55\,kPa/m = 10.82\,psi/100'$$



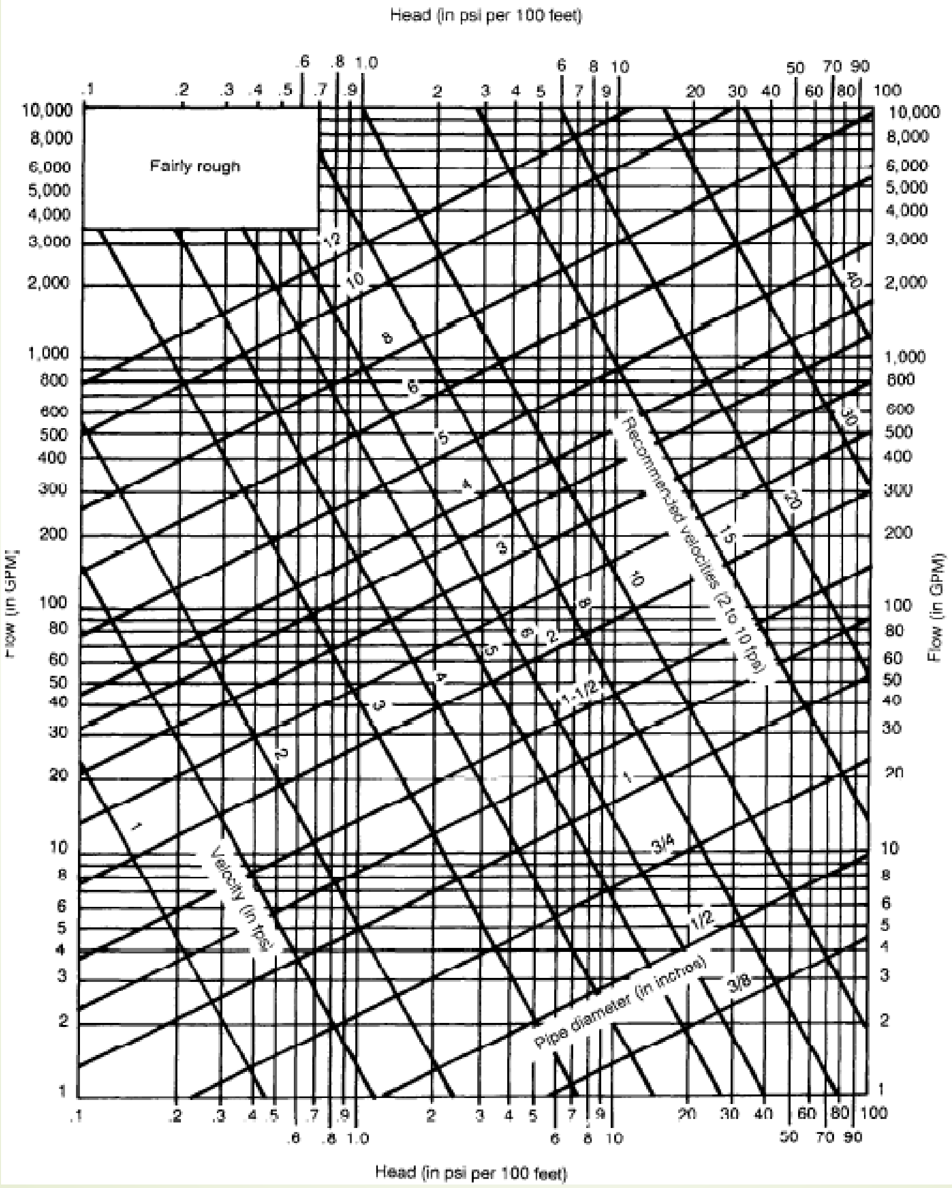
Friction loss diagram
for fairly smooth pipe flow
(e.g. pvc, steel pipe)



Friction loss diagram

for rough pipe flow

(e.g. old cast iron , concrete pipe)



Friction loss diagram

for Fairly rough pipe flow

(e.g. New cast iron pipe)

Example 2

1" S40 galvanized steel pipe delivers 20 GPM of water. Calculate pressure drop per length of water flow using Moody diagram.

$$D_{@D_{nominal}=1"} = 1.049"(0.02664m)$$

$$\dot{Q} = 20\,GPM\,(0.001262\,m^3/s)$$

$$A = \frac{\pi}{4}D^2 = 0.006001\ ft^2\ (0.0005574\,m^2)$$

$$V = \dot{Q}/A = 7.42\,fps = 2.264m/s$$

Example 2 (cont.)

$$\mathrm{Re} = \frac{\rho V D}{\mu} \cong 60{,}011$$

$$e/D = 0.00563$$

$$f \cong 0.032$$

(from Moody diagram)

$$\mathrm{Re} = \frac{\rho V D}{\mu} \begin{cases} < 2300 & \textit{Laminar} \\ 2300 < \mathrm{Re} < 4000 & \textit{Transition} \\ > 4000 & \textit{Turbulent} \end{cases}$$

Moody diagram

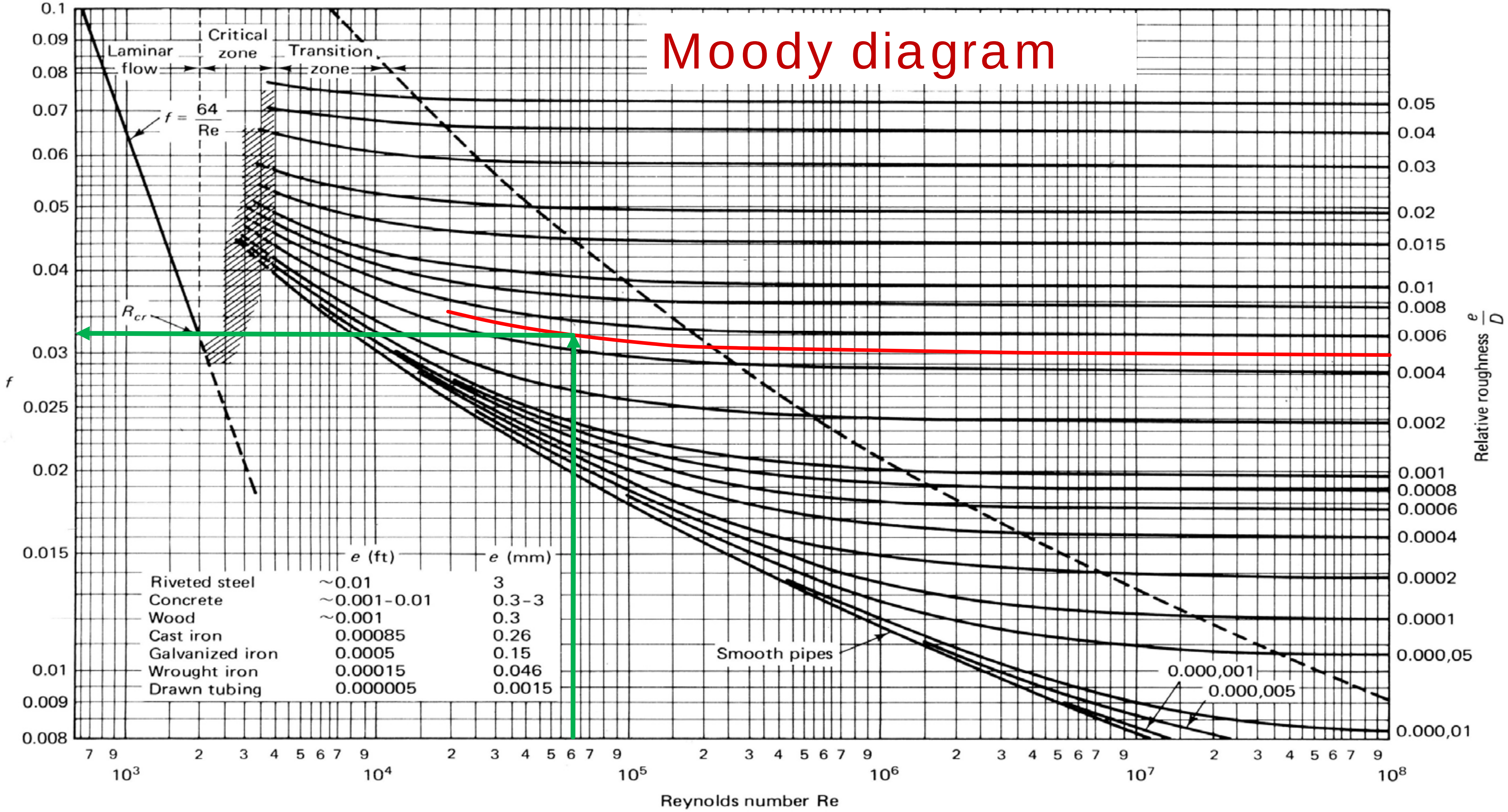


Figure 7.13 Moody diagram. (From L. F. Moody, *Trans. ASME*, Vol. 66, 1944.)

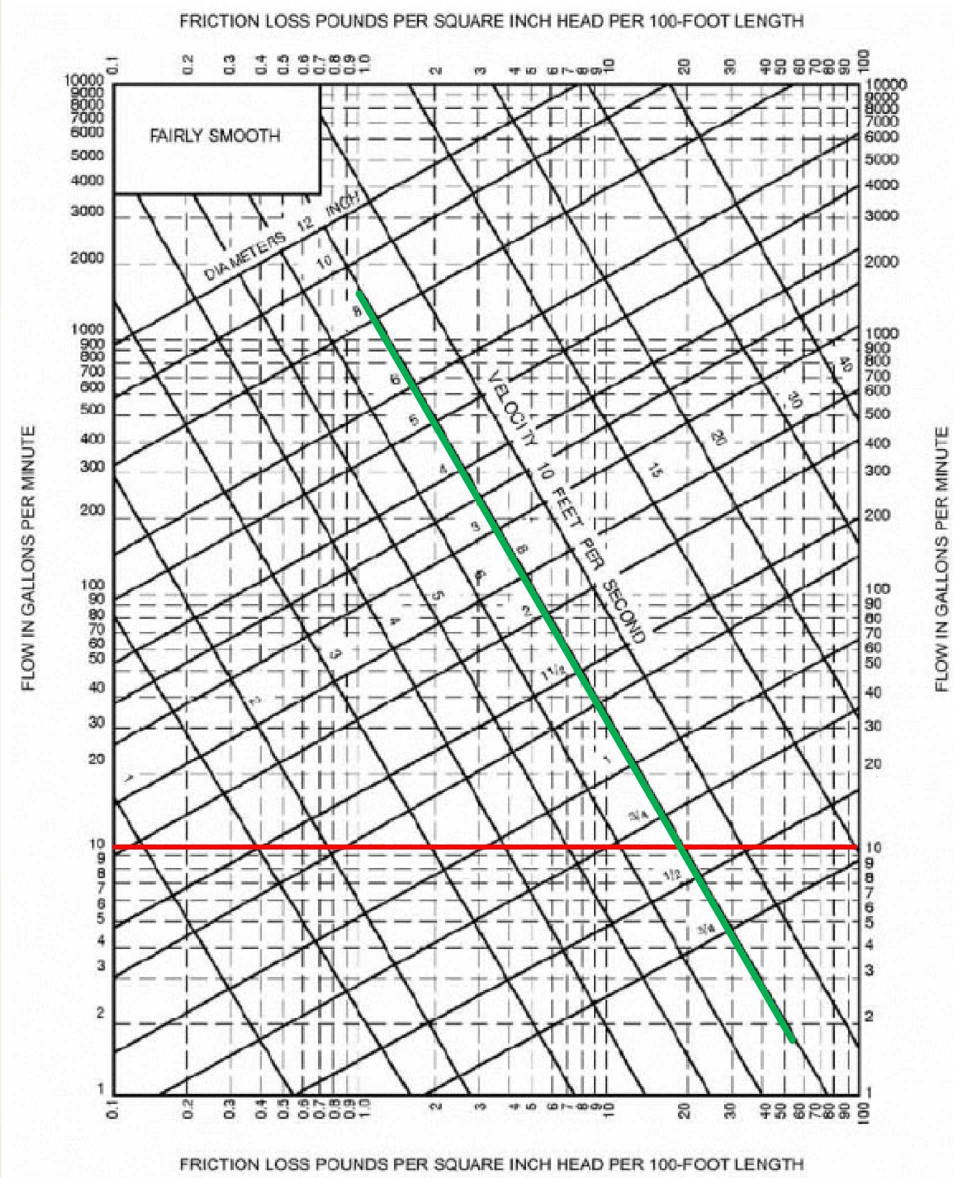
Example 2 (cont.)

$$\frac{\Delta P_{Major}}{L} = f\,\frac{\rho}{D}\frac{V^2}{2} \cong 0.032\,\frac{997}{0.02664}\,\frac{2.264^2}{2} = 3.07\,kPa/m$$

$$\frac{\Delta P_{Major}}{L} = 3.55\,kPa/m = 9.26\,psi/100'$$

Example 3

Determine the diameter of galvanized steel pipe needed to deliver water at a flow rate of 10 GPM and a velocity of 8 fps


FRICTION LOSS POUNDS PER SQUARE INCH HEAD PER 100-FOOT LENGTH
FAIRLY SMOOTH
DIAMETERS 12 INCH
VELOCITY 10 FEET PER SECOND
FLOW IN GALLONS PER MINUTE
FLOW IN GALLONS PER MINUTE
FRICTION LOSS POUNDS PER SQUARE INCH HEAD PER 100-FOOT LENGTH

Plumbing system design

Plumbing fixtures

is an exchangeable device which can be connected to a plumbing system to deliver and drain water. The most common plumbing fixtures are: bathtubs, drinking fountains, kitchen sinks, showers, channel drains, and lavatories.

Supply Fixture Units (SFU)
Demand for water by a plumbing fixture varies according to its type and the occupancy category of the building in which it is installed.

Drainage Fixture Units (DFU)
is a measure of the probable discharge into the drainage system by various types of plumbing fixtures.

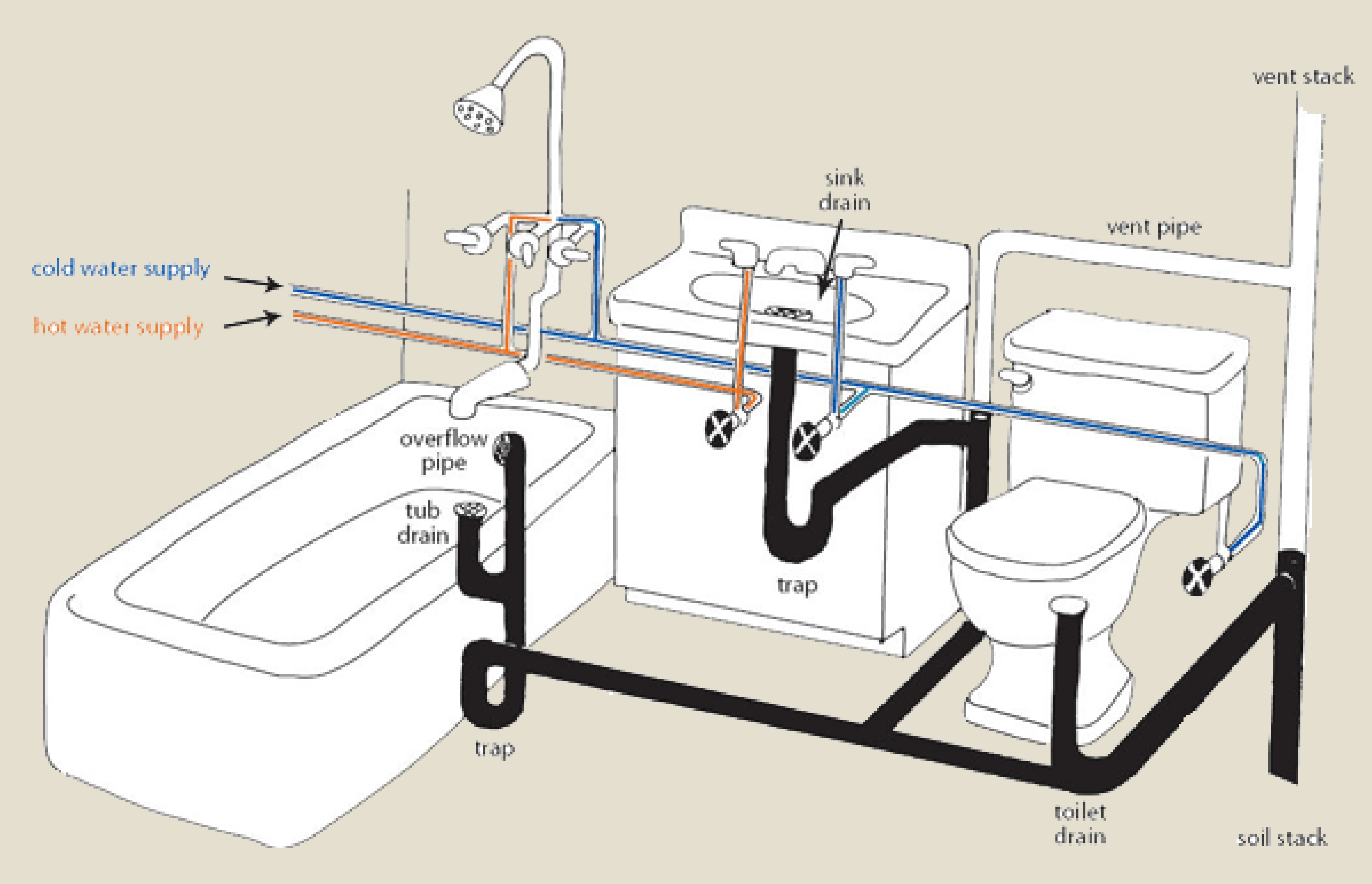
Minimum supply pressure
is a certain demand of water pressure for each fixture.

Fixture Unit is a design factor which represents a probable flowrate of a plumbing fixture. The number of fixture units depends on the volume of water required, the average duration of a single use, and the number of uses per unit time.

TABLE 25.3

Fixture Units

Private	*SFU*	*DFU*	*psi**
Bathroom group (gravity tank)	6	6	10
Bathroom group (pressure tank)	5	5	25
Bathroom group (flush valve)	8	8	25
Lavatory	1	1	10
Tub or shower	2	2	10
Water closet (gravity tank)	3	4	10
Water closet (pressure tank)	2	2	25
Water closet (flush valve)	6	6	25
Kitchen sink	2	2	10
Washer (clothes—8 lb.)	2	3	10
Dishwasher	1	2	10
Hose bib	4	—	10+
Public	***SFU***	***DFU***	***psi***
Lavatory	2	1	10
Tub or shower	4	2	10
Urinal (gravity tank)	3	2	10
Urinal (flush valve)	5	4	15
Water closet (gravity tank)	5	4	10
Water closet (pressure tank)	2	2	25
Water closet (flush valve)	10	6	25
Kitchen sink	4	3	10
Service sink	3	3	10
Drinking fountain	1/4	1/2	10
Hose bib	4	—	10+



WASTE & SUPPLY PLUMBING

Example 4

Calculate SFU and DFU for a public building with 12 water closets (flush valve type), 4 urinals (flush valve type), 8 lavatories, and 3 drinking fountains.

Supply

Type of fixtures	units	SFU	
		per unit	total
Public WC's	12	10	120
Public urinals	4	5	20
Public lavatories	8	2	16
Drinking foundtains	3	0.25	0.75
		Total	**157**

Drainage

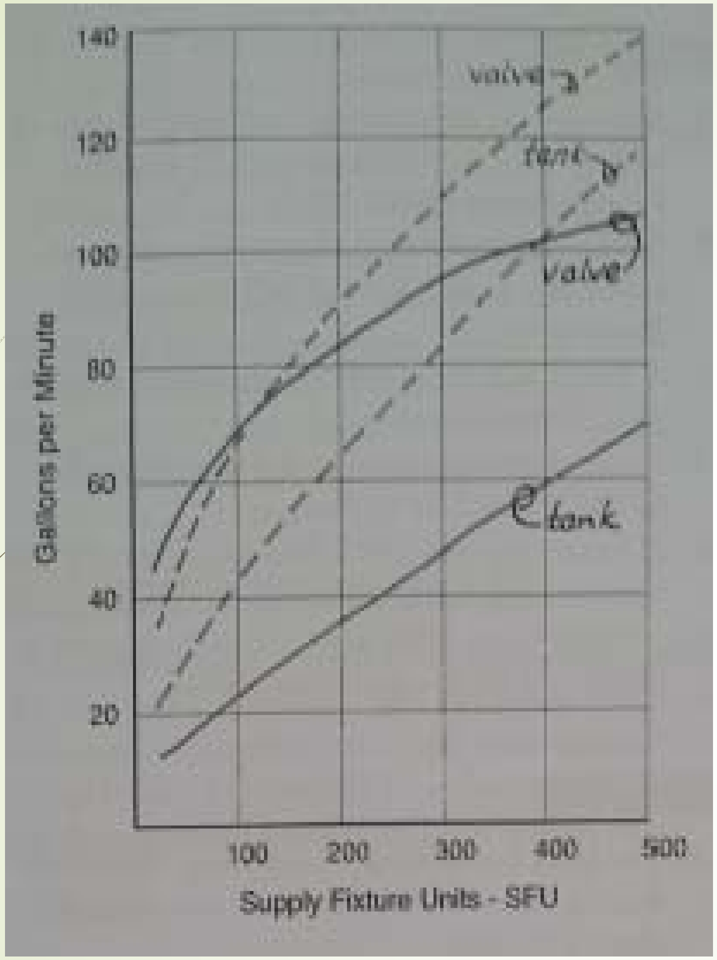
Type of fixtures	units	DFU	
		per unit	total
Public WC's	12	6	72
Public urinals	4	4	16
Public lavatories	8	1	8
Drinking foundtains	3	0.5	1.5
		Total	**98**

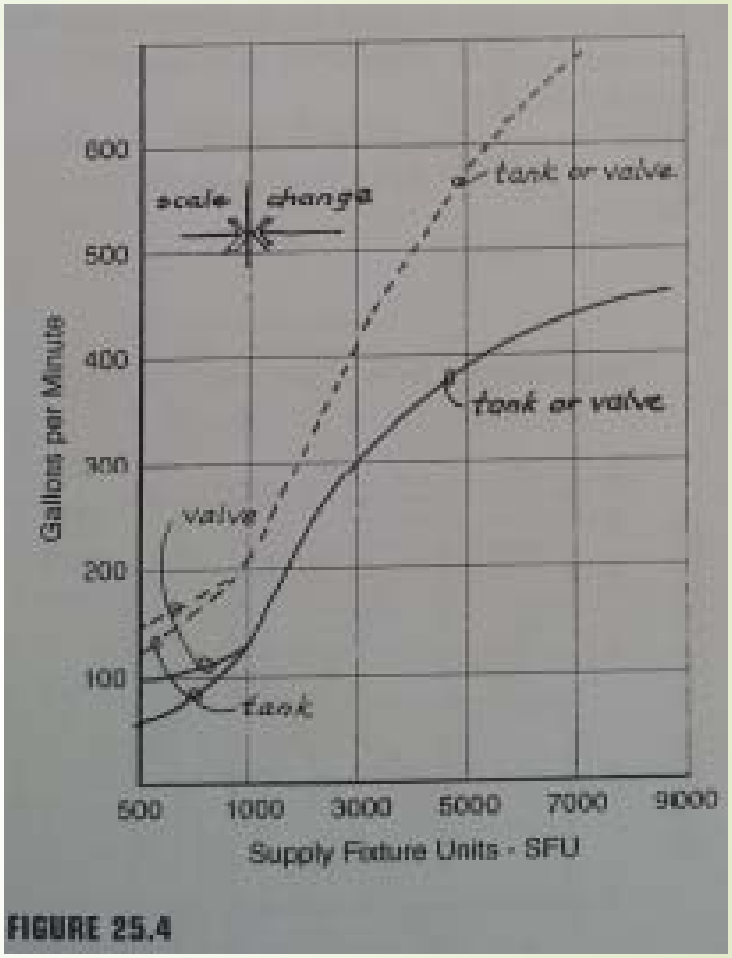
Supply GPM

The Supply Fixture Units - FSU - are used to determine the water demand in water supply systems. One FSU for a single unit corresponds to one GPM.

1 SFU = 1 GPM

This conversion can only be used for one or a few fixtures. When the total amount for many fixtures are added up, the number must be compensated due to the intermittent use of the fixtures. This is normal taken care of in the figures or tables available for sizing supply pipe lines.





Total SFU to water supply demand in gallons per minute (supply GPM)

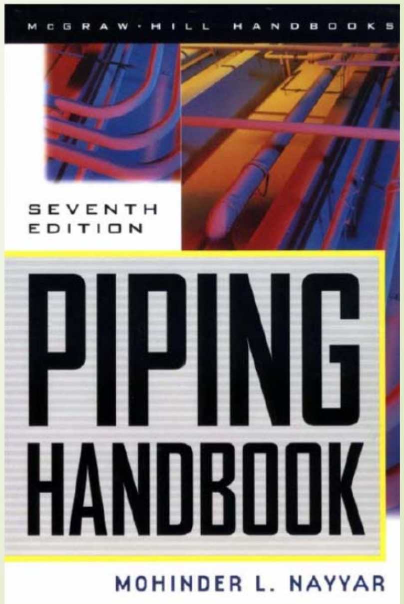
1 GPM = *3.79 liter/min*

Note: Read solid-line curves for residential and commercial occupancies;
use the dashed curves for large assembly occupancies (for examples: stadium, theater)

TABLE C13.18 Maximum Probable Flow, gpm (l/s)

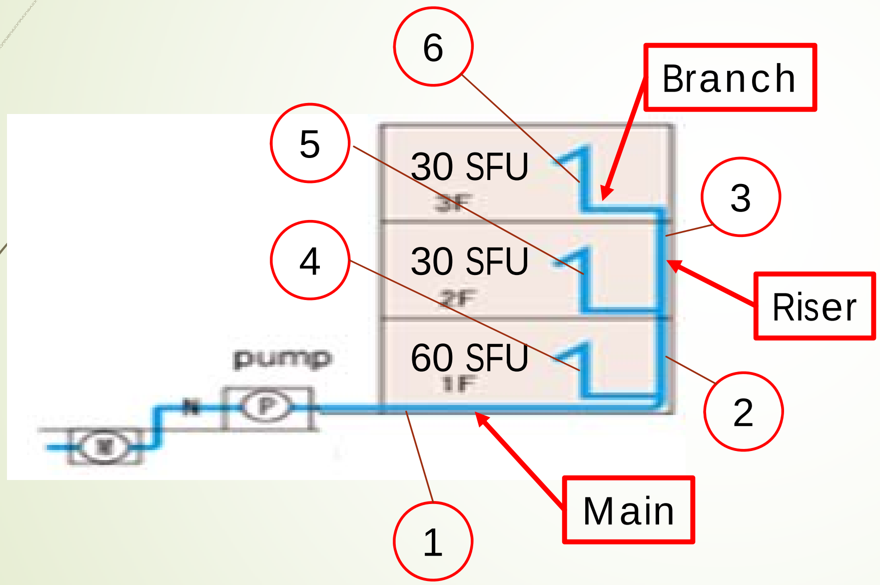
Water supply fixture units	Tank-type water closets	Flushometer-type water closets	Water supply fixture units	Tank-type water closets	Flushometer-type water closets
1	1 (0.07)		120	25.9 (2.0)	76 (5.7)
2	3 (0.21)		125	26.5 (2.0)	76.5 (5.7)
3	5 (0.38)		130	27.1 (2.1)	77 (5.8)
4	6 (0.45)		135	27.7 (2.1)	78 (5.8)
5	7 (0.53)	27.2 (2.2)	140	28.3 (2.1)	78.5 (5.8)
6	8 (0.60)	29.1 (2.2)	145	29.0 (2.2)	79 (5.9)
7	9 (0.68)	30.8 (2.4)	150	29.6 (2.2)	80 (6.0)
8	10 (0.70)	32.3 (2.5)	160	30.8 (2.3)	81 (6.1)
9	11 (0.83)	33.7 (2.5)	170	32.0 (2.4)	83 (6.2)
10	12.2 (0.92)	35 (2.6)	180	33.3 (2.5)	84 (6.3)
12	12.4 (0.94)	37.3 (2.6)	190	34.5 (2.5)	85 (6.4)
14	12.7 (0.96)	39.3 (2.8)	200	35.7 (2.6)	86 (6.5)
16	12.9 (0.98)	41.2 (3.1)	220	38.1 (2.8)	88 (6.7)
18	13.2 (1)	42.8 (3.2)	240	40.5 (3.0)	90 (6.8)
20	13.4 (1.01)	44.3 (3.3)	260	43.0 (3.2)	92 (7.0)
22	13.7 (1.02)	45.8 (3.5)	280	45.4 (3.4)	94 (7.2)
24	13.9 (1.03)	47.1 (3.6)	300	47.7 (3.6)	96 (7.2)
26	14.2 (1.07)	48.3 (3.7)	400	59.6 (4.5)	102 (7.4)
28	14.4 (1.09)	49.4 (3.8)	500	71.2 (5.3)	108 (8.2)
30	14.7 (1.1)	50.5 (3.9)	600	82.6 (6.3)	113 (8.6)
35	15.3 (1.1)	53.0 (4.0)	700	93.7 (7.1)	117 (8.9)
40	15.9 (1.2)	55.2 (4.1)	800	105 (8.0)	120 (9.1)
45	16.6 (1.3)	57.2 (4.2)	900	115 (8.7)	123 (9.3)
50	17.2 (1.3)	59.1 (4.3)	1,000	126 (9.5)	126 (9.5)
55	17.8 (1.4)	60.8 (4.5)	1,500	175 (13.3)	175 (13.3)
60	18.4 (1.4)	62.3 (4.6)	2,000	220 (16.7)	220 (16.7)
65	19.0 (1.5)	63.8 (4.7)	2,500	259 (19.7)	259 (19.7)
70	19.7 (1.5)	65.2 (4.9)	3,000	294 (22.3)	294 (22.3)
75	20.3 (1.5)	66.4 (5.0)	3,500	325 (24.7)	325 (24.7)
80	20.9 (1.6)	67.7 (5.1)	4,000	352 (26.7)	352 (26.7)
85	21.5 (1.6)	68.8 (5.2)	4,500	375 (28.5)	375 (28.5)
90	22.2 (1.7)	69.9 (5.3)	5,000	395 (30)	395 (30)
95	22.8 (1.7)	71.0 (5.3)	6,000	425 (32.3)	425 (32.3)
100	23.4 (1.8)	72.0 (5.4)	7,000	445 (34)	445 (34)
105	24.0 (1.8)	73.0 (5.5)	8,000	456 (34.6)	456 (34.6)
110	24.6 (1.9)	73.9 (5.6)	9,000	461 (35)	461 (35)
115	25.3 (1.9)	74.8 (5.7)	10,000	462 (35)	462 (35)

Source:



Example 4

Select the sizes of PVC pipe for the pluming system (Tank-type WC). The main supply pipe velocity should not exceed 8 fps, and the riser and the branch velocities should not exceed 6 fps.



Pipe #	SFU	GPM	Pipe size	Velocity
1	120	25.9	1 1/4"	<8.0
2	60	18.4	1"	<6.0
3	30	14.7	1"	<6.0
4	60	18.4	1"	<6.0
5	30	14.7	1"	<6.0
6	30	14.7	1"	<6.0

HW#4

A private building with 10 water closets (Gravity tank type), 3 urinals (flush valve type), 2 bathroom group (Gravity tank type) and 4 lavatories. Calculate (a) total supply demand (supply GPM) (b) Total pressure drop of the supply main pipe if the total length is 30 feet. (Note: Designed flow velocity should not exceed 8 fps.)

Pressure loss from fittings and valves

Fittings such as elbows, tees and valves represent a significant component of the pressure loss in most pipe systems. The calculation of pressure losses through pipe fittings and some minor equipment is as follows:

Method 1: K-value

$$\Delta P_{minor} = \gamma\left[K\frac{V^2}{2g}\right]$$,where K = loss coefficient

Method 2: Equivalent length

Friction Loss in Fittings or valves = Equivalent length of Straight Pipe

$$K = f\left(\frac{L_{eq}}{D}\right)$$

Example of Fitting friction loss table

Friction Losses in Pipe Fittings Resistance Coefficient K (use in formula $h_f = Kv^2/2g$)													
Fitting		L/D	Nominal Pipe Size										
			1/2"	3/4"	1	1-1/4"	1-1/2"	2	2-1/2"-3	4	6	8-10	12-16	18-24
			K Value										
Angle Valve		55	1.48	1.38	1.27	1.21	1.16	1.05	0.99	0.94	0.83	0.77	0.72	0.66
Angle Valve		150	4.05	3.75	3.45	3.30	3.15	2.85	2.70	2.55	2.25	2.10	1.95	1.80
Ball Valve		3	0.08	0.08	0.07	0.07	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04
Butterfly Valve								0.86	0.81	0.77	0.68	0.63	0.35	0.30
Gate Valve		8	0.22	0.20	0.18	0.18	0.15	0.15	0.14	0.14	0.12	0.11	0.10	0.10
Globe Valve		340	9.2	8.5	7.8	7.5	7.1	6.5	6.1	5.8	5.1	4.8	4.4	4.1
Plug Valve Branch Flow		90	2.43	2.25	2.07	1.98	1.89	1.71	1.62	1.53	1.35	1.26	1.17	1.08
Plug Valve Straightaway		18	0.48	0.45	0.41	0.40	0.38	0.34	0.32	0.31	0.27	0.25	0.23	0.22
Plug Valve 3-Way Thru-Flow		30	0.81	0.75	0.69	0.66	0.63	0.57	0.54	0.51	0.45	0.42	0.39	0.36
Standard Elbow	90°	30	0.81	0.75	0.69	0.66	0.63	0.57	0.54	0.51	0.45	0.42	0.39	0.36
	45°	16	0.43	0.40	0.37	0.35	0.34	0.30	0.29	0.27	0.24	0.22	0.21	0.19
	long radius 90°	16	0.43	0.40	0.37	0.35	0.34	0.30	0.29	0.27	0.24	0.22	0.21	0.19

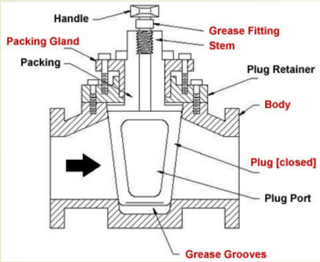
Tee

Elbow

TABLE E103.3(5)
ALLOWANCE IN EQUIVALENT LENGTHS OF PIPE FOR FRICTION LOSS IN VALVES AND THREADED FITTINGS (feet)

FITTING OR VALVE	PIPE SIZE (inches)							
	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
45-degree elbow	1.2	1.5	1.8	2.4	3.0	4.0	5.0	6.0
90-degree elbow	2.0	2.5	3.0	4.0	5.0	7.0	8.0	10.0
Tee, run	0.6	0.8	0.9	1.2	1.5	2.0	2.5	3.0
Tee, branch	3.0	4.0	5.0	6.0	7.0	10.0	12.0	15.0
Gate valve	0.4	0.5	0.6	0.8	1.0	1.3	1.6	2.0
Balancing valve	0.8	1.1	1.5	1.9	2.2	3.0	3.7	4.5
Plug-type cock	0.8	1.1	1.5	1.9	2.2	3.0	3.7	4.5
Check valve, swing	5.6	8.4	11.2	14.0	16.8	22.4	28.0	33.6
Globe valve	15.0	20.0	25.0	35.0	45.0	55.0	65.0	80.0
Angle valve	8.0	12.0	15.0	18.0	22.0	28.0	34.0	40.0

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.



Plug-type cock

Angle valve

Quick finding Method

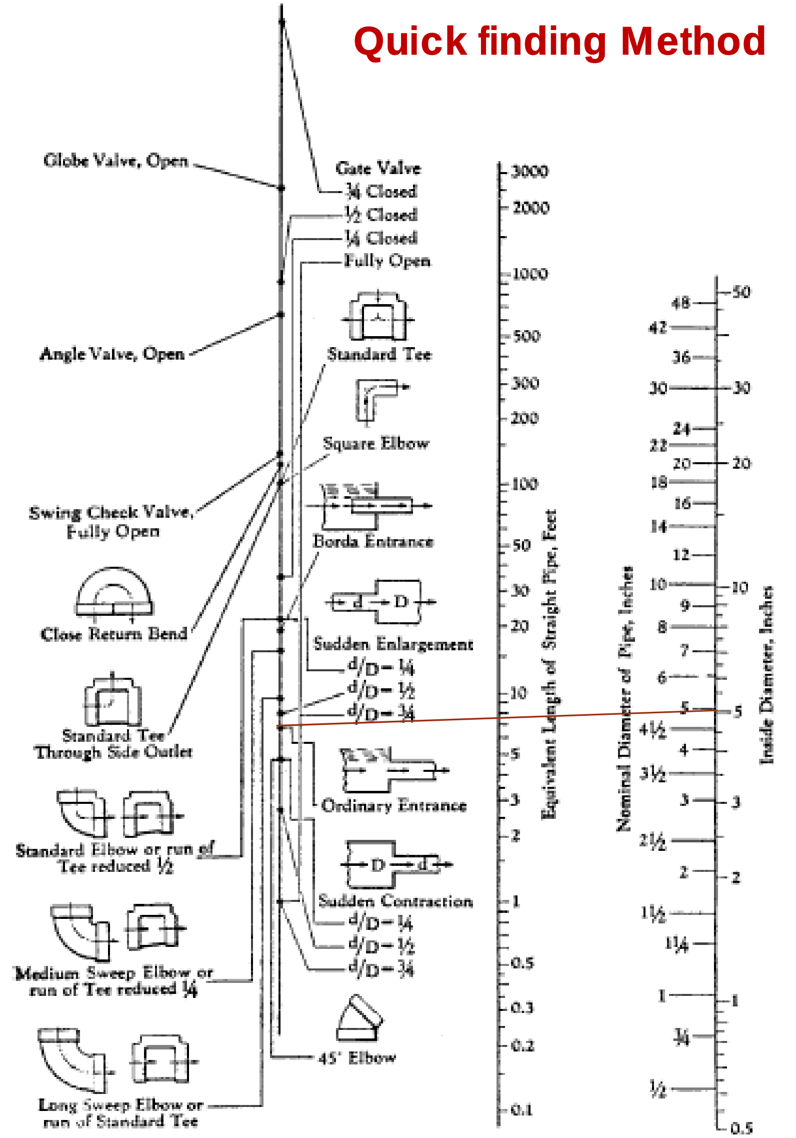


FIGURE C13.1 Resistance of valves and fittings to flow of fluids. (*Courtesy Crane Co.*)

Example 5

Find the fitting loss of 1” gate valve while fully open.

Method 1: K-valve

From fitting loss table

$K_{gate} = 0.18$

Method 2: Equivalent length

From figure C13.1

$L_{eq,\ gate} = 0.6$

($L_{eq} = (KD)/f = 0.18 \times (1/12)/0.025 = 0.6$)

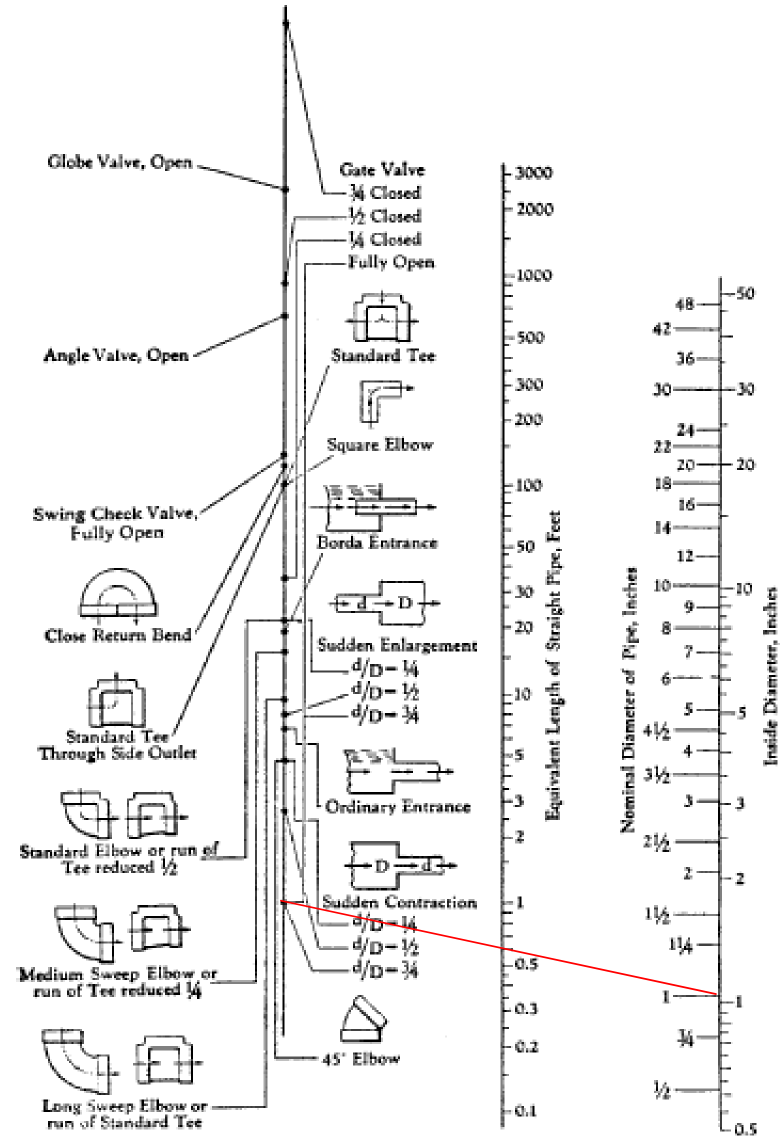
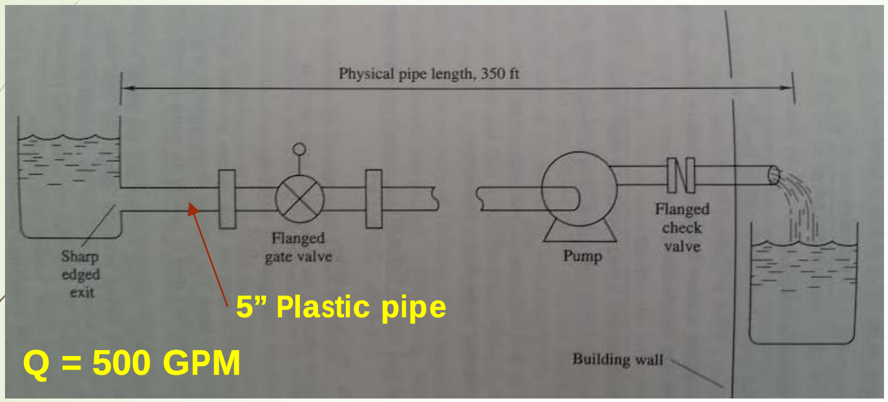


FIGURE C13.1 Resistance of valves and fittings to flow of fluids. (*Courtesy Crane Co.*)

Example 6

Calculate the total loss of the following system.



Minor loss (Pressure loss in fittings and valves)

$$\Delta P_{total} = \Delta P_{Major} + \Delta P_{minor} = \gamma\left[\left(f\frac{L}{D} + \sum_i K\right)\frac{V^2}{2g}\right]$$

Major loss (Pressure loss in a straight pipe)

Example 6 (cont.)

Calculate the total loss of the following system.

Using Moody diagram and Fig c13.1

No.		D (in.)	f	L (ft.)	K	V (fps)	Loss	
							Head (ft)	Pressure (psi)
1	Straight pipe	5	0.0256	350	-	8	21.37	9.26
2	Sharp edged exit	5	0.0256	7.5	0.5	8	0.46	0.20
3	Gate valve	5	0.0256	3	0.18	8	0.18	0.08
4	Check valve	5	0.0256	35	2.2	8	2.14	0.93
						total	**24.15**	**10.47**

Pump selection

is based on two parameters:

Flow Rate (Total water demand: GPM)

Pumps are selected for the peak flow rate. The peak flow rate is the sum of water demands for all plumbing fixtures, i.e. the total water demand.

Total Dynamic Head (Pressure rise)

Total dynamics head of the pump is the head difference between the summation of total head loss H_L, static head loss H_S, and desired discharge head H_D and supply main head H_M.

$$TDH = H_L + H_S + H_D - H_M$$

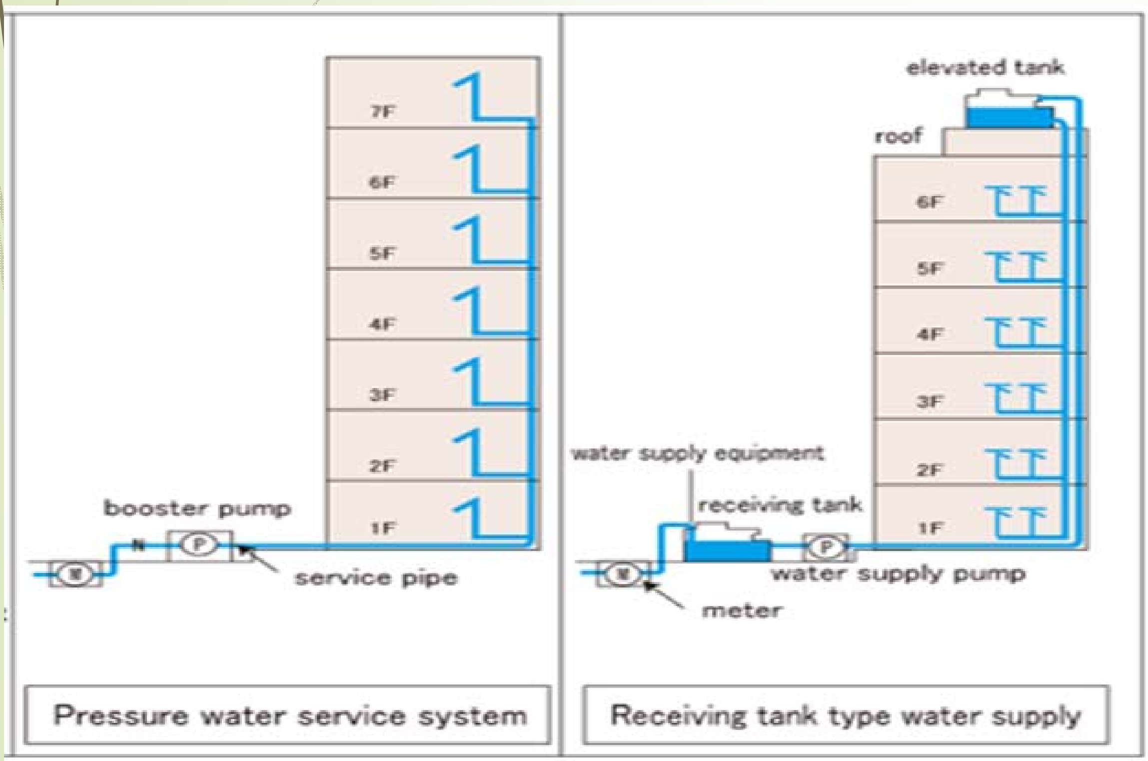
Pressure head

is a term that represents a fluid pressure per specific weight (height of fluid column).

Pressure	Head
Imperial 14.6 psi	33.7 ft_{H_2O}
SI 101.325 kPa	10.33 m_{H_2O}

Pump input power

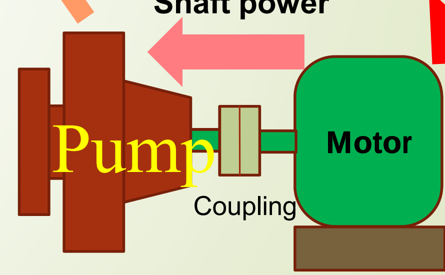
is the power consumed by a pump in order to move and increase pressure of a fluid.



$$P_{hydraulic} = P_{shaft} \cdot \eta_{pump}$$
$$= \dot{Q} \times (\gamma \times H_P)$$

$$P_{elec}$$

$$P_{shaft} = P_{elec} \cdot \eta_{motor}$$



Pump input power (cont.)

$$P_{shaft} = \frac{9.8 \times \dot{Q} \times (SG \times TDH)}{\eta_{pump}}$$

[SI unit: kW]

$$P_{shaft} = \frac{13 \times \dot{Q} \times (SG \times TDH)}{\eta_{pump}}$$

[SI unit: HP]

(1HP = 746 W)

$$P_{shaft} = \frac{\dot{Q} \times (SG \times TDH)}{3960 \times \eta_{pump}}$$

[Imperial unit: HP]

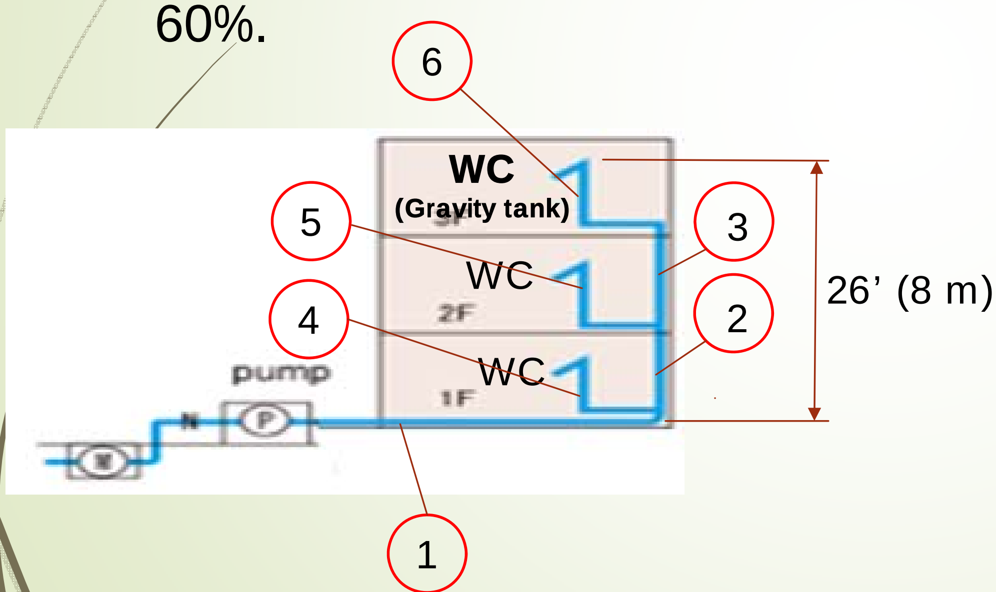
,where Q = GPM, TDH = ft., SG = Specific gravity (e.g. SG_{water} =1)

Pump energy consumption (cont.)

$$kWh_{pump} = \frac{9.8 \times \dot{Q} \times \left(SG \times TDH\right)}{\eta_{pump} \times \eta_{motor}} \times pump\,run\,time[h]$$

Example 7

Calculate the required pump horse power for delivering 26 GPM (5.9 m^3/h) water through a pipe system shown in Figure if the designed friction loss is 10 psi/100'. **Given:** The longest pipe run (1-2-3-6) is 200' (61m), and allow 50% extra for friction losses in the pipe fittings. The supply main pressure is 25 psi. Pump efficiency is 60%.



$$TDH = H_L + H_S + H_D - H_{Ma}$$

Friction loss

$$P_L = 10 \text{ psi}/100' \times (200' + 0.5 \times 200')$$

$$= 30 \text{ psi}$$

$$H_L = 69.2 \text{ ft.}$$

Example 7 (cont.)

Static loss

H_S = 26 ft.

Discharge loss

P_D = 10 psi (Water closet: Gravity tank)

H_D = 23 ft.

Supply main pressure

P_M = 25 psi

H_M = 57.6 ft.

TDH = 69.2 + 26 + 23 – 57.6 = 60.6 ft. (18.5 m)

Example 7 (cont.)

$$P_{shaft} = \frac{26\text{GPM} \times (1 \times 60.6')}{3960 \times 0.6} = 0.66\ HP$$

Final Examination

Date/Time: June 07(Wed), 2017 13:30-16:30

5 Problems:

Conditions of Examination

1. Closed book
2. Calculator allowed

Good Luck !!!