Chapter 5

Calculating Friction Loss

Chapter 5 discusses four aspects of pressure drop:

1. Friction loss in pipes
2. Friction loss in fittings and valves
3. Pressure drop through water meters
4. The use of header pipes

Friction in pipes and fittings is a major contributor to pressure drop within a pipe system. The internal diameter of the pipe, the velocity of the water and the roughness of the internal surface of the pipe, all contribute to the pressure drop, which is expressed in metres head (m/h).

There are a number of methods available to calculate friction loss in pipes, but it is only by using a computer software program that total accuracy can be achieved. Using a software program specially developed for pipe sizing allows all the various elements in the complex calculations to be simultaneously taken into account. The method described in this text has been used by engineers over many years and is considered to be accurate.

Friction Losses in Pipe

The friction losses in a pipe will vary, depending on:

a) The velocity of the water flowing through the pipe.
b) The density of the water.
c) The viscosity of the water.
d) The roughness of the internal surface of the pipe.
e) The actual internal diameter of the pipe.

Refer to Chapter 2 for the Darcy – Weisbach Equation and the alternative Hazen and Williams Equation.

Friction Losses in Fittings and Valves

The most common method of determining pressure drop through fittings and valves is the ***'Equivalent Pipe Length Method'***. A predetermined length of pipe, expressed in metres, represents each fitting. This 'equivalent pipe length' will equate to the same head loss as for a pipe of the same diameter with the same flow and velocity.

Tables 5–1 and 5-2 provide the equivalent pipe length in metres for each fitting and valve.

For example, if a 25mm pipe were to have a flow of 0.8 L/s, the velocity would be 1.9 m/s. (Refer to Table 4-1). Table 5-1 provides an equivalent pipe length for a 25mm diameter long radius bend of 0.62 metres. As the friction loss in Table 4-1 is 20 metres per 100 metres (20%), the head loss through the bend will be 0.124 m/h. (0.62 x 0.20 = 0.124)

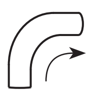
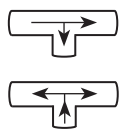
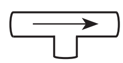
Nominal Tube Size (DN)	Elbows 90° Sharp 	Bends 90° Long Radius 	Branch Flow 	Line Flow 	Reduction in Flow 
mm	Equivalent Pipe Length in Metres				
15	0.50	0.22	0.91	0.55	0.40
20	1.08	0.48	2.25	1.35	0.51
25	1.40	0.62	2.65	1.59	0.66
32	1.80	0.79	3.00	1.80	0.85
40	2.20	0.97	3.30	1.98	1.03
50	2.90	1.28	4.00	2.40	1.36
65	3.50	1.54	4.30	2.58	1.65
80	4.50	1.98	4.95	2.97	2.12
100	6.00	2.64	6.60	3.96	2.85
150	8.50	3.74	9.35	5.61	4.00

Table 5-1 Friction Losses for Fittings Based on Equivalent Pipe Length

Nominal Tube Size (DN)	Gate Valves	Globe Valves	Swing Check Valves	Vertical Lift Check	Butterfly Valves
mm	Equivalent Pipe Length in Metres				
15	0.10	4.80	1.60	7.80	0.40
20	0.15	5.60	2.00	9.40	0.70
25	0.20	7.60	2.35	12.75	1.10
32	0.24	9.75	3.00	17.30	1.40
40	0.30	13.70	3.75	22.45	1.80
50	0.40	17.00	4.65	28.20	2.20
65	0.50	20.25	6.00	35.80	2.70
80	0.60	25.00	7.50	44.25	3.50
100	0.80	32.00	10.00	57.00	4.50
150	1.30	45.00	13.00	80.00	7.00

Table 5-2 Friction Losses for Valves Based on Equivalent Pipe Length

Exercise 5–1

In Figures 5-1 and 5-2, what is the total pressure drop in the system caused by friction loss, expressed in metres head?

Figures 5-1 and 5-2 are from Exercise 4-13. The pipe sizes calculated in Exercise 4-13 are used in this exercise.

Tables 4-1, 5-1 and 5-2 are used to achieve the results.

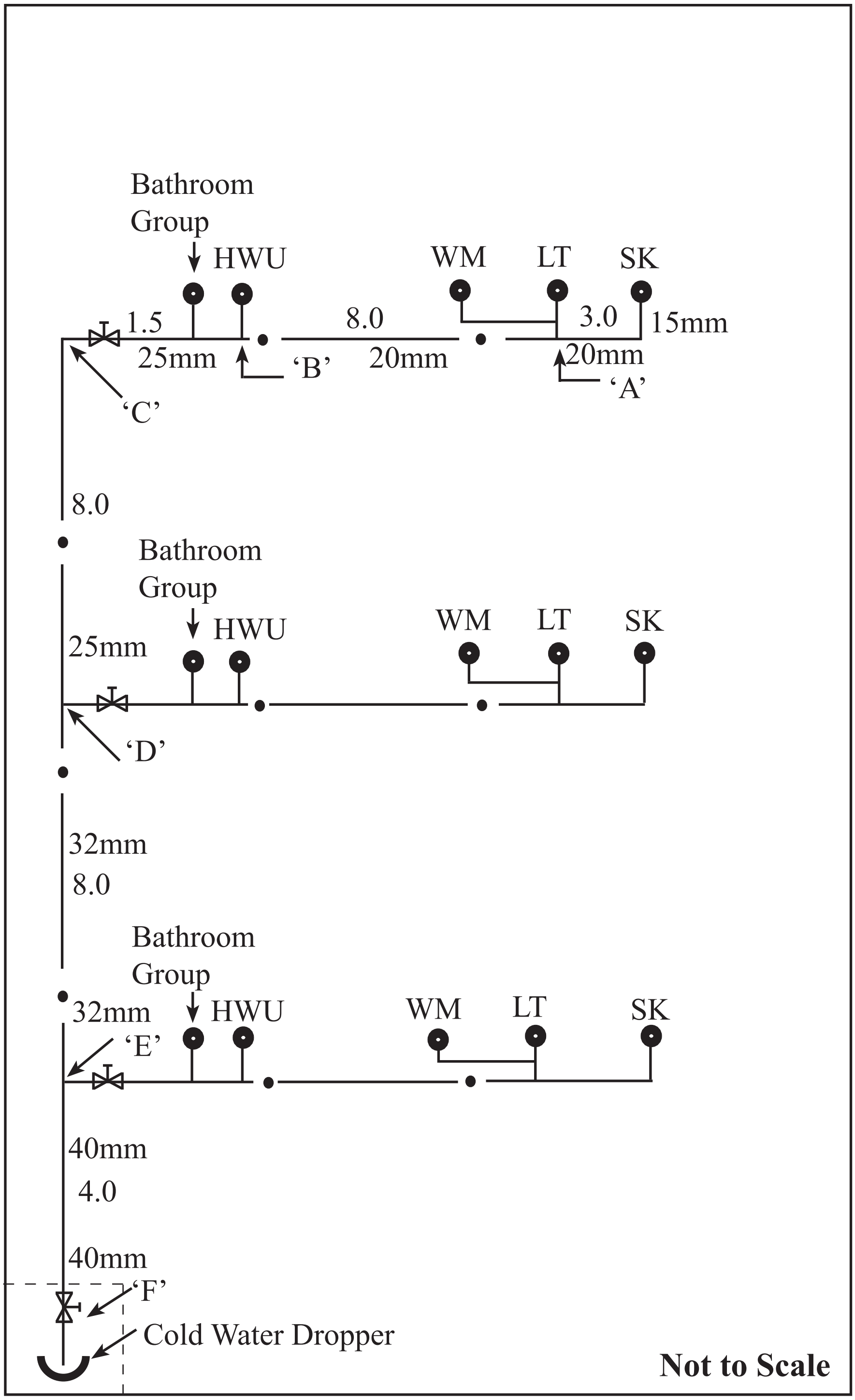


Figure 5-1 Typical Floor Plan of a Cold Water Pipe Layout
3 x Home Units per Floor

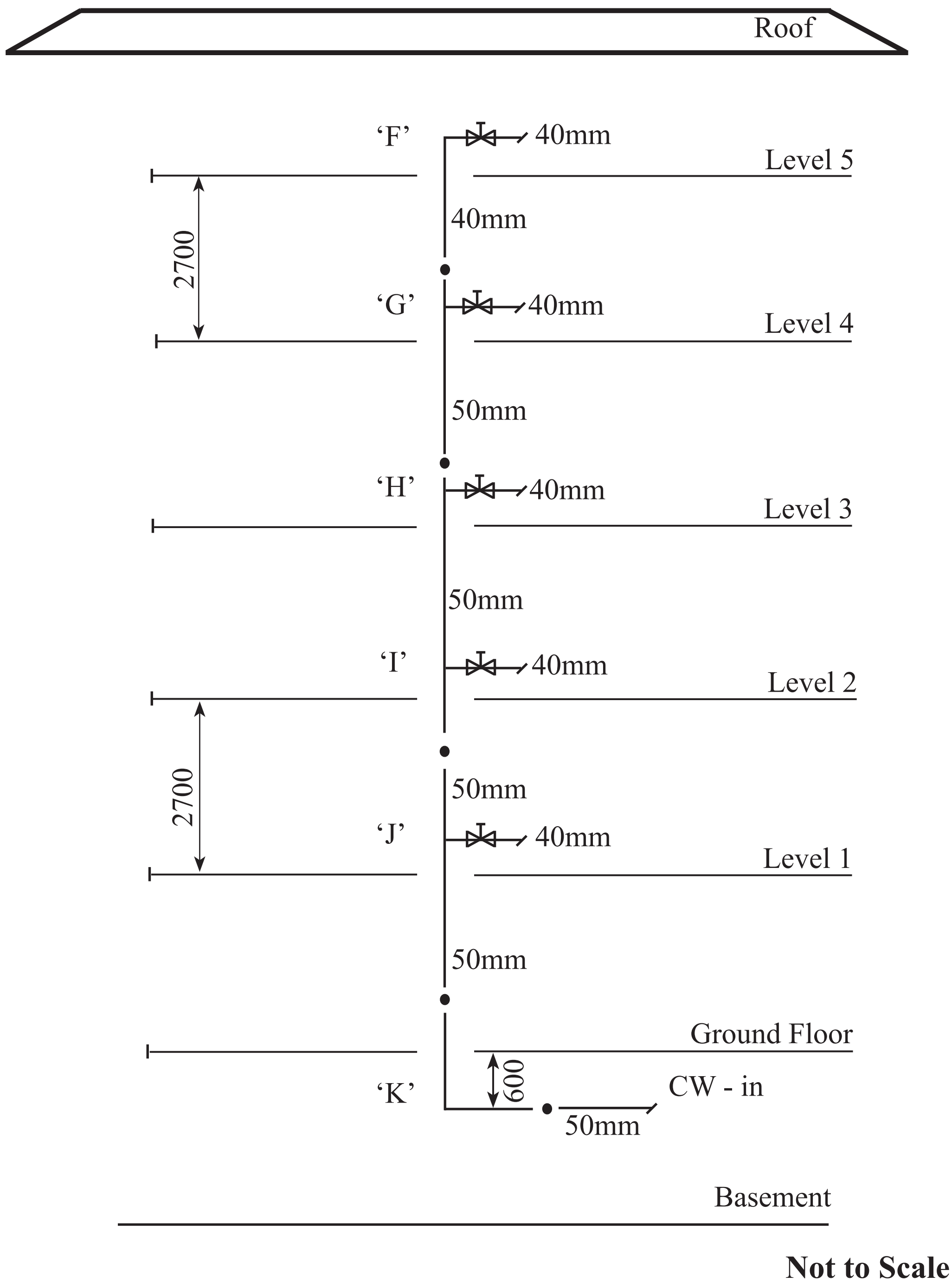


Figure 5-2 Diagrammatic of a Cold Water Pipe System
Total 15 Home Units

Calculations for Exercise 5-1	Size	Length	Flow	Velocity	EPL	Loss	Total
Item	**DN**	**Metres**	**L/s**	**m/s**	**Metres**	**m/h**	**m/h**
Pipe ‘A’	15	1.5	0.20	2.0		55.0	0.83
Pipe ‘A’	20	1.5	0.20	0.8		7.0	0.11
Tee	20		0.40	0.8	1.35	25.0	0.34
Pipe ‘A’ to ‘B’	20	8.0	0.40	1.8		25.0	2.00
25 x 20 Reducer	25		0.40	1.8	0.66	25.0	0.17
Pipe ‘B’ to ‘C’ to ‘D’	25	9.5	0.80	1.9		20.0	1.90
Tees x 2	25		0.80	1.9	3.18	20.0	0.64
Elbows x 2	25		0.80	1.9	2.80	20.0	0.56
32 x 25 Reducer	32		0.80	1.9	0.85	20.0	0.17
Pipe ‘D’ to ‘E’	32	8.0	1.25	1.8		11.0	0.88
Branch Tee ‘D’	32		1.25	1.8	1.80	11.0	0.20
40 x 32 Reducer	40		1.25	1.8	1.03	11.0	0.11
Pipe ‘E’ to ‘F’ to ‘G’	40	6.7	1.60	1.8		9.0	0.60
Branch Tee ‘E’	40		1.60	1.8	1.98	9.0	0.18
Elbows x 2	40		1.60	1.8	4.40	9.0	0.40
50 x 40 Reducer	40		1.60	1.8	1.36	9.0	0.12
Pipe ‘G’ to ‘H’	50	2.7	2.41	1.2		2.5	0.07
Tee to Level 4	50		2.41	1.2	2.40	2.5	0.06
Pipe ‘H’ to ‘I’	50	2.7	3.05	1.7		6.0	0.16
Tee to Level 3	50		3.05	1.7	2.40	6.0	0.14
Pipe ‘I’ to ‘J’	50	2.7	3.66	1.9		7.0	0.19
Tee to Level 2	50		3.66	1.9	2.40	7.0	0.17
Pipe ‘J’ to ‘K’	50	3.3	4.18	2.1		8.5	0.28
Tee to Level 1	50		4.18	2.1	2.40	8.5	0.20
Pipe to Main	50	20.0	4.18	2.1		8.5	1.70
Elbows x 5	50		4.18	2.1	14.50	8.5	1.23
Control valves x 2	50		4.18	2.1	0.80	8.5	0.07
Water Meter	50		4.18	2.1		3.6	3.60
						Total	**17.06**

Exercise 5-2

Based on the pressure drop calculated in Exercise 5-1, what is the residual pressure in the system if the authority's mains pressure is 55 m/h and 21 m/h is to be maintained at the most disadvantaged outlet on Level 5?

Item	Metres Head	
a) The final working pressure	21.0	
b) Static head	16.0	(2.7 x 5) + 1.9 + 0.60
c) Total friction loss	17.06	(from Exercise 5-1)
d) Total required pressure	**54.06 m/h**	
f) Available pressure in the main	55.00	
g) Residual pressure	0.94 m/h	

When the construction for this project is completed and a pressure reading is taken at the most disadvantaged outlet, the pressure will be 21.94 m/h.

Friction in pipes is correctly associated with pressure drop. Friction will also cause damage to the internal surface of the pipe and over time will erode the pipe material. Velocities of 4 to 8 m/s are tolerated in the design of commercial fire sprinkler systems due to the fact they are only required in emergency situations. Consideration must be given to the effect on the pipe and building in such situations.

Exercise 5-3

Using Figures 5-3 and 5-4, what is the total pressure drop in the system caused by friction loss, expressed in metres head?

Figures 5-3 and 5-4 are from Exercise 4-14. The pipe sizes calculated in Exercise 4-14 are used in this exercise.

Tables 4-1, 5-1 and 5-2 are used to achieve the results.

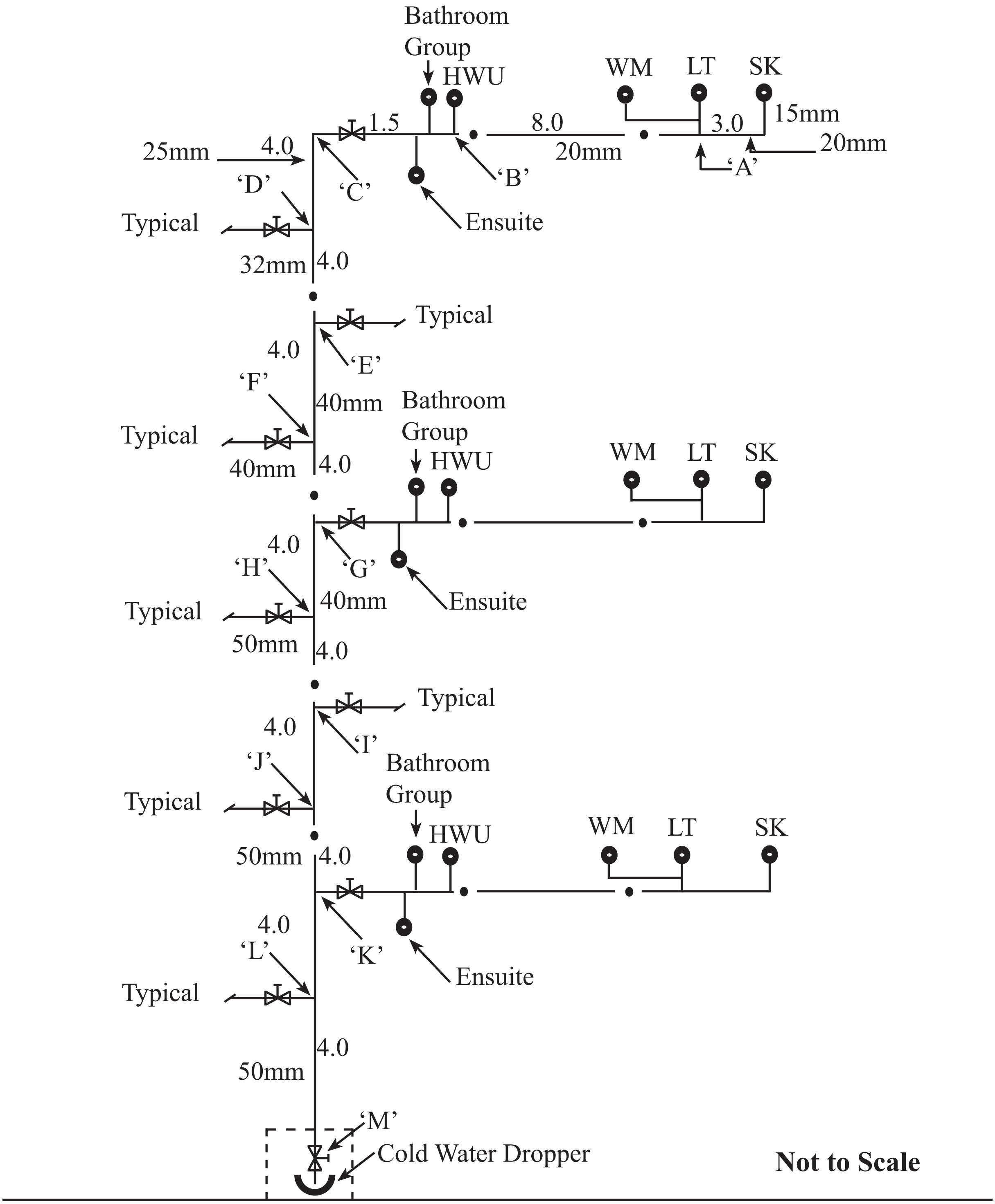


Figure 5-3 Typical Floor Plan of a Cold Water Pipe Layout
10 x Home Units per Floor

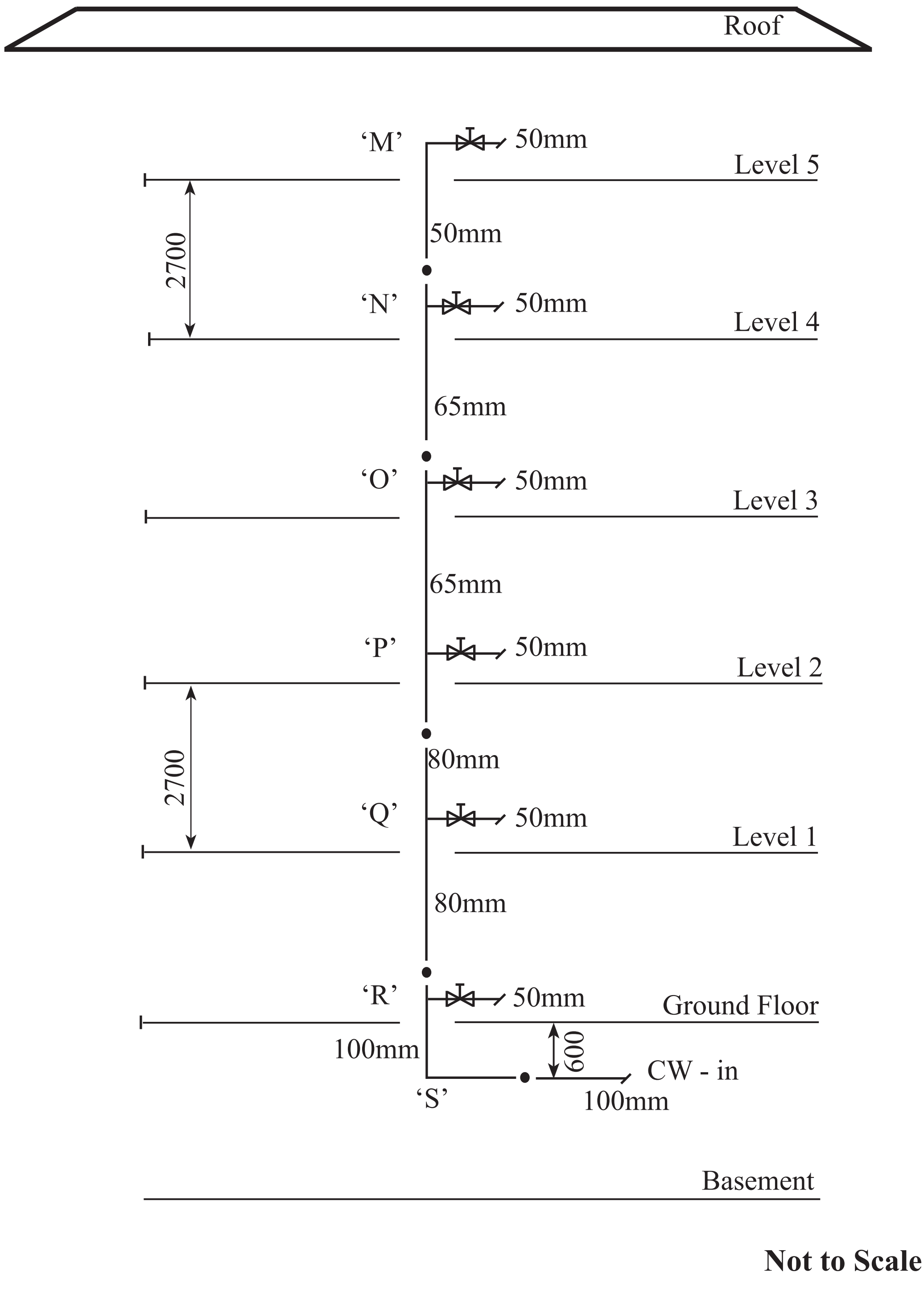


Figure 5-4 Diagrammatic of a Cold Water Pipe System
Total 60 Home Units

Calculations for Exercise 5-3	Size	Length	Flow	Velocity	EPL	Loss	Total
Item	DN	Metres	L/s	m/s	Metres	m/h	m/h
Total for Level 5							
Pipe ‘A’	15	1.5	0.20	2.0		55.0	0.83
Pipe ‘A’	20	1.5	0.20	0.8		7.0	0.11
Tee	20		0.40	0.8	1.35	25.0	0.34
Pipe ‘A’ to ‘B’	20	8.0	0.40	1.8		25.0	2.00
25 x 20 Reducer	25		0.40	1.8	0.66	25.0	0.17
Pipe ‘B’ to ‘C’ to ‘D’	25	5.5	0.80	1.9		20.0	1.10
Tees x 3	25		0.80	1.9	4.77	20.0	0.95
Elbows x 2	25		0.80	1.9	2.80	20.0	0.56
32 x 25 Reducer	32		0.80	1.9	0.85	20.0	0.17
Pipe ‘D’ to ‘E’	32	4.0	1.25	1.8		11.0	0.44
Branch Tee ‘D’	32		1.25	1.8	1.80	11.0	0.20
40 x 32 Reducer	40		1.25	1.8	1.03	11.0	0.11
Pipe ‘E’ to ‘F’	40	4.0	1.60	1.7		9.0	0.36
Branch Tee ‘E’	40		1.60	1.7	1.98	9.0	0.18
Pipe ‘F’ to ‘G’	40	4.0	1.90	1.9		10.0	0.40
Branch Tee ‘F’	40		1.90	1.9	1.98	10.0	0.20
Pipe ‘G’ to ‘H’	40	4.0	2.16	2.0		11.0	0.44
Branch Tee ‘G’	40		2.16	2.0	1.98	11.0	0.22
50 x 40 Reducer	50		2.16	2.0	1.36	11.0	0.15
Pipe ‘H’ to ‘I’	50	4.0	2.41	1.2		2.5	0.10
Branch Tee ‘H’	50		2.41	1.2	2.40	2.5	0.06
Pipe ‘I’ to ‘J’	50	4.0	2.65	1.4		4.5	0.18
Branch Tee ‘I’	50		2.65	1.4	2.40	4.5	0.11
Pipe ‘J’ to ‘K’	50	4.0	2.87	1.5		5.0	0.20
Branch Tee ‘J’	50		2.87	1.5	2.40	5.0	0.12
Pipe ‘K’ to ‘L’	50	4.0	3.08	1.7		6.25	0.25
Branch Tee ‘K’	50		3.08	1.7	2.40	6.25	0.15
Pipe ‘L’ to ‘M’ to ‘N’	50	6.7	3.28	1.8		6.5	0.44
Branch Tee ‘L’	50		3.28	1.8	2.40	6.5	0.16

Calculations for Exercise 5-3 (Continued)	Size	Length	Flow	Velocity	EPL	Loss	Total
Item	**DN**	**Metres**	**L/s**	**m/s**	**Metres**	**m/h**	**m/h**
Elbows x 2	50		3.28	1.8	5.80	6.5	0.38
65 x 50 Reducer	65		3.28	1.8	1.65	6.5	0.11
Pipe ‘N’ to ‘O’	65	2.7	4.97	1.8		4.9	0.13
Tee to Level 4	65		4.97	1.8	2.58	4.9	0.13
Pipe ‘O’ to ‘P’	65	2.7	6.34	2.4		7.5	0.20
Tee to Level 3	65		6.34	2.4	2.58	7.5	0.19
80 x 65 Reducer	80		6.34	2.4	2.12	7.5	0.16
Pipe ‘P’ to ‘Q’	80	2.7	7.38	1.9		3.75	0.10
Tee to Level 2	80		7.38	1.9	2.97	3.75	0.11
Pipe ‘Q’ to ‘R’	80	2.7	8.4	2.1		5.2	0.14
Tee to Level 1	80		8.4	2.1	2.97	5.2	0.15
100 x 80 Reducer	100		8.4	2.1	2.85	5.2	0.15
Pipe ‘R’ to ‘S’	100	3.3	10.08	1.8		2.1	0.07
Tee to Ground	100		10.08	1.8	3.96	2.1	0.08
Pipe to Main	100	20.0	10.08	1.8		2.1	0.42
Elbows x 5	100		10.08	1.8	30.00	2.1	0.63
Control Valves x 2	100		10.08	1.8	1.60	2.1	0.03
Water Meter	100		10.08	1.8		7.8	7.8
						Total	**21.66**

Exercise 5-4

Based on the pressure drop in Exercise 5-3, what is the residual pressure in the system if the authority’s mains pressure is 60 m/h and 21 m/h is to be maintained at the most disadvantaged outlet on Level 5?

Item	**Metres Head**	
a) The final working pressure	21.0	
b) Static head	16.0	(2.7 x 5) + 1.9 + 0.60
c) Total friction loss	21.66	(From Exercise 5-3)

d) Total required pressure **58.66 m/h**

f) Available pressure in the main 60.00

g) Residual pressure 1.34 m/h

When the project is completed and a pressure reading is taken at the most disadvantaged outlet, the pressure will be 22.34 m/h.

Pressure Drop Through Water Meters

Data concerning head loss due to friction in water meters varies considerably depending on the type of meter and it is important to cross reference the manufacturers' technical data when calculating the total head losses for the system. The head losses nominated in Table 5-3 are based on a Multijet Turbine type water meter manufactured by Reliance Worldwide.

	L/s	**0.28**	**0.42**	**0.56**	**0.83**	**1.11**	**1.67**	**2.78**	**5.56**
DN	**Loss in kPa - m/h - bar**								
20	kPa	30.00							
20	**m/h**	3.06							
20	bar	0.30							
25	kPa		45.00	50.00	70.00				
25	**m/h**		4.59	5.10	7.14				
25	bar		0.45	0.50	0.70				
32	kPa		4.00	8.00	11.00	20.00	36.00		
32	**m/h**		0.41	0.82	1.12	2.04	3.67		
32	bar		0.04	0.08	0.11	0.20	0.36		
40	kPa		3.00	5.00	10.00	18.00	30.00	90.00	
40	**m/h**		0.31	0.51	1.02	1.83	3.06	9.17	
40	bar		0.03	0.05	0.10	0.18	0.30	0.90	
50	kPa			2.00	3.00	4.00	5.00	11.00	46.00
50	**m/h**			0.20	0.31	0.41	0.51	1.12	4.69
50	bar			0.02	0.03	0.04	0.05	0.11	0.46

Table 5-3 Head Loss in kPa - m/h - bar for Dual Check Water Meters

Header Pipes

There are many ways to minimise friction loss, only limited by the designer's imagination. Figures 5-5 and 5-6 illustrate two methods of supplying the water through a header, which is positioned in a central location within a residential house. The water is then distributed from the header to each group of fixtures. This method has the benefit of minimising the likelihood of the hot water temperature rising unexpectedly if the cold water kitchen or laundry tap is turned on.

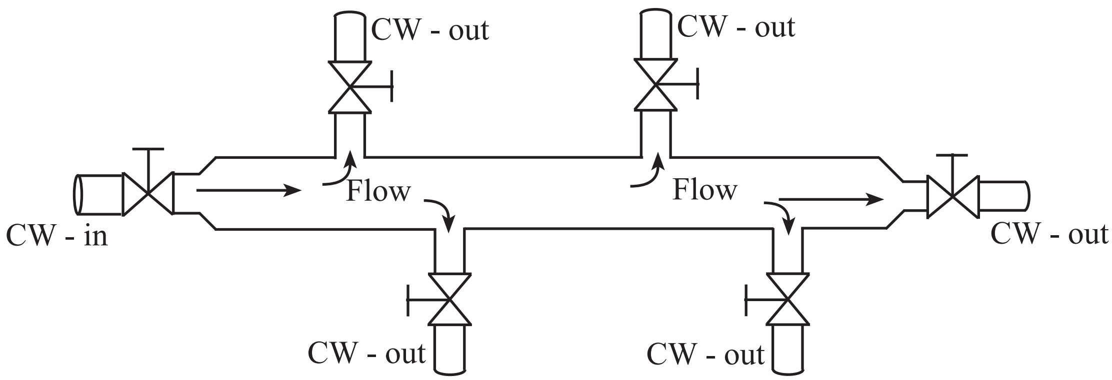


Figure 5-5 Typical Header Using Straight Format

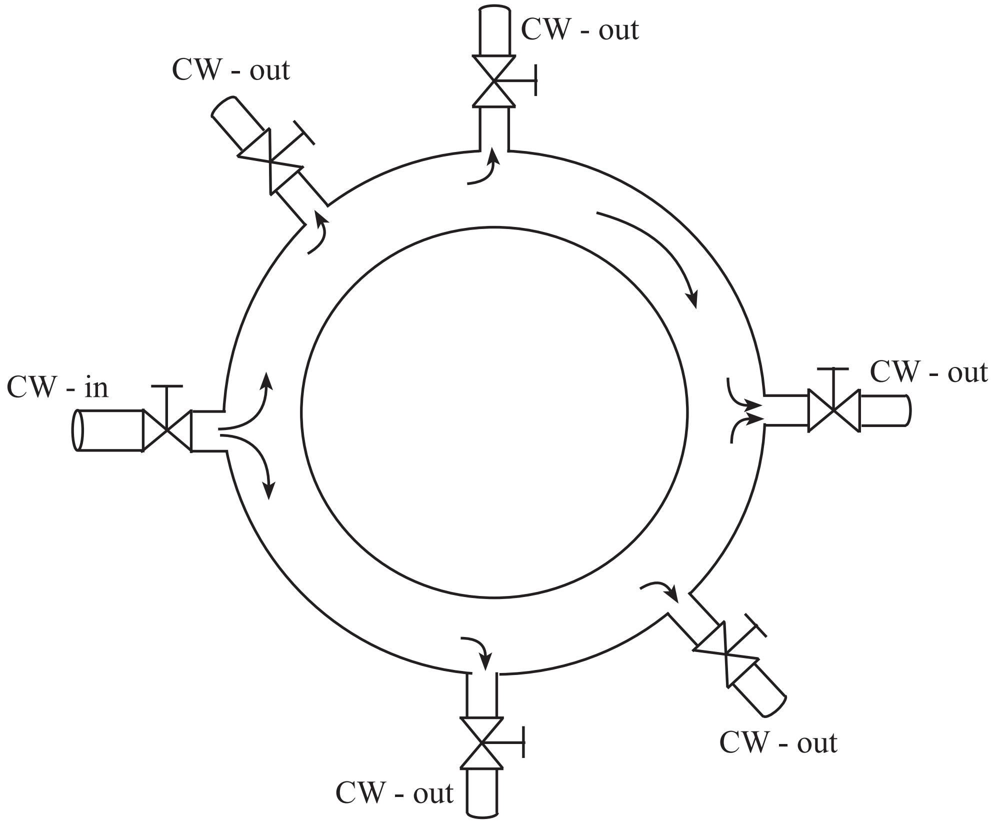


Figure 5-6 Typical Header Using Circular Format