Chapter 4

Calculating Pipe Sizes

Chapter 4 discusses two separate stages in the pipe sizing process:

1. Calculating and selecting the optimum pipe size
2. Friction losses through the pipes, which is also covered in more detail in Chapter 5

The method described in this chapter for manually sizing water pipes is an accurate and reliable procedure to achieve consistency. Specifically designed computer software programs are even more accurate due to the software's ability to simultaneously take into account all the factors that affect the end result. The method detailed below is an established and proven procedure.

After the water service layout has been designed, the pipe sizes are calculated, starting from the most disadvantaged fixture or outlet. The main supply pipe is then tracked back to the source of supply, applying the calculations for each length of pipe, fitting and valve for each branch.

Reading a Pipe-Sizing Chart (Table 4-1)

a) The litres per second are indicated on the vertical axis. The actual litres per second used when reading the chart, are based on the probable simultaneous demand for each branch throughout the project (as opposed to the possible demand).

b) The friction loss for each diameter of pipe, corresponding with the calculated flow, is shown on the horizontal axis. Friction losses are nominated in metres head (m/h) per 100 metres of pipe.

c) The lines running at approximately 30° from left to right indicate the pipe diameters. It is important to appreciate this chart shows 'Diameter Nominal' (DN). However, actual internal diameters for copper pipe have been applied for the accuracy of the chart. (Refer to page 13)

d) The lines running at approximately 50° from right to left indicate the velocity of the water flowing through the pipe.

The design engineer must determine the optimum velocity for the project, which for copper pipe, is most likely to be between 1.2 and 2.2 m/s.

Even when a design velocity has been nominated, it only serves as a guide and the actual velocities for the particular flow in each pipe will fall within an acceptable range. The smaller the pipe for a given flow, the higher the velocity and the greater the pressure drop.

Note: Exercises 4-1 to 4-12 are exercises in reading a pipe sizing chart and are based on full flow in litres per second.

Exercise 4-1

A copper pipe is 100m long and has a flow of 3.25 L/s, designed to a velocity of 1.8 m/s. What is the pipe diameter and head loss?

Step 1

Using Table 4-1, read the flow rates on the vertical axis and select 3.25 L/s.

Step 2

Follow the horizontal line to the left until it intersects 1.8 m/s. In this case it falls on the 50mm diameter pipe size.

Step 3

The optimum pipe size remains at 50mm diameter. Had it fallen between two sizes, the larger should be selected.

Step 4

Where the flow rate intersects the pipe diameter, project it vertically to the horizontal axis of the chart. The result is 6.4 m/h loss per 100m.

Had a 40mm copper pipe been selected for 3.25 L/s flow, the velocity would be 3.25 m/s, with a head loss of 25.0 m/h per 100m.

Answers to Exercises 4-2 to 4-12 are on pages 55 to 57.

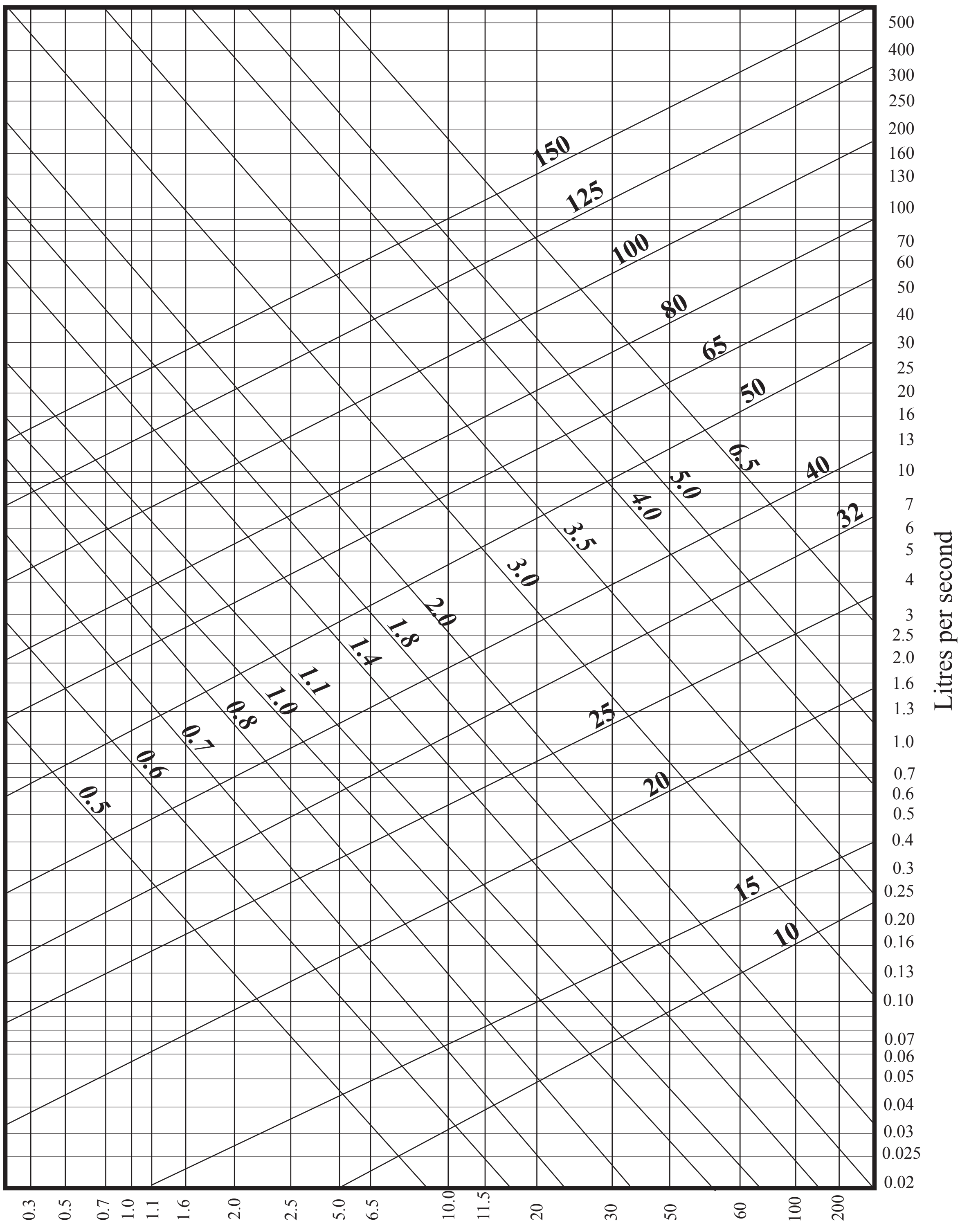


Table 4-1 Copper Pipe Sizing and Friction Loss Chart

Exercise 4-2

A copper pipe 58.2m long has a flow rate of 5.8 L/s, with a target velocity of 1.8 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Exercise 4-3

A copper pipe 22m long has a flow rate of 9.0 L/s, with a target velocity of 1.8 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Exercise 4-4

A copper pipe 78m long has a flow rate of 16.0 L/s, with a target velocity of 1.8 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Exercise 4-5

A copper pipe 146m long has a flow rate of 20.0 L/s, with a target velocity of 1.8 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Exercise 4-6

A copper pipe 16m long has a flow rate of 1.3 L/s, with a target velocity of 1.2 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Exercise 4-7

A copper pipe 79m long has a flow rate of 3.5 L/s, with a target velocity of 1.2 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Exercise 4-8

A copper pipe 18m long has a flow rate of 10.0 L/s, with a target velocity of 1.2 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Exercise 4-9

A copper pipe 46m long has a flow rate of 12.0 L/s, with a target velocity of 1.2 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Exercise 4-10

A copper pipe 14.6m long has a flow rate of 6.0 L/s, with a target velocity of 1.2 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Exercise 4-11

A copper pipe 20m long has a flow rate of 0.50 L/s, with a target velocity of 1.4 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Exercise 4-12

A copper pipe 49m long has a flow rate of 20.0 L/s, with a target velocity of 2.5 m/s. What is the diameter of the pipe, the actual velocity and the head loss for that length of pipe?

Sizing Pipes

Step 1

Table 3-1 is used to determine the flow rates for each individual fixture/outlet.

Step 2

The flow for each fixture is added to the flow for the main water supply line and a new possible flow is determined. Tables 3-2 and 3-3 are used for the conversion from the possible flow to a probable flow. The total sum of the flows for each fixture is referred to as the **'Possible Flow.'** The converted flow rate becomes the '**Probable Flow**'.

Step 3

Table 4-1 is used to determine the pipe size and friction loss in the pipe.

Note: Friction loss is examined in more detail in Chapter 5.

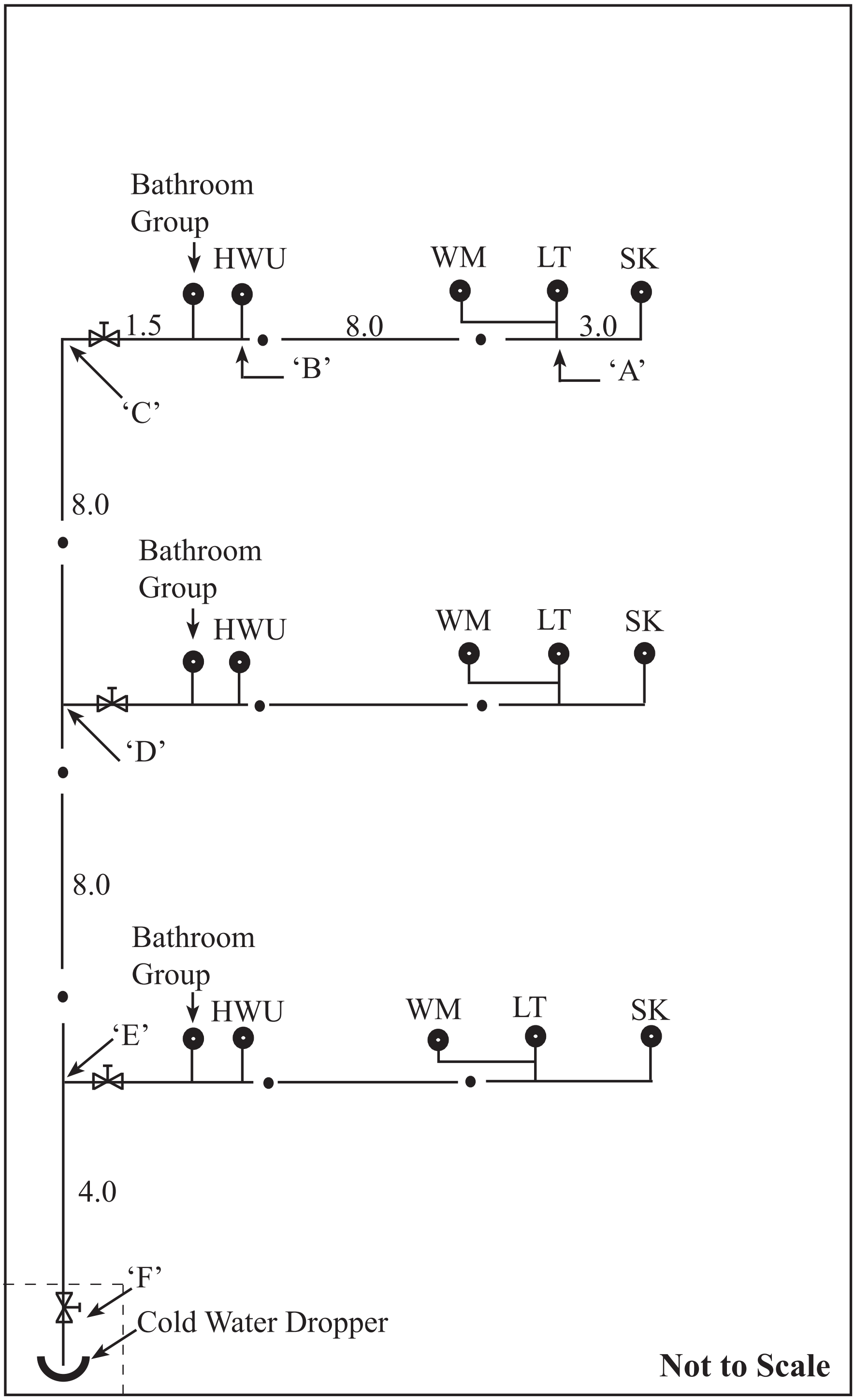
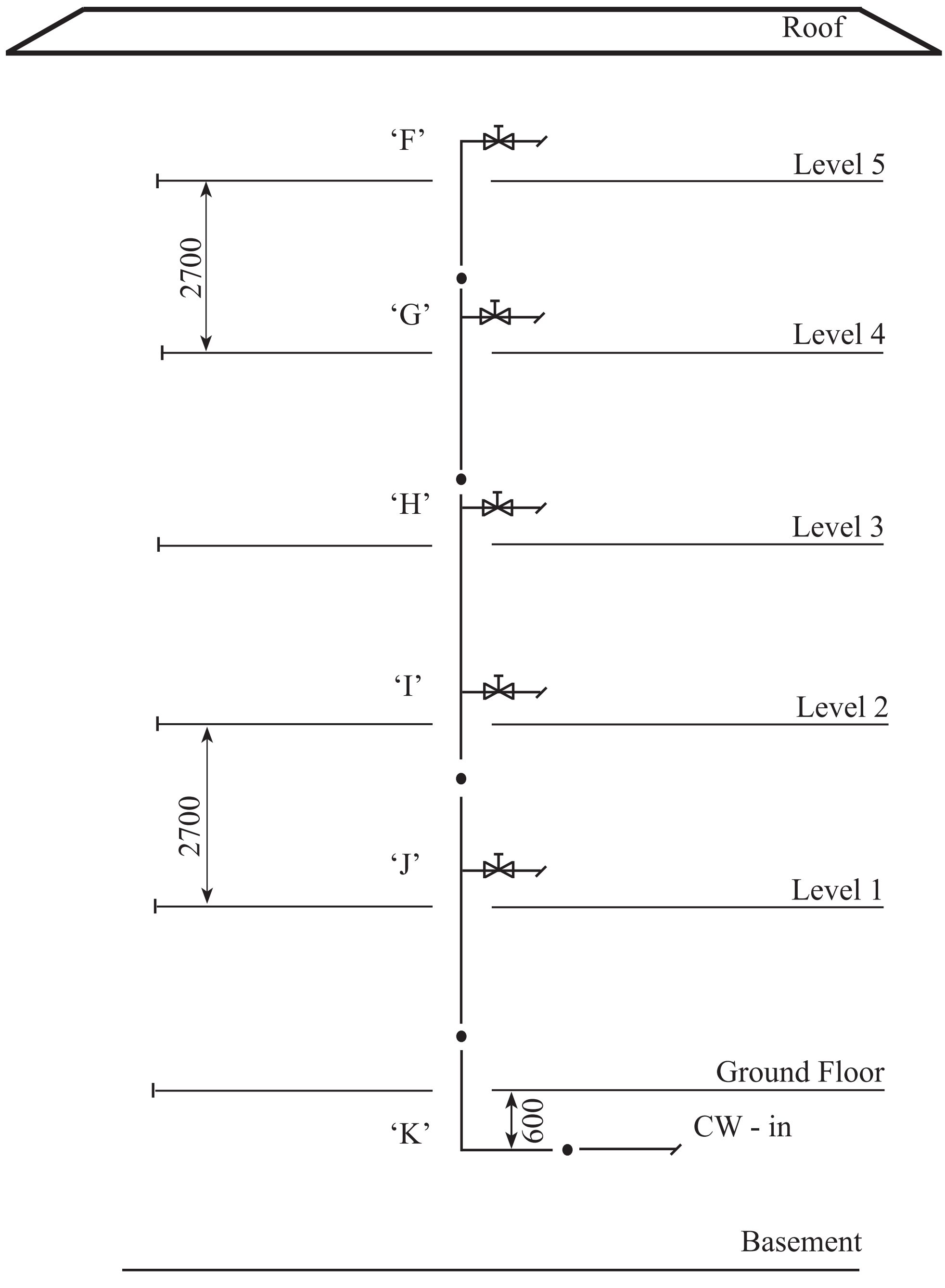


Figure 4-1 Typical Floor Plan of a Cold Water Pipe Layout
3 x Home Units per Floor



Not to Scale

Figure 4-2 Diagrammatic of a Cold Water Pipe System
Total: 15 Home Units

Exercise 4-13

Size the pipes for the fifteen (15) home units shown in Figures 4-1 and 4-2, using a velocity of 1.8 m/s.

Method

The pipe supplying the last fixture on the line is sized by using the required flow rate for the fixture, in this case the sink at 0.20 L/s.

Level 5

(a) Sink at 0.20 L/s

Pipe Size: **15mm** (max 1.5m) 20mm to the next branch.

(b) 0.20 L/s from **(a)** + 0.20 L/s = 0.40 L/s full flow probable.

Pipe Size: **20mm** from **'A'** to **'B'**

(c) 0.40 L/s from **(b)** + 0.30 from HWU + 0.35 from the bathroom = 1.05 L/s .
Converted to 0.80 L/s probable.

Pipe Size: **25mm** from **'B'** to **'C'** and to **'D'**

Note: A home unit or residence may be given a 'Group Flow Rate' as low as 0.50 L/s as shown in Table 3-4, or as high as 1.0 L/s. Regardless, the pipes supplying the home unit must be capable of delivering the minimum flows to each individual fixture in accordance with the local authority requirements and the applicable standards.

This exercise demonstrates that 20mm connections to residential premises are not always sufficient.

In this exercise, all home units on all levels will have the same flow rates and pipe sizes.

(d) 1.05 L/s from **(c)** + 1.05 L/s from branch **'D'** = 2.10 L/s.
Converted to 1.25 L/s probable.

Pipe Size: **32mm** from **'D'** to **'E'**

(e) 2.10 L/s from **(d)** + 1.05 from branch **'E'** = 3.15 L/s.
Converted to 1.60 L/s probable.

Pipe Size: **40mm** from **'E'** to **'F'** and to **'G'**

Level 4

(f) 3.15 L/s from **(e)** + 3.15 L/s from Level 4 = 6.30 L/s.
Converted to 2.41 L/s probable.

Pipe Size: **50mm** from **'G'** to **'H'**

Level 3

(g) 6.30 L/s from **(f)** + 3.15 L/s from Level 3 = 9.45 L/s.
Converted to 3.05 L/s probable.

Pipe Size: **50mm** from **'H'** to **'I'**

Level 2

(h) 9.45 L/s from **(g)** + 3.15 L/s from Level 2 = 12.60 L/s.
Converted to 3.66 L/s probable.

Pipe Size: **50mm** from **'I'** to **'J'**

Level 1

(i) 12.6 L/s from **(h)** + 3.15 L/s from Level 1 = 15.75 L/s.
Converted to 4.18 L/s probable.

Pipe Size: **50mm** from **'J'** to **'K' and to the water connection.**

It costs very little extra to size pipes correctly. In this exercise, 1.05 L/s was calculated for each unit and resulted in a 50mm diameter copper pipe to supply the building. Had 0.50 L/s been applied as shown in Table 3-4, the result would still have been 50mm pipe.

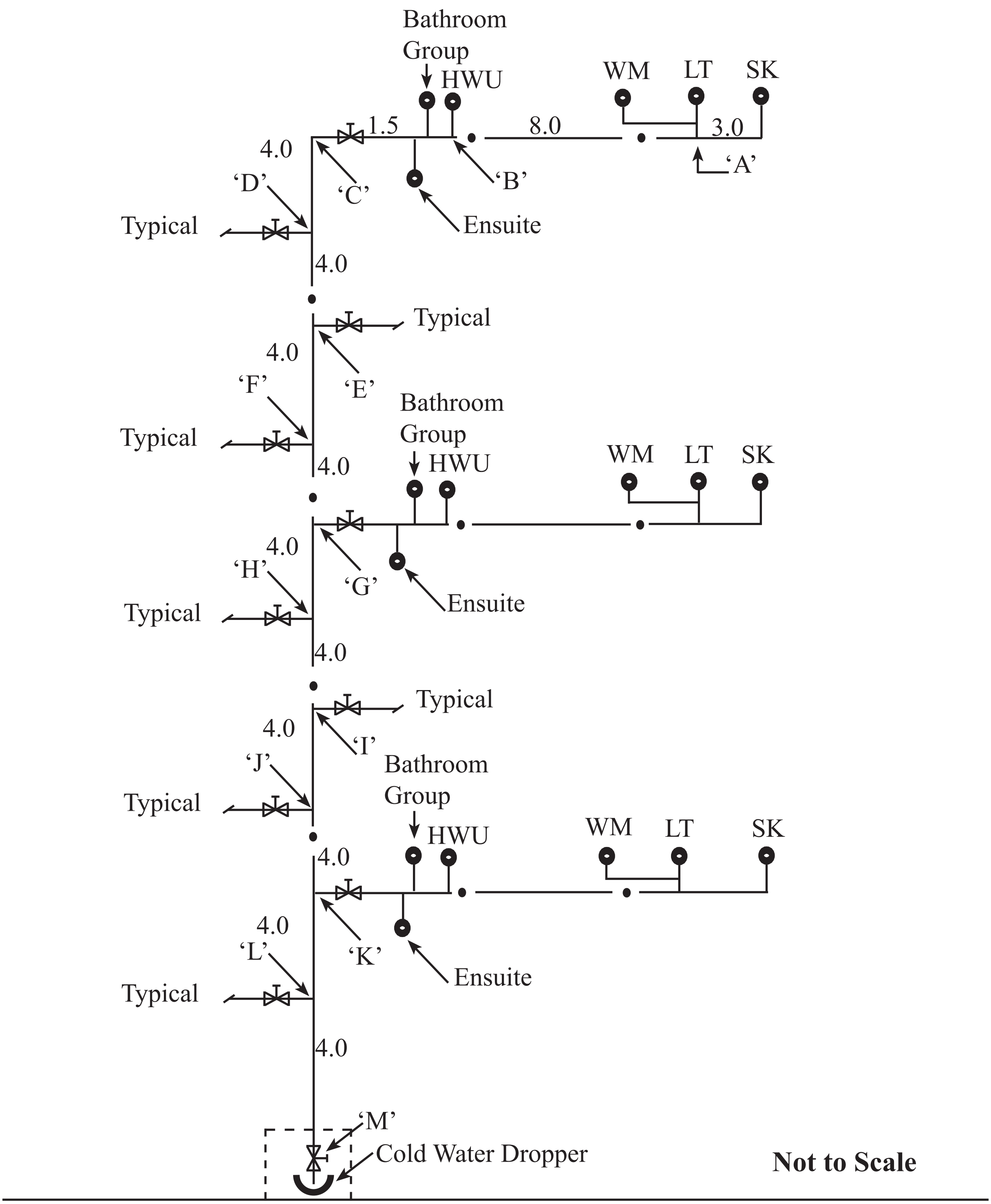


Figure 4-3 Typical Floor Plan of a Cold Water Pipe Layout
10 x Home Units per Floor

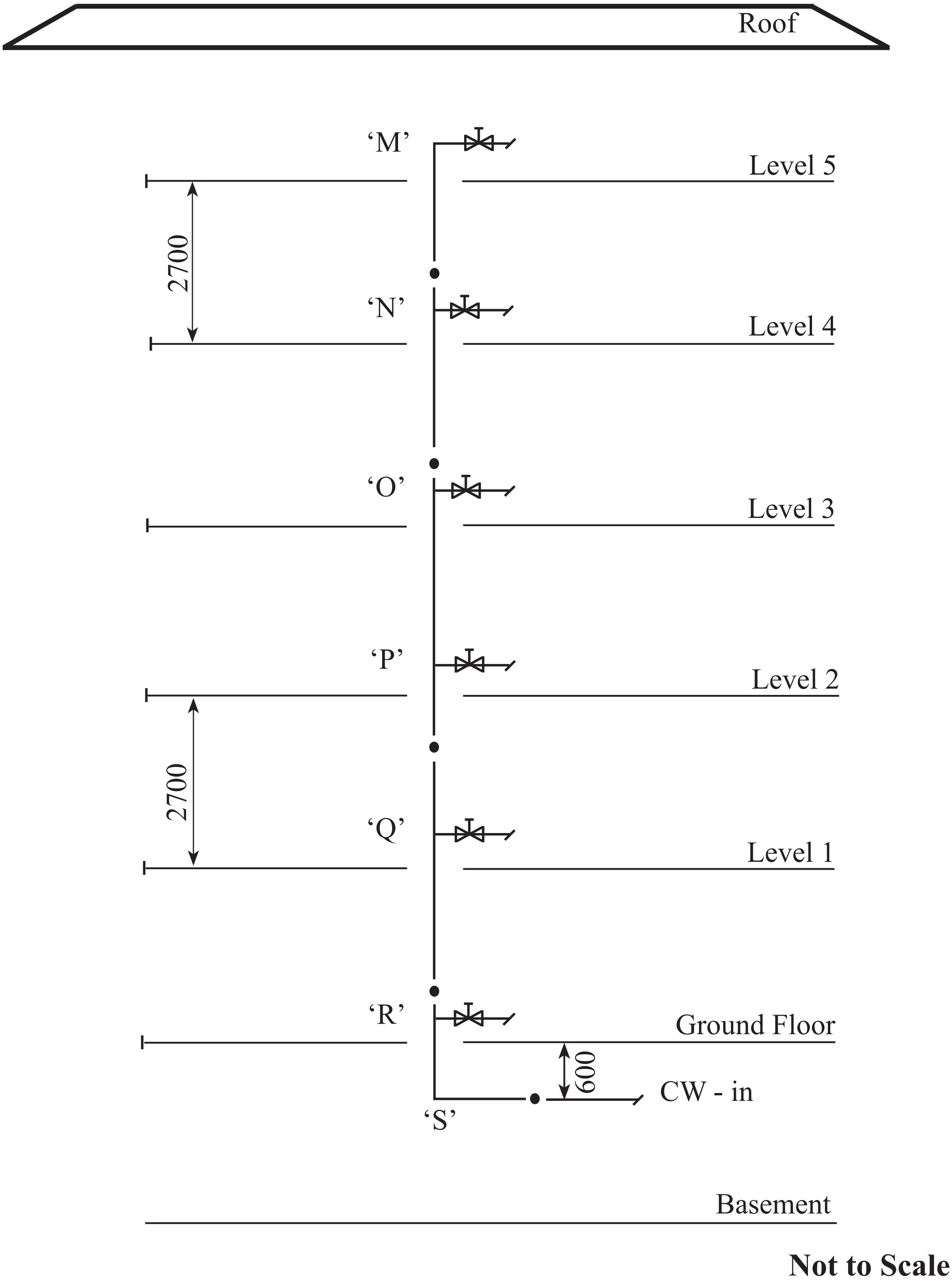


Figure 4-4 Diagrammatic of a Cold Water Pipe System
Total: 60 Home Units

Exercise 4-14

Size the pipes for the sixty (60) home units as shown in Figures 4-3 and 4-4, using a velocity of 1.8 m/s.

Method

The pipe supplying the last fixture on the line is sized by using the required flow rate for the fixture, in this case the sink at 0.20 L/s.

Level 5

(a) Sink at 0.20 L/s

Pipe Size: **15mm** (max 1.5m) 20mm to the next branch.

(b) 0.20 L/s from **(a)** + 0.20 L/s = 0.40 L/s full flow probable.

Pipe Size: **20mm** from **'A'** to **'B'**

(c) 0.40 L/s from **(b)** + 0.30 from HWU + 0.35 from the bathroom = 1.05 L/s. Converted to 0.80 L/s probable.

Pipe Size: **25mm** from **'B'** to **'C'** and to **'D'**

Note: No additional loading has been included for the ensuite, as it is unlikely to make a difference to the probable demand.

(d) 1.05 L/s from **(c)** + 1.05 L/s from branch **'D'** = 2.10 L/s. Converted to 1.25 L/s probable.

Pipe Size: **32mm** from **'D'** to **'E'**

(e) 2.10 L/s from **(d)** + 1.05 from branch **'E'** = 3.15 L/s. Converted to 1.60 L/s probable.

Pipe Size: **40mm** from **'E'** to **'F'**

(f) 3.15 L/s from **(e)** + 1.05 from branch **‘F’** = 4.20 L/s.
Converted to 1.90 L/s probable.

Pipe Size: **40mm** from **‘F’** to **‘G’**

(g) 4.20 L/s from **(f)** + 1.05 from branch **‘G’** = 5.25 L/s.
Converted to 2.16 L/s probable.

Pipe Size: **40mm** from **‘G’** to **‘H’**

(h) 5.25 L/s from **(g)** + 1.05 from branch **‘H’** = 6.30 L/s.
Converted to 2.41 L/s probable.

Pipe Size: **50mm** from **‘H’** to **‘I’**

(i) 6.30 L/s from **(h)** + 1.05 from branch **‘I’** = 7.35 L/s.
Converted to 2.65 L/s probable.

Pipe Size: **50mm** from **‘I’** to **‘J’**

(j) 7.35 L/s from **(i)** + 1.05 from branch **‘J’** = 8.40 L/s.
Converted to 2.87 L/s probable.

Pipe Size: **50mm** from **‘J’** to **‘K’**

(k) 8.40 L/s from **(j)** + 1.05 from branch **‘K’** = 9.45 L/s.
Converted to 3.08 L/s probable.

Pipe Size: **50mm** from **‘K’** to **‘L’**

(l) 9.45 L/s from **(k)** + 1.05 from branch **‘L’** = 10.50 L/s.
Converted to 3.28 L/s probable.

Pipe Size: **50mm** from **‘L’** to **‘M’** and to **‘N’**

Level 4

(m) 10.50 L/s from **(l)** + 10.5 L/s from Level 4 = 21.0 L/s.
Converted to 4.97 L/s probable.

Pipe Size: **65mm** from **'N'** to **'O'**

Level 3

(n) 21.0 L/s from **(m)** + 10.50 L/s from Level 3 = 31.5 L/s.
Converted to 6.34 L/s probable.

Pipe Size: **65mm** from **'O'** to **'P'**

Level 2

(o) 31.5 L/s from **(n)** + 10.5 L/s from Level 2 = 42.0 L/s.
Converted to 7.38 L/s probable.

Pipe Size: **80mm** from **'P'** to **'Q'**

Level 1

(p) 42.0 L/s from **(o)** + 10.5 L/s from Level 1 = 52.5 L/s.
Converted to 8.40 L/s probable.

Pipe Size: **80mm** from **'Q'** to **'R'**

Ground Floor

(q) 52.5 L/s from **(p)** + 10.5 L/s from Ground Floor = 63.0 L/s.
Converted to 10.08 L/s probable.

Pipe Size: **100mm** from **'R'** to **'S' and to the water connection.**

Continuous Flows

There are situations on projects where continuous flows are required to fixtures, storage tanks and machinery in manufacturing plants, or to equipment in hospitals. In such cases the conversion from possible flow demand to probable flows is not appropriate.

In the case of a hotel complex with four hundred accommodation rooms. The probable flow will be in the vicinity of 32 L/s during the peak period. In many cases the local authority will not allow such a high draw-off from their water mains, except in emergency situations for fire fighting purposes. A storage tank can be included in the design and the pipe sized to trickle the water into the tank over a 12 to 24 hour period, thus allowing a reduction in the size of the pipes and the demand on the local authority water main.

Operating equipment and sterilising units in hospitals will require the total possible demand at any given time. In these cases, it is good design practice to allow for continuous flows and only apply the possible/probable conversions at the branches, after the pipe has been connected to the main supply line.

Some machinery in manufacturing plants requires water for cooling purposes on a continuous basis. As the demand will coincide with the demands on other machinery, plant and equipment it would be inappropriate to apply probable flow demands. Sizing the pipes for continuous flow in this situation is prudent.

A most important practice in designing and sizing potable pipe systems is not to assume all situations are the same. Carry out in-depth research regarding the intended use of the water, as well as the pattern of usage. Acquire knowledge regarding the precise time that the peak periods will occur, not just the length of time the peak periods will last. When these fundamentals are in place, a system that benefits the end user can be designed.

Answers to Exercises 4-2 to 4-12

Exercise 4-2 Answer

Pipe Size	65 dia.
Velocity	2.0 m/s
Friction Loss	6.5m / 100m
Total Head Loss	3.78 m/h

Exercise 4-3 Answer Option 1

Pipe Size	100 dia.
Velocity	1.4 m/s
Friction Loss	1.7m / 100m
Total Head Loss	0.37 m/h

Exercise 4-3 Answer Option 2

Pipe Size	80 dia.
Velocity	2.3 m/s
Friction Loss	6.0m / 100m
Total Head Loss	1.32 m/h

Exercise 4-4 Answer

Pipe Size	125 dia.
Velocity	1.7 m/s
Friction Loss	1.6m / 100m
Total Head Loss	1.25 m/h

Exercise 4-5 Answer

Pipe Size	150 dia.
Velocity	1.35 m/s
Friction Loss	0.7m / 100m
Total Head Loss	1.02 m/h

Exercise 4-6 Answer

Pipe Size	40 dia.
Velocity	1.25 m/s
Friction Loss	6.5m / 100m
Total Head Loss	1.04 m/h

Exercise 4-7 Answer

Pipe Size	65 dia.
Velocity	1.15 m/s
Friction Loss	2.1m / 100m
Total Head Loss	1.66 m/h

Exercise 4-8 Answer

Pipe Size	125 dia.
Velocity	1.05 m/s
Friction Loss	0.55m / 100m
Total Head Loss	0.10 m/h

Exercise 4-9 Answer

Pipe Size	125 dia.
Velocity	1.15 m/s
Friction Loss	0.8m / 100m
Total Head Loss	0.37 m/h

Exercise 4-10 Answer

Pipe Size	100 dia.
Velocity	1.00 m/s
Friction Loss	0.7m / 100m
Total Head Loss	0.10 m/h

Exercise 4-11 Answer Option 1

Pipe Size	25 dia.
Velocity	1.10 m/s
Friction Loss	9.0m / 100m
Total Head Loss	1.80 m/h

Exercise 4-11 Answer Option 2

Pipe Size	20 dia.
Velocity	2.1 m/s
Friction Loss	33m / 100m
Total Head Loss	6.6 m/h

Exercise 4-12 Answer Option 1

Pipe Size	125 dia.
Velocity	2.0 m/s
Friction Loss	2.0m / 100m
Total Head Loss	0.98 m/h

Exercise 4-12 Answer Option 2

Pipe Size	100 dia.
Velocity	3.1 m/s
Friction Loss	7.0m / 100m
Total Head Loss	3.43 m/h