Chapter 9

High-Rise Buildings

Chapter 9 discusses four aspects of pipe sizing for high-rise buildings:

1. Up-feed system
2. Down-feed system
3. Pump duties
4. Water storage

Selecting the right potable water system for each project is a critical part of the design process. The type of project, as well as the designer's experience and local knowledge will be contributing factors in the decision making process. Balancing the system can be a very complex process and will also be an influencing factor when considering design options.

Up-Feed System

An 'up-feed system' is a simple design where all the levels of a multistorey building are served directly from the ground floor. In many cases the pressure in the local authority's water main will be adequate to serve all floors. On other projects, as illustrated in Figure 9-1, a pressure pump will need to be included to serve the upper levels.

The available pressure in the local authority's water main determines the level to which the water will rise without the assistance of pressure pumps. It may be that the building is on a hill and level six is the upper limit, or it could be that the building is at the foot of a hill and the water pressure will reach level eighteen. There is no standard answer, every project must be assessed individually, which is precisely why design engineers are required.

It is possible an up-feed system may have a storage tank, as shown in Figure 9-2. In this example the tank has effectively reduced the pressure to zero and a pressure pump has been introduced to deliver the water to the top of the building.

Introducing pumps requires that the final water pressure must be calculated at each individual level/floor of the building. To achieve the minimum pressure at the highest level or at the most disadvantaged outlet, the pressure on the lower levels will exceed the maximum 50 m/h, in which case a pressure-limiting valve will need to be fitted.

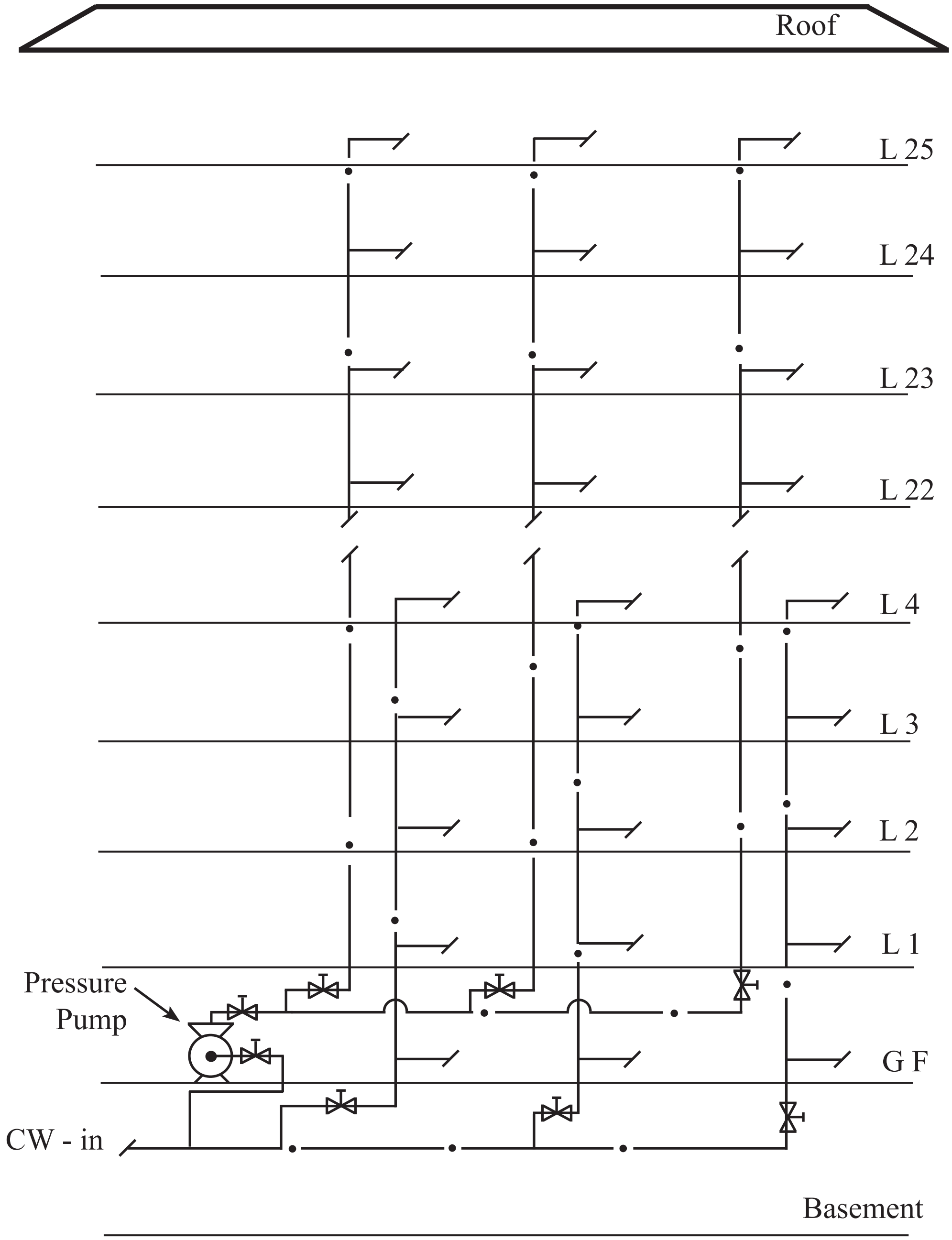

Figure 9-1 Cold Water Up-Feed System

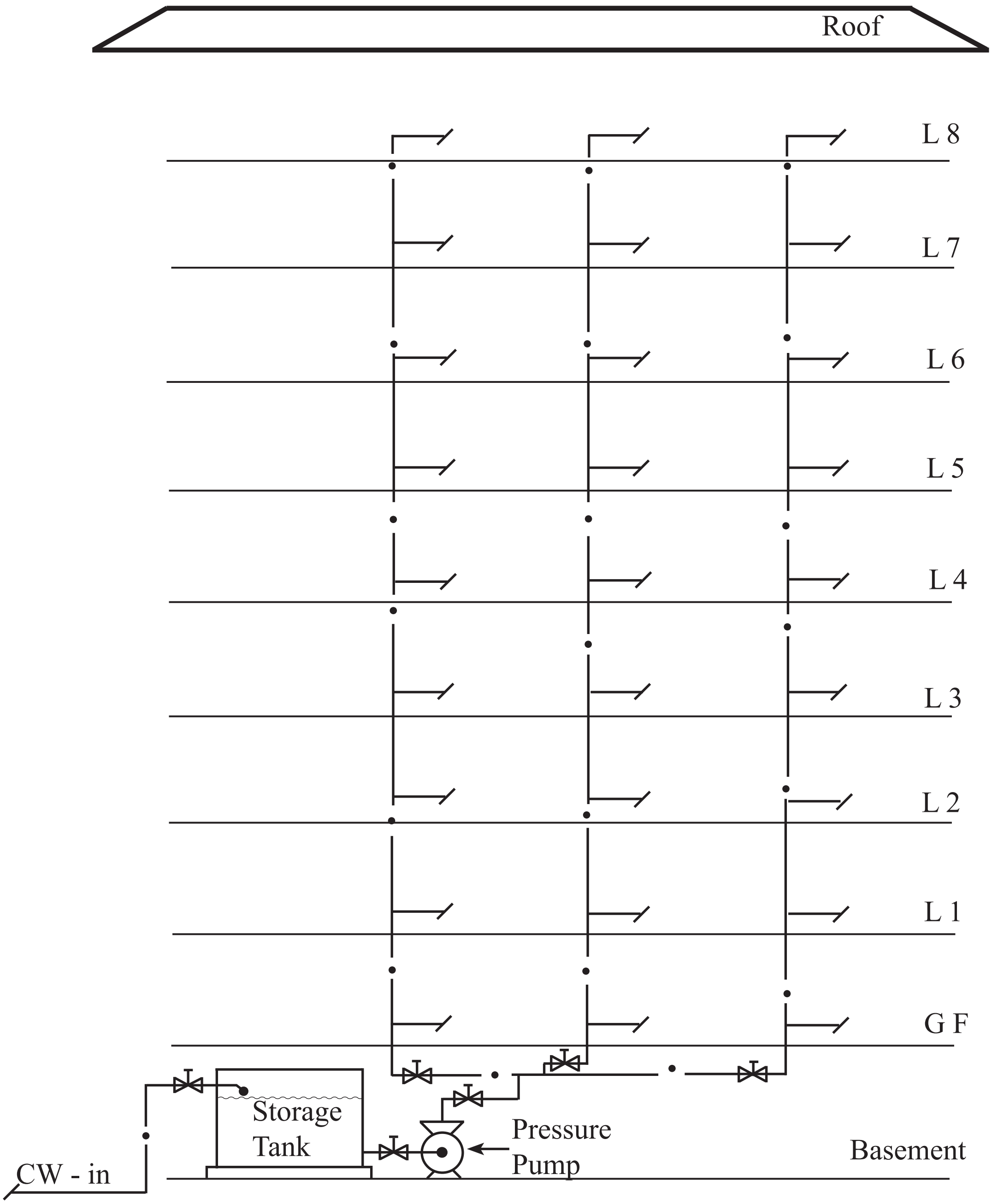

Figure 9-2   Cold Water Up-Feed System Incorporating a Storage Tank

Down-Feed System

A ‘down-feed system’ is more complex in its design and there is a greater need to balance the system efficiently. The name ‘down-feed’ adequately describes the process, by which the water is first pumped to a header tank at a high level and then gravity fed to each level below. The exception being, the top three or four levels of the building are supplied via a pressure pump system due to insufficient pressure being created by the height of the storage tank. The number of levels supplied by the pressure pump will vary, depending on the relative height of the storage tank.

Figure 9-3 illustrates the supply pipe from the storage tank feeding the top three levels via a pressure pump. All other levels are supplied directly from the tank by gravity feed.

Pressure-Limiting Valves

As stated in Chapter 1, for every one metre a column of water rises, the pressure at the base of that column increases by 1 m/h, 9.81 kPa or 0.0981 bar. Therefore, if the height from one floor to the next were three metres, it follows that 3 m/h or 29.43 kPa or 0.29 bar of pressure is created. In a down-feed system the pressure is created as the water supply pipe drops from level to level.

Based on good design practices and a three metre floor to floor height, for the pressure to be balanced with a minimum of 21 m/h and a maximum of 50 m/h, a pressure-limiting valve would be required every ninth level (starting from the top level).

In cases where the specification states that the pressure not exceed 350 kPa, the pressure-limiting valve would need to be fitted every fourth floor. Alternatively, a pressure-limiting valve can be fitted to the branch at each level, which has the advantage of providing every level with the same water pressure.

Figure 9-4 illustrates a down-feed system with dual pressure-limiting valves. Where a pressure-limiting valve is fitted in the main supply line it must have dual valves for the system to remain operable in the event of maintenance being required.

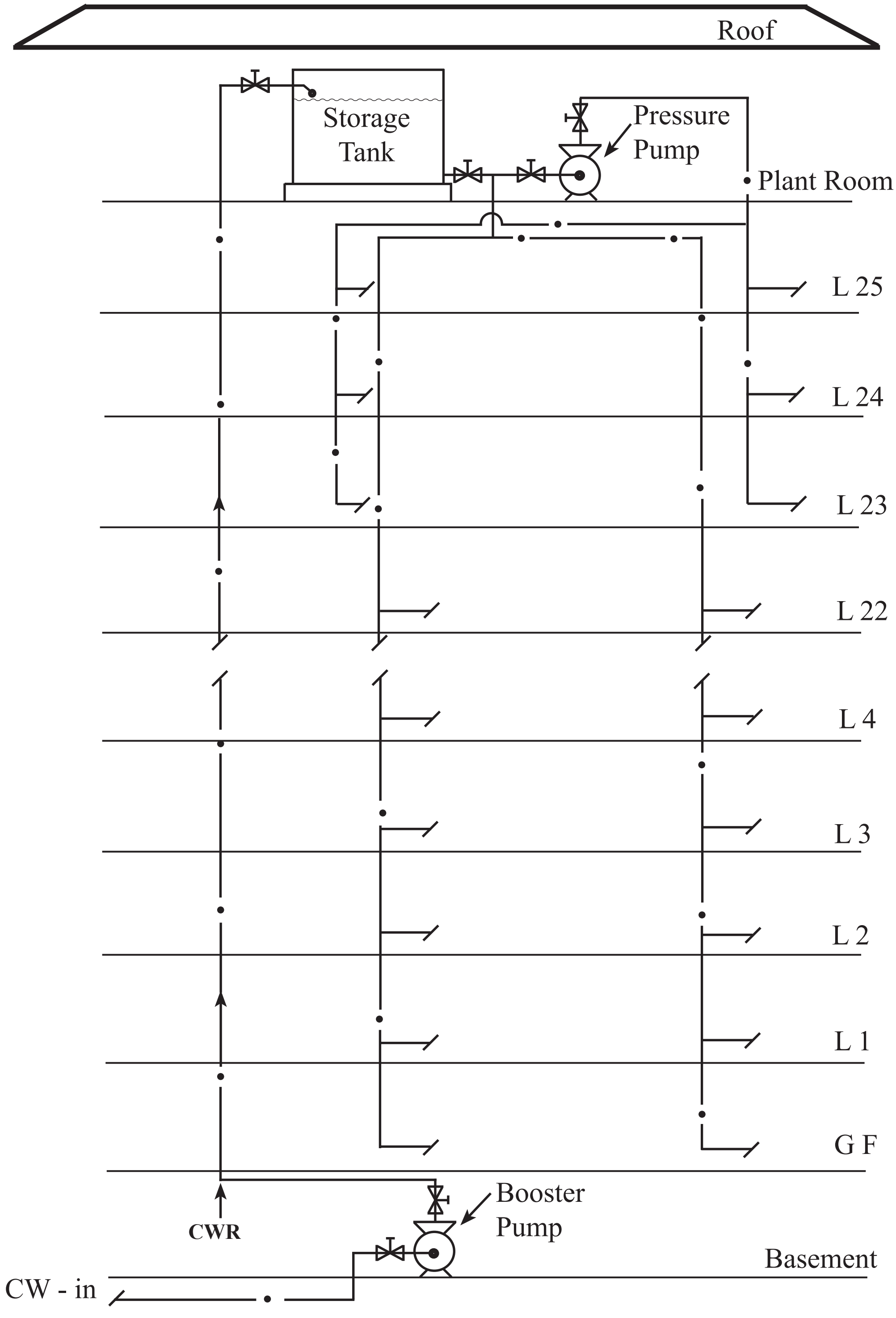

Figure 9-3 Cold Water Down-Feed System

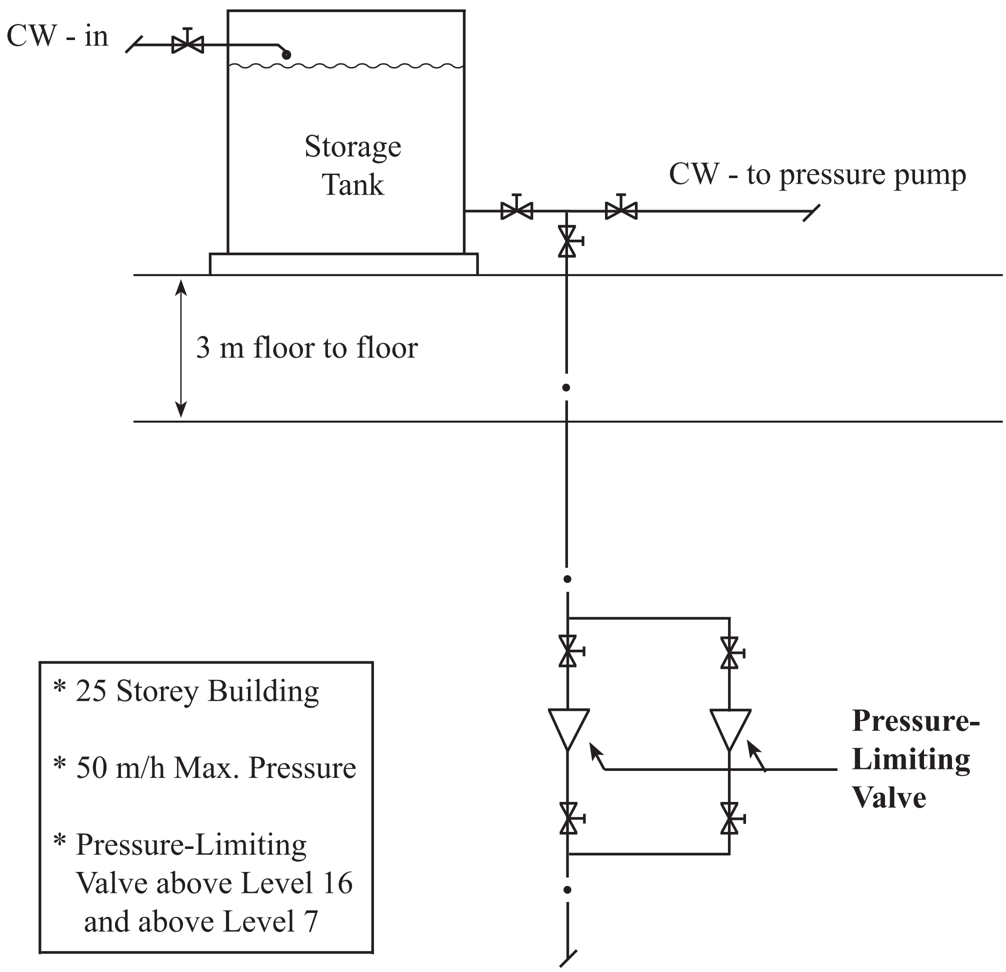

Figure 9-4 Dual Pressure-Limiting Valves

Pump Duties

Calculations for pump flows and duties are the responsibility of the design engineer. The actual specifications of the impeller size, motor and material from which the pump is constructed, are the responsibility of the manufacturer.

A pump selected for a particular task on a project, is specified as being capable of delivering a given number of litres per second against a calculated head in metres.

For example, it is correct to state: 5.25 L/s against a 30 m/h.

The flow is determined using the methods and procedures set down in Chapter 4 for sizing pipes. The calculated probable demand, not the possible flow, is used in the pump calculation.

Friction losses are calculated as detailed in Chapter 5 and applied in Table 9-1. The layout for the calculations for sizing a pump are as follows:

Item	Metres Head
a) The required working pressure	______________
b) Static head	______________
c) Friction loss in pipes.	______________
d) Friction loss in valves and fittings	______________
e) Total required head	______________
f) Available pressure in the main	______________
g) Residual pressure	______________

Table 9-1 Layout for Calculating Pump Duties

Note: If the residual pressure is a negative figure, it reverts to a positive number and is the equivalent pressure required for the pump duty. The incoming pressure from the source of supply assists and reduces the head against which the pump must push. It is only the residual shortfall that the pump must compensate for.

Exercise 9-1

A building has 14 storeys plus a ground floor. Each level is 2.7 m floor to floor, the pipe is 600mm deep and 1.9 m from the floor to the shower on the top level. The total friction loss is 5.5 m/h and the pressure at the main is 45 m/h. What is the pump duty if a total of 6.25 L/s is required, with 21 m/h at the most disadvantaged outlet?

Item	Metres Head	
a) The final working pressure	21.00	
b) Static head	40.30	(14 x 2.7) + 1.9 + 0.60
c) Friction loss in pipes	5.50	
d) Total required pressure	**66.80**	

e) Available pressure in the main	45.00
f) Residual pressure	-21.80

Pump Duty : 6.25 L/s against a head of 21.8 metres.

Exercise 9-2

A building has 22 storeys plus a ground floor. Each level is 2.7 m floor to floor, the pipe is 600mm deep and 1.9 m from the floor to the shower on the top level. The total friction loss is 6.56 m/h and the pressure at the main is 56 m/h. What is the pump duty if a total of 9.30 L/s is required, with 21 m/h at the most disadvantaged outlet?

Item	**Metres Head**	
a) The final working pressure	21.00	
b) Static head	61.90	(22 x 2.7) + 1.9 + 0.60
c) Friction loss in pipes and fittings	6.56	
d) **Total required pressure**	**89.46**	
f) Available pressure in the main	56.00	
g) Residual pressure	-33.46	

Pump Duty: 9.30 L/s against a head of 33.46 metres.

Note: Pump duties are also stated in L/m and L/h.

Water Storage

Water storage may be a requirement of the local authority for a number of reasons:

a) To form a break between the water main and the building service.
b) A header tank in a high-rise building.
c) To compensate for insufficient flows from the water main during peak periods.

Local Authorities

In densely populated areas such as costal towns and cities that are affected by a periodic influx of holiday-makers, the population can, at times, grow by a factor of five to ten times that of the permanent resident population. It is highly possible the local authority may not have the storage capacity in their reservoirs to accommodate the short bursts of demand during peak periods. Also, they may not have large enough pipes in their distribution network to convey the volume of water required for the peak demands. In such cases they look for ways of spreading the load to reduce demand on their purification plants and infrastructure.

A successful method of doing this is for buildings to store one day's supply of water, thus allowing the water to trickle into the storage tank over a twenty four hour period. The actual demand may in fact be over a twelve hour period.

Local authorities with by-laws requiring water storage will have a formula for calculating the storage capacity. In the absence of a formula being available, a method of calculating the quantity of water to be stored is detailed on pages 124 and 125.

Forming an Air Break

Storage tanks are an effective way of deliberately creating an air break between the local authority's water main and the building service. Farms, industrial buildings and manufacturing plants are examples of properties most likely to have a storage tank immediately inside the property alignment.

Backflow devices are the most common method of protecting the local authority's main from cross connection and possible contamination. Regardless of this, installing a storage tank is an extremely successful method of eliminating backflow with possible contamination.

Header Tanks in High-Rise Buildings

The ongoing running cost of a pressure pump to service an up-feed potable water system may be expensive. By using a header tank and down-feed system the running cost may be more economical. A storage tank is required to create the pressure for the floors below.

The tank is generally located in a plant room on the highest level. Alternatively, it can be positioned over the lift well shaft, which has the advantage of additional height to create greater pressure. The lift well also provides a good location to distribute the weight of the tank and the water being stored.

*** 1 litre of water = 1 kg,** *** 70,000 litres stored is 70 tonne**

Insufficient Flows from the Source of Supply

A storage tank may be installed where insufficient water supply is available. Lack of flow from a water main is one problem that can be experienced on a project. The building service may also experience a shortage due to high demand in peak periods.

Industrial buildings, manufacturing plants and commercial laundries are just a few examples where this may occur.

Case Study

A commercial laundry servicing a holiday resort has six large washing machines, which on the first fill require 2.5 L/s each for one minute. A 100mm ring main is supplying the resort.

If the attendant were to start the washing machines at ten minute intervals, the water main would be able to cope with the demand. However, there is a greater probability that the attendant will start the machines simultaneously.

The real demand now becomes 15 L/s, which is too high, when the demand occurs at the same time as other facilities at the resort. There is a risk of syphoning the main dry or leaving the guests without water. In this case a storage tank should be installed with a two to three hour capacity.

Sizing Water Storage Tanks

In situations where local authorities have a water storage policy for new building projects, the authority should provide a formula for sizing the water storage tank. In the absence of a formula, the following method can be adopted with confidence.

Step 1. Calculate the equivalent population for the project.

a) 1 x bed accommodation unit = 1.5 people

b) 2 x bed accommodation unit = 2.5 people

c) 3 x bed accommodation unit = 4.5 people

A 100 unit accommodation development consisting of:

50 x 1 bed accommodation units	=	75 people
25 x 2 bed accommodation units	=	62.5 people
25 x 3 bed accommodation units	=	112.5 people
Total	**=**	**250 people**

Step 2. Apply the storage per person, per day.

Depending on the type of building; eg. hotel, apartment, motel, or office block the storage capacity can be from 200 to 350 litres per person, per day.

In this example 275 litres per person has been used.

250 people x 275 litres = 68,750 litres capacity (68.75m^3).

Calculating the storage tank dimensions

The tank will be 68.75m^3, plus air gap at the top.

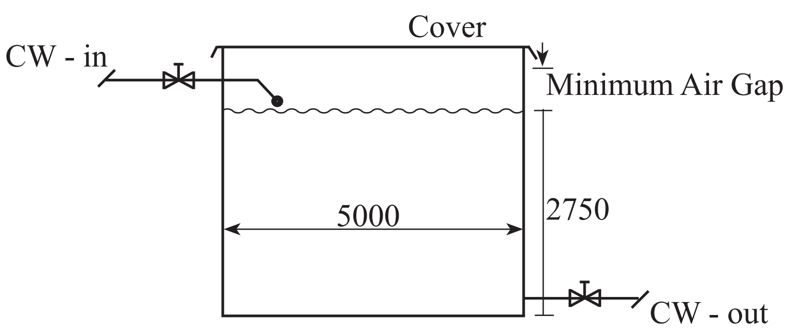

Figure 9-5 Dimensioned Storage Tank

In this example the tank will be 5 x 5 x 2.75, plus the required air gap to accommodate the 68.75m^3 storage capacity.