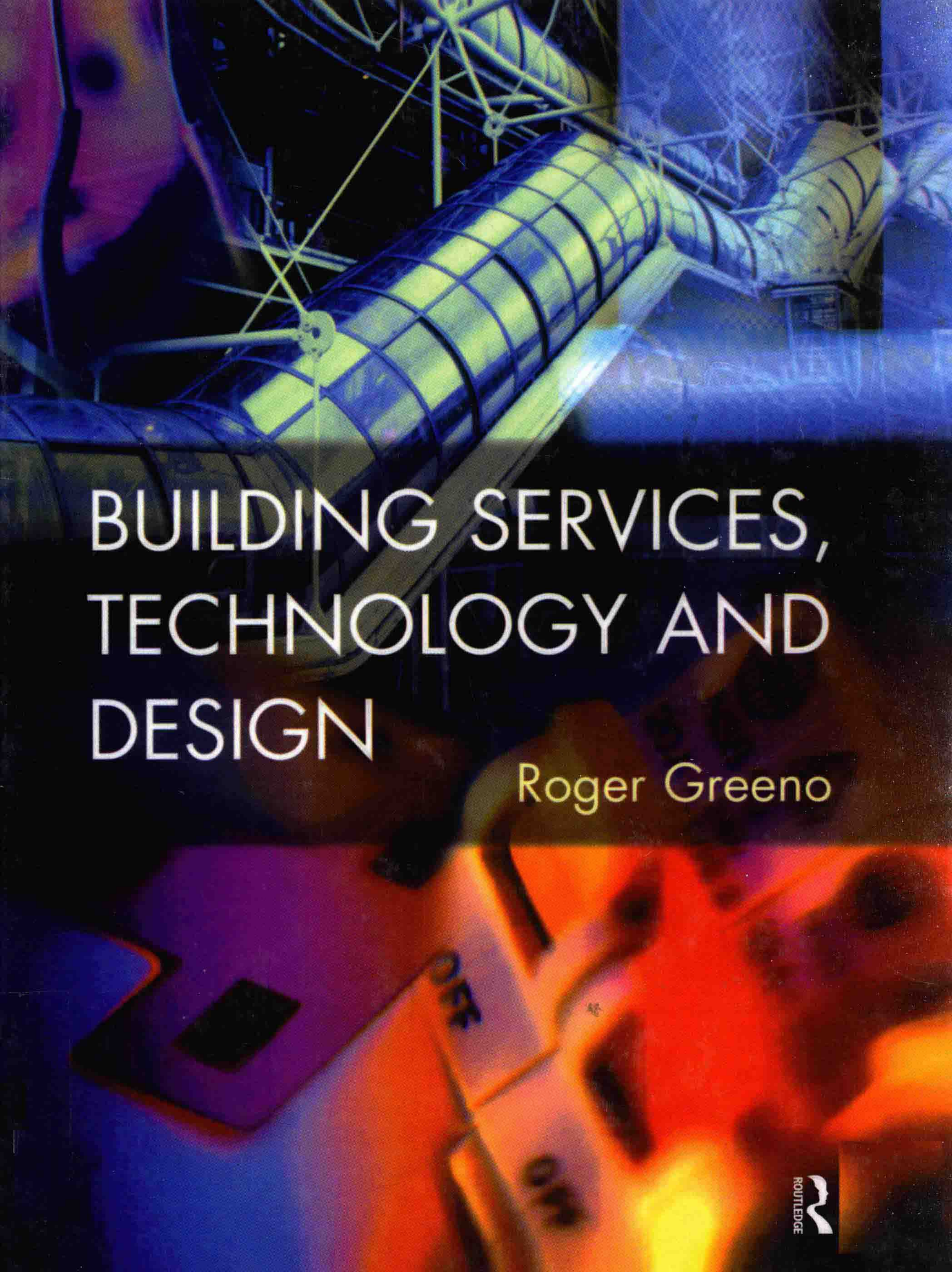

BUILDING SERVICES, TECHNOLOGY AND DESIGN

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Contents

1 Cold water supply

Hydrological cycle

The origins of drinking water are found in the hydrological or water cycle. This continuous process includes evaporation of moisture from the sea, rivers and lakes to form clouds. The condensation droplets coalesce and fall as rain to replenish the water levels.

Extraction

In the United Kingdom, water is derived from:

1. Surface sources, i.e. rivers and large lakes
2. Boreholes into aquifers (water-bearing strata)
3. Roofs, paved areas and shallow wells.

The first two categories lend themselves to subsequent filtration and chemical treatment, before distribution and consumption, as shown in Figure 1.1. The latter category could be contaminated and are only used in remote locations.

In some parts of the world where rainwater is scarce, desalination plant is used to process sea water, but this is very expensive.

Processing and distribution

In Figure 1.1 the three principal sources of United Kingdom water are identified. About one-third of consumption comes from each, although regional variations are inevitable, e.g. the Highland areas of Scotland will provide the bulk of water for that area, while the flat Fenlands of East Anglia will need boreholes.

Surface water is stored in man-made reservoirs or impounding reservoirs, the latter created from damming valleys to create catchment areas and to provide the potential for hydroelectricity generation. Coarse and fine sand filtration removes most debris and impurities before a minute amount of chlorine is added to classify the water drinkable. Borehole supplies are well filtered through the strata and normally only require chemical treatment.

After processing, the water is pumped to a high-level storage reservoir or

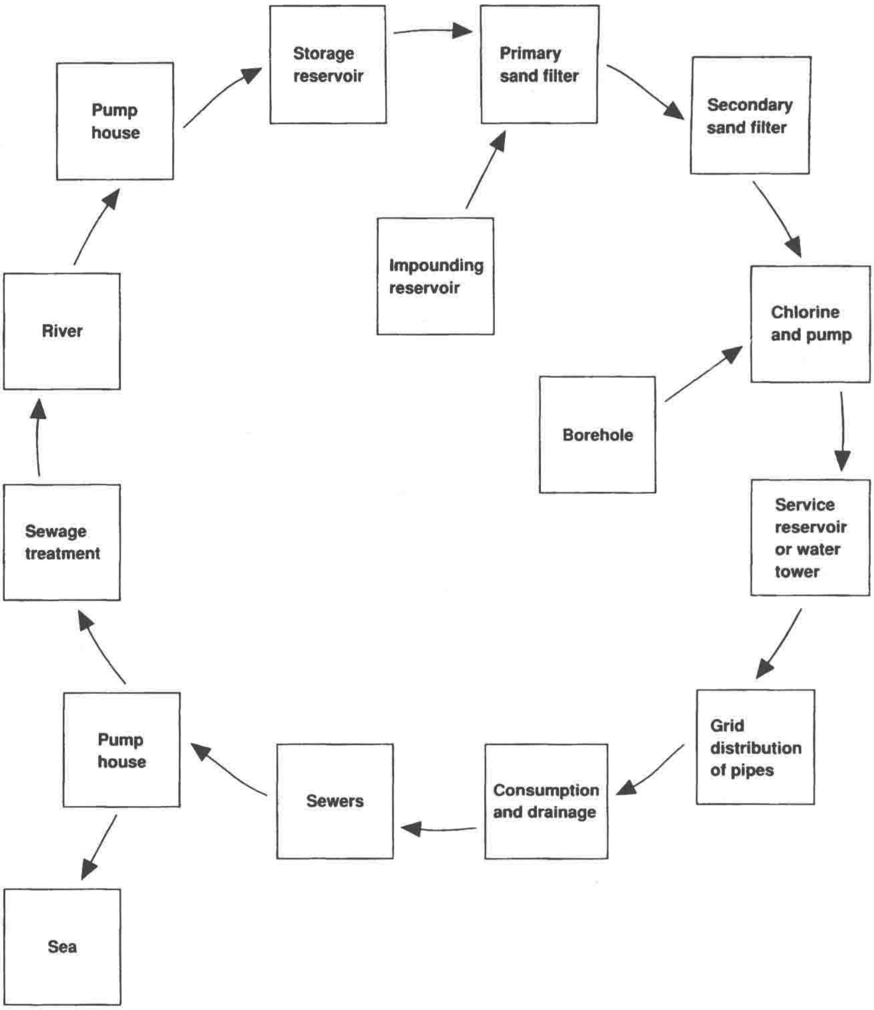

Figure 1.1 The water process

water tower for gravity distribution through iron or uPVC pipes (coloured blue) jointed as shown in Figure 1.2.

Connection to buildings

The grid distribution of underground pipework enables sections to be isolated for repair and maintenance without severe local disruption. Connections to the grid are made by the local water authority or its approved contractor at the expense of the developer or building owner. An isolation stop valve is usually provided at the crown of the water main and a communicating pipe terminated inside the property boundary with another stop valve for the building owner's use. This pipe remains the water authority's, but the service pipe thereafter is the responsibility of the building owner. A typical installation is shown in Figure 1.3.

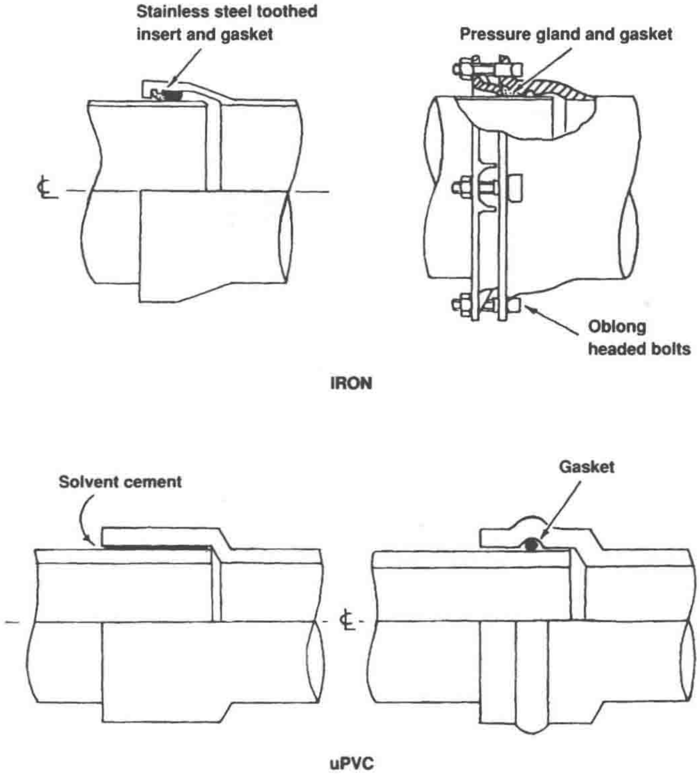

Figure 1.2 Jointing of water mains

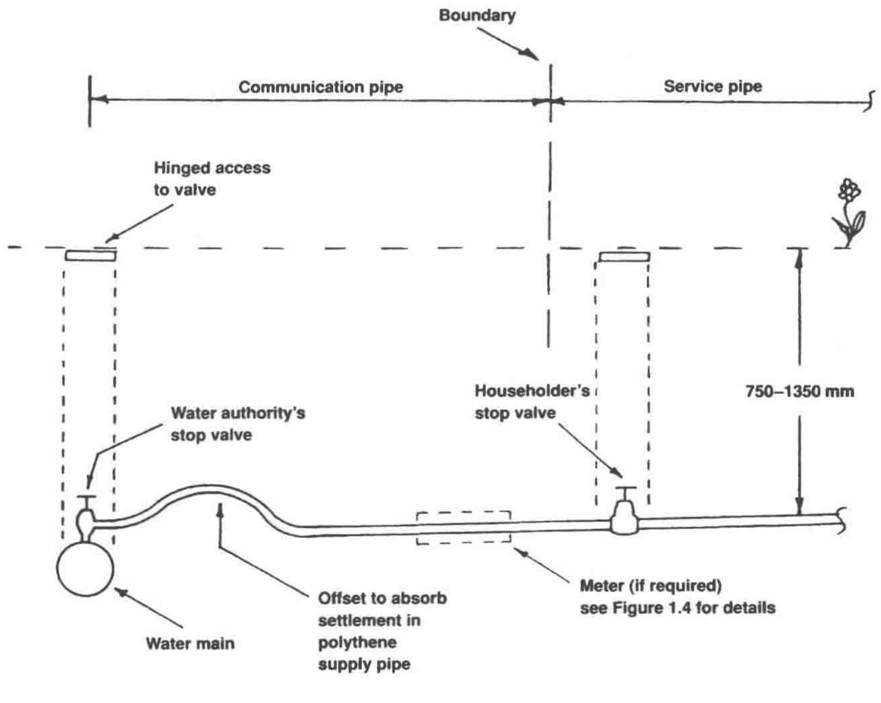

Figure 1.3 Domestic water supply

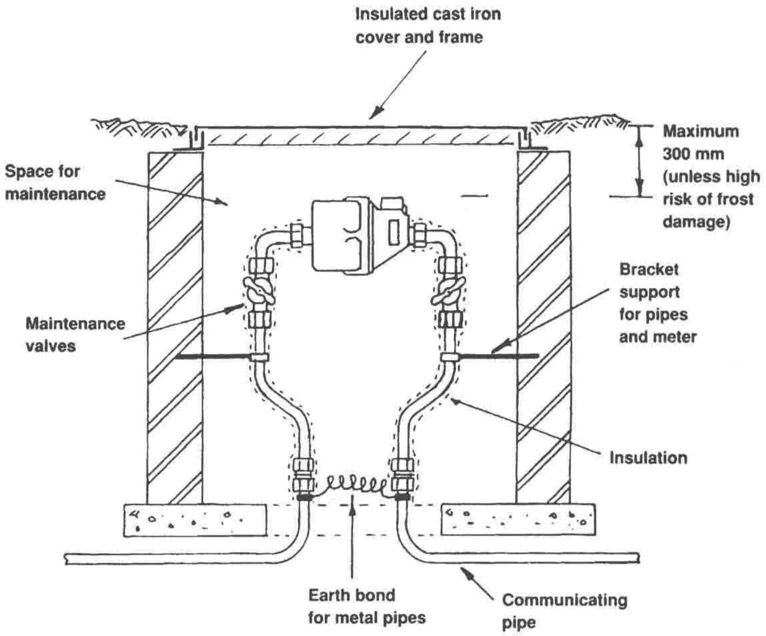

Figure 1.4 Meter housing

Water meters

Water meters are supplied at the discretion of the local water authorities and most new buildings are required to have them. The preferred location is underground, just beyond the property boundary as shown in Figure 1.3. If this is impractical, location within the building at the base of the rising main may be agreed with the water authority. Figure 1.4 shows a possible installation in a waterproof chamber, with an electrical earth continuity bond for metal pipework should the meter be removed. Figure 1.5 is an innovative patent meter connection to an existing stop valve body.

Internal distribution, direct and indirect systems

Direct systems are not favoured by many water authorities, as they require a consistent supply of pressurised water, which may be difficult during periods of peak demand. In the Highland areas this is viable where the sources of supply and distribution are well elevated relative to draw-off points, but for most areas the indirect system is mandatory. Although more expensive to install, with its larger cistern and almost twice as much pipework, it has the advantage of constant water pressure from the storage cistern which reduces the possibility of back siphonage (possible negative mains pressure drawing dirty water back into the main, e.g. hosepipe attached to an outside tap, with the open end submerged in a pond!).

Figures 1.6 and 1.7 provide a comparison of the systems with characteristics of installations. Note that even with an indirect system, the sink tap is connected directly to the rising main. This is the only direct connection permitted

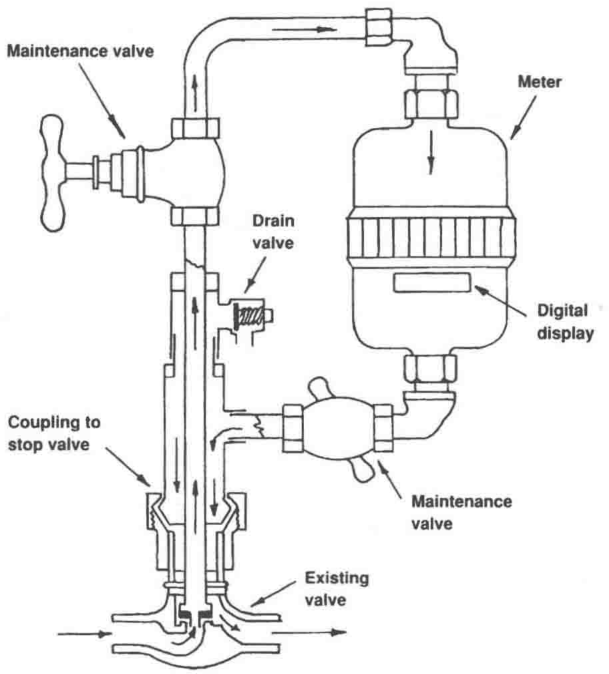

Figure 1.5 Patent meter connection

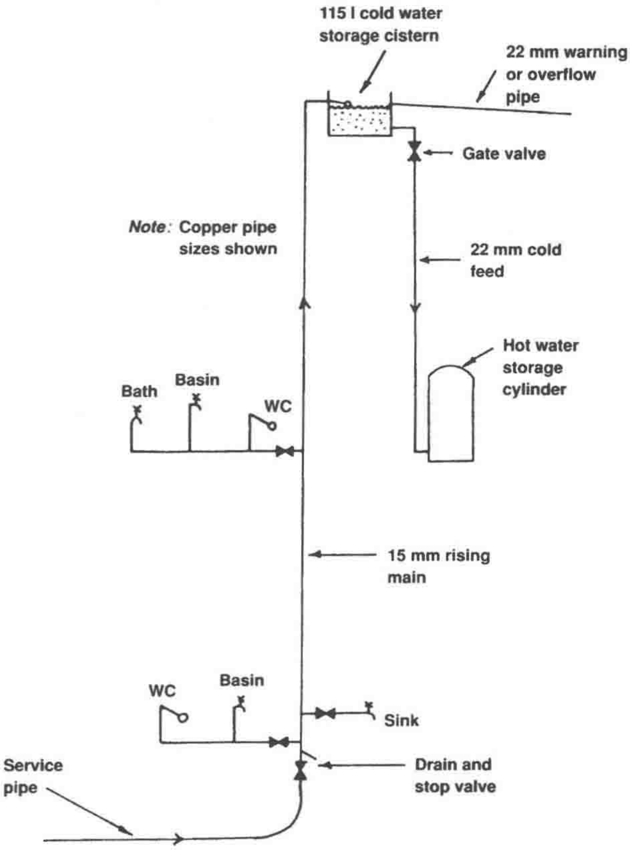

Figure 1.6 Direct cold water supply system

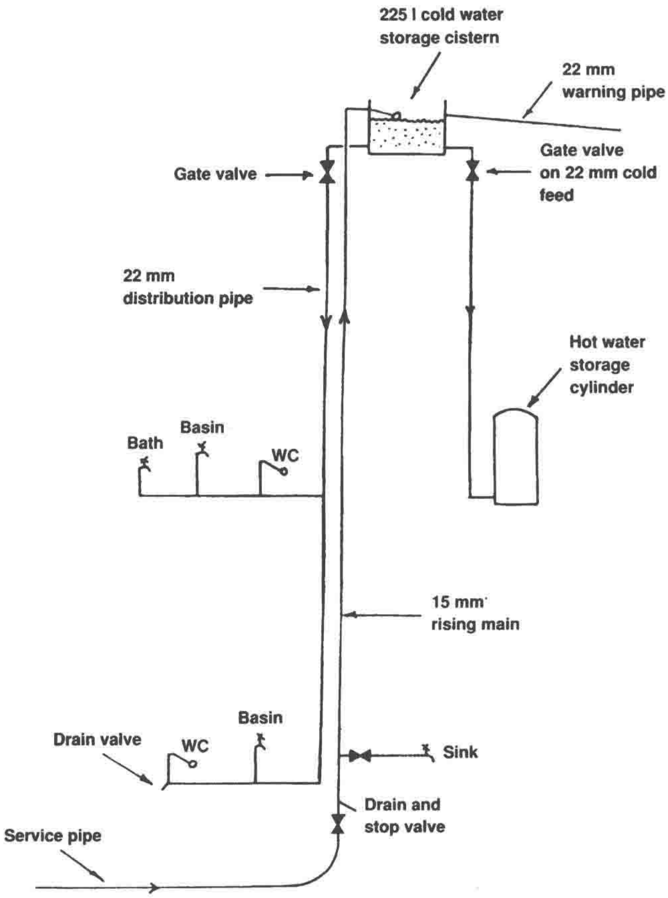

Figure 1.7 Indirect cold water supply system

in order to ensure a safe drinking water supply, as cistern-stored water could be contaminated.

Gate valves and stop valves

All mains distribution pipework is subject to high pressure, therefore the use of gate valves is not recommended in this situation as the metallic gate or sluice which slides vertically within a guide is likely to vibrate and send tremors through the pipework. This could cause fractures as well as acoustic discomfort. Also as the gate wears, it is unlikely to retain the ability totally to isolate high-pressure supplies, whereas the stop valve contains a plastic washer which will absorb wear and is easy to replace. Sectional details of both valves showing their operating features are shown in Figure 1.8.

Storage

Storage of water is in the highest possible location to maintain reasonable pressures throughout a building. This is normally in the roof space of a house,

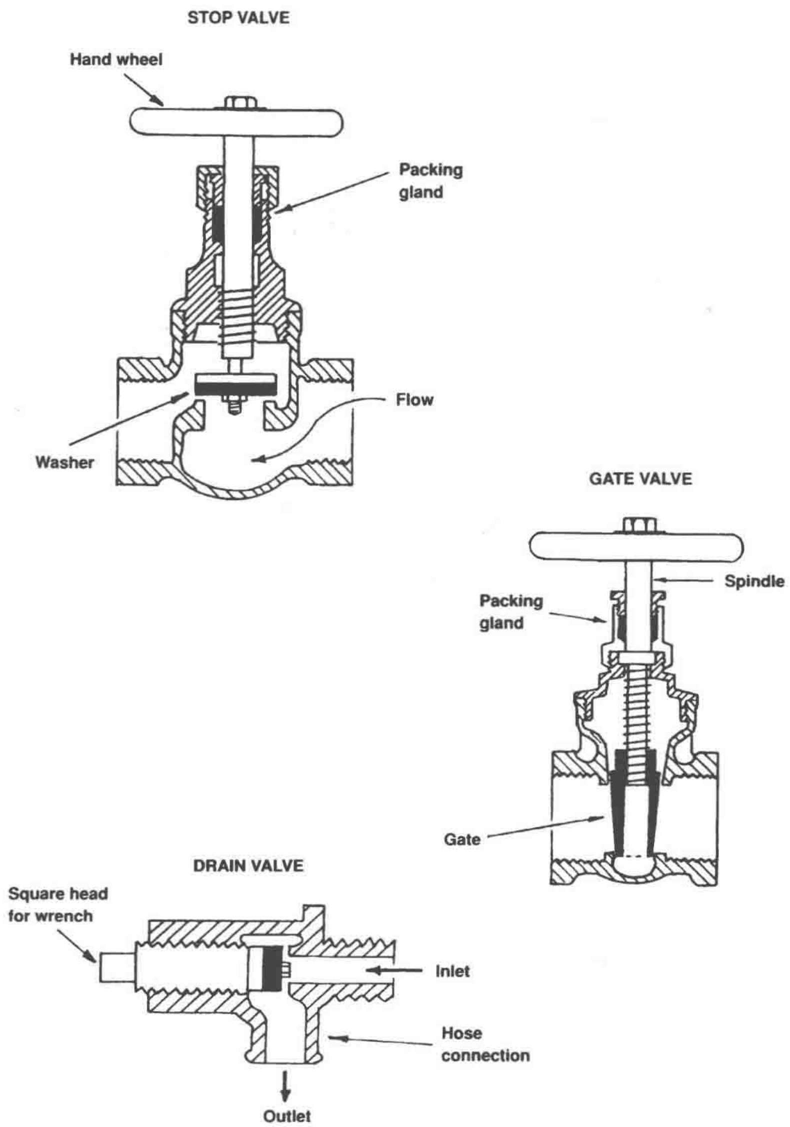

Figure 1.8 Valves

but care must be exercised to ensure that the water is not affected by dust, debris and frost. A typical installation is shown in Figure 1.9, which will provide a reserve if the mains supply is interrupted – it will reduce demand on the main and provide constant pressure to all outlets. The low-pressure supply will also limit wear on taps and fittings, reduce water wastage and noise transmission.

Cistern manufacturers and installers should comply with the following:

- use of non-corrosive, shatter-proof materials
- provide a close-fitting lid with a vent
- adequate insulation
- substantial support with a level platform

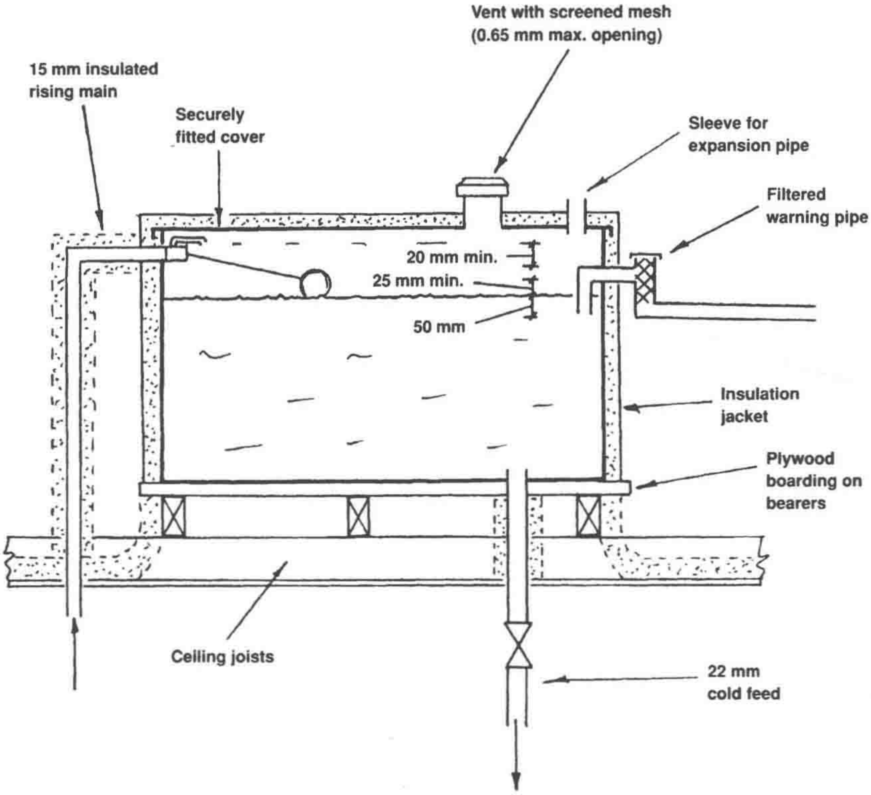

Figure 1.9 Installation of cold water storage cistern

- fitting of a warning (overflow) pipe larger in diameter than the inlet
- provide valves on every outlet (except warning pipe!)
- on large cisterns, the outlet to be opposite the inlet to encourage throughflow of water
- fitting of a float valve to regulate and control the water level.

Float valves

Float or ball valves are used to control the water level in a cistern automatically. They are manufactured in two distinct types, the traditional piston ball valve with bottom outlet and the now preferred diaphragm valve with a top outlet. Both are shown in sectional detail in Figure 1.10. In order to satisfy current legislation, a substantial air gap is required between cistern water level and float valve outlet, to prevent the possibility of back siphonage if the valve mechanism and overflow fail. This is easily achieved with the top outlet diaphragm valve, but where the bottom outlet piston-type valve is used, a non-return device known as a check valve shown in Figure 1.11 must be applied just before the ball valve. These are also required with outside tap installations.

Cold water storage capacity

Water storage is usually quantified to satisfy a 24-hour interruption of supply. As this is very rare, the designer may choose to reduce the following design guidance accordingly:

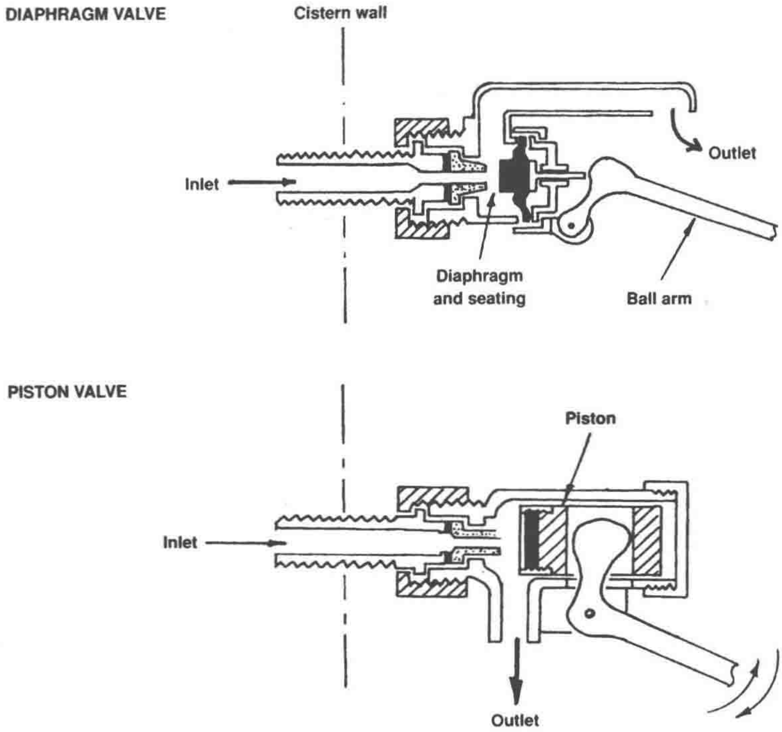

Figure 1.10 Float-operated valves

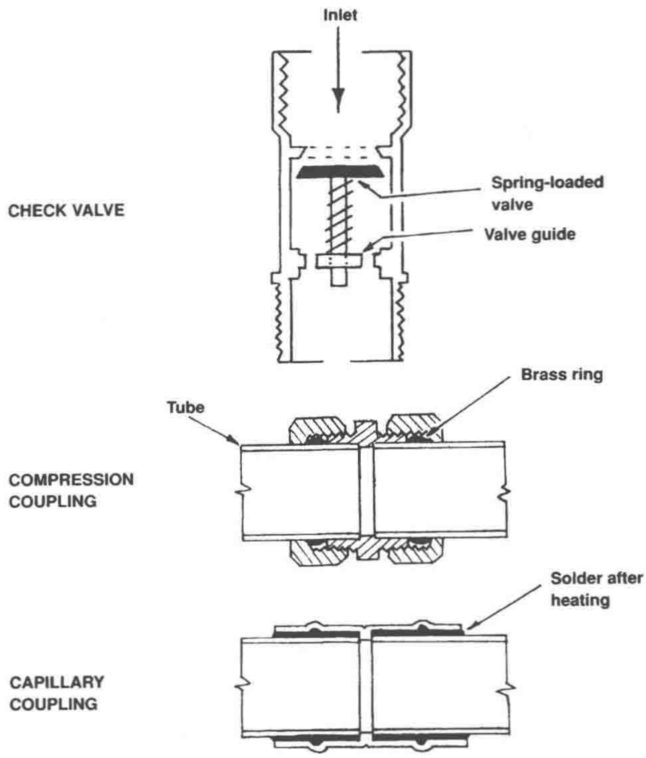

Figure 1.11 Check valve and copper couplings

Building type	Storage for 24 hours	
Dwellings	90	litres per person
Hostels	90	litres per person
Hotels	90	litres per person
Medical accommodation	115	litres per person
Offices	35–45	litres per person
Schools – boarding	90	litres per person
day	15–20	litres per person
Restaurants	7	litres per meal

If a hostel is designed to accommodate 100 students, determine the cold water storage capacity.

$$100 \text{ students} \times 90 \text{ litres (l)} = \underline{9000\text{ l}}$$

However, in the unlikely disruption of supply, the designer would be wise to acknowledge that a shut-down for 24 hours is unusual and as the situation is not desperate for water, it would be reasonable to allow perhaps 10 hours' reserve supply. Therefore the calculation could be revised thus:

$$9000\text{ l} \times \frac{10}{24} = \underline{3750\text{ l}}$$

Pipe sizing

The size of distribution pipes may be determined by established knowledge and experience, empirical formulae and calculation based on statistical usage data. The former method is appropriate for simple repetitive systems such as domestic plumbing, but when installations become more complex, calculations are essential to incorporate the numerous variables. Formulae and rules of thumb abound. One of the most successful is the formula attributed to Thomas Box, whose aged mathematical calculation of pipe diameter has survived metrication to appear thus:

$$q = \sqrt{\frac{d^5 \times H}{25 \times L \times 10^5}}$$

where q = flow rate (l/s)
d = internal diameter of pipe (mm)
H = head or pressure (m)
L = effective length of pipe (m).

When transposed to make d the subject, Box's formula appears as follows:

$$d = \sqrt[5]{\frac{q^2 \times 25 \times L \times 10^5}{H}}$$

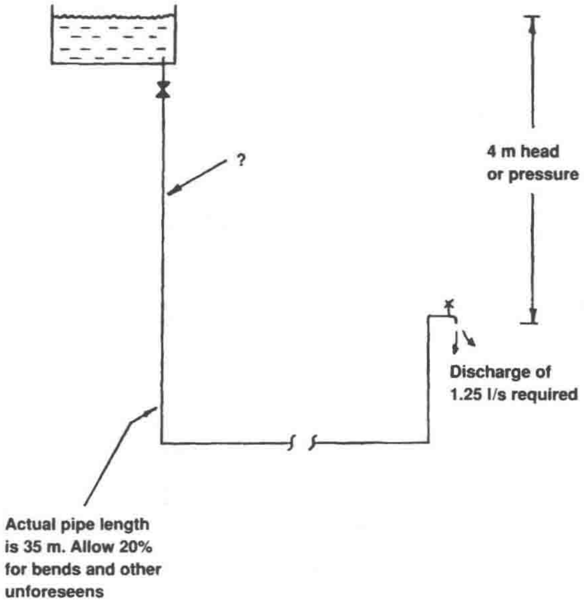

Figure 1.12 Pipe sizing

The simple installation shown in Figure 1.12 provides an opportunity to illustrate an application of this formula:

$$d = \sqrt[5]{\frac{(1.25)^2 \times 25 \times (35 + 20\%) \times 10^5}{4}}$$

$$= \sqrt[5]{410 \times 10^5} = \underline{33.3 \text{ mm}}$$

This is a general pipe-sizing formula applying to all materials, so the nearest commercial pipe size over 33.3 mm would be 38 mm inside diameter steel or 42 mm outside diameter copper. Note, steel pipes are specified internally and copper externally.

Loading unit method

Loading units are the result of statistical surveys and analysis to provide practical guidance based on intermittency of use and an expectation of flow rate at a variety of fitments:

Fitment	Loading units
Wash basin	1.5–3, depending on size
WC cistern	2
Washing machine	3
Dishwasher	3
Shower	3
Sink ($\frac{1}{2}$ in. tap)	3
Sink ($\frac{3}{4}$ in. tap)	5
Bath ($\frac{3}{4}$ in. tap)	10
Bath (1 in. tap)	22

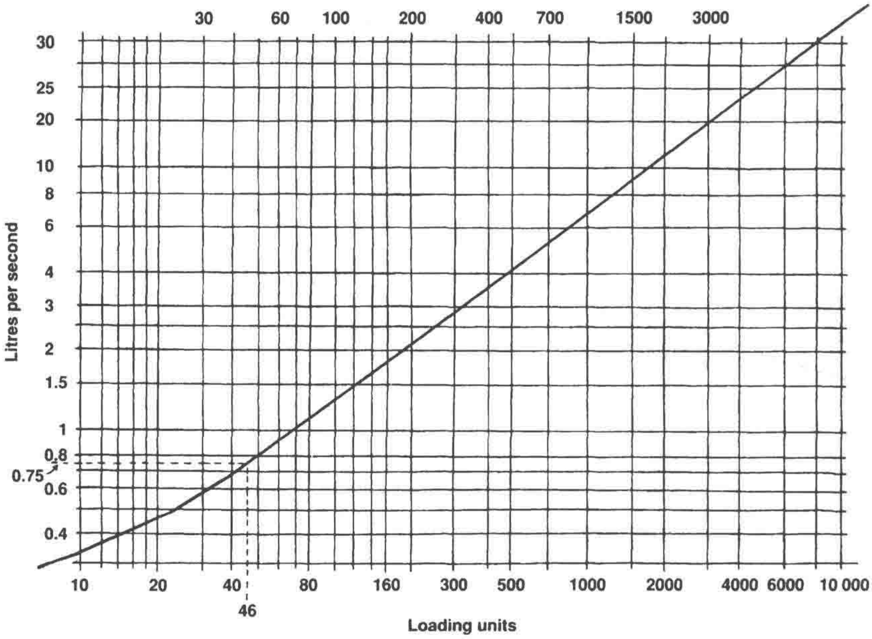

Figure 1.13 Conversion chart

Procedure

- determination of flow rate
- calculation of effective length of pipe run
- calculation of pressure or head loss due to friction.

Determination of flow rate

For industrial machinery and commercial equipment, e.g. vending machines, the desired flow rate can be established from manufacturer's data. For general use and supplies to sanitary fitments, the loading units are summed and converted to a flow rate in litres per second using the chart shown in Figure 1.13.

Calculation of effective pipe length

An allowance for bends, offsets, etc. must be made to the theoretical length of pipework, and turbulence due to valves, tee branches, etc. will also affect the flow conditions. Table 1.1 shows the effect of fittings, but at the design stage it is impossible to ascertain the number of obstructions and deviations a pipeline will have to overcome during installation. Therefore, a sensible increase (generally 10–50 per cent depending on complexity) to the actual pipe length, based on the perceived situation, will normally suffice.

Calculation of pressure or head loss

This is the relationship between potential pressure and the effective length of pipe, found by dividing the former by the latter. This, and the flow rate may be plotted on the nomogram shown in Figure 1.14. The two coordinates are extended to obtain the pipe diameter. This nomogram is specifically for copper