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The City & Guilds textbook

Book 2

Plumbing

SECOND EDITION

REVISED & UPDATED EDITION

LEVEL 3 APPRENTICESHIP (9189)
LEVEL 3 ADVANCED TECHNICAL DIPLOMA (8202)
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COLD WATER SYSTEMS, PLANNING AND DESIGN

This chapter provides learning in the application of design techniques, installation, maintenance, diagnostics and rectification of faults and commissioning procedures, along with the backflow protection in plumbing systems to comply with current legislation and regulations. The chapter also covers systems in multi-storey dwellings with water supplied from the water undertaker and private water supplies.

By the end of this chapter, you will have knowledge and understanding of the following:

- the legislation relating to the installation and maintenance of cold water systems
- cold water system layouts
- backflow protection in plumbing systems
- design techniques for cold water systems
- diagnosing and rectifying faults in cold water systems and components
- commissioning cold water systems and components
- servicing and maintenance of cold water systems.

Return to Book 1, Chapter 5, Cold water systems, which covered the following topics:

- the sources and properties of water
- the types of water supply to dwellings
- the treatment and distribution of water
- the sources of information relating to cold water systems
- the water service pipework to dwellings
- selecting cold water systems
- backflow protection
- installing cold water systems and components
- replacing or repairing defective components
- decommissioning cold water systems.

1 THE LEGISLATION RELATING TO THE INSTALLATION AND MAINTENANCE OF COLD WATER SYSTEMS

In this, the first section of this chapter, we will look at some of the many pieces of legislation that govern the installation and maintenance of cold water systems.

Cold water system legislation

The water industry in England and Wales is regulated by the Water Industry Act 1991 (the Act), as amended by the Water Act 2003 (Commencement No. 11) Order 2012, the Private Water Supplies Regulations 2016 and the Water Supply (Water Fittings) Regulations 1999. These three documents have specific roles to play within the plumbing industry. We will look at the impact of each of these documents separately.

HEALTH AND SAFETY

Return to Book 1, Chapter 1, Health and safety practices and systems.

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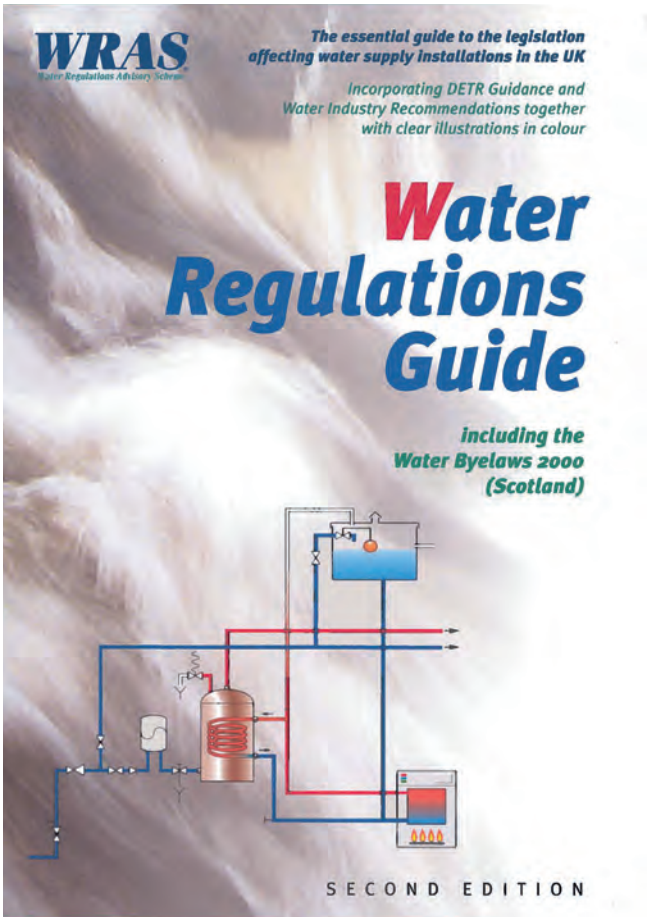

▲ Figure 1.1 Water Regulations Guide

The Water Act 2003 (Water Industry Act 1991)

The Water Act 2003 amalgamates and amends two previous pieces of legislation; the Water Industry Act 1991 and the Water Resources Act 1991. The Water Act 2003 introduced changes to the regulation of the water industry in England and Wales originally made under the Water Industry Act 1991. They are enforced by the Environment Agency and deal with such matters as:

- the appointment and regulation of water and sewerage companies and licensed water suppliers by the Water Services Regulation Authority (OFWAT)
- water supply and sewage disposal powers and duties of the water companies and suppliers
- the obligations of the water companies and licensed water suppliers to supply water that is fit for human consumption and the enforcement of those obligations by the Department of the Environment, Food and Rural Affairs (DEFRA) and the Drinking Water Inspectorate
- charging powers of water companies and suppliers and the control of those charges by OFWAT
- protection of customers and consumers by OFWAT and the Consumer Council for Water.

Under the provisions laid down by the Water Act 2003, the UK Government introduced two documents that regulate how plumbers install, commission and maintain water supplies within domestic buildings. These are:

- The Water Supply (Water Fittings) Regulations 1999
- The Private Water Supplies Regulations 2016.

The Water Supply (Water Fittings) Regulations 1999

Before 1999, each water authority had its own set of water by-laws that were based upon the 101 model water by-laws issued by the UK Government in 1986. The problem was that each **water undertaker** had local variations, which caused much confusion, as there was no 'common' standard throughout the UK.

KEY TERM

Water undertaker: a water authority or company that supplies clean, cold wholesome water under Section 67 of the Water Act 1991.

On 1 July 1999, the Office of the Deputy Prime Minister issued the first ever water regulations to be enforced in the UK. They are known as 'The Water Supply (Water Fittings) Regulations 1999' and they offer a common practice throughout the United Kingdom. **BS 8558** is the lead British Standard on the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. **BS EN 806** contains specifications for installations inside buildings conveying water for human consumption.

BS EN 806 is a relatively new British Standard that came into force in 2011. It is divided into five parts:

- general recommendations
- design
- pipe sizing
- installation
- operation and maintenance.

Both **BS 8558** and **BS EN 806** replace the old British Standard, **BS 6700**, Design, installation, testing and

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maintenance of services supplying water for domestic use within buildings and their curtilages. However, parts of **BS 6700** that are not covered in either **BS EN 806** or **BS 8558** will be retained.

INDUSTRY TIP

For more information go to the Water Regulations Advisory Scheme (WRAS) website at: www.wras.co.uk

Simply put, the Water Supply (Water Fittings) Regulations were made under Section 74 of the Water Industry Act 1991 and have been put in place to ensure that the plumbing systems we install and maintain prevent:

- contamination of water
- wastage of water
- misuse of water
- undue consumption of water
- **erroneous** metering of water.

An important factor here is that these regulations ONLY cover installations where the water is supplied from a water undertaker's water main and are enforced by the water undertaker in your area. They are NOT, however, enforceable where the water is supplied from a private water source.

KEY TERM

Erroneous: wrong or incorrect.

INDUSTRY TIP

A free copy of the Water Supply (Water Fittings) Regulations 1999 can be downloaded from: www.legislation.gov.uk/uksi/1999/1148/contents/made

The Private Water Supplies Regulations 2016

A private water supply is defined as any water supply, which is NOT provided by a water undertaker. It is not connected to any part of the water mains network and, as such, water rates are not charged, although the owner of any such supply may make a charge for any water used. Private supplies are commonly used in rural areas where connection to the water mains is difficult. A private supply may serve one property or many properties on a private network. The water may be supplied from a borehole, spring, well, river, stream or pond.

Under the Water Act 2003, the local authority in the area where the private water supply is located is responsible for the inspection and testing of the water supply to ensure that it is maintained to a quality that is fit for human consumption. These inspections and tests are made in accordance with the Private Water Supplies Regulations 2016. Generally speaking, the more people that use the supply, the more detailed the tests and the more regular the inspections have to be. Supplies for commercial properties and activities or food production and preparation have to be tested more frequently and meet more stringent requirements than domestic supplies.

The Private Water Supplies Regulations 2016 stipulate that a risk assessment must be made of ALL private water supplies including the source, storage tanks, any treatment systems and the premises using the water supply.

INDUSTRY TIP

A free copy of the Private Water Supplies Regulations 2016 can be downloaded from: www.legislation.gov.uk/uksi/2016/618/contents

Installer and user responsibilities under the Water Supply (Water Fittings) Regulations 1999

Plumbers who install plumbing systems and fittings, users, owners and occupiers have legal responsibilities under the Water Supply (Water Fittings) Regulations 1999 to ensure that any installation and the materials and fittings used comply with the regulations. In most cases, as we have seen, advanced notification of the proposed installation must be given and so architects, building developers and plumbers have to abide by the regulations on behalf of their client. These regulations are not **retrospective**, so systems installed BEFORE the regulations came into force can still be used without the need to update to current standards, even if that

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installation would not meet current requirements. However, any alteration or extension completed on an existing installation must comply with the regulations in force at the time of the installation date. Regulation 3 of the Water Supply (Water Fittings) Regulations 1999 makes this very clear.

KEY TERM

Retrospective: looking back, in this case, at previous installations.

Regulation 3 states:

1 No person shall:
   a Install a water fitting to convey or receive water supplied by a water undertaker, or alter, disconnect or use such a water fitting; or
   b Cause or permit such a water fitting to be installed, altered, disconnected or used, in contravention of the following provisions of this Part.
2 No water fitting shall be installed, connected, arranged or used in such a manner that it causes or is likely to cause:
   a Waste, misuse, undue consumption or contamination of water supplied by a water undertaker; or
   b The erroneous measurement of water supplied by a water undertaker.
3 No water fitting shall be installed, connected, arranged or used which by reason of being damaged, worn or otherwise faulty, causes or is likely to cause:
   a Waste, misuse, undue consumption or contamination of water supplied by a water undertaker; or
   b The erroneous measurement of water supplied by a water undertaker.

The following points are worth remembering:

- Plumbers should obtain a copy of the regulations, any amendments and guidance notes from Her Majesty's Stationery Office (HMSO) or a copy of the Water Regulations Guide from the Water Regulations Advisory Scheme (WRAS) to ensure that any plumbing work complies with the regulations. They must ensure that any fittings and materials are of a sufficient quality and that any installation is installed in a workmanlike manner to an approved installation standard requirement. Membership of a competent person scheme is advisable.
- Users, owners and occupiers must ensure that the person employed to undertake the proposed work is aware of the regulations and that any work completed is done so in accordance with the regulations. A certificate of compliance MUST be obtained for the work and retained for future reference by the user, owner or occupier. Regulation 3 also makes it clear that the user, owner or occupier is responsible for ensuring that waste, misuse, undue consumption, contamination or erroneous metering of the water supply does not occur during usage.
- The Government requires the water undertakers enforce the regulations within their area of supply. They will undertake inspections of new and existing installations to check that the regulations are being complied with. Where breaches of the regulations are found, they must be remedied as soon as practicable. Where breaches present a significant health risk, the water supply to the premises may be isolated or, in severe cases, disconnected immediately to protect the health of occupants and/or others fed from the same public supply. The Government has deemed that it is a criminal offence to breach the regulations, and offenders, including users, owners and occupiers in cases where the original installer cannot be traced, may face prosecution.

Notification requirements

Now we will investigate the requirements of notification and consent with regard to cold water installations. We need to consider:

- Who needs to notify?
- Which types of installations require notification and consent?
- Why do we need to notify?
- Who do we notify?

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The Water Supply (Water Fittings) Regulations requirements

Regulation 5 of the Water Supply (Water Fittings) Regulations requires that the water undertaker must be notified before work is commenced on most types of plumbing installations and anyone installing or using the installation without the water undertaker's written consent could be committing a criminal offence.

VALUES AND BEHAVIOURS

Being aware of the regulations that may apply to any job you commence will ensure you are working within the law.

Notification and consent are also legally required where water fittings are to be installed on any water or waste water plants. This requirement applies irrespective of whether the plant is owned/operated by the same organisation as the enforcing water undertaker.

Consent is necessary for the installation of fittings in new buildings and dwellings, extensions and alterations of water systems in existing non-domestic premises, where there is a material change of use of a building and for the installation of certain specified items. These include:

- a bidet with an ascending spray or flexible hose
- a bath larger than 230 litres (measured to the centre of the overflow)
- a shower unit of a type specified by the regulator
- a pump or booster drawing more than 12 litres per minute
- a reverse osmosis unit
- a water treatment unit producing a waste water discharge or requiring water for regeneration or cleaning
- a reduced pressure zone (RPZ) valve or other mechanical device for protection against backflow in fluid category 4 or 5
- a garden watering system unless designed to be a hand-operated one
- any water system laid outside a building and either less than 750 mm or more than 1350 mm below ground level
- construction of an automatically-replenished pond or swimming pool of more than 10,000 litres.

When notifying the water undertaker, the following information must be sent:

- the name and address of the person giving notice and, if different, of the person to whom the consent should be sent
- a description of the proposed work and any related change of use of premises
- the location of the premises and their use or intended use
- the plumbing contractor's name and address, if an approved plumber is to do the work.

Consent cannot be withheld unless there are reasonable grounds to do so, and may be granted subject to conditions, which must be followed. If written approval is not given within ten working days it can be assumed that consent has been granted but this does not alter the obligation upon the installer and the owner or occupier to ensure that the regulations have been complied with.

Notification and consent requirements: the Building Regulations Approved Document G requirements

From 6 April 2010 an updated and extended version of Part G was implemented, bringing in a number of new areas under Building Regulations control. As such, under these new areas of control, the installation of the systems mentioned in Regulation 5 of the Water Supply (Water Fittings) Regulations are notifiable to the local authority building control. In general terms, notification must take place prior to the work starting and within five working days of the work being completed.

INDUSTRY TIP

A free copy of the Building Regulations Approved Document G can be downloaded from: www.gov.uk/government/publications/sanitation-hot-water-safety-and-water-efficiency-approved-document-g

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The new regulation Approved Document G is broken down into six parts:

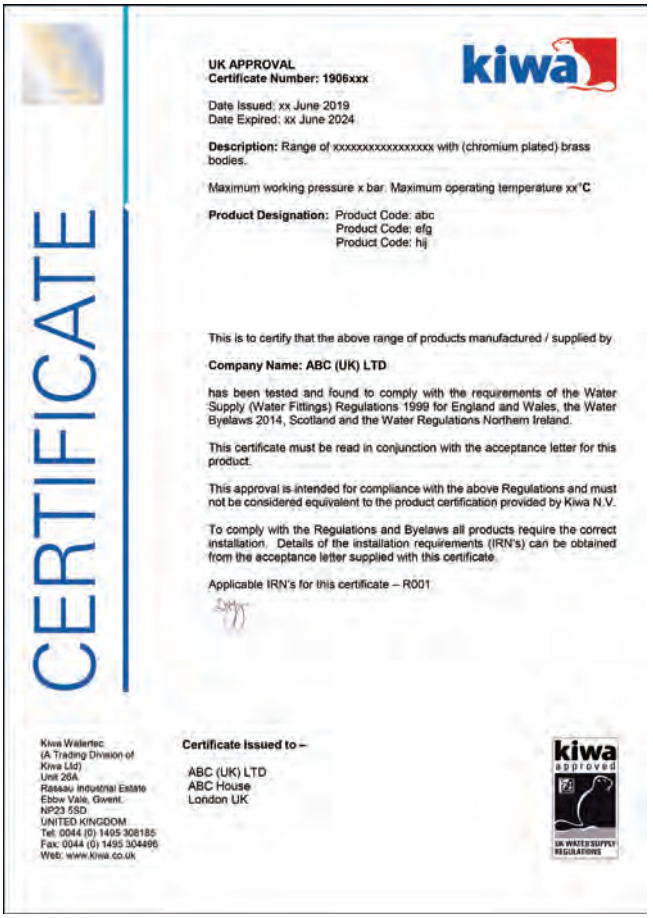
- G1 Cold water supply – new requirements on supply of wholesome water for purposes of drinking, washing or food preparation. Also for the provision of water of a suitable quality to sanitary conveniences fitted with a flushing device.
- G2 Water efficiency – G2 and Regulation 17K of the Building Regulations 2000 set out new requirements on water efficiency in dwellings.
- G3 Hot water supply and systems – sets out enhanced and amended provisions on hot water supply and safety, applying safety provisions to all types of hot water systems and a new provision on scalding prevention.
- G4 Sanitary conveniences and washing facilities – sets out requirements for sanitary conveniences and hand washing facilities.
- G5 Bathrooms – sets out requirements for bathrooms, which apply to dwellings and to buildings containing one or more rooms for residential purposes.
- G6 Kitchens and food preparation areas – contains a new provision requiring sinks to be provided in areas where food is prepared.

Certification of plumbing installations

As a direct result of the introduction of the Water Supply (Water Fittings) Regulations in 1999, the water undertakers began to recognise competent persons schemes, approved plumber schemes and self-certification of certain plumbing installations. These are administered and regulated by the local water undertaker.

Under Water Supply Regulation 5, if a person proposes to carry out plumbing work on any building other than a house or dwelling, they can either:

- notify their local water undertaker, or
- use an **approved plumber**/contractor who will issue a Water Regulation Compliance Certificate. This certificate confirms that the work has been carried out in accordance with the regulations and that the fittings and materials used meet the strict requirements of the regulations.


CERTIFICATE

kiwa

UK APPROVAL
Certificate Number: 1906xxx

Date Issued: xx June 2019
Date Expired: xx June 2024

Description: Range of xxxxxxxxxxxxxxxx with (chromium plated) brass bodies.

Maximum working pressure x bar. Maximum operating temperature xx°C

Product Designation: Product Code: abc
Product Code: efg
Product Code: hij

This is to certify that the above range of products manufactured / supplied by

Company Name: ABC (UK) LTD

has been tested and found to comply with the requirements of the Water Supply (Water Fittings) Regulations 1999 for England and Wales, the Water Byelaws 2014, Scotland and the Water Regulations Northern Ireland.

This certificate must be read in conjunction with the acceptance letter for this product.

This approval is intended for compliance with the above Regulations and must not be considered equivalent to the product certification provided by Kiwa N.V.

To comply with the Regulations and Byelaws all products require the correct installation. Details of the installation requirements (IRN's) can be obtained from the acceptance letter supplied with this certificate.

Applicable IRN's for this certificate – R001

Kiwa Watertec
(A Trading Division of Kiwa Ltd)
Unit 26A
Rassau Industrial Estate
Ebbw Vale, Gwent.
NP23 5SD
UNITED KINGDOM
Tel: 0044 (0) 1495 308185
Fax: 0044 (0) 1495 304496
Web: www.kiwa.co.uk

Certificate Issued to –

ABC (UK) LTD
ABC House
London UK

kiwa approved
UK WATER SUPPLY REGULATIONS

▲ Figure 1.2 An example of a certificate produced by KIWA, which proves quality, credibility and compliance

KEY TERM

Approved plumber: a plumber that has undertaken specific Water Regulations training and is recognised as competent by the water undertaker.

What are competent persons schemes and approved plumber schemes?

A plumber who can prove, via an assessment, a substantial knowledge of the Water Supply (Water Fittings) Regulations, can join a competent persons scheme (CPS). The main benefit for members of these schemes is that they can self-certify plumbing supply work (domestic commercial and industrial) that would otherwise have to wait for water company approval before work could commence.

The first of these schemes to emerge was the water industry approved plumber scheme (WIAPS), set up by most of the water undertakers in England and Wales.

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2 COLD WATER SYSTEM LAYOUTS

In this section, we will take a look at the component layout features and functions for cold water systems and the methods of providing water supplies.

Layout features for multi-storey dwellings

In plumbing systems, the phrase '**multi-storey**' applies to buildings that are simply too tall to be supplied totally using just the pressure of the water main. Because of their design, these buildings have particular cold water system requirements that can only be satisfied by pumping or 'boosting' the cold water supply either in part or in total.

KEY TERM

Multi-storey building: a building having more than three floors.

Most cold water supplies that are delivered from the mains cold water supply arrive at a building at a three to seven bars pressure (30–70 metres head). A 30 m head is equivalent to around eight storeys in height. When taking into account a two-storey margin to allow for frictional losses, it becomes obvious that the height of the building will often outstrip the head of pressure available. In some parts of the UK, it is not unusual to find premises with pressures lower than two bars and flow rates of below 15 litres/minute. In these cases, the water undertaker should be consulted as to where supply pressures can be relied upon to ensure the correct operation of the cold water system.

If the public supply is inadequate or the building too high, then the water supply within the building must be boosted. There are several ways that this can be achieved and these can be divided into:

- direct boosting systems, direct from the cold water mains supply
- indirect boosting systems, from a break cistern.

Indirect systems are the most common, as direct boosting systems are often forbidden by the water undertakers because they can often reduce the mains pressure available to other consumers in the locality and can increase the risk of contamination by backflow.

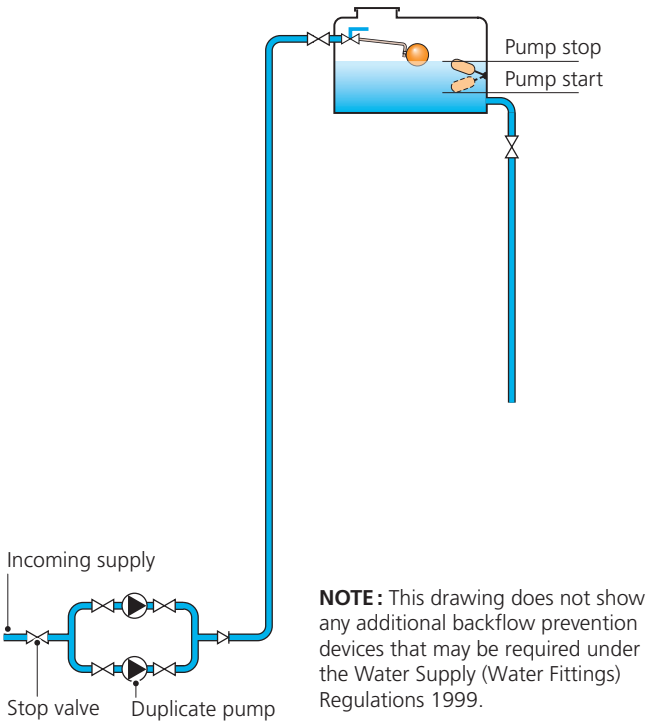
However, where insufficient water pressure exists and the demand is below 0.2 litres/second, then drinking water may be boosted directly from the supply pipe provided that the water undertaker agrees. With indirect systems, a series of float switches in the break cistern starts and stops the pumps depending upon the water levels in the cistern.

Boosting pumps can create excessive aeration of the water, which, although causing no deterioration of water quality, can cause concern to the consumer because of the opaque, milky appearance of the water. There are several common examples of these systems:

- direct boosting systems
- direct boosting to a drinking water header and duplicate storage cisterns
- indirect boosting to a storage cistern
- indirect boosting with a pressure vessel.

Direct boosting systems

Where permission from the water undertaker has been granted, pumps can be directly fitted to the incoming supply pipe to enable the head of pressure to be increased.



▲ Figure 1.3 Direct boosting system

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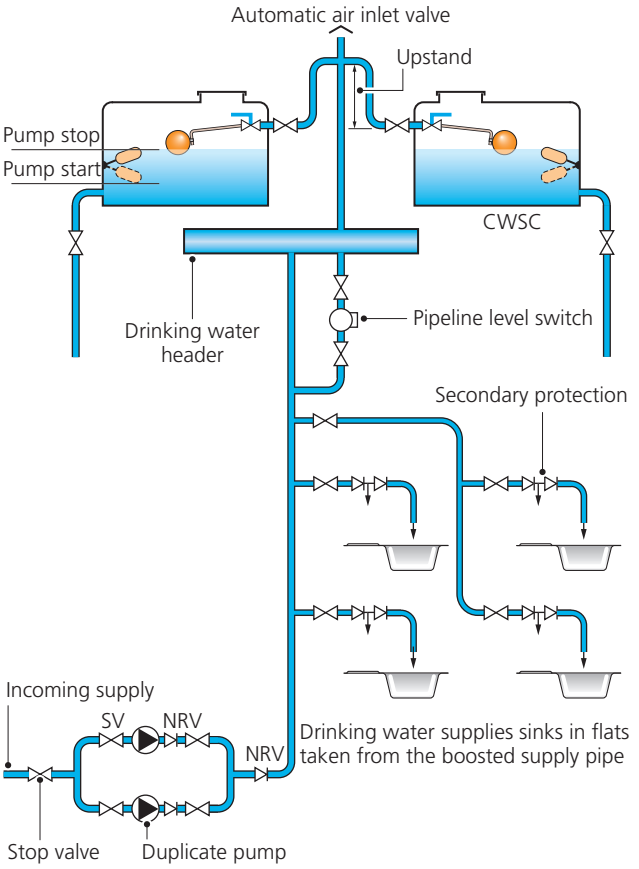
A float switch, or some other no less effective device, situated inside the high-level cistern controls the pumps. The pumps either switch on or off depending upon the water level in the cistern. The pumps are activated when the water drops to a depth normally equal to about half cistern capacity and switch off again when the water level reaches a depth approximately 50 mm below the shut off level of the float operated valve.

If the cistern is to be used for drinking water, then it must be of the protected type.

Direct boosting to a drinking water header and duplicate storage cisterns

This system is mainly used for large and multi-storey installations. With this system, the cisterns at high level are for supplying non-drinking water only, a drinking water header sited on the boosted supply pipe provides limited storage of 5–7 litres drinking water to sinks in each dwelling when the pump is not running. Excessive pressure should be avoided as this can lead to an increase in the wastage of water at the sink taps along with the nuisance of excessive splashing.



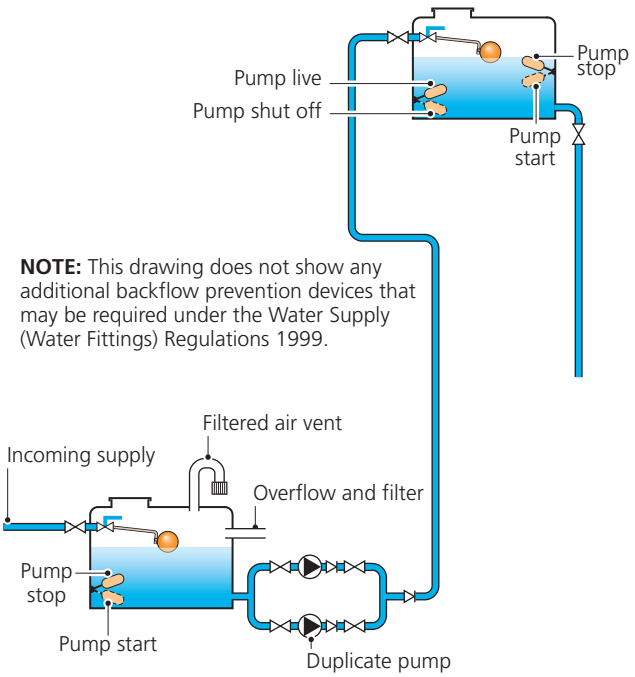
▲ Figure 1.4 Direct boosting to drinking header

A pipeline switch on the header by-pass starts the pumps when the water level falls to a predetermined level. The pumps can be time controlled or activated to shut down by a pressure switch. When filling the cisterns, the pumps should shut down when the water levels in the cisterns are approximately 50 mm below the shut off level of the float operated valve.

Secondary backflow devices may be required at the drinking water outlets on each floor.

Indirect boosting to a storage cistern

This system incorporates a break cistern to store the water before it is pumped via a boosting pump (known as a booster set) to a storage cistern at high level. The pumps should be fitted to the outlet of the break cistern. The capacity of the break cistern needs careful consideration and will depend upon the total water storage requirements and the cistern's location within the building, but it should not be less than 15 minutes of the pumps maximum output. However, the cistern must not be oversized as this may result in water stagnation within the cistern.



▲ Figure 1.5 Indirect boosting to a storage cistern

The water level in the storage cistern (or cisterns) is usually controlled by means of water level switches which control the pumps. When the water drops to a predetermined level the pumps start filling the storage

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cisterns. The pumps are then switched off when the water level reaches a point about 50 mm from the shut off level of the float operated valve. A water-level switch should also be positioned in the break cistern to automatically shut off the pumps if the water level drops to within 225 mm of the suction connection near the bottom of the break cistern. This is simply to ensure the pumps do not run dry.

Indirect boosting with a pressure vessel

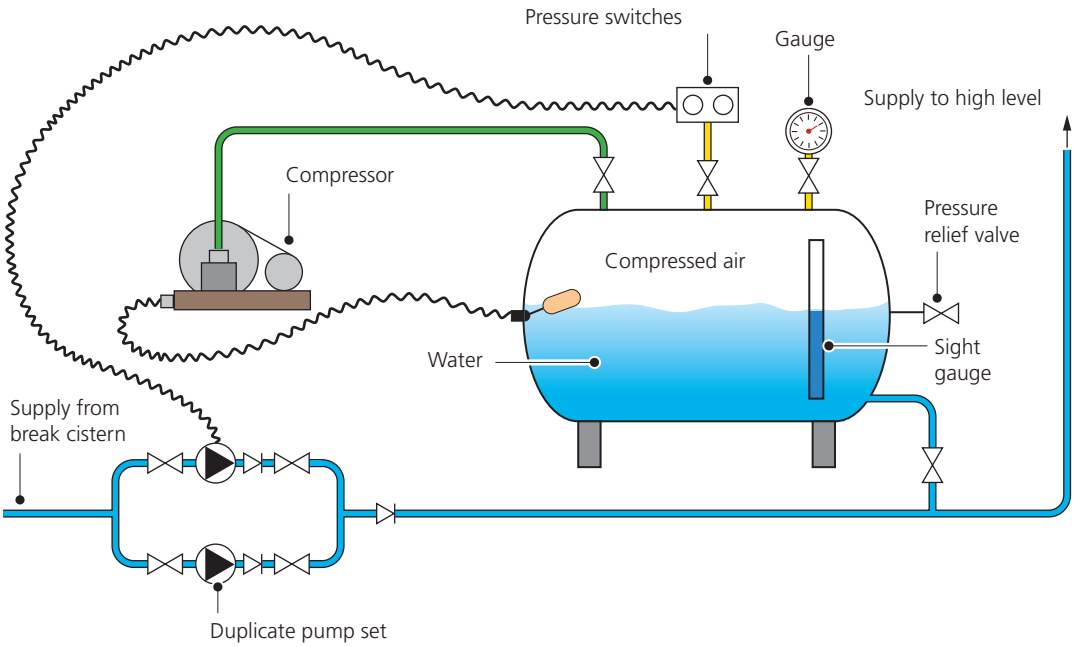
This rather complicated system is mainly used in buildings where a number of storage cisterns are fed at various floor levels making it impractical to control pumps by water level switches. It utilises a pneumatic pressure vessel to maintain the pressure boost to the higher levels of the building.

The pneumatic pressure vessel comprises of a small water reservoir with a cushion of compressed air. The water pumps and the compressed air operate intermittently. The pumps replenish the water level and the pressure vessel maintains the system pressure. Since the system may be supplying drinking water, the vessel capacity is kept purposely low to ensure a rapid and regular turnover of water. The compressed air must be filtered to ensure that dust and insects are eliminated.

▲ Figure 1.7 A typical booster set with pressure vessel and control boards

Normally, the controls including the pressure vessel, pumps, air compressor and control equipment are purchased as a package, although self-assembled booster sets are available.

As can be seen in Figure 1.8, some of the floors below the limit of the mains cold water supply pressure are supplied un-boosted directly from the cold water main with the floors above the mains pressure limit being supplied via the break cistern and booster set. Drinking water supplies must be from a protected cistern.



▲ Figure 1.6 Auto pneumatic pressure vessel

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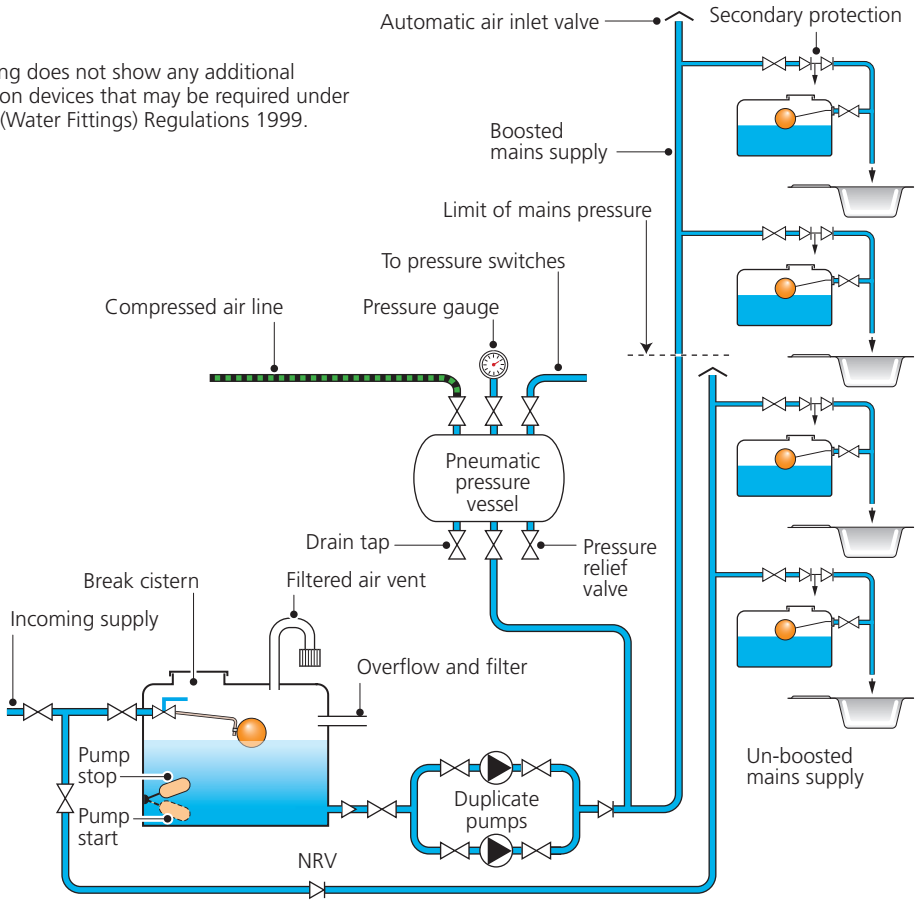
NOTE: This drawing does not show any additional backflow prevention devices that may be required under the Water Supply (Water Fittings) Regulations 1999.



▲ Figure 1.8 Indirect boosting with pressure vessel

Layout features for large-scale storage cisterns used in multi-storey cold water systems

The installation of large-scale cisterns differs somewhat from the cisterns that were introduced in Chapter 5 of Book 1. Large cisterns must be installed in accordance with the Water Supply (Water Fittings) Regulations 1999 (and the Scottish Water Byelaws 2014). Regulation 5 states that the water undertaker must be notified before the installation of large cisterns begins and it is important to remember that the correct backflow protection must be present in relation to the fluid category of the contents of the cistern.

In this section of the chapter, we will look at the general requirements of large-scale cisterns.

Materials for large-scale cisterns

Large cisterns can be made from several materials and can be either one piece or sectional.

Sectional cisterns are constructed, usually on site, from 1 m² sections, which are bolted together and can be made to suit literally any capacity and tailored to fit any space. Sectional cisterns can be internally or externally flanged and are bolted together with stainless steel bolts.

The main materials used for:

- One-piece cisterns:
  - glass-reinforced plastic (GRP) **BS EN 13280:2001**
  - plastic **BS 4213:2004** and **BS EN 12573.1:2000**:
    - polyproylene (PP)
    - polyethylene (PE)
    - polyvinyl chloride (PVC)
- Sectional cisterns:
  - glass-reinforced plastic (GRP) **BS EN 13280:2001**
  - steel with protection against corrosion and subsequent water contamination in the form of:
    - paint protected with a paint that is listed in the Water Materials and Fittings Directory

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- glass-coated
- galvanised
- rubber-lined.
- aluminium – rubber-lined.

▲ Figure 1.9 One-piece GRP cisterns

▲ Figure 1.10 A sectional cistern

Overflow and warning pipe requirements of large-scale cisterns

Overflows for large cisterns are quite different from those fitted to cisterns for domestic purposes. The objective is the same – to warn that the float operated valve is malfunctioning and to remove water that may otherwise damage the premises. But with larger cisterns, the potential for water wastage and water damage is far greater. Therefore, the layout is different.

The overflow/warning pipe on large-scale cisterns must:

- contain a vermin screen to prevent the ingress of insects and vermin
- be capable of draining the maximum inlet flow without compromising the inlet air gap
- contain an air break before connection to a drain
- not be of such a length that it will restrict the flow of water, causing the air gap to be compromised
- discharge in a visible, conspicuous position.

The warning pipe invert needs to be located a minimum of 25 mm above the maximum water level of the cistern and the air gap not less than 20 mm or TWICE the internal diameter of the inlet pipe, whichever is the greater.

The general features of larger cisterns are:

- Cisterns with an actual capacity of 1000 litres to 5000 litres:
  - The discharge level of the inlet device must be positioned at least twice the diameter of the inlet pipe above the top of the overflow pipe.

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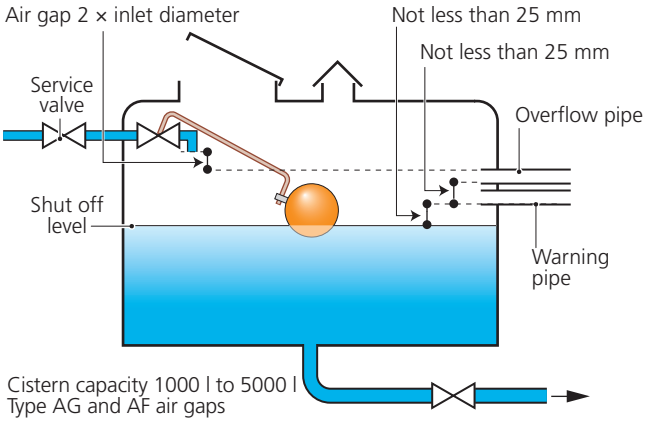
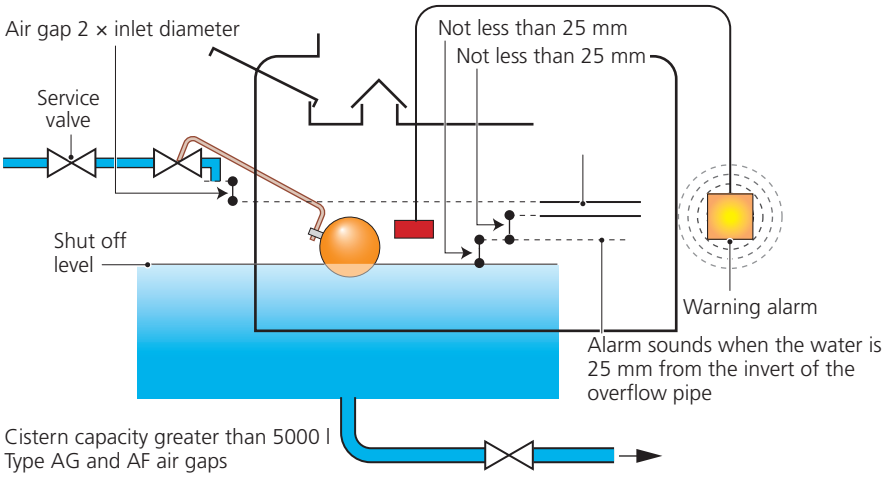
  - The overflow pipe invert must be located at least 25 mm above the invert of the warning pipe (or warning level if an alternative warning device is fitted).
  - The warning pipe invert must be located at least 25 mm above the water level in the cistern and must be at least 25 mm diameter.
- Cisterns with an actual capacity greater than 5000 litres:
  - The discharge level of the inlet device must be positioned at least twice the diameter of the inlet pipe above the top of the overflow pipe.
  - The overflow pipe invert must be located at least 25 mm above the invert of the warning pipe (or warning level if an alternative warning device is fitted).
  - The warning pipe invert must be located at least 25 mm above the water level in the cistern and must be at least 25 mm diameter.



▲ Figure 1.11 Cisterns 1000–5000 litres



▲ Figure 1.12 Cisterns greater than 5000 litres

- Alternatively, the warning pipe may be discarded provided a water level indicator with an audible or visual alarm is installed that operates when the water level reaches 25 mm below the invert of the overflow pipe.

INDUSTRY TIP

References to the 'actual capacity' of a cistern simply means the maximum volume which it could hold when filled to its overflowing level. 'Nominal capacity' is the total volume it could hold when filled to the top of the cistern.

In both cases, the size of the overflow pipe will depend upon the type of air gap incorporated into the cistern (we will look at air gaps and backflow protection a little later in this chapter) and this will depend upon the fluid category of the cistern contents. It must be remembered that:

- if a type AG air gap (fluid category 3) is fitted, the overflow diameter shall be a minimum of twice the inlet diameter
- if a type AF air gap (fluid category 4) is fitted, the minimum cross-sectional area of the overflow pipe must be, throughout its entire length, four times the cross-sectional area of the inlet pipe.

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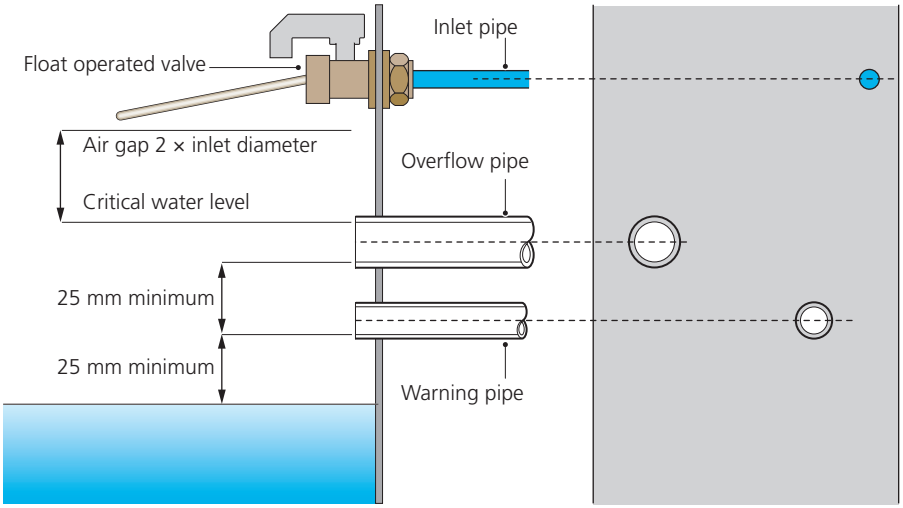

▲ Figure 1.13 Relative positions of inlet, warning pipe and overflow for type AG and AF air gaps

For all cisterns greater than 1000 litres, the invert of the overflow must not be less than 50 mm above the working level of the cistern.

Methods of filling large-scale cisterns

Section 7, Schedule 2, Paragraph 16 of the Water Supply (Water Fittings) Regulations states:

> Every pipe supplying water connected to a storage cistern shall be fitted with an effective adjustable valve capable of shutting off the inflow of water at a suitable level below the overflowing level of the cistern.

In domestic cistern installations up to 1000 litres, this is usually a float operated valve to **BS 1212**. In large-scale cisterns, however, other means of filling the cistern are available:

- float operated valves
- solenoid valves.

Float operated valves BS 1212

There are basically four types of float operated valve (FOV) that can be installed on large-scale cisterns. These are:

- **BS 1212** Parts 1 and 2 float operated valves
- equilibrium float operated valves
- pressure operated float valves
- Keraflo delayed action float valves.

We will look at the merits of each valve in turn.

BS 1212 Parts 1 and 2

These are the most common types of FOV. The main problem with this type of FOV is that they are very restrictive to water flow and incur a much greater pressure (head) loss than other types of FOVs, making cistern filling a long process. Wear on the washer and orifice can also be problematic when the valve is in constant use. They are, however, satisfactory when intermittent use is anticipated. These were looked at in detail in Book 1.

Equilibrium float operated valves

The **equilibrium** FOV offers a greater flow rate and lower pressure loss than the **BS 1212** type and are especially beneficial for large cisterns with a high-pressure inlet cold water supply.

KEY TERM

Equilibrium: in perfect balance. In this case, the pressure is balanced both sides of the valve.

Unlike other FOVs, the equilibrium type does not rely solely on the float to successfully close the valve. Instead, the closing operation is aided by the water pressure of the incoming mains cold water supply allowing a smaller float to be used.

As can be seen in Figure 1.14, the piston has a hole running through its length. This allows water to pass through to the back of the piston, which has the effect

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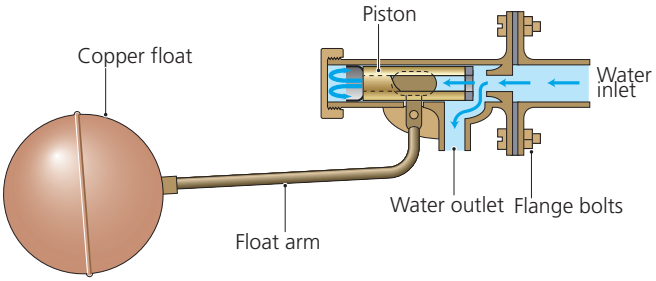
of pushing the piston towards valve shut off whilst the water at the front of piston tends to push it away, equalising the pressure both sides of the barrel. The float now only has to lift the arm to close the valve greatly reducing the effort required to stop the flow of water.



▲ Figure 1.14 An equilibrium float operated valve

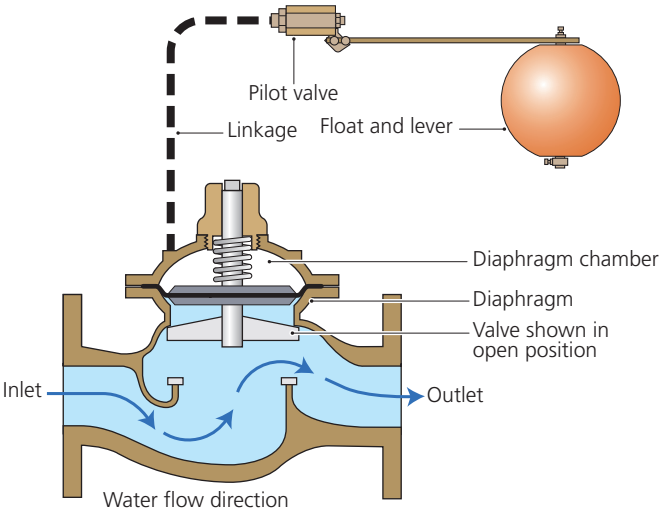
Equilibrium valves are an advantage where the water pressure is high and water hammer may be a concern. Almost all FOVs above 54 mm are of this type.

Pressure operated valves

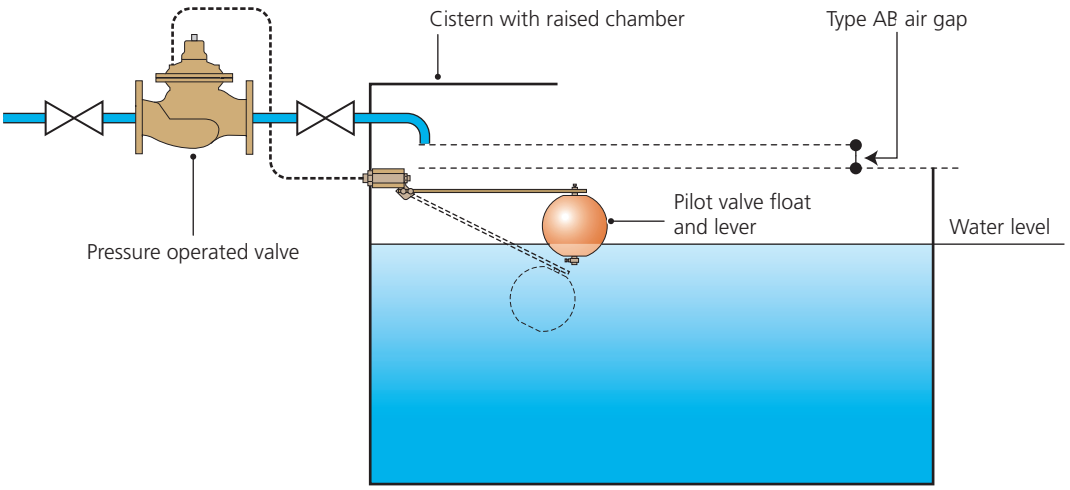
The pressure operated FOV uses the pressure of the cold water main to assist the valve closure by the use of a pilot valve controlled by the lever and the float. Often called the pilot operated valve, the advantage here is that the variations in water tank levels between fully open and fully closed are greatly reduced. Although the head loss is greater than with the equilibrium type, the pressure operated valve is particularly suited to large cisterns with a high-pressure supply.

How do pressure operated valves work?

At zero pressure, the valve is closed. As water enters the valve inlet and the pressure increases, the valve opens to allow water to flow to the cistern. When the water has reached its shut off level, the pilot valve, operated by the float and lever, closes. This causes the pressure within the diaphragm chamber to increase, thereby closing the water inlet and stopping the flow of water. As the water level drops, the float operated pilot valve opens, releasing the pressure of the diaphragm chamber. Water pressure then re-opens the inlet valve and the cistern fills again to its shut off level.



▲ Figure 1.15 The pressure operated valve



▲ Figure 1.16 The pressure operated valve cistern layout

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Keraflo delayed action float valve

An alternative approach to cistern filling is the Keraflo delayed action float valve. This type of valve only opens when the water falls to a pre-set level in the cistern, opening fully to achieve a fast cistern fill. The benefits here are that not only does the cistern fill quickly but also that the velocity of the water entering the cistern means that the water will mix with the cistern contents preventing **stratification**.

The valve opens at a predetermined water level, opening and closing fully eliminating water hammer and unwanted system noise. An adjustable water level enables the levels to be set based upon water usage or, in the case of large domestic installations, occupancy levels.

The design of the valve means that boosting pumps are used less frequently. With a conventional FOV, pumps activating every few minutes wastes energy and increases pump wear. A delayed action float valve eliminates this by allowing the pumps to be activated only once every few hours when the water level has fallen sufficiently.

KEY TERM

Stratification: describes how the temperature of the water varies with its depth. The nearer the water is to the top of the cistern, the warmer it will be. The deeper the water, the colder it will be. This tends to occur in layers, whereby there is a marked temperature difference from one layer to the next. The result is that water quality can vary, the warmer water near the top being more susceptible to biological growth such as *Legionella pneumophila* (Legionnaires' disease).

Solenoid valves

A solenoid valve is an electromechanical valve that controls the flow of water into the cistern. The solenoid is an electromagnet that operates when an electrical current runs through the coil. When the coil is not energised, a spring keeps the valve shut.

Most solenoid valves used on large cisterns are of the servo-type (also called the pilot type solenoid valve). With this type, the electromagnet operates a plunger, which opens and closes a pilot orifice. The incoming water pressure, which is fed through the pilot orifice, opens the valve seal allowing water to flow through the valve. As the pilot valve closes, the pressure on the valve seal decreases and a spring closes the valve.

Although very rarely used with modern systems, a solenoid valve discharging through an open-ended pipe when used in conjunction with a float switch to activate the solenoid valve is an acceptable alternative method of filling large-scale cisterns (we will look at float switches a little later in the chapter). They are generally associated with boosted cold water systems.

▲ Figure 1.17 The Keraflo 'Aylesbury' type delayed action float valve

▲ Figure 1.18 A servo-type solenoid valve

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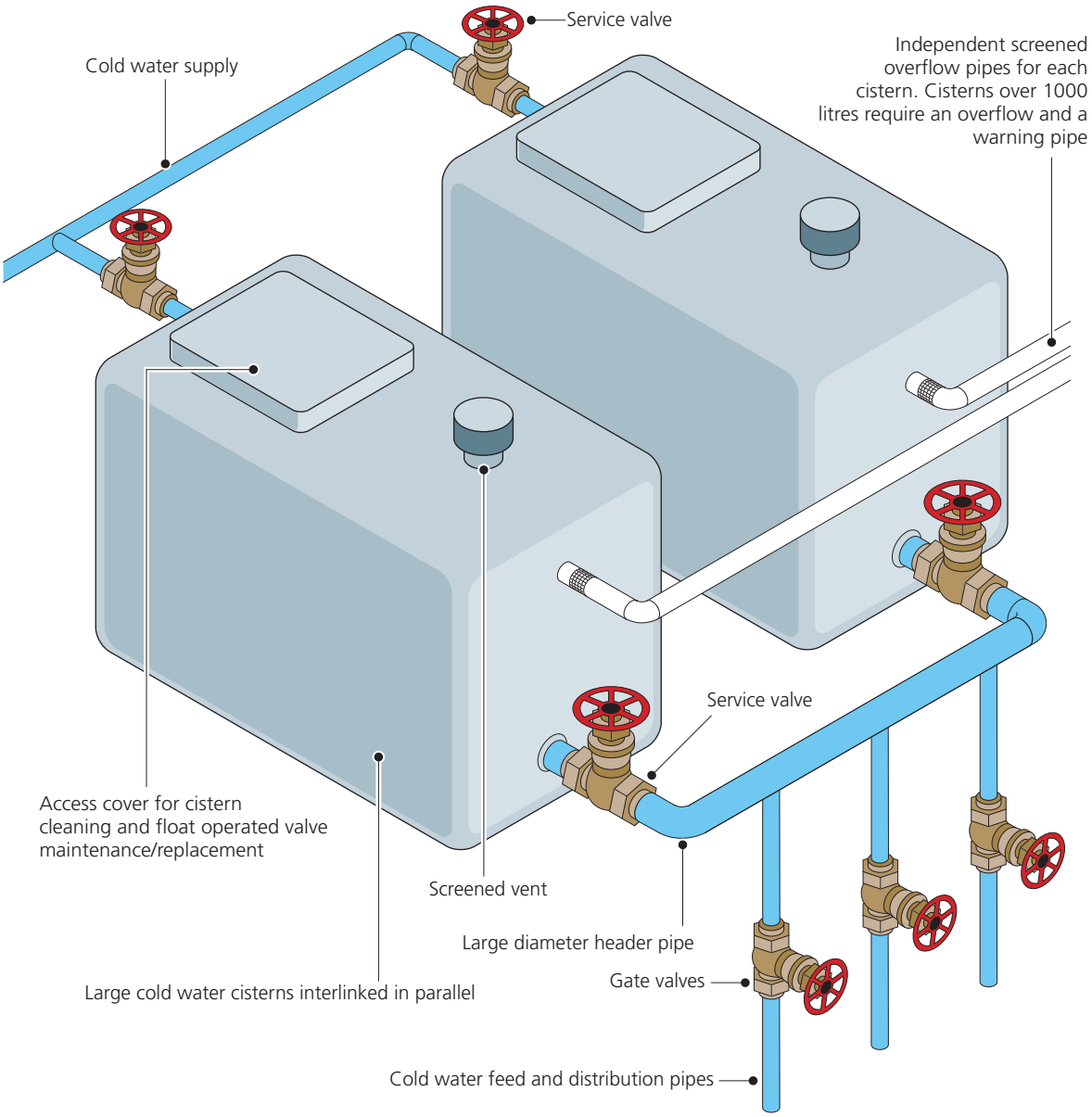
Multiple cistern installations

Where large quantities of water are required but space is limited, then cisterns can be interlinked, provided the cisterns are the same size and capacity. Problems can occur if the cisterns are not linked correctly, especially where the cisterns are to supply drinking water. Stagnation of the water in some parts of the cistern may cause the quality of the water to deteriorate. It should be remembered that the number of cisterns to be linked should be kept to a minimum.

Stagnation can be avoided by following some basic rules. Connection must be arranged to encourage the flow of water through each cistern. This can be achieved by:

- keeping the cistern volumes to a minimum to ensure rapid turnover of water to prevent stagnation
- connecting the cisterns in parallel wherever possible
- connecting the inlets and the outlets at opposite ends of the cistern
- using delayed action float operated valves to limit stratification.

Where it is not possible to connect cisterns in parallel, cisterns may be connected in series.



▲ Figure 1.19 Cisterns in parallel

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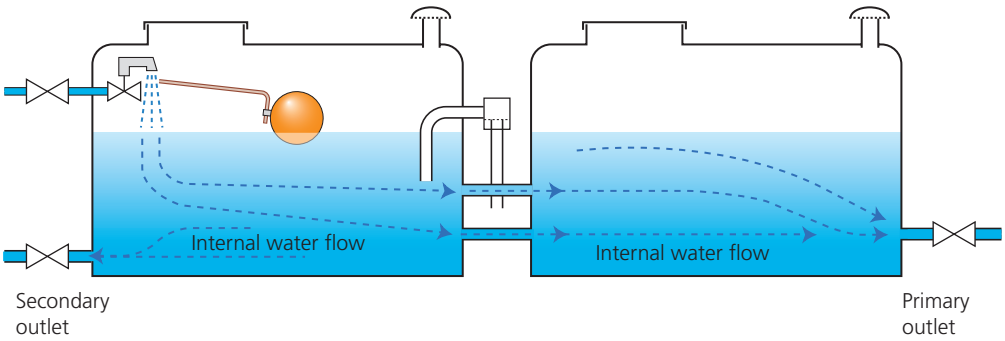


▲ Figure 1.20 Cisterns in series

In practice, cisterns in series should be **interconnected** to allow free movement of water from one cistern to the other. They should be connected at the bottom AND the middle so that water passes evenly through them. The primary outlet connection should be made on the opposite cistern to the FOV to encourage water movement with the secondary connection made on the cistern with the FOV installed. The overflow/warning pipe should be fitted on to the same cistern as the FOV. Both cisterns must be of the same size and capacity.

KEY TERM

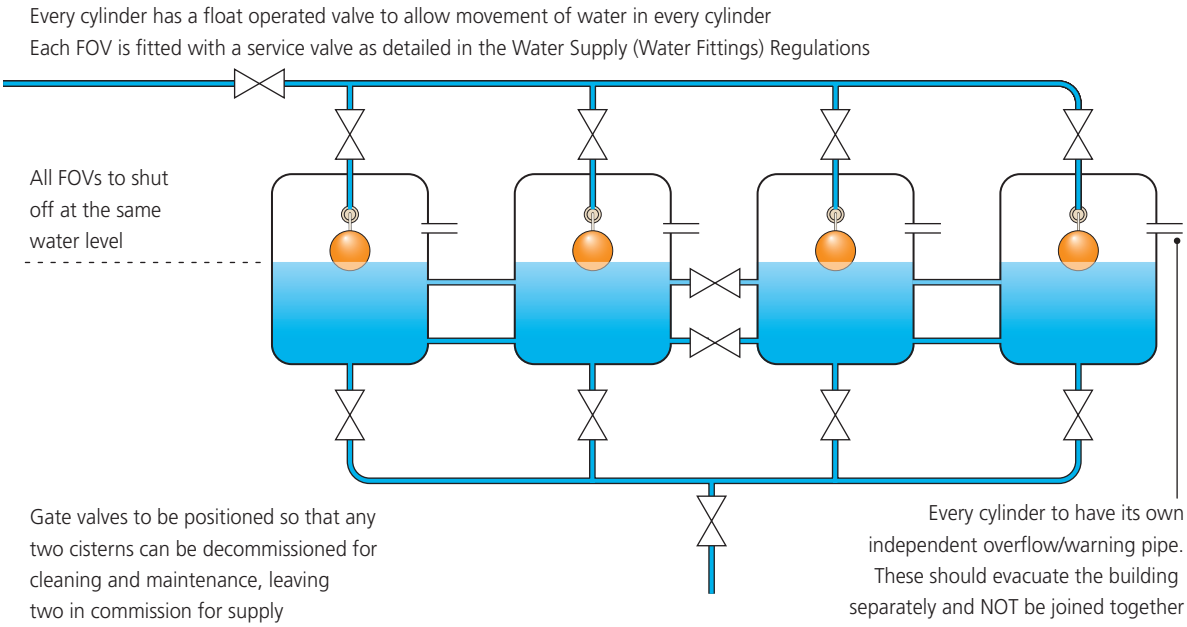
Interconnected: connected together to form one cistern.

When connecting two or more cisterns together, care should be taken to ensure that the water movement is regular and even across all cisterns. In this situation, it is a good idea to install FOVs on ALL cisterns with appropriate service valves as detailed in the Water Regulations:

> Every float operated valve must have a service valve fitted as close as is reasonably practicable.

Wherever an FOV is fitted, then an overflow/warning pipe must accompany it. These should terminate in a conspicuous, visible position outside the building. On no account should they be coupled together.

There should be service/gate valves positioned to allow for isolation and maintenance of the cisterns without interrupting the supply. In Figure 1.21, you will see that any two of the four cisterns can be decommissioned, leaving two in operation. This ensures continuation of supply.



▲ Figure 1.21 Installing three or more cisterns

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Break cisterns

Break cisterns (often called break tanks) are used in large cold water installations in order to supply the system with water via a set of boosting pumps when the mains supply is insufficient. They provide a 'break' in the supply between the mains supply and the installation. This has several advantages over pumping direct from the mains supply:

- Using break cisterns ensures that there is no surge on the mains supply when the boosting pumps either start or stop.
- Break cisterns ensure that contamination of the mains cold water supply from multi-storey installations does not occur.
- Break cisterns ensure that there is sufficient supply for the installation requirements at peak demand.
- Break cisterns safeguard the water supply to other users by not drawing large amounts of water from the mains supply through the boosting pumps.

Break cisterns are often used in very tall buildings as intermediate cisterns on nominated service floors, thus dividing the system into a number of manageable pressure zones. The break cisterns provide water to both user outlets and other break cisterns higher up where the water is then boosted to other pressure zones further up the building.

As with all cistern installations, break cisterns must be fitted with an appropriate air gap that ensures zero backflow into any part of the system.

Components of systems in multi-storey dwellings

Float switches, transducers and temperature sensors

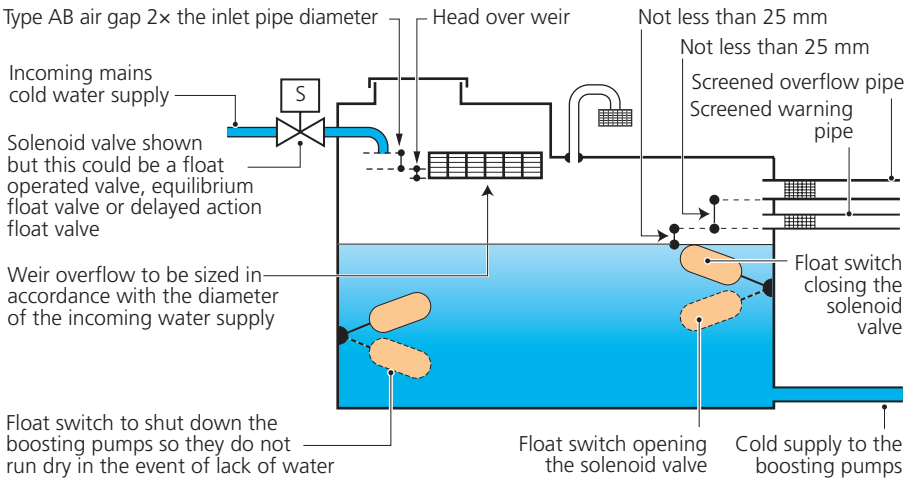
Float switches, transducers and temperature sensors play a vital part in modern boosted large-scale cold water systems. The problems encountered are not just those of how to install them but also where to install them. Installations of large cisterns are often undertaken in tight and restricted spaces. Difficulties arise in positioning these components whilst providing access for maintenance and inspection.

We will look at these important components.

Float switches

Float switches, often called level switches, provide detection of water levels within the cistern to activate various other pieces of remote equipment such as start/stop functions on boosting pumps, open/close functions on solenoid valves, water level alarms, and water level indicators.

There are many different types of float switches available and these can vary in design from simple magnetic toggle switches to ultrasonic and electronic types.



▲ Figure 1.22 The layout of a break cistern with a raised chamber

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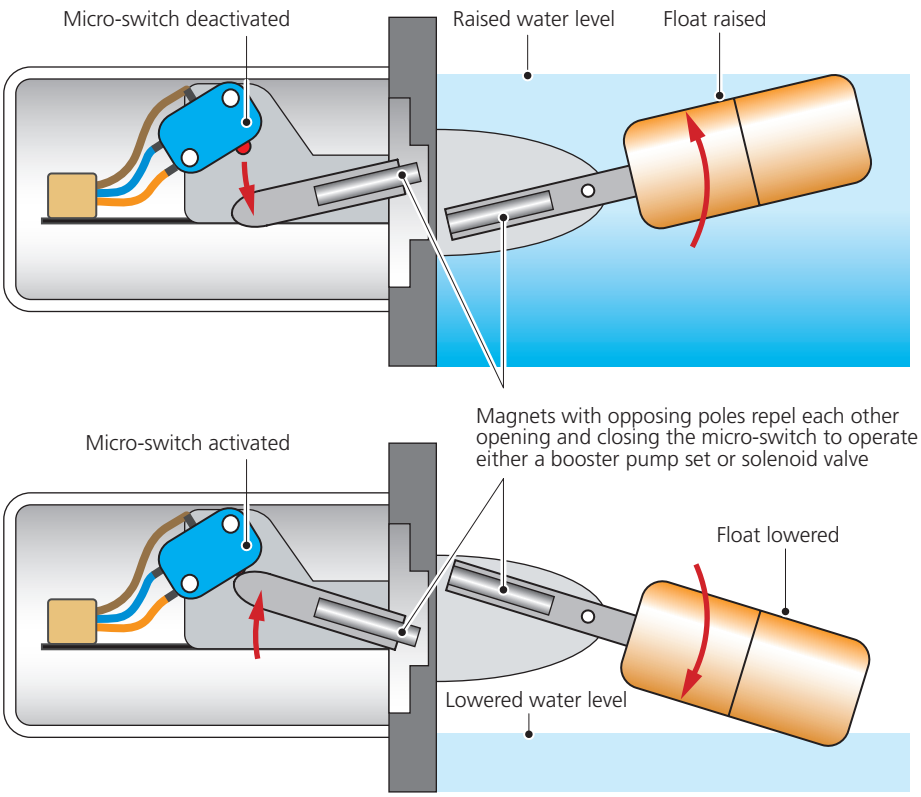

▲ Figure 1.23 Magnetic toggle float switch – how it works

Popular types include:

- magnetic toggle – a simple float switch that uses the opposing forces of magnets to activate a micro-switch
- sealed float
- pressure activated diaphragm
- electronic
- ultrasonic.

Transducers

A transducer is an electronic sensor that converts a signal from one form to another. In large-scale, multi-storey water systems it senses system pressure variations and converts a pre-set low pressure into voltage to activate either the boosting pumps or the compressor feeding the pressure vessel to boost the pressure to normal operating pressure. They may also be used to sense over-pressurisation.

▲ Figure 1.24 Water pressure transducer with pressure gauge

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