Scottish Health Technical Memorandum 2027

(Part 2 of 4)

Design considerations

Hot and cold water supply, storage and mains services

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Contents

1. Introduction

1.1 Current statutory legislation requires both "management" and "staff" to be aware of their individual and collective responsibility for the provision of hot and cold water supply, storage and distribution in healthcare premises.

1.2 Healthcare premises are dependent upon water, to maintain a safe and comfortable environment for patients and staff, and for treatment at all levels of clinical and surgical care.

1.3 The development, construction, installation and maintenance of hot and cold water supply systems are vital for public health. Water quality is influenced by political, environmental and technical issues. It is governed by legislation, water byelaws, building regulations, approved codes of practice and technical standards intended to safeguard quality.

1.4 Interruptions in water supply can disrupt healthcare activities. The design of systems must ensure that sufficient reserve water storage is available to minimise the consequence of disruption, while at the same time ensuring an adequate turnover of water to prevent stagnation in storage vessels.

Scope

1.5 This part outlines the principles involved in the design and installation of the hot and cold water supply, storage and distribution systems and will apply to all healthcare premises.

1.6 Although many of its recommendations will be applicable, this document does not set out to cover water supply for fire-fighting services nor water supply for industrial or other specialist purposes, other than to indicate precautions that should be taken when these are used in association with other water services. The point at which a domestic activity becomes an industrial process, for example in food preparation, has not been defined and the applicability will need to be considered in each case.

1.7 Advice on the prevention of legionnaires' disease is included where appropriate, but reference should be made to SHTM 2040 for more detailed advice on this topic.

1.8 As well as complying with the recommendations outlined in this document, the design and installation of the hot and cold water services, new or extended, in any NHS premises in Scotland should also comply with:

a. the model water byelaws of the local water authority;

b. BS 6700, British Standard specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages.

1.9 In 1989 the model water byelaws came into effect and these are set out, along with the water industry's interpretation of these provisions, in the 'Water Supply Byelaws Guide' 1989. The WRc (Water Research Centre) operates the Evaluation and Testing Centre which provides advice on byelaws on a national basis and administers the Water Byelaws Scheme which tests and lists water fittings and materials for compliance with the byelaws. The 'Water Fittings and Materials Directory ' (WFMD) contains information on suitable fittings and materials and is updated every six months.

1.10 Designers and installers of hot and cold water distribution systems are required to liaise with the local water Authorities.

1.11 While some guidance on the water services applications mentioned below is included in this SHTM it is not intended to cover them fully:

laundry – see Health Building Note 25; Health Building Note is suitable for use in Scotland subject to the amendments contained in the Management Executive Letter MEL 94/108;

sterile supply departments – see Health Building Note 13; Scottish Hospital Planning Note 13 issued with MEL 94/63;

hydrotherapy pools – see Public Health Laboratory service booklet, 'Hygiene for Hydrotherapy Pools'.

Water Authorities

1.12 Three public water authorities were established under the Local Government etc (Scotland) Act 1994, to provide water supply and sewage services throughout Scotland.

They are:

The West of Scotland Water Authority

The North of Scotland Water Authority

East of Scotland Water

Water customer interests are represented by The Scottish Water and Sewage Customer Council, Suite 4, Ochil House, Springkerse Business Park, Stirling FK7 7XE, Tel: 0345 413132.

The Scottish Environment Protection Agency (SEPA) was established under the terms of the 1995 Environment Act to protect the Scottish environment. This section contains notes to help you understand who is responsible for what and general information.

1.13 The Water Authorities

a. Provide reliable water supplies which meet the required standards for quality.

b. Provide drains, sewage and surface water for properties.

c. Offer water and sewage services to new customers wherever they think the cost is reasonable.

d. Protect the quality of water they supply and stop water being wasted by enforcing byelaws.

e. Deal with trade effluent from business properties.

f. Use water resources effectively and manage reservoirs for leisure activities.

g. Promote conservation and improvement of the environment.

h. Empty domestic septic tanks.

i. Set charges for their services and send bills to customers direct or through the local authorities.

1.14 The Customer Council

a. Protects the interests of customers and represents their views to the water authorities.

b. Approves charges and codes of practice.

c. Gives advice to the Secretary of State for Scotland on the standard of service provided by the water authority.

d. Investigates customers' complaints.

1.15 The Scottish Environment Protection Agency (SEPA)

a. Sets standards for and monitors discharges into inland waters, estuaries and the sea.

b. Keeps a record of river flows and is involved in any new water schemes.

c. Provides flood warnings.

1.16 **Local Authorities**

a. Are responsible for environmental health, including monitoring the quality of public and private water supplies.

b. Oversee the safety of all large reservoirs in their area.

c. Control planning and building activities relating to altering and developing property.

d. Maintain road gullies and road drainage systems (but not public sewers).

e. Are responsible for flood prevention in urban areas and for coast protection and dealing with oil pollution around the coast.

f. Collect domestic water and sewerage charges for the water authority along with the Council Tax.

g. Collect water charges for the water authority from businesses which do not have a water meter.

h. Collect sewerage charges for the water authority from businesses.

1.17 **The Secretary of State for Scotland**

a. Is responsible to Parliament for the water authority.

b. Lays down financial responsibilities.

c. Approves charges and code of practice.

d. Decides certain appeals related to water and sewerage services.

1.18 **Health boards**

a. Are responsible for health in the community.

b. Can ask to have fluoride put in the water.

c. Investigate outbreaks of disease and give the water authority advice if water quality is seriously below standard.

1.19 **Property owners**

a. Maintain their private water supply pipework to the water byelaws. This may include shared pipes from the boundary stopcock to the various properties they serve. In rural areas this can involve considerable lengths of pipe and include storage tanks, valves and so on.

b. Are recommended to provide water storage for 24 hours in case there is an interruption in the supply.

c. Maintain their private drains and septic tank (if they have one).

d. Maintain streams or channels within their land.

(There may be different agreements between owners and tenants.)

1.20 **The Water Industry acts**

The Acts regulate the water industry. They lay down the conditions under which the water authorities operate and give them the right to make conditions on the way that consumers are connected to the public supply.

The 1945 Water Act gave water authorities the power to make BYELAWS so as to prevent their customers wasting, unduly consuming, misusing or contaminating the water supplied to them.

1.21 **The Model Water Byelaws**

The current set of 100 water byelaws came into force on 1 January 1989 for a period of 10 years. The 1991 Water Act did not give authorities the power to renew the Byelaws it does however give the water authorities wide powers to prevent contamination of the public main.

The Water Byelaws were due to expire on 30 June 1999. They will be replaced by a new set of regulations to be known as 'The Water Regulations 1998' and an accompanying ' Guidance Document'. The issue of the new regulations may be delayed by moves to 'harmonise' European standards.

Compliance with British Standards

1.22 All materials used in the construction of works referred to in this memorandum must be in accordance with relevant British Standards and Codes of Practice.

Definitions

1.23 Definitions of terms are as those contained in the Model Water Byelaws, BS 6100 Sections 2.7 and 3.3 and BS 6700.

2. Source of supply

General

2.1 Normally, the source of water supply to a health building is a service pipe connection to the mains of the water authority. If the quantity and rate of flow is inadequate or if the cost of providing the service appears to be uneconomical, alternative sources of supply should be investigated.

2.2 Where the constraint is only that of inadequacy of the water authority's supply, the health building needs could be met by using a private supply as a backup to the authority's supply. In such cases, the water authority's supply should be the priority supply for drinking, culinary and special hygienic services. By limiting the use of the private supply to services not requiring the highest level of hygiene, the extent of treatment of the private supply may be reduced. Private supplies used in this way should convey water through a separate pipework system which is clearly labelled. Outlets served by the private supply system should also be appropriately labelled.

2.3 Provision should be included for alternative arrangements to meet an emergency, regardless of the source or sources of supply finally adopted. Any provision to cover emergencies should result from a reasoned assessment of the probabilities of loss of the selected source, the possible duration of such a loss in relation to the storage capacity on the site, and the ease with which temporary facilities could be set up, bearing in mind the hazards that interruption of supply could cause.

2.4 Alternative arrangements would include the provision of a second service connection from the water authority or another private supply. In either case these alternative supplies should not be likely to be affected by the same cause that resulted in the loss of the original supply. Physical interconnection of pipework and valves of a water authority's supply with any private supply is prohibited by model water byelaws.

2.5 The water authority must be advised if it is proposed to use any private supply as well as the water authority's supply, and advice should be sought on the limitations imposed in respect of break cisterns and interconnection thereafter. In Scotland all water intended for human consumption is required by legislation to comply with the quality standards laid down in the 'Water Supply (Water Quality) (Scotland) Regulations 1990 (amended)' and the 'Private Water Supplies (Scotland) Regulations 1992'. These regulations apply to water sampled at the point where the water is available for use and embrace not just drinking water but also water used in the preparation of food and beverages.

Supplies from a Water Authority

2.6 The following factors should be taken into consideration in the initial stages of the design:

a. the Water Authority requirements;

b. the estimated daily consumption, and the maximum and average flows required, together with the estimated time of peak flow;

c. the location of the available supply;

d. the quality, quantity and pressure required;

e. the cold water storage capacity required;

f. the likelihood of ground subsidence due to mining activities or any other reason;

g. the likelihood of contamination of the site;

h. the proposed method of storage and probable number and purpose of direct connections to pressure mains;

i. the minimum and maximum pressures available at service connection;

j. details of the physical, chemical and microbiological characteristics of the water supply and scope of any possible variations in such characteristics;

k. the possibility of an alternative service connection from some other part of the water authority's network, including pressure details.

2.7 These initial design investigations should normally reveal the need for any further treatment, pressurisation and storage of the water authority's supply to meet health building requirements and enable an estimate of costs to be made.

2.8 BS 6700 gives further guidance on the procedures that should be followed when carrying out preliminary investigations in relation to new water supplies.

2.9 During the design stage, close collaboration with the water authority should be maintained and agreement should be sought to the final arrangements before proceeding with the contract. These arrangements should include:

a. siting of service connection, access chamber, metering, bypassing, flushing out, physical security of service connection installation and provisions for fire-fighting service;

b. compliance with byelaw requirements.

Private supplies

2.11 Private supplies independent of the water authority are governed by legislation including the Private Water Supplies (Scotland) Regulations 1992.

2.12 The feasibility of such a private supply should be decided by comparing, on a present worth basis, the capital costs (of the construction of works, including mains, pumping plant, treatment plant etc.) and revenue costs (of electricity for pumping, water treatment chemicals, direct and indirect maintenance and associated management costs, regular water analysis tests etc.) with the long-term cost of water supply from the water authority. Due consideration should be given to the long-term costs of a private supply and account should be taken of potential deterioration in water quality and/or capacity of the private supply source.

2.13 Where consideration is being given to the use of a private supply, specialist assistance should be sought to:

a. confirm the long-term availability of water in sufficient quantity ,either of proper quality or else suitable for treatment

b. confirm the long-term quality of water and define requirements for water treatment;

c. design and specify the works needed;

d. carry out a full evaluation of the costs and practicability of a private supply compared with a connection from the water authority.

2.14 The quality of water from a private supply is governed by the Private Water Supplies (Scotland) Regulations 1992. The standards are very similar to those for public supplies. Reference should also be made to, 'The Microbiology of Water, 1994 Part 1 - Drinking Water' (HMSO) and Report 71, 'The Bacteriological Examination of Water Supplies' (HMSO), ISBN 011 7530107

3. Water treatment regimens

3.1 The regimen of water treatment chosen should be agreed by the infection control officer (water) and the nominated person (water). The regimen should be of proven efficacy, and substances and products to be used in contact with potable water supplies must be listed in the current edition of the Water Byelaws Scheme's (WBS) Water Fittings and Materials Directory (WFMD).

3.2 Chemical conditioning systems which are used in conjunction with potable water systems should be selected with care. Addition of any substance must not cause a breach of any requirement in the Water Supply (Water Quality) (Scotland) Regulations 1990, and any system for introducing a substance must be listed in the current edition of the WFMD.

NOTE: Reference should be made to Scottish Hospital Technical Note 2.

3.3 Consideration should be given as to whether or not the process kills only the organisms flowing through the equipment (leaving no residual disinfecting agent) or whether disinfecting agents are released into the water circuits.

3.4 To ensure that adequate filtration and/or reverse osmosis is used to ensure a pure water supply free of contaminants for conventional treatment, chlorine may be used. Ultra-violet (UV), ozone or the release of metal ions are further methods of treatment, each with specific applications and effectiveness. Further care should be taken in water serving clinical processes, for example dialysis equipment.

3.5 Where process water is to be treated, including cooling towers or water circuits as part of a production process, it is advisable to ensure that the concentration of any chemical treatment is not harmful if the treated water comes into contact with operators or product, and that safe conditions are maintained.

3.6 Water treatment systems should be fail-safe and have sufficient instrumentation to monitor their operation. For example, UV systems should incorporate a UV detector so that any loss of transmission can be acted upon immediately.

3.7 Regular inspection and maintenance of water treatment regimens at intervals, including quarterly records of inspection and testing both of equipment and water quality, should be instituted.

3.8 Hot or cold water delivered to basins and baths should be considered potable and as such, monitored regularly for wholesomeness; the period will normally be quarterly. Where automatic equipment is used for disinfection it should indicate any change in the amount or concentration delivered into the water.

Water treatment

General

3.9 All water supplied to healthcare premises must comply with current legislation on water quality.

3.10 Appendix 2 of this part provides a brief overview. Further details can be found in BSRIA Application Guide AG 2/93, 'Water Treatment for Building Services Systems'.

4. Disinfection

General

4.1 Water from a water authority will normally have an adequate chlorine residue to ensure the microbiological wholesomeness of the supply. For large sites with on-site storage and extended distribution in old pipes, there may be a need for additional chlorination or other appropriate treatment. This should be checked by the regular monitoring of chlorine residuals and microbiological quality around the site.

4.2 If a private supply is used, disinfection will be required at the water source or the water treatment plant. There are two practical forms of disinfection for health sites: chlorination and ultraviolet (UV) disinfection.

Chlorination

4.3 Chlorination involves dosing water either with chlorine gas or with a solution of sodium hypochlorite or calcium hypochlorite. For healthcare premises, the more practical option is to use hypochlorite solution. Gaseous chlorine is not considered suitable for small installations.

4.4 Hypochlorite is normally dosed automatically using a dosing pump controlled by the signal from a flow meter. This ensures a steady dose under varying flow conditions. On larger installations, or where there are variations in the quality of the water being dosed, there may be automatic monitoring, of the chlorine level in the treated water or full automatic control. On smaller installations where there is no automatic chlorine monitoring, the chlorine level in the treated water should be monitored daily.

4.5 Because the disinfection of water by chlorine is time-dependent, it is normal to provide a contact time of 30 minutes after dosing chlorine prior to using the water; this would be in a contact tank. If this period cannot be guaranteed, chlorination should be combined with UV disinfection; the UV disinfects the water and the chlorine provides residual bactericidal activity.

4.6 Chlorination is equally suitable at a private treatment works or as a booster to supplies from the authority, where needed.

4.7 Further information on chlorination can be found in Part 4 ‘Validation and verification’ of this SHTM.

4.8 Other less common methods of disinfection include chlorine dioxide treatment and ionisation.

Chlorine dioxide

4.9 Chlorine dioxide is an oxidising biocide which kills bacteria by destroying their cell walls. Research into the effectiveness of this method of water treatment in the control of legionella is currently being undertaken and further guidance will be made available when this work is complete.

Ionisation

4.10 Ionisation is a technique whereby silver and copper ions are introduced into the water to kill micro-organisms. Silver and copper both have bactericidal properties and copper also has algicidal properties. When silver and copper are used together they act synergistically providing a more effective bactericide than either of them on their own. The method is unsuitable for certain specialist applications, e.g. dialysis departments. Research into the effectiveness of this research of water treatment is currently being undertaken and further guidance will be made available when this work is complete.

UV disinfection

4.11 Ultra-violet disinfection uses a powerful ultra-violet lamp to kill bacteria and viruses. It can be a highly effective form of disinfection for water that is low in solids. The efficacy of ultra-violet disinfection is dependent on the UV transmittance property of the water and, with coloured/organically rich water, filtration is recommended prior to UV treatment. The disadvantage of UV disinfection is the lack of a residual biocide and this method is normally used in association with chlorination.

Water softening

4.12 Hard waters are unsuitable for many industrial and domestic purposes. Treatment may therefore be necessary to remove or alter the constituents to render the water suitable for particular purposes.

4.13 Hardness is due to calcium and magnesium salts in the water, expressed in terms of milligrams per litre as calcium carbonate ($CaCo_3$). Temporary (carbonate) hardness is related to the bicarbonate salts of calcium and magnesium. Permanent (non-carbonate) hardness is related to the other salts of calcium and magnesium, that is chlorides, sulphates, nitrates etc. The generally accepted classification of waters is as follows:

	Milligrams per litre (mg/l) as $CaCo_3$
Soft	0 to 50
Moderately soft	50 to 100
Slightly hard	100 to 150
Moderately hard	150 to 200
Hard	200 to 300
Very hard	Over 300

4.14 When the temperature of water is raised above approximately 60°C the hardness will be reduced by some of the dissolved salts (temporary hardness) coming out of solution and forming solids in suspension, some of which will be deposited on heating surfaces to form an adherent limescale, thus reducing the heat transfer rate.

4.15 The extent of treatment required to prevent scale formation will depend upon the process for which the water is being heated; it may therefore be necessary to achieve one of the following conditions:

a. removal of calcium and magnesium salts;

b. conversion of calcium and magnesium salts to salts of sodium;

c. a combination of (a) and (b);

d. removal of all salts, that is, demineralisation.

4.16 Softening is not considered necessary for palatability. In some instances the softening process makes the water less pleasant to taste without affecting the potability.

4.17 Epidemiological studies in the United Kingdom and other countries have shown that death rates from cardiovascular disease tend to be higher in areas with soft water supplies than in areas with hard water supplies. The association is clearest where the soft water supplies contain hardness below about 150mg (as $CaCo_3$) per litre. The explanation is not known, but it is considered prudent, where possible, not to drink water which has been artificially softened to concentrations lower than this. Softened water may also tend to dissolve metals from pipes. Water softeners containing ion-exchange resins may be subject to bacterial contamination if not adequately maintained. Softeners using salt-regenerated ion-exchange resins increase the sodium content of the water during softening, and this may be undesirable for premature babies, and for patients on strict salt-restricted diets. These concerns will be avoided if water intended for drinking and cooking is not softened.

4.18 Drinking water points, drinks-vending machines and ice-making machines in any new scheme or installation should not be connected to the softened water supply system. In the case of existing installations where drinking water supplies are already taken from the softened water supply system, action to change the supply is not at present required.

4.19 Waters having a hardness of up to 400 mg/l have been used for public supplies without preliminary softening. While it is accepted that supplies for domestic purposes need not be softened, many water authority's do in fact carry out partial softening.

4.20 The need for softened water in hospitals for domestic purposes other than drinking and cooking should be considered on the merits of each case and if treatment is considered essential, the hardness should be to a degree acceptable to users. The value found to be generally acceptable is between 80 and 150 mg/l, and not less than 60 mg/l but this should not be taken as a requirement for hospitals as it may be impracticable to achieve. The cost and difficulties of treatment may be prohibitive for certain waters if the hardness value is particularly high and the content of magnesium is appreciable.

4.21 Generally, with regard to hot and cold water services in health service establishments, softening of a hard water supply will be required on feeds to the following:

a. boilers and hot water supply systems – to prevent sludge and limescale building up in pipework and plant (see BS 2486:1997, 'Treatment of Water for Steam Boilers and Water Heaters');
b. spray taps and blending valves – to avoid clogging by limescale of control ports and fine spray orifices;
c. laundries – high maintenance costs and the uneconomic use of soap or detergents are caused by the presence of hardness (see Health Building Note 25, 'Laundry and MEL 94/108').

NOTE: Problems often occur at thermostatic mixing valves whereby unsoftened hard cold water is heated in the blending process and scale is deposited at the valve.

4.22 One of the most common water softening processes which can be adopted for the protection of hot water services calorifiers is base exchange softening. This process removes permanent and temporary hardness from water. The technique uses an ion exchange process in which the calcium and magnesium ions in solution are removed and replaced by an equivalent number of sodium ions. This method of water softening is not recommended for drinking water or water for culinary use since sodium is associated with heart disease.

4.23 Other water softening methods include physical water conditioning and magnetic water conditioning. Physical water conditioners function by triggering the growth of nuclei or seed crystals in the water. When the water is heated or subjected to pressure change, dissolved salts precipitate onto these seeds to form crystals which do not adhere to the sides of the pipes and are washed out with the flow. Some hard scale will still form but it will be dissolved provided sufficient seeds are created. The main problem is to ensure an adequate supply of the seed crystals which have a relatively short life before they are absorbed back into the water.

4.24 Magnetic water conditioning systems work on the principle that by passing water through a magnetic field a single polarity is induced into dissolved calcium bicarbonate and magnesium particles. By taking on the same polarity, it is claimed that the particles repel each other, thereby staying in solution in the water and passing through the distribution system without forming hard scale.

4.25 For further details on processes which control scale formation in hot water services systems refer to BSRIA Application Guide AG 2/93, 'Water Treatment for Building Services'.

Metal contamination

4.26 Analytical results have shown that there can be a serious problem from lead contamination of hospital water supplies. The 1993 edition of the World Health Organisation, 'Guidelines for drinking water quality' has lowered its prescribed concentration value for lead, from 0.05 mg/l to 0.01 mg/l. The WHO guidelines value is likely to be exceeded if lead pipes are present, or if copper pipes have been joined with solder containing lead. In general terms if hospital drinking water contains more than 0.05 mg/l of lead, remedial action should be taken.

4.27 Copper concentrations above 1 mg/l may cause staining of laundry and sanitary ware, and increase the corrosion of galvanised iron and steel fittings. Whilst the maximum allowable copper concentration in drinking water is 3.0 mg/l, most supplies will give a level at the tap of less than 1.0 mg/l.

4.28 Water supplies to certain specialist units such as maternity, neo-natal paediatric, general paediatric and renal dialysis units must not be contaminated by copper or heavy metals in excess of 0.05 mg/l. The aluminium content of such water supplies should also be monitored to ensure that levels are below acceptable limits. The designer should consult a microbiologist to ascertain the exact water quality requirements for water supplies to specialist units.

4.29 Where the water supply is known to dissolve metals, regular sampling tests should be made at strategic sampling points to ascertain that the level of metal contamination in the water supply to the hospital, plus any added during its passage through the hospital distribution system, does not result in limits above the stated safe levels. This will especially apply if the hospital distribution pipework includes a multiplicity of leaded solder capillary joints. In soft water areas, metal contamination can occur by simple dissolution. Pitting corrosion arising in hard water areas, as a result of deleterious carbonaceous films laid down during the manufacturing process, does not normally give rise to elevated copper levels in the water and is not nowadays a problem if third party certified tubes to BS EN 1057: 1996 are used.

4.30 Where the proposed water supply is likely to pick up metals in excess of acceptable limits it will be necessary to consider using an alternative water supply, or treatment of the water.

5. Water storage

General

5.1 Water is stored in large developments, like health buildings, for the following reasons:

a. to provide reserve supply during failure of the main cold water supply to the development;

b. to reduce the maximum demand on the cold water main;

c. to provide accommodation for the expansion of any water subjected to heat, that is, hot water and heating services;

d. to limit the pressure on the distribution system.

5.2 The purpose for which the storage is used can vary, but this has only a minor effect on its design. The range of uses is generally covered by the following:

a. cold water services, domestic, laundry etc;

b. cold water feed to hot water services;

c. treated cold water for laundries, heating etc. when local supplies are unsuitable;

d. break cisterns on cold water supplies serving points of use where backflow is or is likely to be, harmful to health from a substance continuously or frequently present, for example supplies to pathology laboratories;

e. feed and expansion for heating service;

f. fire-fighting.

Extent of storage

5.3 Storage, from the viewpoint of obtaining an economic balance, reduces the maximum rate of demand on the mains, and limits the pressure on the distribution and service pipes and fittings.

5.4 Storage should be calculated on the requirements of peak demand and the rate of make-up from source of supply. There may be more than one peak period in each 24 hours. The interval between peak periods is important as it determines the amount of make-up that can be expected and the shut-down time for maintenance, if twin cisterns are not installed.

5.5 Water storage design estimates are based upon data generated by The Hospital Engineering Research Unit (HERU) in the early 1960s and the results published in a series of data sheets DY 1.

5.6 Appendix 1 to this part is based on the results of this study. CIBSE Guidebook B, Section B.4 gives further guidance on sizing cold water storage, based on the HERU results. While it is accepted that the desirable minimum for total storage will vary with the classification of the particular health building, the upper limit of storage for a district general hospital is 900 litres per bed per day and for a teaching hospital 1350 litres per bed per day, excluding provision for the staff residences, laundries and any special storage for fire-fighting purposes.

5.7 A summation of the average daily consumption for each ward unit contained in a building should be made. From the requirements of each building, the policy of water storage for the whole complex should be decided. It does not always follow that peak demands for each building will coincide, and therefore there may be scope for applying a diversity factor to the whole site.

5.8 Where the water requirement is to be met from a private supply, the summation for each building may require assessment on the basis of storing and using water according to the minimum treatment of the water for each particular use. Likewise, where the water is hard enough to require softening for certain domestic and/or laundry purposes, separate storage will be required, and this should be taken into account when assessing the total stored water.

5.9 Appendix 1 (sheet 1) does not cater for water requirements for staff quarters or such support services as laundries, bulk stores, transport garages and workshops etc. The staff quarters and industrial areas may be remote from the main hospital and supporting departments. The laundry may serve a number of health buildings as well as the health building at which it is located. The storage requirement for such accommodation should therefore be calculated separately and integrated with the accommodation whenever this is practical. Appendix 1 (sheet 7) provides data on typical demands expected from staff residences.

5.10 Where new healthcare premises are to be built in separate phases, the water storage, supply and distribution service for the whole premises should, as far as possible, be planned and evaluated at the design stage. This will enable the total water supply requirement to be assessed in the planning stages, and appropriate areas of accommodation (but not tank storage) to be allocated.

Location and form of storage

5.11 It is more convenient and more secure to house water storage cisterns at sufficient height to provide adequate flow to all parts of the development by gravity, thus avoiding reliance on pumps etc. Health buildings generally provide this requirement by housing cistern rooms at roof level. Widely-spread building layouts sometimes require a special cistern tower, although this practice is less common nowadays.

5.12 The location of storage will depend on the total volume required, the topography and layout of the site proposed for development, and the sources and adequacy of the water supply. A limited site may call for much higher buildings to achieve the required accommodation. To this restriction might be added an insufficient water pressure, thus leading to fragmentation of storage and considerable increase in pressurising equipment. The cost of the supporting structure will have an important bearing on the solution adopted.

5.13 A hospital built on a restricted site might need both central and local storage to be provided in each building or in one of the buildings, to serve other buildings in the development. Local storage at high level should give about 4 hours (or one-third of a day's) average supply if gravity fed, but if the building structure will economically accept greater storage this should be adopted. The balance of a day's supply should be provided in central storage at high or low level depending on economics and other factors. There are some advantages in locating central storage at low level, for example easier access for maintenance, and reduced structural costs.

5.14 Where such storage is located in individual buildings and an adequate supply is available from the water authority, a connection in accordance with the model water byelaws to each point of storage may be the most economical arrangement. In such cases, interconnections between selected points of storage should be provided to deal with emergency and maintenance requirements always providing that such interconnections do not contravene the water byelaws and do not result in water stagnating within the storage or distribution system. Where the development is widespread and a water authority's multiple connections are not the best solution, the general arrangement might consist of a total storage reservoir, strategically sited, serving cisterns located as conveniently as possible to the major centres of usage. The alternatives available for the location and design of the reservoir will vary from the installation of a water tower to the construction of the unit at ground level.

5.15 To maintain good water quality, common practice now favours the use of smaller decentralised storage capacity as opposed to large central storage and distribution. The use of smaller local cisterns helps to avoid the problem of water stagnation in cisterns and also avoids long runs of distribution pipework between cisterns and points of use. Shorter pipework runs reduce the amount of heat picked up in the cold water service en route to points of use.

5.16 Although the final assessment of the capacities of storage cisterns will emerge from the design requirements of Appendix 1, the architect's structural design will influence the number of cisterns required and the cistern layout. Generally, manufactured standards should be applied where possible and practicable. Specials should be avoided as they are usually more expensive.

5.17 Cisterns must not be located in any position where there is any likelihood of flooding, excessive heat gain or any other threat of contamination affecting the contents of the cisterns, neither should they be located in any location where access for general inspection or maintenance is restricted.

5.18 There is a minimum risk whenever pathology and mortuary departments are supplied from a common whole hospital hot and cold water service system, however given the traditional installation of laboratory taps with hose union outlets, separate systems are recommended.

External storage

5.19 The ideal location for external cold water storage cisterns is the roof of the highest building, provided the structural design can support the load. Concrete water cisterns should be designed to form an integral part of the building provided that the materials of construction comply with the water byelaws.

5.20 Where storage is below ground, as distinct from being housed within a building, it is most important to ensure that there is no risk of contamination. Investigations of such risk require careful consideration of site conditions and should include such aspects as flooding; subsidence; the location of sewers and drains and other buried services; the maximum and minimum height of the water table in the area; the natural drainage of surface water; ingress of contaminants such as dust, debris etc; and, in the event of storage below a car parking area or roads, the danger of oil/fuel seepage. The future development of the health building and probable extensions should also be taken into account in this respect.

5.21 Storage below ground should be accepted only in the last resort, and cisterns should be installed within a watertight bund allowing sufficient space all around and beneath the storage vessel to permit inspection and maintenance. Any underground construction arrangement, concrete or otherwise, not directly against earth will reduce the risk of contamination. The cistern chamber must include provision for a sump to collect drainage water and any piping necessary to pump out cisterns to site drainage. Attention is drawn to Water Byelaw No. 30 which requires that any buried concrete reservoir be designed, constructed and tested in accordance with BS 8007, 'Code of practice for the design of concrete structures for retaining aqueous liquids'.

5.22 The economic depth for reservoirs constructed in concrete is a function of the quantities to be stored. It should be considered at the outset of the planning stage, and will be influenced by soil-bearing characteristics of the locality and take account of the outlet main's position and particulars. Normally where concrete reservoirs are used in the National Health Service it is not anticipated that the quantity of water stored will merit a depth in excess of 3.6 metres. If it is found necessary to exceed this depth a specialist should be consulted. A rectangular or square concrete reservoir will generally provide a more economic proposition than one or more circular reservoirs.

Internal storage

5.23 As in the case of external storage, cisterns should be installed in positions where they can be readily inspected and maintained and where they will not be affected by frost or high temperatures.

5.24 It is essential in all cistern installations that a clear working space of not less than 0.8 m but ideally 1 m is maintained around the cistern. Minimum clearances of 0.6 m below and 0.8 m above the cisterns are necessary to facilitate erection, inspection and maintenance. A minimum of 0.6 m should be provided between the floor of the catchment basin and the underside of the cistern subject to cistern manufacturer's requirements.

5.25 Roof spaces in which cisterns are to be installed must have adequate trap doors or other means of access and adequate lighting to facilitate inspection and maintenance.

Construction of cisterns

5.26 All storage cisterns should be constructed in accordance with manufacturers' recommendations and should comply with the water byelaws and BS 6700. Glass-reinforced plastic (GRP) tanks should comply with BS 7491: Parts 1, 2 and 3.

5.27 Depending on size and/or capacity, cisterns should be divided into convenient compartments suitably interconnected and valved to facilitate cleaning, disinfection, repair, modification and inspection, without seriously disturbing the cold water service.

5.28 Water cisterns could also be subdivided in order to provide economic storage for different water supplies, for example cold water storage, softened water and fire-fighting water. Precautions must be taken to ensure that mixing does not take place between such supplies.

5.29 Normally the materials used for storage cisterns serving health buildings are predominantly GRP, but concrete or steel may also be considered. The material selected should comply fully with WRc recommendations.

5.30 Sectional cisterns fabricated from GRP or pressed steel provide a convenient means of bulk storage of water not under pressure. The components can be readily transported to site and, subject to unit multiples, they can be erected to give varying proportions of length to breadth and depth. It is also possible to make provision for future extension in capacity by an increase in available floor area or, within limits, depth.

5.31 If sectional cisterns are selected, designs with external assembly flanges and self-draining profiles should be used, since this arrangement facilitates easy cleaning of internal surfaces of the cisterns.

5.32 One advantage of using concrete as a cistern material is that it can form part of the building structure. If this is the case and the structure is directly adjacent to the soil, special analysis of groundwater and soil may prove necessary; for further information refer to BS 8007. Where the water to be stored tends to be corrosive, it may be advantageous to increase the cement content of the mix and to increase the cover to the steel used for reinforcement. Additionally, the provision of an impermeable protective coating or lining will be necessary.

5.33 The water byelaws lay down the minimum requirements for potable water storage cisterns. The requirements are covered in Byelaw 30 in particular and are indicated in Figure 1.

5.34 Each storage cistern or compartment thereof should also be provided with the following:

a. internal and external access ladders as necessary to comply with current health and safety requirements;

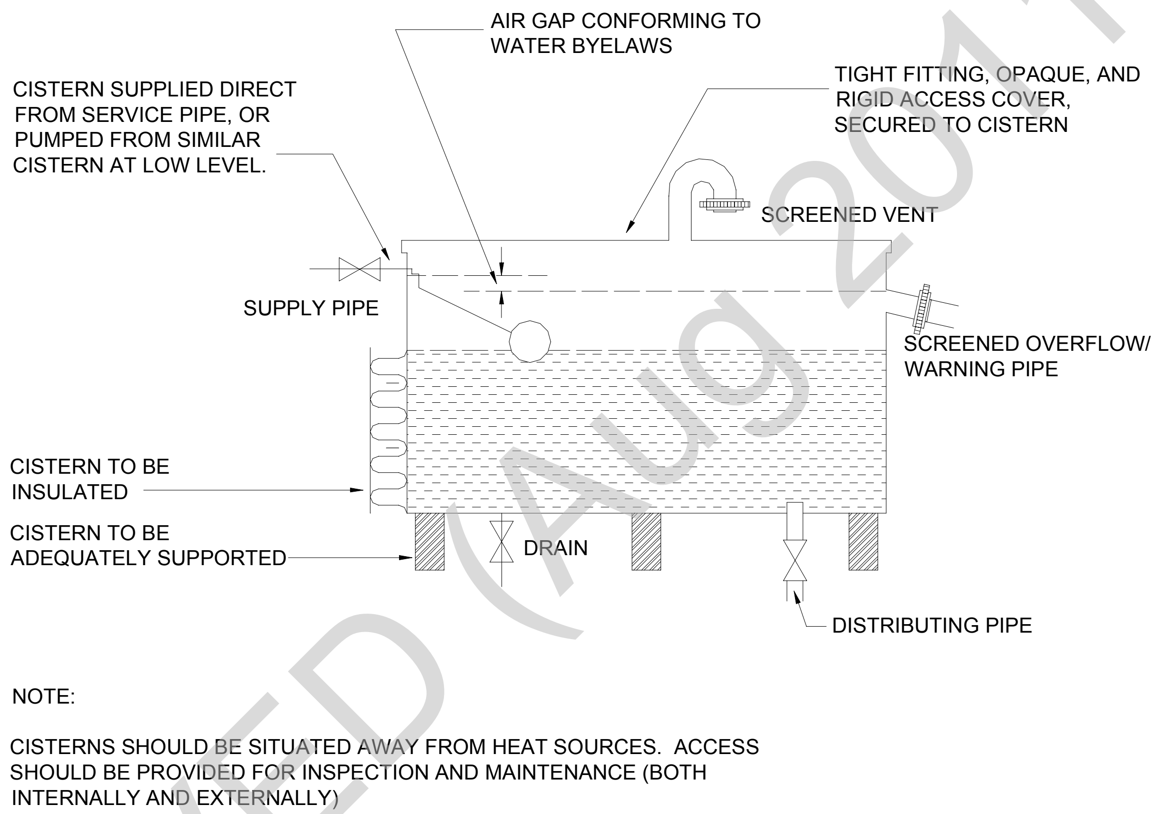
b. a fullway type of isolating valve at each inlet and outlet connection. The outlet connection should be positioned sufficiently above the floor of the cistern to accommodate any precipitation which might accumulate, and at the end opposite the inlet to avoid zones of stagnant water within the cistern;

c. a suitably sized drain connection complete with isolating valve. The invert of the drain connection should be positioned so as to provide maximum drainage of the cistern.

5.35 Cisterns should be adequately supported on bearers placed under the longitudinal or lateral cistern section joints in such a way that water condensing on the side of the cistern may drain off without causing corrosion to the bottom of the unit. The design may incorporate a watertight drip tray under the cistern to contain condensed water or leakage, so as to avoid damage to accommodation below. The necessity of a drip tray or watertight bund with drainage will depend on individual case requirements. The floor of the catchment tray should be graded to a drainage sump complete with drain pipe. A single pipe should drain off any overflow water from the sump, and lead to a discharge point at ground level where any water flow would be readily noticed. If it is not possible to terminate the discharge pipe from the sump so that any discharge of water can be seen, an audible alarm should be installed to warn of overflow conditions. Cistern support levels should be constructed to keep the valves clear of the water level in the catchment basin in the event of cistern leakage. Special requirements apply to the supporting of glass-reinforced plastic sectional cisterns on bearers, and manufacturers' recommendations should be observed.

5.36 On no account should a cistern be installed on a concrete plinth (directly or on steel beams) which is protected by an asphalt membrane. Subsequent irregular settlement into the asphalt may lead to cistern distortion and leakage.

Figure 1: General potable water storage cistern requirements



5.37 A cylindrical cistern is economical in respect of material costs, though not in the use of space. It is more usual for the designer to fit the cistern into a given space having previously specified the total area required.

5.38 A further difficulty in deciding cistern shape and layout is the location of the services duct. Whereas the cistern room may be positioned aesthetically in relation to the main building, the duct serving it may be positioned to suit the internal layout of the main building. The services duct, in relation to the cistern area, therefore has a number of possibilities.

5.39 Schematics illustrating the general potable water storage cistern requirements and the piping and valve arrangements for break cistern operation during normal running and maintenance periods are included in Figure 2 of this part.

Cistern rooms

5.40 Properly covered GRP or steel cisterns should be installed in well-ventilated but draughtproof housings constructed so as to prevent the ingress of birds, rodents and insects. The housing accommodating the cistern and the positioning of the cistern within the room must be designed to permit easy access for inspection and maintenance.

5.41 Prefabricated GRP housings (preferably insulated) can provide an economical and aesthetic solution. Ventilation by means of louvred doors fitted with insect screens is considered sufficient on rooftop cistern rooms.

5.42 The load-carrying capacity of the main structure will sometimes limit the distributed load that the cistern room and its contents will be allowed to impose on the main structure and will in turn limit the depth of water and hence the depth of cistern. If, however, cisterns can be located above main service ducts or stairwells this will minimise the effects.

5.43 There may be occasions when the main building shape will not lend itself to a simple rectangular cistern room. These occasions will be very few and even then, the overall shape will constitute a series of rectangles, that is a T-shaped or L-shaped room. It is reasonable, therefore, to base the layout on a single rectangular cistern room. Rooftop cistern rooms, although generally rectangular in shape, are variable in the ratio of height to length to breadth.

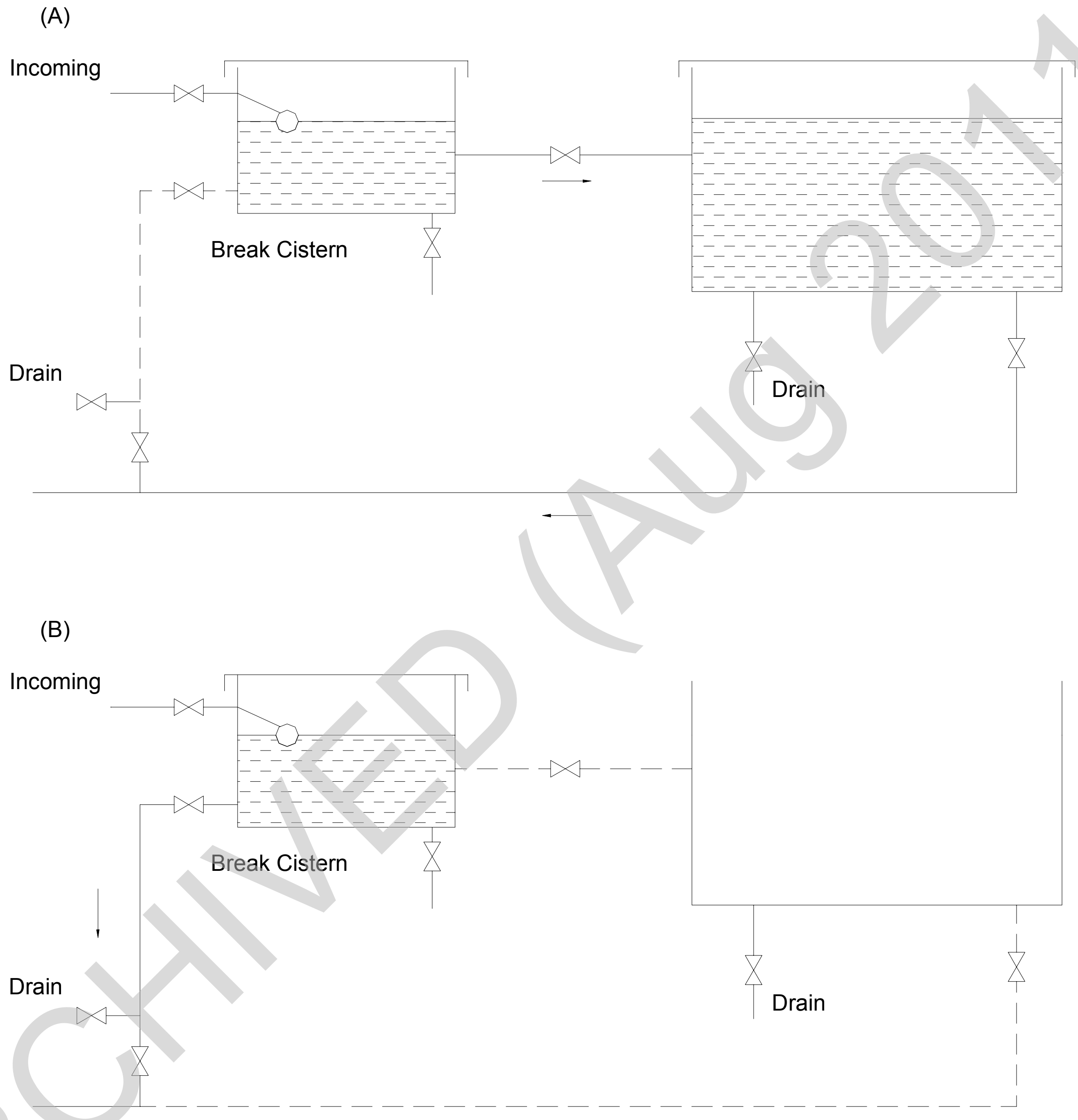
5.44 General space lighting should be provided in cistern rooms, together with suitable power points for low voltage small tools and inspection lamps.

5.45 It is recommended that a branch tee with valve, double check valve and hose connection be provided at some convenient point in the water inlet to provide cistern washdown facilities. The hose itself should be disconnected and drained down when not in use to prevent stagnation of water in the hose.

5.46 A diagram showing the arrangement of cisterns and associated pipework and valves should be mounted in a prominent position in the cistern room. The diagram should be adequately illuminated and framed or otherwise treated to preserve its quality.

5.47 The contents and capacity of all cisterns should be clearly labelled in letters not less than 100 mm high on white background.

Figure 2: Piping and valve arrangements for break cistern operation (A) Normal running, (B) During maintenance



Note: Break tank can be maintained during run down of main tank from full.

Ancillary pipework and valves

5.48 The arrangement of the cisterns in the room should be such that the pipework runs will be as short as possible, but ensure accessibility and walkway clearance. Flanges on parallel runs should be staggered.

5.49 Adequate allowance should be made in the pipework layout for possible future cistern extension.

5.50 It is recommended that provision for total flow sub-meters should be included in the main outlet flows with appropriate bypass arrangements as required.

5.51 All cistern room pipework and valves should be insulated and clearly labelled to identify their purpose.

5.52 The use of delayed-action ball valves on water storage cisterns should be considered since these help avoid stagnation of water in the cistern.

6. Cold water distribution system

6.1 The design and installation of the cold water distribution system should comply with the model water byelaws and BS 6700. Reference should also be made to SHTM 2040; *The control of legionellae in healthcare premises - a code of practice*.

6.2 The installation should be designed to avoid waste, undue consumption, misuse and contamination.

6.3 The design of the pipework should ensure that there is no possibility of a cross-connection between installations conveying potable water and an installation containing non-potable water or water supplied from a private source. There should be no possibility of backflow towards the source of supply from any tank, cistern or appliance, whether by backsiphonage or otherwise.

6.4 From an early stage in the design process of the water installation, liaison and consultation should take place with the designer of the building, the building owner or their agent, the water authority and all other public and private utilities, highway and local authorities, landowners and others involved.

6.5 The Water Supply (Water Quality) (Scotland) Regulations 1990 permit cold water to be delivered at temperatures up to 25°C, although in normal circumstances it will be well below 18°C but the aim should be to keep the temperature below 20°C as far as is practicable to restrict microbiological growth.

6.6 The cold water systems should be designed to ensure that the inlet, outlet and surface water temperatures of cisterns and cold water feed/header cisterns for the hot water calorifiers are not greater than 2°C above that measured at the main water meter. Also, at cold water draw-off points, a temperature of not greater than 2°C above the temperature measured in cistern and cold water/header cisterns should be reached within one minute.

6.7 Chilling of the cold water system is not considered necessary. All cold distribution pipework, mains and cistern downfeeds should be located to minimise heat gains from their environment. They should also be thermally insulated.

6.8 All cold distribution pipework, mains and cistern downfeeds should be located, as far as is practicable, to minimise heat gains from their environment. All pipework should be insulated, except for any exposed final connections to sanitary appliances, and should be arranged to eliminate or minimise dead-legs.

6.9 Pipework should not be routed through hot ducts or adjacent to heat sources, such as radiators.

6.10 The hot and cold water distribution systems should be designed so that the pressures are the same for both hot and cold water at draw-off points. This may require the inclusion of pressure-reducing valves in the distribution pipework.

Pumped systems

6.11 Where the pressure of the water authority's supply is inadequate, it will be necessary to achieve the required pressure by using pressurisation plant. Similarly, pumping or pressurisation may be required for fire-fighting purposes

6.12 Various arrangements of pumping system are indicated in BS 6700. Where booster pumps are to be installed, a break cistern will be required between the mains supply pipe and the pumps. This is required in order to comply with the model water byelaws with regard to prevention of backflow.

6.13 Control of the pump operation by pressure sensors would be preferable to continuous running for the following reasons:

a. to reduce energy consumption;

b. to prevent heat gain from the pump to the water, which could become significant if large pumps are used;

c. to reduce wear on the pumps and hence reduce maintenance.

6.14 Factors to be considered when selecting pumps are:

a. quantity and pressure of water to be pumped;

b. the number of units required to obtain the necessary output and to provide adequate standby capacity;

c. the desirability of speed variation;

d. the degree of automatic sequence control required;

e. the characteristics of the system on both the delivery and suction sides, and in pumping efficiency and priming requirements;

f. the type of materials used in manufacturing the pumps relative to the chemical analysis of the water to be pumped.

6.15 The operation and shutdown of pumps may be controlled by various methods depending on the circumstances, such as water level float switches, pressure switches, flow switches, electrode probes or pneumatic systems. Certain services may require the pumping equipment to be energised also from the emergency electrical service, as recommended in SHTM 2011; *Emergency electrical services.*

6.16 Where two or more pumps are installed, automatic control should be provided to sequence the pumps to ensure that each pump is regularly brought into service (at least daily) as the main duty or lead pump in order to minimise any danger of stagnation.

6.17 The pumping sets for lifting to higher-level storage should be controlled from the level in the high-level cisterns by transmitting sensors, level switches or other suitable devices. A low level alarm should be arranged to give a warning when the storage volume of water falls to a predetermined low level.

6.18 The electrical control circuit should make provision for pumps to run either individually or in parallel.

6.19 The plantroom should be constructed with a waterproof and non-dusting type of floor, with a slight fall to a drainage trench which should terminate in a trapped gully. The trapped gully should incorporate provisions to either avoid or replenish any trap water seal loss. The plantroom will require adequate lighting, ventilation and heating (to prevent freezing or condensation), with electric power points and/or provision for low voltage supplies for portable lighting and tools.

6.20 If heavy plant is to be installed which may, on occasion, need to be removed for testing, maintenance or replacement, fixed lifting beams of suitable capacity should be considered.

6.21 A coloured line diagram of the pumping system, with clear working instructions should be suitably displayed on the wall.

Specialist systems

6.22 Where water supplies are required for specialist systems such as endoscope cleaning installations, dialysis departments etc., the designer should consult the hospital infection control team to establish any specific water treatment requirements for the process, and also the local water authority to clarify any special precautions that may be necessary, such as a type A air gap.

6.23 The Automatic Vending Association of Britain (AVAB) Codes of Practice should be followed regarding hygiene and water quality and hygienic operation of vending machines.

6.24 Before installation of drinks-vending machines, ice-making machines or water dispensers, a site survey should be carried out to ensure that:

a. the water supply is direct from the mains supply;

b. the water supply is not softened;

c. the ambient air temperature is such that it will not allow the water to enter the machine at a temperature in excess of 25°C and that there is no localised warming of the supply.

Reference should also be made to 'Food Safety (Temperature Control) Regulations 1995' and 'Food Safety (General Food Hygiene) Regulations 1995'.

7. Water meters

7.1 BS 6700 gives guidance on the design and installation of water meters,

7.2 Revenue meters are normally supplied and installed by the water authority whereas sub-meters may be installed by the consumer.

7.3 Adequate sub-metering of water supplies should be provided in order that supplies can be monitored for individual heavy-use departments. Such monitoring will assist in detection of leaks or abnormal water demands.

8. Hot water service

General

8.1 Hot water services should be designed and installed in accordance with BS 6700 and should meet the requirements of the local water authority and the model water byelaws.

8.2 The components of a typical vented hot (and cold) water service system as used within hospitals are shown in Figure 3 of this part; some installations may have fewer or additional features or components.

8.3 A vented system usually consists of a cold water storage cistern (situated above the highest outlets) feeding a hot water storage vessel (for example a calorifier or direct-fired water heater).

8.4 The hot water, taken from the top of the storage vessel, will be distributed around the building in a piped system. The individual outlets, taps, mixing valves or other outlet devices will be served from the distribution system. The distribution system should be provided with either a secondary circulation system designed to have a minimum available temperature for draw off of 55°C or trace heating. To maintain the temperature for control of for example legionellae an absolute minimum of 50°C is required.

8.5 An unvented system usually has the hot water storage vessel fed direct from the supply mains via a backflow prevention device and a pressure-reducing valve.

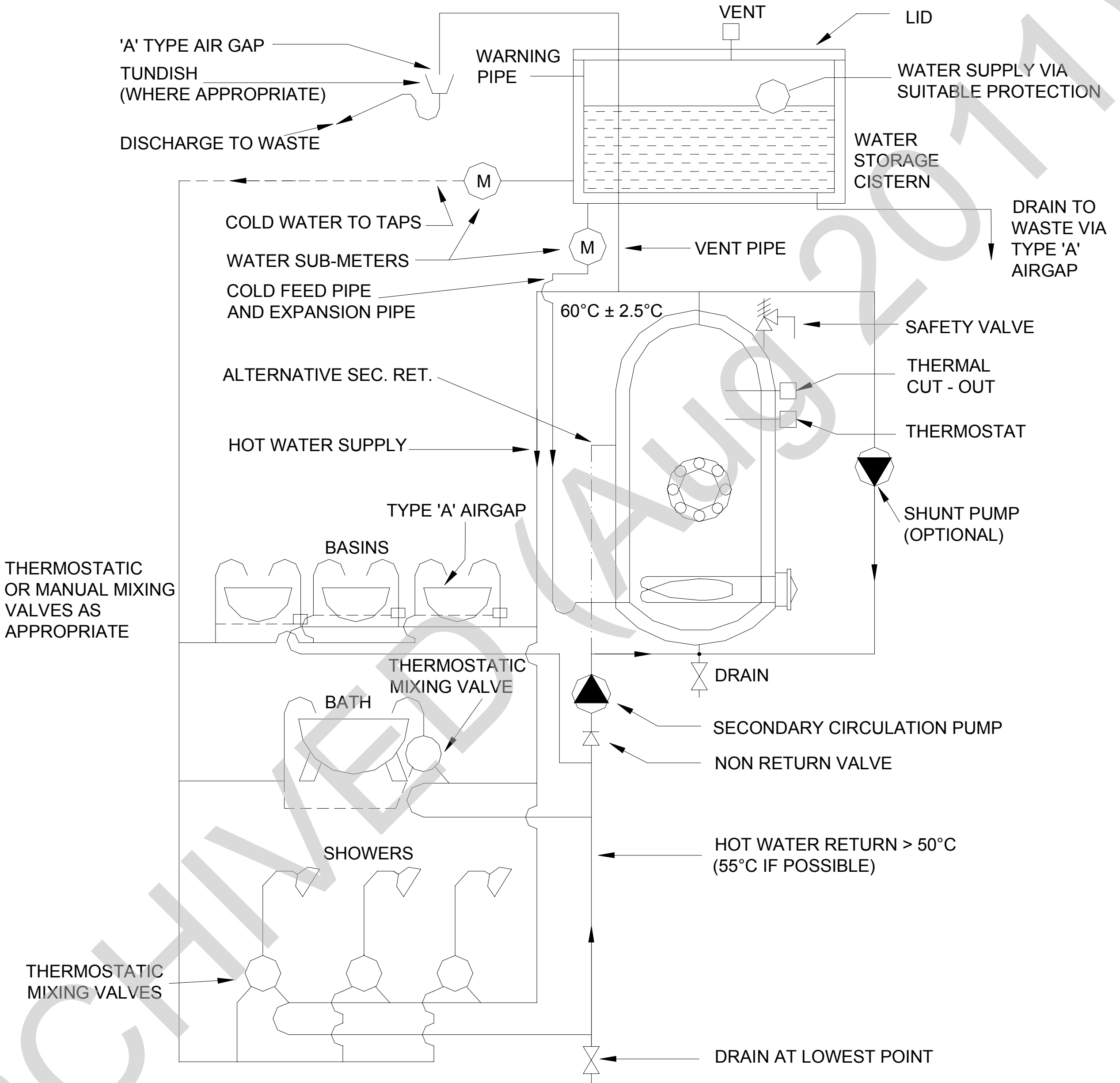
8.6 Particular attention is drawn to the requirement to incorporate within the design, measures to minimise the risk of infection from legionella bacteria. Guidance on the control of legionellae in healthcare premises is given in SHTM 2040.

8.7 A small number of localised hot water distribution systems can have advantages over one large centralised system. With smaller systems, hot water heaters are located closer to points of use and it is therefore easier to maintain hot water distribution temperatures within recommended values. Balancing water flow rates in the hot water secondary distribution system becomes less of a problem, and distribution losses are reduced. A small, localised hot water distribution system may comprise a gas-fired water heater or a storage calorifier heated by a site steam or medium temperature hot water (MTHW) supply, for example. The adoption of localised hot water distribution systems will require the provision of local plantrooms.

8.8 With large centralised hot water systems, it is more difficult to maintain secondary distribution temperatures within recommended values; also, water flow rates in large secondary distribution systems can prove difficult to balance.

8.9 There are also maintenance factors to be considered. With a central hot water system, plant maintenance can be focused in one location, whereas with localised systems there will be a number of plantrooms at remote locations.

Figure 3: Schematic hot and cold services distribution



NOTES:

1. ALL PIPEWORK TO BE INSULATED
2. ISOLATING AND CONTROL VALVES NOT SHOWN
3. ALL DRAINS SHOULD DISCHARGE TO WASTE VIA A TYPE 'A' AIR GAP

Operating conditions

8.10 Hot water at 55°C is required for many applications in hospitals such as washing in kitchen and laundries. In order to be sure of achieving 55°C at the draw-off point, a margin of 5°C has traditionally been added to allow for distribution heat losses. This then gives a design flow temperature of 60°C and a minimum return temperature of 55°C. To maintain the temperature for the control of, for example, legionellae, an absolute minimum of 50°C is required.

8.11 The following is a summary of the temperatures that should be maintained in the various sections of a hot water supply system in order to minimise the risk of legionellae growth.

Location	Recommended hot water temperature
Storage	60 ± 2.5°C
Secondary distribution system (at return to calorifier)	55°C minimum
Kitchen/process	55°C minimum
Normal safe delivery	43°C but up to 48°C maximum (see 8.12 and 8.13 below)
Bidets	37 to 38°C

8.12 The delivery of hot water requires avoiding legionellae in water systems and ensuring that patients are not exposed to high temperature with the corresponding risk of scalding. The quoted "safe" hot water temperature of 43°C is a "sensed" temperature which will not cause injury, it is not necessarily a "delivery" temperature. In areas where assisted patient bathing is needed, it is often necessary to fill baths before patients are presented and the delivery temperature needs to be somewhat higher, 47° - 48°C to achieve a comfortable bath. Where patients use bidets a lower temperature of 37°C is required. Individual perception of comfort is variable, particularly when showering where the ambient temperature can seem to be cool.

8.13 To ensure the correct functioning of fail-safe thermostatic mixing valves for baths, it will be necessary to have a minimum differential of 7°C between the hot and cold water supplies and the mixed flow temperature. When required to provide a higher mixed flow up to 48°C, a minimum temperature draw-off of 55°C will be required. If the system can only achieve 50°C, that is, the minimum permissible for the control of legionellae, higher mixed temperatures may not be possible. This may not be acceptable for the comfort of patients.

8.14 All the temperatures should be sustainable under prolonged maximum continuous demand conditions (of at least 20 minutes) for which the system is designed.

8.15 For more detailed guidance on this topic, reference should be made to:

a. SHTM 2040 and Supplementary Guidance applicable to intermittently used Healthcare premises;
b. Health and Safety Services booklet HS(G)70, 'The control of legionellosis including legionnaires' disease';
c. Health and Safety Commission Approved Code of Practice, 'The prevention or control of legionellosis (including legionnaires' disease)';
d. CIBSE Technical Memorandum TM 13, 1991, 'Minimising the risk of Legionnaires' Disease;
e. CIBSE Guidance Note GN3, 1993, 'Legionellosis – interpretation of HSC Approved Code of Practice';
f. BSRIA Application Guide AG4/94, 'Guide to legionellosis – temperature measurements for hot and cold water services'.
g. Model Engineering Specification (MES) DO8, 'Thermostatic Mixing Valves (Healthcare premises)'.
h. Scottish Health Guidance Note 'Safe hot water and surface temperatures (1998)'.

Cold feed cisterns and tanks

8.16 The requirements for the cold feed cisterns serving hot water service installations, when separate from cold water cisterns, are the same as for cold water cisterns.

Hot water heater types

8.17 In most healthcare premises, hot water storage vessels include the heating source, which can be steam, high or medium pressure hot water, or electric immersion heating elements. The flow to the pipeline distribution system is normally taken from the top of the vessel, as is the open vent, which may or may not be separate. The cold feed is usually taken in towards the base of the vessel and the return water circulation at about one-third of the height; in older calorifiers the return water connection is likely to be one-third from the top. Instantaneous water heaters for distribution systems have similar pipeline connections.

8.18 Traditional design practice has been to provide a non-check-valved cold-feed and expansion pipe to the calorifier/water heater and an open vent discharging over the cold-feed cistern. It is generally believed that means should be taken to prevent warm water entering the cold-feed line and possibly leading to conditions conducive to colonisation by legionellae. A check valve can be provided in the cold feed to prevent such circulation, but this will defeat the operation of the cold-feed as an expansion pipe. An alternative is to provide a U-bend or S-bend in the cold-feed sufficient distance from the connection to the calorifier so that water which is warm is not displaced (on heating up) beyond the bend and the vertical pipe rise. Similarly with a need to preserve the potability of water at all times in the storage cistern, the practice of terminating the air vent over the cistern should be discouraged. The vent should be arranged to discharge over a separate tundish arrangement, with visible Type A air gap, sited at a level which takes account of the hydrostatic head of the system. The calorifier or water heater should be provided with a suitable safety valve of appropriate size and vacuum release arrangement.

8.19 Most vessels have some means of access for inspection, either via a special panel or by removing the heating coils/elements. When new calorifiers are required, it should be specified that they have separate and adequately-sized access panels.

8.20 Where water quality indicates the need, new units should be specified to have cathodic protection from galvanic action by means of sacrificial anodes.

8.21 The combined storage capacity and heater output must be sufficient to ensure that the outflow temperature, under design continuous demand (at least 20 minutes) from calorifiers or other heaters, should not be less than 60°C. This applies to both circulation and single-pipe hot water systems. The positioning of the control and high limit thermostats, cold feed and return water connections must ensure that these temperatures are achieved.

8.22 There are basically three types of water heater; they are:

a. the instantaneous heater;

b. the storage calorifier;

c. the limited storage calorifier.

Instantaneous water heaters

8.23 This type of heater can be further subdivided into:

a. instantaneous water heaters for single or multi-point outlets. These devices usually serve one draw-off only and are either electrically or gas heated. The general principles and limitations of instantaneous water heaters are given in BS 6700. Basically:

   (i) the hot water flow rate is limited and is dependent upon the heater's power rating;

   (ii) the water in instantaneous water heaters is usually heated to about 55°C at its lowest rate, and its temperature will rise and fall inversely to its flow rate. Where constant flow temperature is important, the heater should be fitted with a water governor at its inflow. Close control of temperature is of particular importance for showers. To attain constant temperatures on delivery, water flow and pressure must also be constant. Variations in pressure can cause flow and temperature problems when the heater is in use, and when setting up or adjusting flow controls;

   (iii) they are susceptible to scale formation in hard water areas, where they will require frequent maintenance;

   (iv) this form of hot water heating should be considered only for smaller premises or where it is not economically viable to run a hot water circulation to a remote outlet.

b. instantaneous type water heaters for distribution systems. These devices, which normally use steam or high/medium pressure hot water as the primary heating medium, are designed to heat their rated throughput of water rapidly from cold to the design outlet temperature. They can be used either to feed directly into a hot water distribution system or in conjunction with a storage vessel which reduces the load on the heater during periods of peak demand. This type of heater includes:

   (i) hot water generators. These are vertical instantaneous water heaters which contain modular helical primary coils normally served by either steam, MTHW or high temperature hot water (HTHW). The unit incorporates a temperature control device which varies the rate of primary energy input so as to maintain a constant hot water flow temperature over a range of secondary flow rates through the heater;

(ii) plate heat exchangers. Plate heat exchangers consist of a number of rectangular plates sandwiched between two steel flat ends and held together by tie bolts. The plates have ports in all four corners which allow entry and discharge of the primary and secondary liquids. Primary liquid is directed through alternate pairs of plates while the domestic hot water is normally fed in a counterflow direction through the remaining pairs of plates. Each plate is sealed round the edges by a gasketing system, the design of which should ensure that fluids cannot, under normal operating conditions either leak to atmosphere or mix. This type of heat exchanger can be extended easily or shortened to suit changes in hot water demand.

Storage calorifiers

8.24 Storage calorifiers are usually cylindrical vessels mounted either vertically or horizontally; the bottom of vertical cylinders is usually concave and the top is usually convex. Heater batteries are usually located near the bottom of the cylinder, which can give rise to an area of water beneath the battery significantly below the storage temperature. This “dead” area can provide an ideal breeding ground for bacteria. Galvanised cylinders are particularly susceptible to scale formation, which can also provide a source of nutrition and shelter for bacteria. As a result of this, galvanised cylinders are not recommended in new hospital installations or for replacement.

8.25 Pipework connections should be arranged to eliminate the region of lukewarm water below the heater. For example, the hot water secondary return could be connected to the bottom of the cylinder. If this is done, a check valve should be provided on the secondary return to prevent cold feed water entering the distribution system before it is heated (but see paragraph 8.18). Alternatively, an independent shunt pump can be provided to draw hot water from the top of the hot water storage and pump it into the bottom.

8.26 The pipework connections to existing storage calorifiers should be modified to eliminate the region of lukewarm water below the heater as described above.

8.27 The following points should be considered during the design process:

a. the entire storage volume should be capable of being heated to 60°C without permanent pockets of lukewarm water;

b. storage capacities should be limited to minimise stagnation and stratification;

c. the shell lining should be resistant to bacterial growth;

d. sufficient access to ensure adequate cleaning of the shell must be provided;

e. a suitably-sized drain should be connected to the base of the calorifier.

Limited storage calorifiers

8.28 These calorifiers can either have an independent heating facility such as oil or gas burners or electric elements, or use primary water/steam from a boiler to heat the water via a heat exchanger. The equipment is available in a range of storage capacities and recovery flow rates. This type of equipment is particularly suitable where systems are being decentralised and water heaters are required close to the point of use.

Sizing of hot water storage vessels

8.29 Storage should be calculated on the requirements of peak demand and the rate of heat input. There may be more than one peak period in each 24 hours. the interval between peak periods is important, as it affects the recovery time.

8.30 Water storage design estimates are based upon data generated by the Hospital Engineering Research Unit (HERU) in the early 1960s, and the results published in data sheet DY 1. CIBSE Guidebook B, Section B.4 give guidance on sizing hot water storage, based on the HERU results. Appendix 1 to this part is based on the results of the above.

8.31 Where storage calorifiers are used, the hot water storage capacity should be sufficient to meet the consumption for up to two hours; this must include the period of maximum draw-off. The installed hot water capacity should be sized for current needs and should not be designed with built-in capacity for future extensions.

8.32 Some devices are optimistically rated so that, at a continuous demand equal to their design rating, the flow temperature quickly falls below 60°C. Semi-storage or high-efficiency minimum storage calorifiers and instantaneous heaters are especially prone to this if under-sized. While it is acceptable that occasionally under peak instantaneous or prolonged demand the temperature will fall, it is not acceptable if this occurs frequently (more than twice in any 24-hour period) and/or for lengthy periods (exceeding 20 minutes).

Arrangement of run/standby calorifiers

8.33 Where more than one calorifier or heating device is used, they should be connected in parallel, taking care to ensure that the flow can be balanced so that the water temperature from all the calorifiers exceeds 60°C at all times.

8.34 Where calorifiers are operated in series, the first is effectively a pre-heater where water could remain at temperatures <50°C for extended periods.

Minimising stratification in storage vessels

8.35 Calorifiers should be designed to minimise or eliminate stagnation and stratification. Water temperatures in the range 20 to 45°C favour legionella growth. Stratification may occur in any calorifier or heater; the temperature gradient will depend on the rate of draw-off and heat input. In some calorifier designs stratification is significantly more pronounced and is a feature of their design. There will always be a layer of water in the temperature range that encourages maximum growth. It is not necessary to reduce the stratification in a calorifier during periods of demand.

8.36 Some semi-storage/high-efficiency calorifiers are supplied with an integral pump which circulates water in the calorifier.

8.37 In other storage and semi-storage calorifiers, temperature stratification within hot water service heating vessels should be reduced by introducing independently pumped, time clock-controlled circulation from the top to the bottom of the calorifier. It is important that this pump is only operated at times of low demand; it is often called the "shunt pump". The pumps should be run at least once per 24 hours for sufficient time to eliminate the temperature gradient within the storage vessel and to raise the base temperature of the calorifier to 60°C for at least 30 minutes, but preferably 1 hour. To avoid the redistribution of "sludge", the direction and velocity of flow are important. The shunt pump may not be required if the return hot water circulation enters the calorifier at the same level as the cold feed and below the heating bundle.

Provisions for maintenance

8.38 There should be adequate access to calorifiers for inspection and cleaning.

8.39 All calorifiers and water heaters must be fitted with a drain valve located in an accessible position at the lowest point on the vessel so that accumulated sludge may be removed effectively from the lowest point.

8.40 The drain should be of sufficient size to empty the vessel in a reasonable time. A schedule of approximate calorifier emptying times is included in Table 1.

Table 1: Emptying times for calorifiers (approx)

Calorifier type	Diameter/length ratio	Capacity litres (gallons)	Drain valve sizes mm (inch)		
			25 (1.0)	38 (1.5)	50 (2.0)
Horizontal	1:2.5	13,500 (3,000)	3 hr 15 min	1 hr 30 min	45 min
		9,000 (2,000)	2 hr 15 min	1 hr 00 min	30 min
		4,500 (1,000)	1 hr 15 min	30 min	20 min
		2,2500 (500)	45 min	20 min	10 min
		1,800 (400)	35 min	15 min	9 min
		1,400 (300)	28 min	12 min	7 min
Horizontal	1:1.5	13,500 (3,000)	3 hr 00 min	1 hr 20 min	45 min
		9,000 (2,000)	2 hr 10 min	1 hr 00 min	30 min
		4,500 (1,000)	1 hr 10 min	30 min	20 min
		2,250 (500)	39 min	17 min	10 min
		1,800 (400)	32 min	14 min	8 min
		1,400 (300)	25 min	11 min	6 min
Vertical	1:1.5	13,500 (3,000)	2 hr 45 min	1 hr 15 min	40 min
		9,000 (2,000)	2 hr 00 min	55 min	30 min
		4,500 (1,000)	1 hr 10 min	30 min	20 min
		2,250 (500)	38 min	17 min	9 min
		1,800 (400)	31 min	14 min	8 min
		1,400 (300)	25 min	11 min	6 min

Times assume no hose and simple gate valve.
Notes: 1. Ball type valve(s) should be specified to avoid "clogging".
2. The drain from the gully should be of sufficient size to take the flow from the calorifier drain.

Hot water distribution system

8.41 The hot water distribution system should be designed so as to keep to an absolute minimum the length of pipework that will contain water below 50°C.

8.42 The operating pressures for both hot and cold water at draw-off points should be the same.

Secondary circulation system

8.43 The secondary circulation pipework should be designed to facilitate balanced flows in the complete system. The minimum temperature anywhere in the circulation pipework should not be less than 50°C under prolonged maximum continuous flow conditions. While it is acceptable that occasionally under peak instantaneous or prolonged demand the temperature will fall, it is not acceptable if this occurs frequently and/or for lengthy periods.

8.44 The design of the distribution system should be such as to minimise the length of any dead-leg. In particular, a hot water service return connection should be taken as close as is practicable to any draw-off. Spurs from circulation systems serving one or more outlets should not exceed 5 m. This length is measured from the centre of the circulation pipework to the point of discharge, along the centre line of the pipe.

8.45 Any hot water service circulation pump should be installed with an appropriately sized and positioned non-return valve. In-line standby pumps should not be provided; this is to remove the risk of tepid water being maintained within a non-operational pump. A replacement pump, with any necessary jointing gaskets, should be supplied and stored adjacent to the operating pump so that in case of failure, a quick replacement may be made. To simplify replacement, valves should be provided immediately upstream and downstream of the pump. The standby pump and associated pipework should be disinfected before use. Pump bypasses should be avoided since they can harbour stagnant water. If a permanently installed standby pump is considered essential, pumps should be arranged to automatically change over every 12 hours.

8.46 Circulating pumps should be of adequate performance to ensure a minimum circulation temperature of 55°C at the furthest draw-off point under normal design conditions. It is not permissible to shut down the pumped circulation system overnight. The position of the pump on circulation systems should be decided by the application.

8.47 The domestic hot water system should not be used for space heating. This includes all radiators, towel rails, heated bedpan racks etc, whatever the pipework configuration.

Dead-legs at blending valves

8.48 Water stored in the 20-45°C range encourages the growth of legionellae, therefore, particular attention should be given to ensuring that pipework containing blended water is kept to the minimum. Generally the downstream dead-leg should not exceed 2 m, and the complete length of the spur should not exceed 5 m. Again, the length is measured from the centre of the circulation pipework to the point of discharge, along the centre line of the pipe. The same restriction applies to “communal” blending, that is, where more than one outlet is served by one device. For practical purposes, certain sanitary appliances with flexible shower hoses may exceed the 2 m overall length; 3 m would normally be adequate. This is acceptable provided the hose assembly can be detached for draining and, if necessary, cleaning.

8.49 Central blending systems should not be used normally, since the length of distribution pipework containing water in the temperature range that supports legionellae growth would far exceed the maximum permissible lengths mentioned above.

Electrical trace heating

8.50 A single-pipe distribution system with electrical trace heating can avoid the problems of balancing a secondary circulation system and ensure that the minimum temperature is maintained. Electrical trace heating of the self-limiting temperature type should be capable of maintaining the water in the distribution pipework at 55°C. Care should be taken to avoid cool spots within the system.

8.51 Where trace heating is used, dead-leg lengths, which should not exceed 5 m, are measured from where the trace heating ends. The continuity of the trace heating should be monitored to avoid localised failures.

8.52 Temperature alarms would also be advantageous (set to 50°C) to highlight a failure of the trace heating system or a deterioration in its performance.

Unvented hot water systems

8.53 Hot water storage systems in the UK have traditionally been provided with an open vent pipe which relieves any steam generated in the event of failure of temperature controls. The open vent pipe also protects against rupture of the cylinder by expansion of water.

8.54 The use of unvented hot water systems is now permitted in the UK and is covered by Part P of the Building Standards (Scotland) Regulations which specifies the minimum safety precautions that should be taken when adopting such systems.

8.55 Where an unvented hot water system is connected directly to the water mains, no back-up will exist in the event of a water supply failure. Such an arrangement may also be unacceptable to the local water authority since they will be required to meet the maximum demand at any time over a 24-hour period.

8.56 The design and installation of unvented hot water systems should comply fully with the Building Regulations BS 6700 and BS 7206.

8.57 The key requirements are that the temperature of stored water should be prevented at any time from exceeding 100°C and that discharges from safety devices should be conveyed to a safe and visible place.

8.58 A schematic layout of a typical directly heated unvented hot water system is illustrated in Figure 4 of this part along with a brief description of the main components.

8.59 It is important that the expansion vessel be located on the cold feed rather than on the hot water side of the system. This will avoid the problem of water standing in the expansion vessel at temperatures that may support the growth of legionellae.

8.60 Expansion vessel components in direct contact with water should be compatible with the remainder of the system.

8.61 The discharge pipes from temperature relief valve and expansion valve should be carefully located so that they are readily visible but do not present a risk to people.

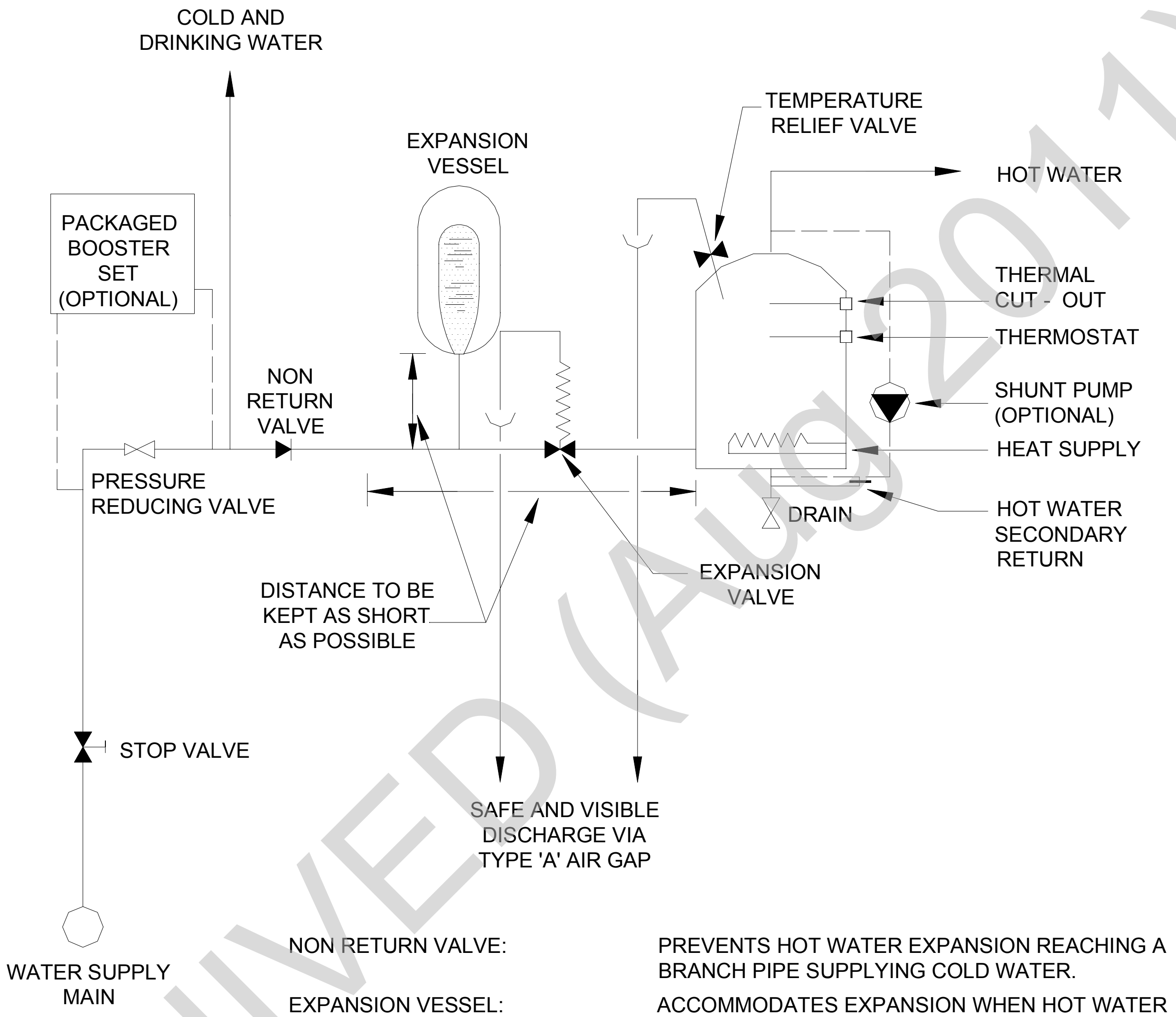
8.62 Where the hot water is heated directly, for example by a steam or LTHW primary coil, a non-self-resetting thermal cut-out wired to a motorised valve, (or a non resetting direct acting valve) on the primary coil must be provided for control of excessive temperature.

Hot water ancillaries

Strainers

8.63 Consideration should be given to the fitting of strainers within the water pipework system to protect expansion vessels, thermostatic valves etc. against ingress of particulate matter. The installation of these fittings should allow adequate access for maintenance/replacement.

Figure 4: Directly heated unvented system



NON RETURN VALVE:	PREVENTS HOT WATER EXPANSION REACHING A BRANCH PIPE SUPPLYING COLD WATER.
EXPANSION VESSEL:	ACCOMMODATES EXPANSION WHEN HOT WATER IS HEATED UP FROM COLD.
EXPANSION VALVE:	DISCHARGES EXPANDED WATER UPON FAILURE OF THE EXPANSION VESSEL.
TEMPERATURE RELIEF VALVE:	USED AS A BACK-UP IN THE EVENT OF FAILURE OF BOTH THE THERMOSTAT AND THE THERMAL CUT-OFF.
THERMAL CUT-OFF:	CUTS OFF HEAT SOURCE AT A PREDETERMINED MAXIMUM TEMPERATURE.
THERMOSTAT:	CONTROLS THE TEMPERATURE OF STORED WATER AT 60°C ± 2.5°C.

9. Materials of construction

General

9.1 Any materials that come into contact with the water in a hot and cold water installation must comply with the requirements of the water byelaws. A list of products and materials which have been assessed for compliance with water byelaws requirements are listed in the current edition of the Water Fittings and Materials Directory which is updated every six months. Further information on the selection of materials can be found in BS 6700 and BS 6920.

Reference should be made to the guidance contained in Scottish Hospital Technical Note 2, 'Domestic hot and cold water systems'.

9.2 Materials of construction should be selected to take account of water quality and its potential corrosive properties. Water authorities should be asked to provide details of any specific requirements and variability from standard conditions.

9.3 Water supplied by the various water authorities, although remaining uniformly wholesome, will nevertheless differ chemically. Some waters are slightly acidic while others are slightly alkaline, and this affects the choice of materials for pipes, fittings and cisterns. Water authorities also blend water and accordingly the character of the water supply may vary from time to time. It will therefore be necessary to consult the water authority in whose area the health building complex is to be sited for advice on what materials should be avoided.

9.4 The choice of materials for piping and fittings should take into account the nature of the soil in which the piping is to be laid and the character of the water to be conveyed. The materials selected should where necessary resist possible corrosion both inside and outside. The extent, if any, of anti-corrosion treatment of the outside of the piping will depend on the analysis of the soil. The advice of the water authority should be sought on the protective measures usually adopted in the area.

9.5 Corrosion (or erosion) can be caused by the motion of water when it is in a turbulent state and thus subject to rapid changes in pressure. Minute vapour or gas bubbles may be released at instants of low pressure, these collapse with implosive force the moment the pressure is increased. The collapse of such bubbles upon a metallic or concrete surface will quickly cause deep pitting or erosion of that surface. The designer should therefore avoid high velocities, the sudden increase of pressures, or pulsating pressures.

9.6 Metallic piping should not be installed in contact with corrosive building products and materials.

9.7 Corrosion may result from galvanic action where dissimilar metals are connected. The use of dissimilar metals should be avoided as far as practicable but if that is not possible it should be determined that deterioration through galvanic action is unlikely to occur or else effective measures should be taken to avoid deterioration.

9.8 The materials generally used for the conveyance of water in health buildings are copper, steel, stainless steel and plastics. Lead is no longer allowed under the water byelaws for pipework or solders. Lead-free solders are now widely available.

9.9 Substances leached from materials of construction of pipes, cisterns or other water fittings in contact with water must not adversely affect water quality, stored or drawn for culinary and drinking purposes, see Byelaw 7.

9.10 Direct gas-fired water heaters are particularly prone to corrosion and scale formation, and the insides of these heaters should be provided with suitable linings to limit these effects.

Steel pipes and fittings

9.11 Where steel is used for bolts, nuts and slip-on couplings, adequate protection from corrosion should be provided. This usually takes the form of bitumen coating.

9.12 Unless adequately protected, steel is liable to corrosion both internally and externally, and therefore should not be used untreated. Steel piping is usually supplied zinc galvanised, but dependent on the character of the water to be conveyed, it may be necessary to use piping with an internal coating of bitumen or with an epoxy phenolic lining which requires special application techniques.

9.13 External protection for piping may consist of a bitumen or tar wrapping with reinforcing layers of fibreglass, or a plastic cladding.

9.14 Where screwed steel piping is used, any threads exposed after jointing should be painted, or in the case of underground piping, thickly coated with bituminous or other suitable composition to prevent corrosion.

9.15 Where the soil is of a corrosive nature, the pipes must be additionally protected by means of bitumen and glass-fibre cloth wrappings.

9.16 Screwed steel piping is jointed with screwed socket joints, using fittings of wrought iron, steel or malleable cast iron. A jointing compound or tape, which may be one of the many proprietary makes, is used according to the makers' instructions. Compounds containing red lead should not be used because of the danger of contamination of the water. Jointing compounds must not support microbial growth, should comply with BS 6920 and should be listed in the Water Fittings and Materials Directory. Care should be taken to remove any burr from the ends of pipes and to prevent the entry of excess jointing material. Steel piping may also be jointed with screwed flanges of steel or cast iron or with mechanical couplings.

Stainless steel

9.17 Stainless steel is widely used in the pharmaceutical and food industries but has yet to gain great popularity in domestic hot and cold water service systems. The role of stainless steel may change in the future as more experience is gained about its long-term performance and developments in water quality standards.

Copper pipes and copper/copper alloy fittings

9.18 Copper is in general resistant to destructive corrosion. Unless they are dezincification-resistant, brass fittings must not be used where water conveyed is capable of dissolving undue amounts of zinc from the fitting. External protection from corrosion for buried pipework may be obtained by using copper tube with a factory-applied polythene sheath. Copper piping laid underground and copper piping laid above ground should conform to the respective Tables contained within BS EN 1057: 1996.

9.19 Fittings should comply with the requirements of BS 864. Copper piping may be jointed by means of compression joints or capillary joints. Effective capillary joints in copper pipes can be achieved if care is taken in their construction. Where compression joints are used with fully annealed copper piping, these should be manipulative joints, that is, joints in which the tube ends are flared or grooved.

9.20 Lead-free materials must be used in the formation of all potable water pipe capillary joints

Plastics

9.21 Plastics are becoming popular as an alternative to metal pipework in distributing hot and cold domestic water in healthcare premises. Already one or two major healthcare premises have been successfully plumbed using uPVC and cPVC pipework. Most healthcare premises' water systems operate at modest pressures and at a maximum temperature of 70°C. Such operating conditions are within the specified performance of plastics being produced in a range of sizes and costs suitable for healthcare premises' applications.

9.22 Advantages include corrosion resistance, light weight and ease of handling.

9.23 Disadvantages include poorer mechanical strengths than metals, greater thermal expansion (about 7 times that of copper) and low temperature (and possible long-term embrittlement [20-25 years]) and shorter distances between pipe supports.

9.24 All materials used for the transportation of water can give rise to contamination by differing processes. It is therefore important when introducing new materials that care is taken to ensure that appropriate health standards are maintained. In the case of plastic materials, this can often be achieved by introducing a suitable “flushing” routine during the commissioning period.

9.25 Materials in common use for plastic pipework are medium density and high density polythene, the latter being stronger. Unplasticised polyvinyl chloride (uPVC) and chlorinated polyvinyl chloride (cPVC) are also used. PVC pipes to BS 3506 are of rigid material which has a greater tensile strength than polythene, but are less resistant to fracture. These materials are less susceptible to frost damage than metal pipes but nevertheless should be buried to a minimum of 0.75 m. Although the freezing of water inside it is unlikely to damage the pipe, it will result in interruption of supply and subsequent leakage from joints may occur.

9.26 Polythene pipes are immune to corrosive environments likely to be encountered from the water flowing through the pipes or from the ground in which they are laid. However, plastic pipes are not recommended in any soils contaminated with organic materials likely to permeate the plastics and taint the water such as coal gas, methane, oils, petrol or other organic solvents.

9.27 It is essential to consider the locality of exposed plastic pipes to ensure that there is no likelihood of mechanical damage, otherwise suitable protection around the pipe will be necessary. Plastic piping should be adequately supported and incorporate adequate means of accommodating expansion, bearing in mind that plastic pipes have a much greater coefficient of thermal expansion than metal pipes.

9.28 Methods of jointing employed include compression joints with insert liners, flanged, screwed and fusion welded joints, as well as joints of the spigot and socket type. The method of jointing employed is dependent on the bore of the pipe and the applied internal pressure, and should be in accordance with the manufacturer’s recommendations. Joints should be made by a competent fitter who has been trained under an approved scheme.

Composite materials

9.29 Less proven but available on the market are composite pipes, for example aluminium pipe with an external and internal sheath of plastic. Little experience on the performance of such pipes is yet available and questions remain over earth bonding.

Iron pipes and fittings

9.30 Iron has good resistance to corrosion, and this is further enhanced if the casting skin on the metal is still intact. Although ductile iron pipes are thinner than grey iron pipes, their resistance to corrosion is at least as good, and there is evidence that they tend to be rather more resistant. In assessing the life expectancy of ductile iron pipelines, account should be taken of any intended higher operating pressures that may be used or permitted.

9.31 In made ground containing ashes, clinker, refuse or industrial wastes, or in certain natural soils, such as aggressive waterlogged clays, saline and peat marshes, additional external protection may be required. This may be provided by the use of protective coatings such as bitumen or coal tar sheathing, by protective tapes, by loose polythene sleeving or, in certain circumstances, by concrete.

Lead

9.32 No new lead piping should be installed in any building. In the unlikely event of any lead pipework being discovered in existing healthcare premises it should be removed as soon as practical.

Concrete

9.33 Protection of concrete pipes may be required against sulphate and acid attack. The minimum size available in concrete pipework is 150 mm diameter and therefore its practical use for health buildings is very limited.

9.34 Standard concrete pipes may be used when not subjected to internal pressure. Pre-stressed concrete pipes are available as pressure pipes, but only in larger sizes.

Asbestos cement pipes and fittings

9.35 Asbestos cement pipes generally withstand corrosion but may have to be protected when laid in soil of high sulphate content. If iron fittings are used, both internal and external protection must be applied.

9.36 Specialist advice should be taken if work on materials containing, or suspected of containing, asbestos is to be carried out.

10. Pipework installations

10.1 All hot and cold water pipework should be designed and installed in full accordance with the water byelaws and BS 6700.

10.2 It is essential to include within the system, facilities for measuring, regulating, isolating, venting, draining and controlling the flow of water. Regulating valves with built-in pressure tappings or orifice plates with manometer tappings will be required for the measurement of pressure drop, which enables the volume rates of flow to be determined. Care must be taken to ensure that measuring valves or orifice plates are sited well away from bends or fitments.

Sizing

10.3 Mains should be capable of a rate of flow to satisfy the combined maximum demand of all the services to be supplied. All the maximum demands of the separate services may not occur simultaneously, and the actual combined maximum demand may be a proportion of the sum of the separate maximum demands, which will be determined by the number and character of the services.

10.4 Hot and cold water pipework should be sized using the procedure outlined in CIBSE Guidebook B.

Routing of pipework

10.5 Pipework in buildings should be designed and installed so that it is accessible for inspection, maintenance and repair as far as is practicable and in accordance with the bye laws. Ducts, trenches and chases containing pipework should be large enough to facilitate repairs.

10.6 Pipework distribution networks should be divided into sections by the provision of isolating valves to facilitate isolation for repairs, maintenance and flushing.

10.7 Underground mains need not be laid at unvarying gradients but may follow the general contour of the ground. As far as possible, however, they should, fall continuously towards drain points and rise continuously towards air vents. They should not rise above the hydraulic gradient; that is to say, there should always be a pressure, greater than atmospheric, at every point under working conditions. The gradient between air release and drainage valves should be not less than 1:500 rising in the direction of flow and not less than 1:200 falling in the direction of flow.

10.8 Long dead-legs should be avoided, unless terminating at a regularly used draw-off point, otherwise stagnation might take place with potential for microbial growth. Drinking-water points or connections to vending machines, ice-making machines etc. should be connected well upstream of final draw-off points and never at the end of the system. Final connections to such drinking-water points should be as short as possible and flexible assemblies should be constructed from materials which are listed in the Water Fittings and Materials Directory. Ice-making machines should be positioned so that their warm air exhaust does not impinge directly on taps or hoses supplying cold water.

10.9 Underground pipes entering a building should do so with a cover of not less than 0.75 m below the external ground surface and should pass through the wall within a watertight built-in sleeve. The sleeve should be filled in around the pipe with a suitable material for a minimum length of 152 mm at both ends to prevent the ingress of water or vermin. External underground pipes should be at a depth, or otherwise sufficiently protected, to prevent damage by traffic and any consequent vibrations. A minimum depth under roadways of 1 m measured from the top of the pipe to the surface of the roadway is necessary. In other underground locations the depth should not be less than 0.75 m, subject to this depth being sufficient protection against frost; frost penetration depends on the nature of the subsoil and the ground surface. Freezing can occur at depths of up to 1.1 m. Local information on the prevalence of frost should be sought.

10.10 Marker tapes should be laid over the whole length of all underground water services pipework. The tapes should be clearly marked with the description of the service and should be coloured blue.

Vents and drains

10.11 Air release valves should be provided at summits and drainage valves at low points between summits, unless adequate provision is made for the discharge of air and water by the presence of service connections. Large-orifice air valves will discharge displaced air when mains are being charged with water. When air is liable to collect at summits under ordinary conditions of flow, small-orifice air valves, which discharge air under pressure, may be required. “Double-acting” air valves having both large and small orifices should be provided where necessary. Air-valve chambers should be adequately drained to avoid the possibility of contamination.

10.12 Automatic air release valves should be installed where accessible for maintenance. Installations in ceiling voids are not recommended.

10.13 Drain points should not discharge into a drain or sewer or into a manhole or chamber connected thereto. Where a washout discharges into a natural watercourse, the discharge should at all times be well above the highest possible water level in the watercourse. In some cases it may be necessary for the washout to discharge into a watertight sump which has to be emptied while in use by portable pumping equipment.

10.14 In order to minimise quantities of water that may collect in stub pipes at drain points, the length of such stub pipes should be kept to an absolute minimum. This relates in particular to drains from hot water calorifiers, storage cisterns and distribution pipework.

Valves

10.15 A clear indication should be given on all valves of the direction of rotation needed to close the valve. This direction of rotation should be the same for any one pipe installation. Normal practice is to have clockwise closing when facing the handwheel or lever of the valve.

10.16 Where mixing valves have been installed at the end of a run of hot water pipework, consideration should be given to the inclusion of a drain valve adjacent to each mixing valve. These should be located upstream of the mixing valves so as to facilitate flushing out and routine temperature testing of the hot water without having to dismantle the mixing valves.

Prevention of contamination

10.17 In all cold water installations it is important that adequate protection is provided to all supplies against backflow. Health buildings are premises where a high degree of protection should be afforded not only to the water in the water authority's mains, but also within the installations to protect the patients and staff. In addition to protection against backflow being afforded at every point of use, whole installation protection should be provided as required by the water byelaws.

10.18 Health buildings and medical premises have been identified as involving Schedule A risks (see Byelaw 25) which are defined in the water byelaws as points of use or delivery of water where backflow is likely to be harmful to health from a substance continuously or frequently present. Within these establishments, water usage ranges over the whole spectrum from domestic use by patients and staff, to specialised use in operating theatres and pathology laboratories and with equipment such as bedpan washers and haemodialysis machines. In addition, many users may be classed as industrial, such as centralised laundries.

10.19 The hot and cold water storage and distribution systems should be designed so as to avoid the risk of contamination of the water supply. Such contamination may be caused by backflow, interconnections between potable and non-potable water supplies, stagnation, contact with unsuitable materials or substances, legionellae growth, etc.

10.20 Comprehensive guidance on the measures required to prevent contamination of the water supply is given in the Water Supply Byelaws Guide and in BS 6700.

10.21 Guidance on the control of legionellae is given in SHTM 2040.

10.22 Certain hospital departments such as pathology laboratories present particular risks of water contamination. Attention is drawn to Water Byelaw 12 which requires that a dedicated storage cistern be provided for such facilities.

10.23 Instances of water use in hospitals where backflow is likely to be harmful to health include bedpan washers, dental spittoons and equipment, mortuary equipment, and water outlets located in laboratories.

10.24 Where any doubt exists with regard to the level of protection required against water supply contamination, guidance should be obtained from the Water Byelaws Advisory Service or water authority.

Frost protection

10.25 The water byelaws require that all cold water pipework and fittings be adequately protected against damage from freezing.

10.26 In the case of external pipework which should be run underground, the byelaws specify a minimum depth of cover of 750 mm to prevent frost damage.

10.27 Particular care is required when routing pipework externally above ground or through unheated areas within buildings, and BS 6700 gives guidance on the minimum thickness of thermal insulating materials that should be applied in such cases.

10.28 Adequate provisions for isolating and draining sections of cold water distribution pipework will ensure that disruption caused by frost damage can be minimised.

10.29 For further guidance on frost protection, refer to the Water Supply Byelaws Guide and BS 6700.

Noise and vibration

Pump noise

10.30 Noise generated by centrifugal pumps need not cause serious trouble, providing the water velocity in the pipes and the speed of the pumps are kept low, for example about 1 m/s and 16 rev/s (960 rpm) respectively.

10.31 Care should be taken in locating water boosting pumps within health buildings to ensure that they will not cause interference to wards and other quiet zones.

10.32 Such interference may be due to break-out noise from the boosting equipment, or noise transmitted through the pipework system or through the building structure. Pump noise may also be due to cavitation caused by low suction head.

10.33 Where pumps are located close to sensitive areas, provisions for noise and vibration reduction must be incorporated within the design. Such provisions will include selection of quiet-running motors, vibration isolation of boosting equipment from pipework and structure and, if required, acoustic lining to booster plant enclosure.

10.34 Guidance on recommended noise levels for various locations is given in CIBSE Guidebook A.

Other forms of system noise

10.35 Other forms of nuisance noise which may be generated by hot and cold water distribution systems are listed below:

a. noise from pipework owing to excessive water velocity;
b. water hammer caused by rapid closure of valves or taps;
c. oscillation of the float of a float-operated valve;
d. tap washer oscillation;
e. noise caused by water discharging through a float-operated valve into a cistern;
f. noise caused by thermal movement of pipes;
g. noise due to trapping of air within pipework, particularly on hot water systems.

10.36 Further details on the above sources of noise, including guidance on avoiding such noise problems, is given in BS 6700.

11. Water economy and energy conservation

Water economy

11.1 Hot and cold water distribution systems for healthcare buildings should be designed so as to minimise the use of water. The cold water distribution systems should incorporate an adequate number of water meters to allow for close monitoring of water consumption. Where practicable, consideration should be given to linking water meters to a building energy management system.

11.2 Measures to minimise water consumption which should be considered at design stage include:

a. provision of automatic systems to control flushing of urinals;

b. use of showers rather than baths wherever practicable;

c. use of WC pans which deliver no more than 7.5 litres per flush;

d. control of water pressure to a level that is not excessive for the purpose required;

e. provision of water flow restrictors at hot and cold water taps;

f. use of percussion taps in appropriate circumstances;

g. locating warning pipes from cisterns and discharge pipes from relief valves in such a way that any discharge can be readily observed and/or fitting alarms on such pipes.

11.3 Further guidance on the prevention of wastage of water is given in the Water Supply Byelaws Guide and BS 6700. Reference should also be made to the Audit Commission Report, ‘Untapped Savings-Water Services in the NHS’ 1993 and NHS Estates, ‘Strategic guide to water and sewerage policy for general managers and chief executives’ 1993.

Energy conservation

11.4 Energy used in the generation of hot water can be minimised by ensuring that the hot water storage and distribution system is adequately insulated and that thermostats controlling water temperature in hot water storage vessels are set no higher than is necessary to prevent growth of legionellae.

11.5 Hot and cold water systems should be designed to operate by gravity as far as possible. Where water boosting pumps are necessary, the pump motors should be selected to operate at maximum efficiency at the required duty.

11.6 Pre-heating of the cold feed to calorifiers should not be used. The only time it is acceptable is when under all flow/demand conditions a temperature greater than 45°C can be guaranteed at the entry to the calorifier. Any pre-heater should have a low water capacity.

11.7 Further guidance on energy conservation in relation to hot and cold water systems is given in BS 6700.

12. Testing and commissioning

12.1 A commissioning brief, prepared by the designer, will be required by the contractor's commissioning person. This brief should specify fully and clearly the extent of the commissioning and the objectives which must be achieved and should include:

a. full design data on temperatures, water flow rates and pressures;

b. plant and equipment data;

c. drawings and schematics;

d. a list of test certificates to be provided.

12.2 The designer's attention is drawn to CIBSE, 'Commissioning Code Series W, Water Distribution' which provides guidance on information which will be required by the commissioning personnel.

12.3 In the preparation of commissioning instructions for domestic hot and cold water services, designers should ensure that their work is in accordance with up-to-date guidance from the Property and Environment Forum Executive.

12.4 The designer should prepare for inclusion in the contract documents a list of tests and measurements which are to be taken by the contractor and recorded by him/her. These will be witnessed by the supervising officer or project engineer on his/her behalf and the results, if approved, will be circulated by him/her in accordance with the client's instructions.

12.5 The installation, on completion, should be operated by the contractor as a whole and subjected to functional or performance tests as specified by the designer.

12.6 The commissioning manual should be prepared by the contractor and submitted to the client's commissioning adviser for review before being issued in final form.

12.7 Typical schedules of checks and performance tests should be included in the commissioning manual together with record sheets. These should be amended and supplemented as the designer considers necessary.

12.8 Once the client's commissioning adviser is satisfied that the system meets the design intent, the Final Accordance Record sheets should be completed. If performance is not acceptable, the matter should be dealt with in accordance with the contract requirements.

12.9 Commissioning and testing should be witnessed by the supervising officer or project engineer who should countersign any relevant test record documents.

12.10 Further information on this topic can be found in Part 4, 'Validation and verification', of this SHTM.

13. Record drawings and operation and maintenance manuals

13.1 At the end of any hot and cold water installation works, the client should be provided with a full set of operation and maintenance manuals, and “as installed” record drawings of the new or refurbished system.

13.2 Operational and maintenance manuals should be in accordance with BSRIA Application Guide 1/87, ‘Operating and Maintenance Manuals for Building Services Installations'.

13.3 The guidance given in Scottish Hospital Technical Note 1; *Post Commissioning Documentation for Health Buildings in Scotland* should be followed.

Appendix 1: Water consumption for ward units

Ward Unit

All rooms which make up the working area for patient care i.e. patients' bedrooms, day spaces, treatment, utility and test rooms, bathrooms, showers, WCs, pantry, staff rooms, cleaners' room, etc. and circulation spaces.

Use of Nomogram

Project line from type of unit to number of beds. The intersection on the 20,000 scale gives average daily consumption of total stored water in litres. This figure also applies to the storage capacity required for an average 24 hour supply. The result obtained relates to one ward unit. For a given number of ward units multiply by the number.

Water consumption for ward units

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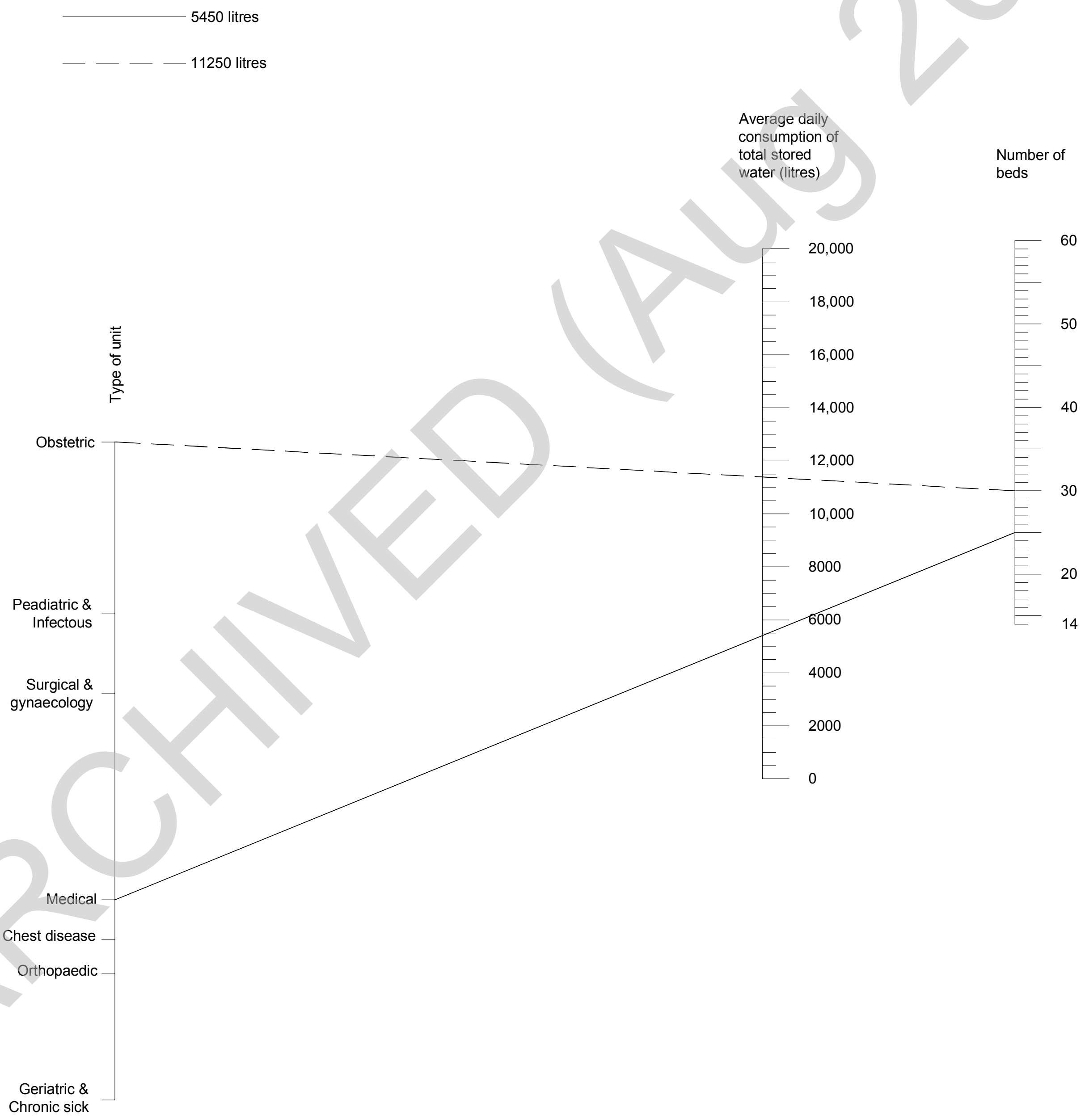
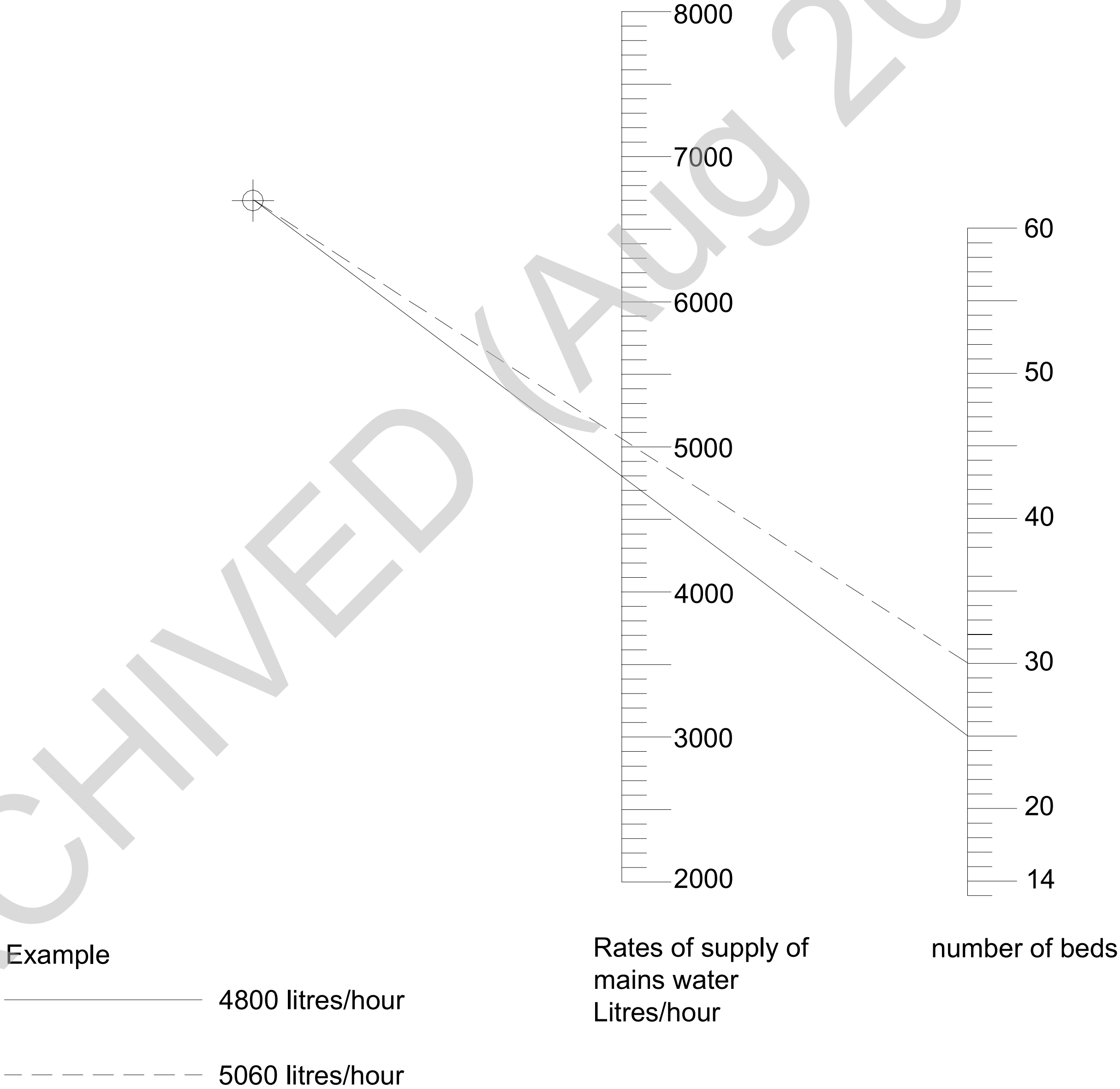
Example



average daily consumption of total stored water

Water consumption for ward units

Use of Nomogram
Project line from point ⌖ to number of beds.
The intersection on the 8000 scale gives rate of supply of mains water in litres/hour. The result obtained relates to one ward unit. For a given number of ward units multiply by the number.



Rate of supply of mains water to cistern

Appendix 1 (continued)

Average water consumption by type and size of hospital

The following tabulated results of a survey of National Health Service Hospitals by the Department of Health and Social Security in 1974 provides basic data for design guidance on the estimation of water storage and consumption for whole hospitals.

The definitions which have been used for the classification of hospitals are as below. “Excluded departments ” are those for psychiatry (mental illness), psychiatry (mental handicap) diseases of the chest, chronic sick, geriatrics and convalescence (including rehabilitation, but not pre-convalescence).

Type of Hospital	*Type number*	*Definition*
Acute	1	Hospitals with not more than 15 per cent of their beds allocated to the 'excluded departments'.
Mainly Acute	2	Hospitals with more than 15 per cent and up to 40 per cent of their beds allocated to the 'excluded departments'.
Partly Acute	3	Hospitals with more than 40 per cent and up to 60 per cent of their beds allocated to the 'excluded departments'.
Mainly Long - Stay	4	Hospitals with more than 60 per cent and up to 85 per cent of their beds allocated to the ' excluded departments'.
Long - Stay	5	Hospitals with more than 85 per cent of their beds allocated to the ' excluded departments'.
Pre - convalescent	7	Hospitals with 90 per cent or more of their beds allocated to patients who have already received elsewhere the most intensive part of their treatment, but who still require active nursing care and medical oversight.
Convalescent	8	Hospitals with 90 per cent of their beds allocated to patients recovering from a disability who no longer require active medical supervision or nursing care in bed although they may need such simple nursing procedures as renewal of dressings or the administration of medicines.
Rehabilitation	9	Hospitals with 90 per cent of their beds allocated to patients who no longer require nursing care in bed and who, with or without the aid of appliances, can get about and attend to their own needs with occasional assistance but who require remedial and re – educative treatment with a view to their attaining the maximum degree of recovery of use of function.
Maternity	11	Hospitals (including General practice Maternity Hospitals) with 90 per cent or more of their beds allocated to obstetrics.
Psychiatric (Mental Illness)	12	Hospitals with 90 per cent or more of their beds allocated to mental disorder and 50 per cent or more of the psychiatric beds allocated to mental illness.
Psychiatric (Mental Handicap)	13	Hospitals with 90 per cent or more of their beds allocated to mental disorder and more than 50 per cent of psychiatric beds allocated to handicapped and/or severely handicapped patients.
Orthopaedic	14	Hospitals with 90 per cent or more of their beds allocated to traumatic and orthopaedic surgery, including bone and joint tuberculosis.
Tuberculosis and Chest	15	Hospitals with 90 per cent or more of their beds allocated to tuberculosis (both respiratory and non – respiratory) or diseases of the chest (including thoracic surgery) or both.
Tuberculosis and Chest and Isolation	16	Hospitals with 90 per cent or more of their beds allocates to tuberculosis (both respiratory and non – respiratory) or diseases of the chest (including thoracic surgery) or both, and infectious diseases.
Children's (Acute)	17	Hospitals with 90 per cent or more of their beds allocated as in Type 1 but for children only.
Eye	18	Hospitals with 90 per cent or more of their beds allocated to that one function.
Other hospitals	19	These include Dental and E.N.T hospitals and also: All hospitals with 90 per cent or more of their beds allocated to a single department not specifically named above unless that department is ' General Medicine', 'General Surgery' or 'general Practice (Medical)' in which event the hospital would be classified as 'Acute' (Type 1). Type 19 will include geriatric and Chronic sick Hospitals.

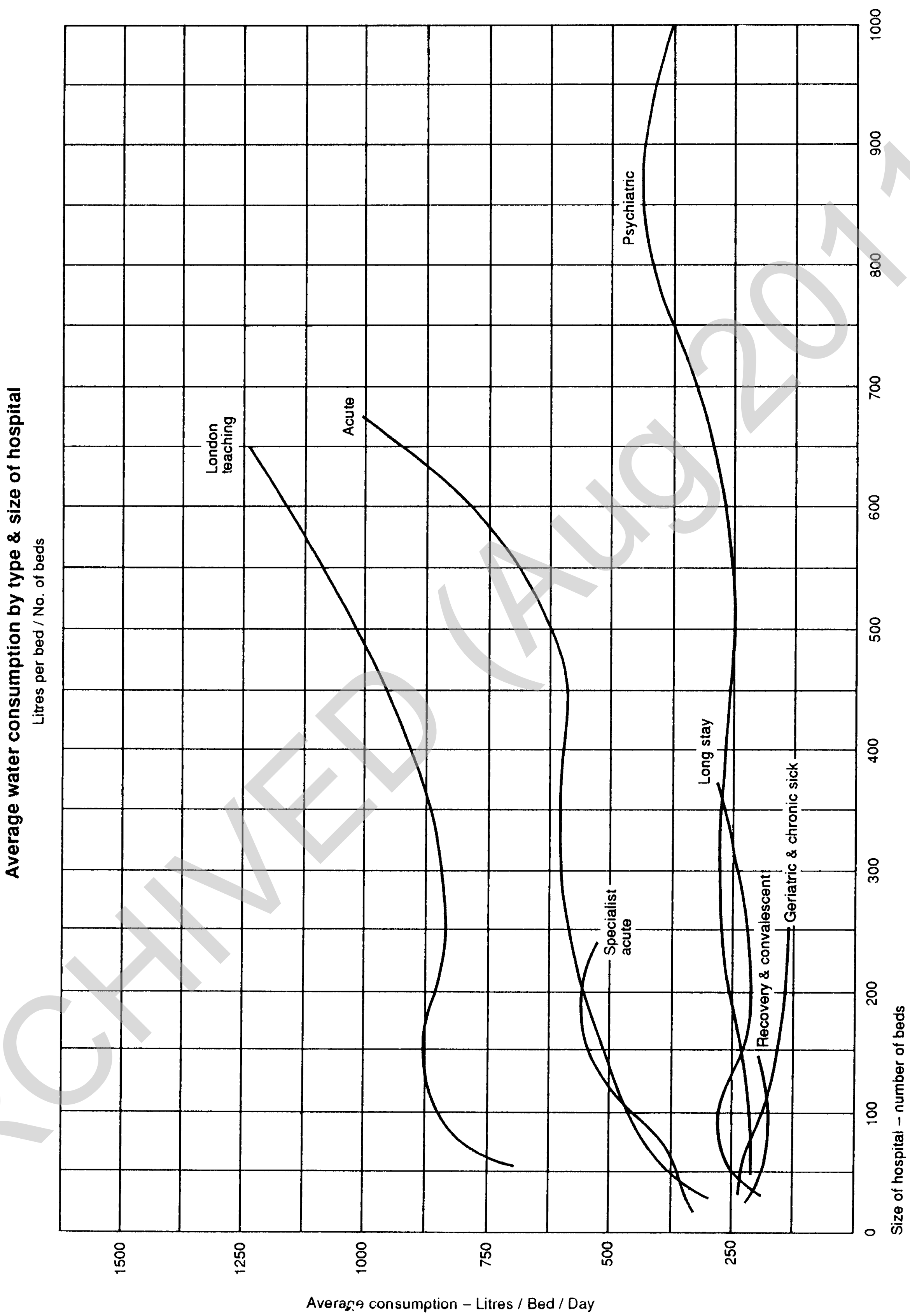
Appendix 1 (continued): Average water consumption by type and size of hospital.

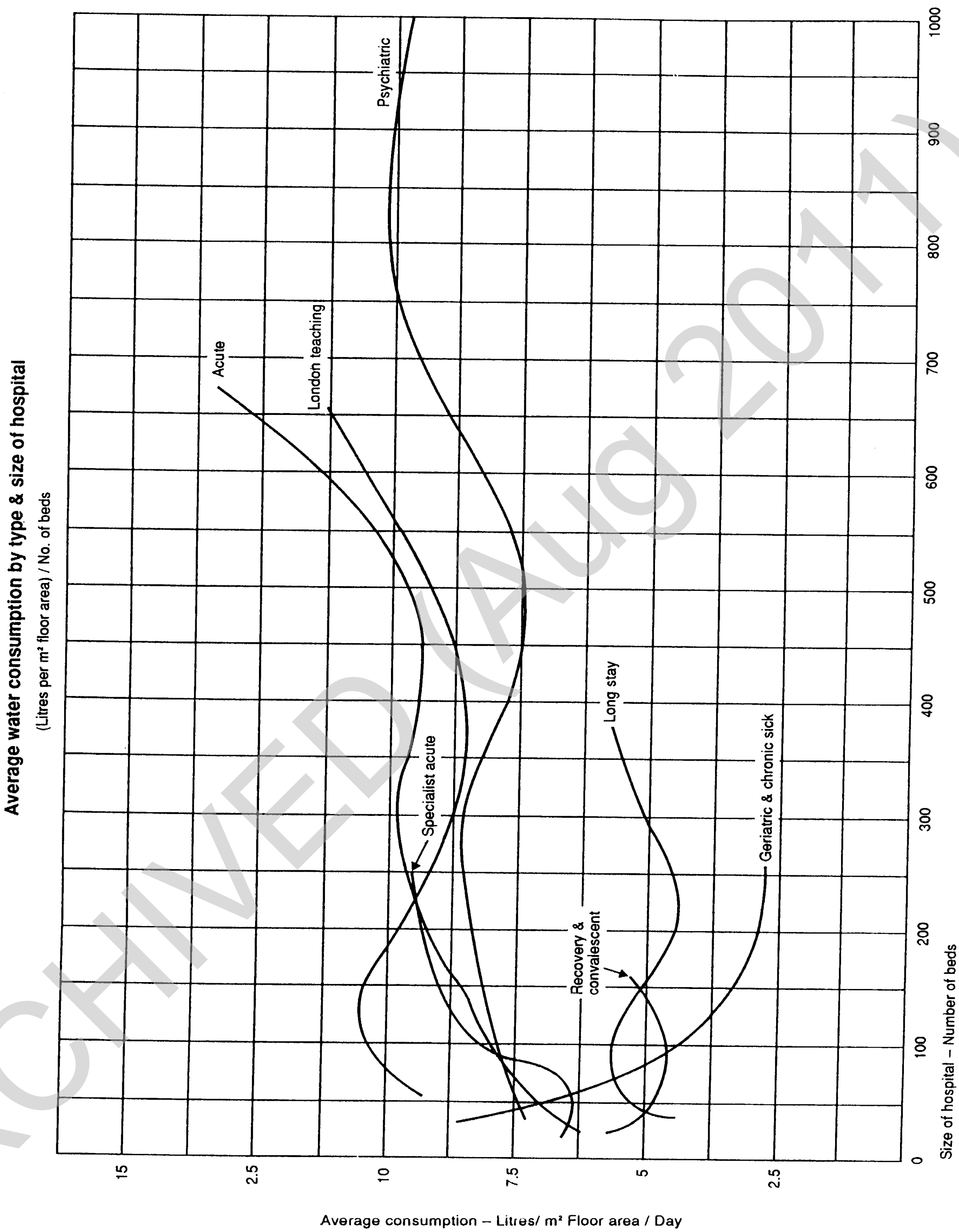
Size band (no. of beds)	No. of hospitals in sample	Total no. of beds in sample	Average size of hospital (no. of beds)	Total consumption m^3 per annum	Average consumption Litres/ Bed/ Day
Acute (Types 1, 2 3 and 17)					
0 - 50	150	4,208	28	458,900	299
51 - 100	58	4,151	72	602,909	398
101 - 200	70	9,946	142	1,780,700	490
201 - 400	62	18,167	293	3,914,351	590
401 - 600	23	10,741	467	2,348,682	599
Over 600	3	2,023	674	721,887	978
Specialist acute (Types 11,14,15,16 and 18)					
0 - 25	53	931	18	108,336	319
26 - 50	18	651	36	82,455	347
51 - 100	38	2,664	70	352,133	362
101 - 200	16	1,952	122	341,004	479
Over 200	7	1,633	233	316,874	531
Long stay (types 4 and 5)					
0 - 50	30	1,126	38	74,009	180
51 - 100	45	3,463	77	339,791	269
101 - 200	44	6,222	141	560,731	247
Over 300	10	2,300	230	182,617	217
	3	1,121	374	125,247	306
Recovery and convalescent (Types 7,8 and 9)					
0 - 25	6	126	21	9,965	216
26 - 50	35	1,339	38	100,721	206
51 - 100	19	1,357	71	91,947	185
Over 100	3	449	150	29,663	181
Geriatric and chronic sick (Type 19)					
0 - 50	18	573	32	51,520	246
51 - 100	20	1,460	73	108,163	203
101 - 200	6	788	131	46,987	164
Over 200	2	512	256	23,748	127
Psychiatric (Types 12 and 13)					
0 - 100	46	2,186	48	166,588	209
101 - 200	12	1,773	148	156,814	242
201 - 400	13	3,782	291	376,559	273
401 - 600	10	4,884	488	443,662	249
601 - 1000	7	5,112	730	654,024	350
Over 1000	5	6,098	1,220	747,676	336
London teaching (All Types)					
0 – 100	20	1,161	58	789,422	680
101 – 200	15	1,896	126	1,642,106	866
201 – 300	10	2,580	258	2,141,166	830
301 – 500	8	3,161	395	2,859,434	904
Over 500	4	2,611	652	3,207,658	1,228

Relative-intensity of water consumption

Whilst water consumption per bed content is a convenient estimating and planning yardstick, it does not show the widely differing floor areas which are provided per bed in hospitals of different sizes and type.

To illustrate the relative rates of consumption, as seen against a basis of comparable patient density and showing the amount of water consumed, not only directly by the patient but also in the supporting treatment departments, the following graphical presentation of the preceding figures are complemented by a graph of the same consumption figures presented on a floor area basis.


Average water consumption by type & size of hospital
Litres per bed / No. of beds
London teaching
Acute
Psychiatric
Long stay
Specialist acute
Recovery & convalescent
Geriatric & chronic sick
0
100
200
300
400
500
600
700
800
900
1000
Size of hospital – number of beds
1500
1250
1000
750
500
250
Average consumption – Litres / Bed / Day


Average water consumption by type & size of hospital
(Litres per m² floor area) / No. of beds
Psychiatric
London teaching
Acute
Specialist acute
Long stay
Geriatric & chronic sick
Recovery & convalescent
15
2.5
10
7.5
5
2.5
Average consumption – Litres/ m² Floor area / Day
0
100
200
300
400
500
600
700
800
900
1000
Size of hospital – Number of beds

Appendix 1. Sheet 7

Residential Accommodation for Nursing Staff			
1. Date			
Type of accommodation	*Number of residents*	*Allocation of fittings*	*Total fittings*
A Student Nurses	150	1 LB per person 1 Bath / 1 WC / 1 Sink } Per 5 persons 1 Laundry per 50 persons	150 LBS 30 Baths 30 WC 30 Sinks 3 Laundries
B Staff Nurses	50	1 LB per person 1 Bath / 1 WC / 1 Sink } Per 4 persons	50 LBs 12 Baths 12 WCs 12 Sinks
C – F Deputy matrons MOs etc.	50 plus 50 family residents	1 LB / 1 Bath / 1 WC / 1 Sink } Per Flat	50 LBs 50 Baths 50 WCs 50 Sinks
Totals	300	—	250 LBs 92 Baths 92 WCs 92 Sinks 3 Laundries

2. Daily usage per fitting

Type of fitting	*Accommodation A*	*Accommodation B*	*Accommodation C - F*
LB	3	3	6
Bath	2 ½	2	1
WC	20	16	8
Sink	5	4	6
Washing machine	8	—	—

3. Consumption per use

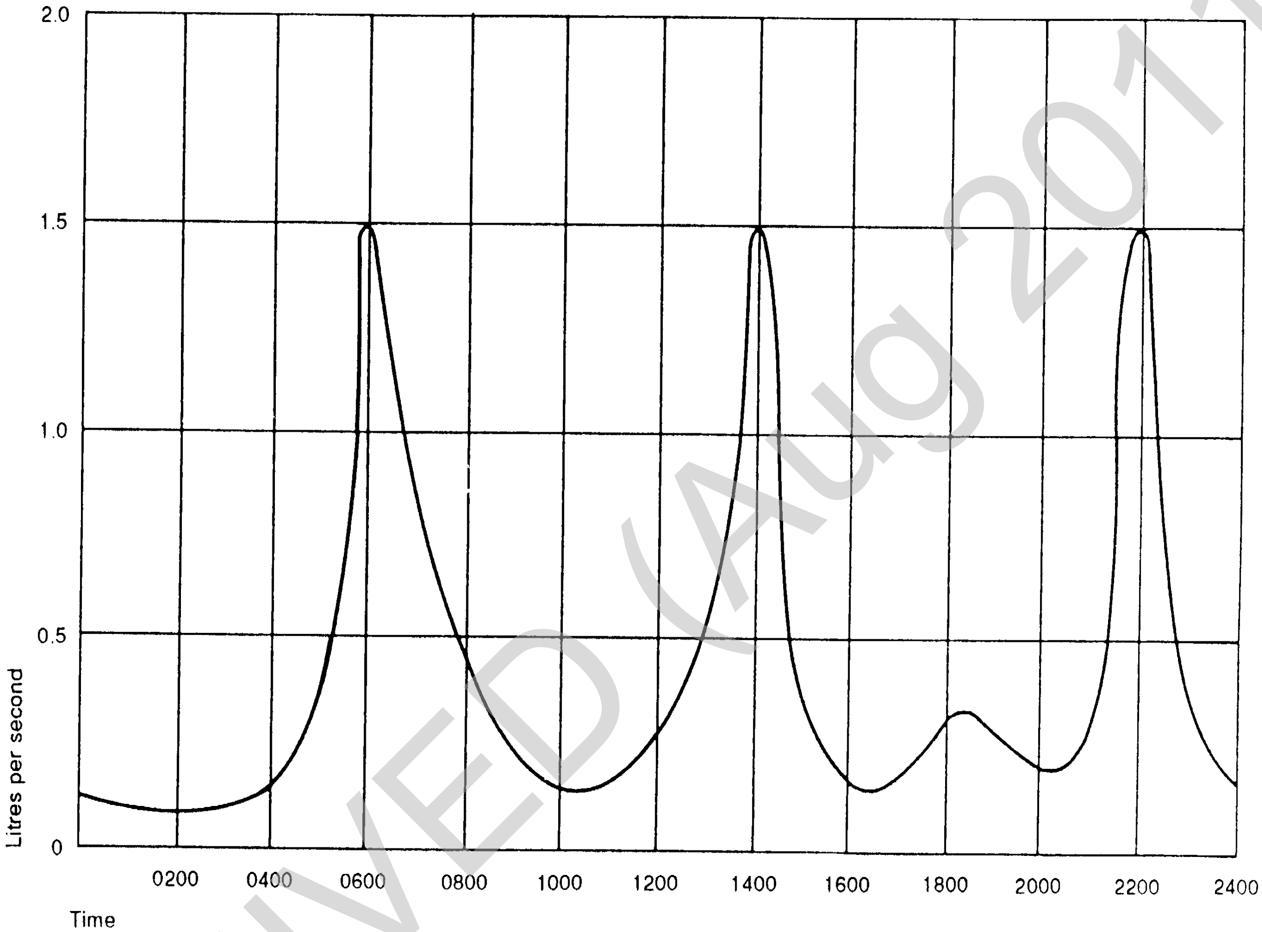
LB	4.5 Litres	Sink	9 Litres
Bath	72 Litres	Washing machine	114 Litres
WC	9 Litres		

4. Estimated daily consumption = 34090 litres
Daily consumption per person = 114 litres

5. Peak demands
If two thirds of resident staff work three shifts commencing at 06.00, 1400 and 22.00 hours peak demand will occur from 05.00 – 07.00, 13.00 – 15.00 and 21.00 – 23.00 hours. Peak demand may reach 1.5 litres per sec with an average demand of 1.06 litres per sec over three periods.

Water consumption for residential accommodation of nursing staff

Total storage = 34,100 litres
Ratio = 114 litres / person



Demand incidence for 200 nursing staff & 100 senior staff flats

Appendix 2: Water treatment

General

1. All water supplied to healthcare premises must comply with current legislation on water quality.

2. The following sections on water treatment are intended to provide a brief overview only. Further details can be found in BSRIA Application Guide AG 2/93, *Water Treatment for Building Services Systems.* Some of the more common water treatment processes are mentioned below. The extent of treatment will vary for each application depending on water quality, intended usage etc, and specialist advice should be obtained when considering the adoption of any water treatment processes.

3. The need for water treatment and the treatment processes used depend on the purposes for which the water is to be used and the quantity required for each purpose. While potability is not normally affected by such characteristics as hardness, colour, and (within limits) smell and/or taste, a measure of treatment may be necessary to provide a more acceptable supply.

4. A supply from a water authority should not normally require any further treatment when used for hospital purposes other than laundries, domestic hot water systems, humidification plant and steam boiler feed water. Private supplies, however, will require some measure of treatment, and in many cases the installation of pumping and treatment plant needs to be extensive to ensure a constant acceptable quality.

5. Water is not naturally found in a state of chemical purity. Surface waters in upland reservoirs, rivers and lakes often contain organic matter including algae, tree foliage and silt. River water may also be polluted by sewage and industrial effluents and chemicals leached from agricultural land etc. Groundwaters in springs, wells and boreholes collect impurities from the surrounding strata; shallow wells collect impurities from surrounding soil.

6. The impurities which must therefore be removed include tree foliage and matter in suspension consisting of mineral particles, algae, organic matter and various kinds of living organisms and bacteria. Other dissolved chemicals may also require removal.

7. Suspended matter in water covers a wide range of particle size varying from the large organic particles and silt found in fast-flowing rivers, to colloidal matter with a size of 1 micron or less. Natural filtration takes place as water percolates through the permeable strata and generally reduces suspended solids.

Water treatment processes

8. For high quality groundwater sources, the only treatment that may be required is disinfection, which is covered in Chapter 4. However, for other water sources, further treatment will be required and this may be extensive.

9. There are a wide range of treatment options available, but the most relevant to health establishments are:

a. coagulation and flocculation;
b. settlement;
c. dissolved air flotation;
d. filtration;
e. iron and manganese removal;
f. pH adjustment;
g. solids treatment and disposal.

Coagulation and flocculation

10. This is the addition of a coagulant (often aluminium sulphate or an organic polymer) followed by gentle agitation. The process is used to destabilise fine particles in the water so that they agglomerate together such that they will settle out more easily in the settlement process or that they can be removed more easily by filtration.

Settlement

11. In this process, water is passed through tanks in which solid particles settle out. Settlement covers a range of designs from simple horizontal flow tanks to complex upflow sludge blanket clarifiers and lamella flow separators. Settlement is basically a gravity process, although the sludge blanket used in some designs of tanks is part of a flocculation process.

Dissolved air flotation

12. Dissolved air flotation uses fine bubbles of air to lift particles present in water to the surface of a tank, from where they are removed by a skimming system. Water to be treated passes through a rectangular tank. High pressure water, saturated with air, is introduced into the bottom of the tank. The air in this water comes out of solution because of the pressure drop and forms fine air bubbles on solids within the water; these solids then rise. The process is particularly suitable for the removal of low-density solids such as algae. It is a sophisticated process and is unlikely to be used except in special circumstances.

Filtration

13. Filtration is a solids removal process that involves passing water through a filtering medium which is normally sand. The most likely form of sand filter to be found in a modern small treatment plant is a pressure filter; these are normally vertical cylindrical steel or GRP pressure vessels.

14. Water enters at the top of the vessel and passes down through 50 cm of sand. The sand rests on gravel which in turn is supported on a perforated floor. After passing through the sand and gravel the filtered water leaves through the bottom of the vessel.

15. As the water passes through the vessel, the sand becomes increasingly clogged with dirt and the pressure drop across the filter increases. Once the pressure drop becomes excessive, the filter is cleaned. This is done by flow reversal with water, and sometimes air, flowing up through the sand to waste. This expands the bed and frees the dirt from the sand.

16. The need to clean filters involves a fairly complex system of pipes and valves. On modern filters, cleaning is normally done automatically, with electrically-operated valves.

17. Filtration removes solids, and for relatively clean waters it may be the only treatment process needed apart from disinfection. For dirtier waters, pre-treatment by settlement or dissolved air flotation is required in order to prevent too great a frequency of backwashing. For sources liable to pollution from animal waste, filtration is essential for the removal of cryptosporidium and/or giardia cysts. The filtering medium may be sand but may also be granular activated carbon, to remove tastes and odours, or a catalytic medium (manganese dioxide or polorite) to oxidise and remove iron and manganese.

18. Modern packaged plants may also use other sorts of filtration system.

Iron and manganese removal

19. A common problem, particularly with ground water, is excessive iron and manganese levels. This problem is often solved by oxidising the iron and manganese to an insoluble form by chlorination, pH adjustment and filtration to remove the iron and manganese. Filtration is often done in pressure filters with a catalytic medium.

pH adjustment

20. This is often needed either to oxidise iron and manganese or to render water less corrosive to the distribution system.

Solids treatment and disposal

21. It should always be borne in mind that a water treatment plant will produce wastes from settlement tanks and filters. These wastes will need to be disposed of, probably to the site foul sewerage system.

22. Contaminated water that is run to waste into a natural watercourse or a drain leading to it should be treated in accordance with the requirements of the authority responsible for land drainage and pollution control. The authority responsible for that sewer should be informed. Dechlorination can be achieved using either sulphur dioxide or sodium thiosulphate. 20 g of sodium thiosulphate crystals are required to dechlorinate 500 litres of water containing 20 mg/l free chlorine.

References

NOTE*:*
Where there is a requirement to address a listed reference, care should be taken to ensure that all amendments following the date of issue are included.

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
Acts and Regulations				
	The Building (Scotland) Act	HMSO	1959	
	Clean Air Act	HMSO	1993	
	Electricity Act	HMSO	1989	
	Food Safety Act	HMSO	1990	
	Health and Safety at Work etc Act	HMSO	1974	
	Registered Establishments (Scotland) Act	HMSO	1998	
	The Water (Scotland) Act	HMSO	1980	
	Water Resources Act	HMSO	1991	
SI 2179 & 187	The Building Standards (Scotland) Regulations (as amended)	HMSO	1990	
	The Building Standards (Scotland) Regulations: Technical Standards Guidance	HMSO	1998	
SI 1460	Chemicals (Hazard Information and Packaging for Supply) Regulations (CHIP2)	HMSO	1997	
SI 3140	Construction (Design and Management) Regulations	HMSO	1994	
SI 437	Control of Substances Hazardous to Health Regulations (COSHH)	HMSO	1999	
SI 635	Electricity at Work Regulations	HMSO	1989	
SI 1057	Electricity Supply Regulations (as amended)	HMSO	1988 (amd 1998)	
SI 2372	Electromagnetic Compatibility Regulations (as amended)	HMSO	1992	
SI 1763	Food Safety (General Food Hygiene) Regulations	HMSO	1995	
SI 2200	Food Safety (Temperature Control) Regulations	HMSO	1995	
SI 2451	Gas Safety (Installation and Use) Regulations	HMSO	1998	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
SI 917	Health & Safety (First Aid) Regulations	HMSO	1981	
SI 682	Health & Safety (Information for Employees) Regulations	HMSO	1989	
SI 2792	Health and Safety (Display Screen Equipment) Regulations	HMSO	1992	
SI 341	Health and Safety (Safety Signs and Signals) Regulations	HMSO	1996	
SI 1380	Health and Safety (Training for Employment) Regulations	HMSO	1990	
SI 2307	Lifting Operations and Lifting Equipment Regulations (LOLER)	HMSO	1998	
SI 3242	Management of Health and Safety at Work Regulations	HMSO	1999	
SI 2793	Manual Handling Operations Regulations	HMSO	1992	
SI 1790	Noise at Work Regulations	HMSO	1989	
SI 3139	Personal Protective Equipment (EC Directive) Regulations (as amended)	HMSO	1992	
SI 2966	Personal Protective Equipment at Work (PPE) Regulations	HMSO	1992	
SI 574	Private Water Supplies (Scotland) Regulations	HMSO	1992	
SI 2306	Provision and Use of Work Equipment Regulations (PUWER)	HMSO	1998	
SI 1550	Public Health (Notification of Infectious Diseases (Scotland) (Amendment)) Regulations	HMSO	1989	
SI 3163	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)	HMSO	1995	
SI 1333 (S129	Water Supply (Water Quality) (Scotland) (Amendment) Regulations	HMSO	1991	
SI 119 (S11)	Water Supply (Water Quality) (Scotland) Regulations	HMSO	1990	
SI 3004	Workplace (Health, Safety and Welfare) Regulations	HMSO	1992	
British Standards				
BS 864	**Capillary and compression tube fittings of copper and copper alloy**	BSI Standards		
BS 1212	**Float operator valves** **Part 1:** Specification for piston type float operated valves (copper alloy body) (excluding floats)	BSI Standards	1990	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
BS 1710	**Specification and identification of pipelines**	BSI Standards	1984 (1991)	AMD 612 10/85
BS 2486	**Treatment of water for steam boilers and water heaters**	BSI Standards	1997	
BS 3505	**Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water**	BSI Standards	1986	AMD 6130, 11/88
BS 3506	**Specification for unplasticized PVC pipe industrial uses**	BSI Standards	1969	AMD 1152, 9/73; AMD 1777, 7/5
BS 5886	**Methods for field pressure testing of asbestos-cement pipelines**	BSI Standards	1980	
BS 6100	**Glossary of building and civil engineering terms**	BSI Standards		
	Section 2.7: Public Health. Environmental Engineering		1992	
	Section 3.3: Sanitation		1992	
BS 6700	**Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages**	BSI Standards	1997	
BS 6920	**Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water**	BSI Standards		
BS 7206	**Specification for unvented hot water storage package and units**	BSI Standards	1990	
BS 7491	**Glass fibre reinforced plastic cisterns for cold water storage**	BSI Standards		
	Part 1: Specification for one-piece cisterns of capacity up to 500L		1991	AMD 7382, 12/92
	Part 2: Specification for one-piece cisterns of nominal capacity from 500L to 25000L		1992	
BS 7671	**The requirements for wiring installations** *(The IEE wiring regulations)*	BSI Standards	2001	16th edition
BS 8007	**Code of practice for design of concrete structures for retaining aqueous liquids**	BSI Standards	1987	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
BS EN 1057	**Copper and copper alloys. Seamless, round copper tubes for water and gas in sanitary and heating applications**	BSI Standards	1996	
CP 312	**Code of practice for plastics pipework (thermoplastic material). Parts 1 to 3**	BSI Standards	1973	
CP 2010-2	**Code of practice for pipelines. Design and construction of steel pipelines in land**	BSI Standards	1970	
Scottish Health Technical Guidance				
SHTM 2005	Building management systems	P&EFEx	2001	CD-ROM
SHTM 2011	Emergency electrical services	P&EFEx	2001	CD-ROM
SHTM 2020	Electrical safety code for low voltage systems (Escode – LV)	P&EFEx	2001	CD-ROM
SHTM 2023	Access and accommodation for engineering services	P&EFEx	2001	CD-ROM
SHTM 2040	The control of legionellae in healthcare premises – a code of practice	P&EFEx	2001	CD-ROM
SHGN	The Pressure Systems and Transportable Gas Containers Regulations 1989	P&EFEx	2001	CD-ROM
SHGN	'Safe' hot water and surface temperatures	P&EFEx	2001	CD-ROM
SHPN 1	Health service building in Scotland	HMSO	1991	
SHPN 2	Hospital briefing and operational policy	HMSO	1993	
SHPN 13	Sterile services department	HMSO		MEL 94/63
SHTN 1	Post commissioning documentation for health buildings in Scotland	HMSO	1993	
SHTN 2	Domestic hot and cold water systems for Scottish Health Care Premises	P&EFEx	2001	CD-ROM
SHTN 4	General Purposes Estates and Functions Model Safety Permit-to-Work Systems	EEF	1997	
	Strategic guide to water and sewerage policy for General Managers and Chief Executives	HMSO	1993	
Scottish Infection Manual	Guidance on core standards for the infection of hospitals, healthcare premises and at the community interface	HMSO	1998	
	NHS in Scotland – PROCODE	P&EFEx	2001	Version 1.1

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
NHS in Scotland Firecode				
SHTM 81	Fire precautions in new hospitals	P&EFEx	1999	CD-ROM
SHTM 82	Alarm and detection systems	P&EFEx	1999	CD-ROM
SHTM 83	Fire safety in healthcare premises: general fire precautions	P&EFEx	1999	CD-ROM
SHTM 84	Fire safety in NHS residential care properties	P&EFEx	1999	CD-ROM
SHTM 85	Fire precautions in existing hospitals	P&EFEx	1999	CD-ROM
SHTM 86	Fire risk assessment in hospitals	P&EFEx	1999	CD-ROM
SHTM 87	Textiles and furniture	P&EFEx	1999	CD-ROM
SFPN 3	Escape bed lifts	P&EFEx	1999	CD-ROM
SFPN 4	Hospital main kitchens	P&EFEx	1999	CD-ROM
SFPN 5	Commercial enterprises on hospital premises	P&EFEx	1999	CD-ROM
SFPN 6	Arson prevention and control in NHS healthcare premises	P&EFEx	1999	CD-ROM
SFPN 7	Fire precautions in patient hotels	P&EFEx	1999	CD-ROM
SFPN 10	Laboratories on hospital premises	P&EFEx	1999	CD-ROM
UK Health Technical Guidance				
CP 312	Code of practice for plastic pipework (thermoplastic material)		1973	
EH 40	HSE Occupational Exposure limits	HSE	Annual	
MES	Model Engineering Specifications	NHS Estates	1997	As required
	Strategic guide to water and sewerage policy for general managers and chief executives	NHS Estates	1993	
Chartered Institute of Building Service Engineers (CIBSE)				
	Environmental design; guide A	CIBSE	1999	
	Installation and equipment data; guide B	CIBSE	1986	
	Reference data; guide C	CIBSE	2001	(expected)
	Water distribution; commissioning code series W	CIBSE	1994	
TM 13	Minimising the risk of Legionnaires' disease	CIBSE	2000	
OOM	Guide to ownership, operation and maintenance of building services	CIBSE	2000	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
Miscellaneous References				
	Model Water Byelaws: Dept. of the Environment	HMSO	1986	
	The microbiology of water: part 1	HMSO	1994	
	Untapped savings: water services in the NHS	HMSO	1993	
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