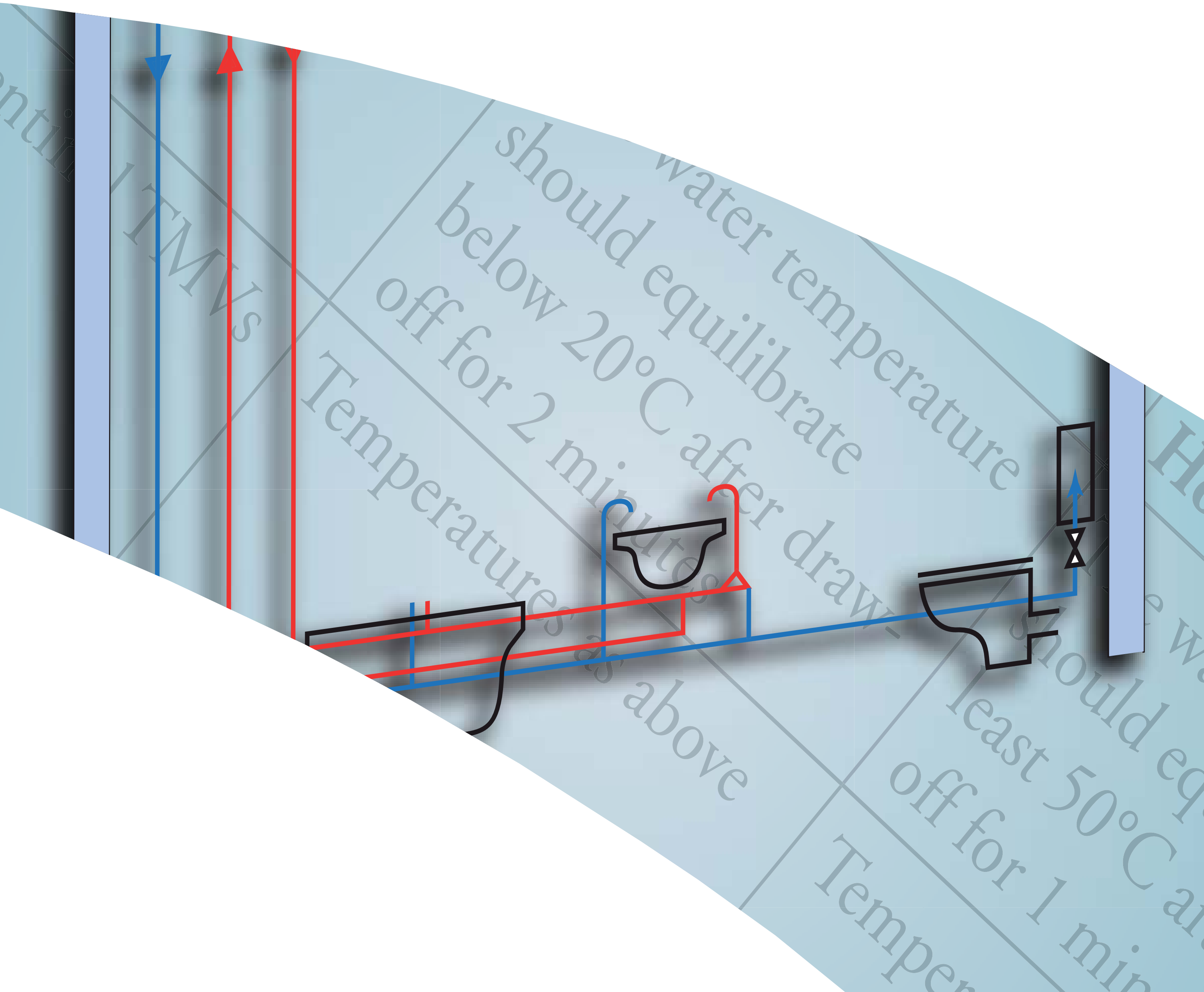
Department of Health

Water systems
Health Technical Memorandum 04-01: The control of Legionella, hygiene, “safe” hot water, cold water and drinking water systems

Part A: Design, installation and testing



Water systems: Health Technical Memorandum 04-01 The control of Legionella, hygiene, “safe” hot water, cold water and drinking water systems – Part A: Design, installation and testing

ISBN 0-11-322744-2
9 780113 227440

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HR / Workforce	Performance
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Clinical	Partnership Working

Document Purpose	Best Practice Guidance		
ROCR Ref:		**Gateway Ref:**	6954
Title	HTM 04-01 The control of Legionella, hygiene, "safe" hot water, cold water and drinking water systems. Part A: Design, Installation and Testing.		
Author	DH Estates and Facilities Division		
Publication Date	October 2006		
Target Audience	PCT CEs, NHS Trust CEs, Care Trust CEs, Foundation Trust CEs , Medical Directors, Directors of Nursing, PCT PEC Chairs, NHS Trust Board Chairs, Special HA CEs		
Circulation List	Department of Health libraries, House of Commons library, Strategic Health Authority, UK Health Departments, Directors of Estates and facilities		
Description	This Health Technical Memorandum outlines the principles involved in design, installation and testing of hot and cold water supply, storage and distribution systems for healthcare premises. It is applicable to both new and existing sites.		
Cross Ref	n/a		
Superseded Docs	HTM 2027 Hot and cold water supply, storage & mains services HTM 2040 The control of legionellae….: a code of practice.		
Action Required	n/a		
Timing	**n/a**		
Contact Details	Chris Holme Department of Health Finance and Investment Directorate Estates and Facilities Division Quarry House Leeds LS2 7UE		
For Recipient's Use			

Water systems
Health Technical Memorandum 04-01
The control of *Legionella*, hygiene, "safe" hot water, cold water and drinking water systems

Part A: Design, installation and testing

Published by TSO (The Stationery Office) and available from:

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www.tsoshop.co.uk

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ISBN 0-11-322744-2
978-0-11-322744-0

First published 2006

Printed in the United Kingdom for The Stationery Office

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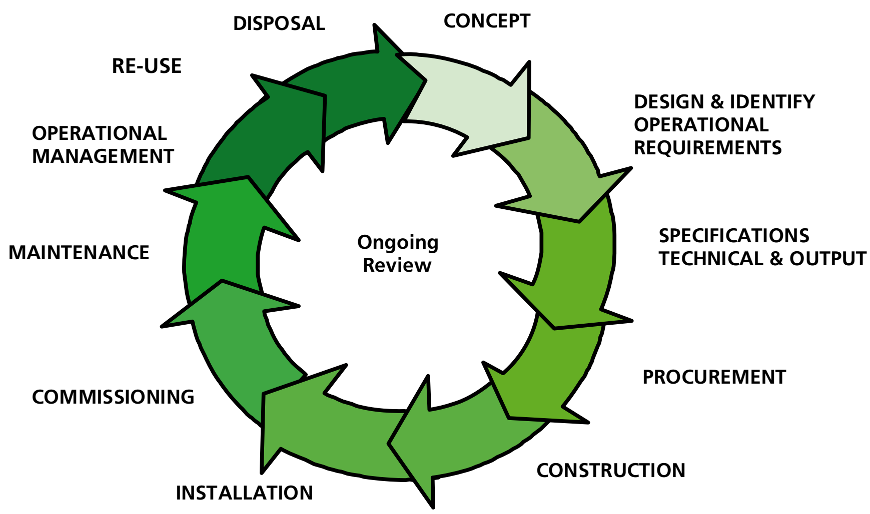
Preface

About Health Technical Memoranda

Engineering Health Technical Memoranda (HTMs) give comprehensive advice and guidance on the design, installation and operation of specialised building and engineering technology used in the delivery of healthcare.

The focus of HTM guidance remains on healthcare-specific elements of standards, policies and up-to-date established best practice. They are applicable to new and existing sites, and are for use at various stages during the whole building lifecycle:

Figure 1 Healthcare building life-cycle



Healthcare providers have a duty of care to ensure that appropriate engineering governance arrangements are in place and are managed effectively. The Engineering Health Technical Memorandum series provides best practice engineering standards and policy to enable management of this duty of care.

It is not the intention within this suite of documents to unnecessarily repeat international or European standards, industry standards or UK Government legislation. Where appropriate, these will be referenced.

Healthcare-specific technical engineering guidance is a vital tool in the safe and efficient operation of healthcare facilities. Health Technical Memorandum guidance is the main source of specific healthcare-related guidance for estates and facilities professionals.

The core suite of nine subject areas provides access to guidance which:

- is more streamlined and accessible;
- encapsulates the latest standards and best practice in healthcare engineering;
- provides a structured reference for healthcare engineering.

Structure of the Health Technical Memorandum suite

The series of engineering-specific guidance contains a suite of nine core subjects:

Health Technical Memorandum 00
    Policies and principles (applicable to all Health Technical Memoranda in this series)

Health Technical Memorandum 01
    Decontamination

Health Technical Memorandum 02
    Medical gases

Health Technical Memorandum 03
Heating and ventilation systems

Health Technical Memorandum 04
Water systems

Health Technical Memorandum 05
Fire safety

Health Technical Memorandum 06
Electrical services

Health Technical Memorandum 07
Environment and sustainabilty

Health Technical Memorandum 08
Specialist services

Some subject areas may be further developed into topics shown as -01, -02 etc and further referenced into Parts A, B etc.

Example: Health Technical Memorandum 06-02 Part A will represent:

Electrical safety guidance for low voltage systems

In a similar way Health Technical Memorandum 07-02 will simply represent:

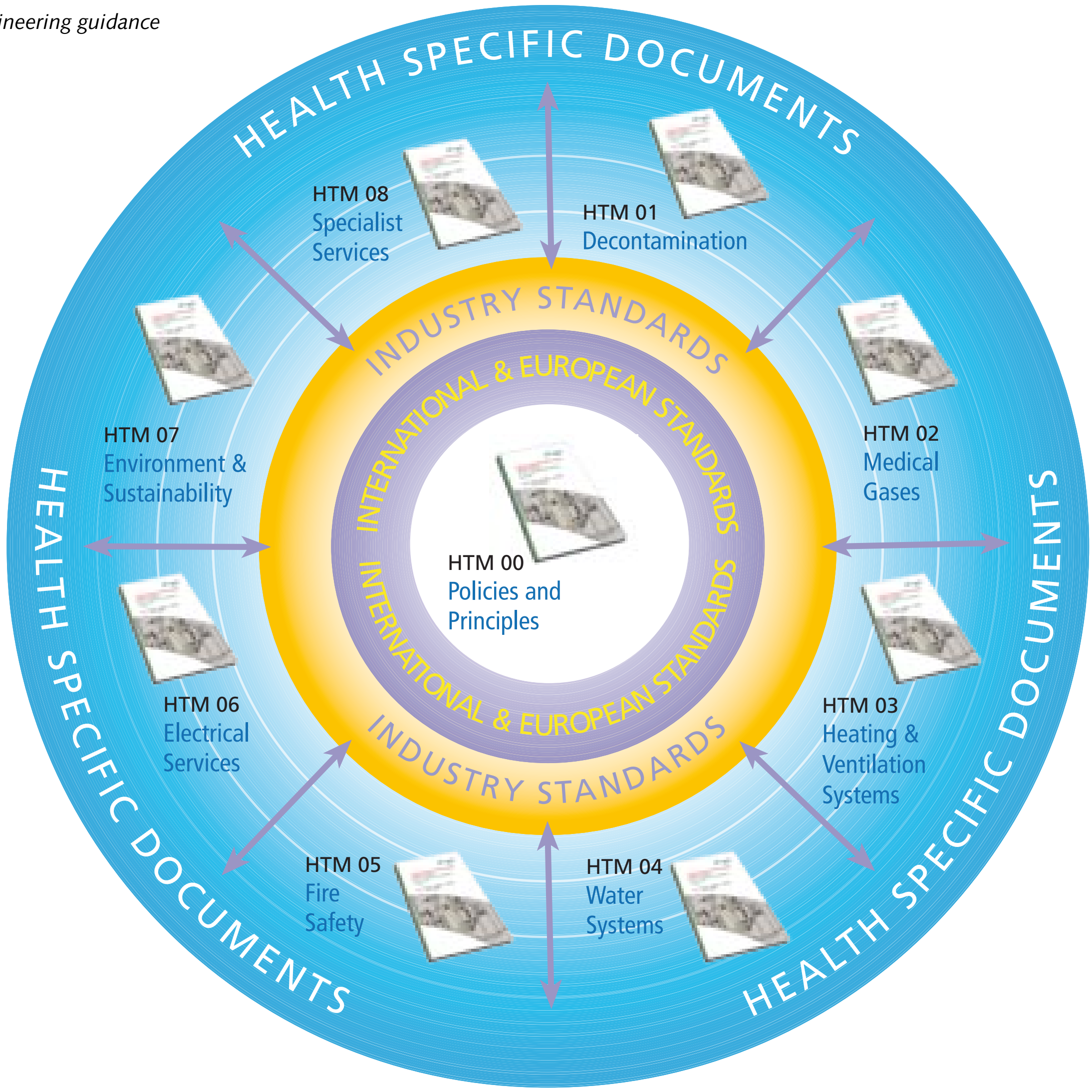
Environment and Sustainability – EnCO_2de.

All Health Technical Memoranda are supported by the initial document Health Technical Memorandum 00 which embraces the management and operational policies from previous documents and explores risk management issues.

Some variation in style and structure is reflected by the topic and approach of the different review working groups.

DH Estates and Facilities Division wishes to acknowledge the contribution made by professional bodies, engineering consultants, healthcare specialists and NHS staff who have contributed to the review.

Figure 2 Engineering guidance



Executive summary

Preamble

Health Technical Memorandum 2027 – 'Hot and cold water supply, storage and mains services' and Health Technical Memorandum 2040 – 'The control of Legionellae in healthcare premises: a code of practice' have both been revised, and have, at the same time, been combined into this single document: Health Technical Memorandum 04-01 – 'The control of Legionella, hygiene, "safe" hot water, cold water and drinking water systems'.

The guidance has been revised in line with changes to relevant regulations, standards and other guidance, and also technical developments.

Health Technical Memorandum 04 now supersedes Health Technical Memorandum 2027 and Health Technical Memorandum 2040.

Introduction

The development, construction, installation and maintenance of hot and cold water supply systems are vital for public health. Healthcare premises are dependent upon water to maintain hygiene and a comfortable environment for patients and staff, and for clinical and surgical care.

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 and distribution systems.

This Health Technical Memorandum gives comprehensive advice and guidance to healthcare management, design engineers, estate managers and operations managers on the legal requirements, design applications, maintenance and operation of hot and cold water supply, storage and distribution systems in all types of healthcare premises. It is equally applicable to both new and existing sites.

Aims of this guidance

This guidance has been written to:

- provide information on thermostatic mixing valve configurations, usage and maintenance requirements;
- outline how quality and hygiene of water supply can preserve system components and safe use by occupants;
- provide a point of reference to legislation, standards and other guidance pertaining to water systems;
- provide a basic overview of possible bacterial contaminants;
- outline key criteria and system arrangements to help stop bacteria proliferate;
- give an overview of some of the different water systems components and their safe installation and operation;
- provide typical system layouts and individual component location;
- illustrate the importance of "safe" delivery of hot water;
- illustrate temperature regimes for sanitary outlets used in healthcare premises to reduce risk of occupant injury;
- identify key commissioning, testing and maintenance requirements for referral by designers, installers, operators and management.

Recommendations

- In healthcare facilities, there is a risk of scalding for vulnerable patients, the very young, older people and mental health patients. Therefore, this guidance strongly recommends that thermostatic mixing devices should be considered for many hot water outlets. Safe water and delivery devices are summarised as follows:

Area/activity	Recommended temperature (°C)	Type of device (see MES D08 for explanation of valve types)
Staff bases, ward and consulting rooms etc basins In-patient, out-patient hand-wash basins	41	Type 3 Thermostatic
General areas to which staff and visitors may have access	41	Type 2 Thermostatic
Paediatric baths	40 – to allow for the cold paediatric bath/sink NB: Paediatric nurses should always use a thermometer	Type 3 Thermostatic
General baths	43	Type 3 Thermostatic
Showers	41	Type 3 Thermostatic
Assisted baths	46 – to allow for the cold mass of bath NB: Nurses should **always** use a thermometer before immersing patients	Type 3 Thermostatic
Hair-wash facilities	41	Type 3 Thermostatic
Bidets	38	Type 3 Thermostatic
All sinks, kitchens, pantries, slop sinks etc	55 – minimum required for food hygiene and decontamination purposes	Separate hot and cold taps or combination tap assembly Type 1; no preceding thermostatic device
Office, staff-only access areas hand-wash basins	43	Type 1

- It is preferable that thermostatic mixing devices are fitted directly to the mixed temperature outlet, or be integral with it, and be the method of temperature and flow control.
- Because of the complexity of hot and cold water systems found in healthcare facilities and the responsibility of maintaining a temperature control regimen at all times, this guidance suggests that chemical and other water treatments that have been shown to be capable of controlling and monitoring *Legionella* may also be considered (for example chlorine dioxide or silver/copper ionisation).

Note

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 must also comply with:

a. the Water Supply (Water Fittings) Regulations 1999, recommendations of the water suppliers in the Water Regulations Advisory Scheme's (WRAS) 'Water Regulations Guide', and any other requirements of the local water undertaker;

b. the Health and Safety Commission's Approved Code of Practice and guidance document 'Legionnaires' disease: the control of *Legionella* bacteria in water systems' (commonly known as L8), which requires that there must be a written scheme in place in respect of controlling *Legionella* in water systems.

Acknowledgements

The Department of Health would like to thank the Steering Group for their advice and support, and all those who contributed to the consultation phase of the document.

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Contents

1 Introduction

Preamble

1.1 Health Technical Memorandum 2027 – 'Hot and cold water supply, storage and mains services' (NHS Estates, 1995) and Health Technical Memorandum 2040 – 'The control of legionellae in healthcare premises: a code of practice' (NHS Estates, 1994) have both been revised, and have, at the same time, been combined into this single document: Health Technical Memorandum 04-01 – 'The control of *Legionella*, hygiene, "safe" hot water, cold water and drinking water systems'. The guidance has been revised in line with changes to relevant regulations, standards and other guidance and also technical developments.

1.2 Health Technical Memorandum 04 now supersedes Health Technical Memorandum 2027 and Health Technical Memorandum 2040.

1.3 This Health Technical Memorandum gives comprehensive advice and guidance to healthcare management, design engineers, estate managers and operations managers on the legal requirements, design applications, maintenance and operation of hot and cold water supply, storage and distribution systems in all types of healthcare premises. It is equally applicable to both new and existing sites.

1.4 In its new form, the document is divided in two parts. This part (Part A) outlines the principles involved in the design, installation and testing of the hot and cold water supply, storage and distribution systems for healthcare premises. Some variation may be necessary to meet the differing requirements for the various water undertakers. Part B covers operational management.

General

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

1.6 Healthcare premises are dependent upon water to maintain hygiene and a comfortable environment for patients and staff, and for clinical and surgical care.

1.7 The development, construction, installation and maintenance of hot and cold water supply systems are vital for public health.

1.8 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 and distribution systems.

1.9 Measures to control the spread of microorganisms in healthcare premises include the regular use of alcohol-based hand-rubs, and this can result in a significant reduction in the use of handwash basins. Under-use of taps encourages colonisation with *Legionella* and other microorganisms. Designers should be aware of this and, accordingly, consider how local infection policies with regard to hand hygiene and the use of alcohol-based hand-rubs might impact on the frequency of use of handwash basins (see also paragraphs 5.7–5.12 in Part B on the extent of utilisation).

Legislation, standards and guidance

1.10 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 should also comply with:

a. the Water Supply (Water Fittings) Regulations 1999, recommendations of the water suppliers in the Water Regulations Advisory Scheme's (WRAS) 'Water Regulations Guide', and any other requirements of the local water undertaker;

b. the Health and Safety Commission's Approved Code of Practice and guidance document L8, which requires that there must be a written scheme in place in respect of controlling *Legionella* in water systems.

Note: The Water Supply (Water Fittings) Regulations 1999 are set out, along with the DEFRA's (1999) guidance (see References) and with the water industry's interpretation of these provisions, in the WRAS 'Water Regulations Guide'. The WRAS is funded by the water suppliers to provide advice on the Water Supply (Water Fittings) Regulations 1999 on a national basis. WRAS also administers the WRAS "approval scheme" that assesses and lists water fittings and materials for compliance with the Regulations. The 'Water Fittings and Materials Directory' contains information on suitable fittings and materials and is updated every six months.

The water industry

Water supply

A company may be appointed to be a water undertaker by the Secretary of State under Section 6 of the Water Industry Act 1991, with a duty under this Act to develop and maintain an efficient and economical system of water supply (see Chapter 2).

Ten water and sewerage companies provide water and wastewater services for 99% of the population of England and Wales and drinking water to 75%. (A number of water supply companies provide drinking water to most of the remainder of the population.)

Regulatory authorities

The Water Act 1989 provided for the establishment of several regulatory bodies whose functions are now set out in the Water Industry Act 1991 and the Water Resources Act 1991 and are summarised below:

a. the Office of Water Services (OFWAT), which regulates the prices set by the water companies, oversees the standards of service provision and protects the interests of water consumers. OFWAT also has ten regional WaterVoice committees that identify customer concerns, pursue them with the companies and report to the director-general of water services;

b. the Environment Agency (EA) regulates the quality and controls pollution of "controlled" waters (that is, most inland and coastal waters) and protects the water resources in England and Wales;

c. the Drinking Water Inspectorate (DWI) regulates the quality of supply of drinking water.

1.11 Designers and installers of hot and cold water distribution systems are required by the Water Supply (Water Fittings) Regulations 1999 to notify the water undertaker of any proposed installation of water fittings and to have the water undertakers' consent before installation commences. It is a criminal offence to install or use water fittings without their prior consent. Liaison with the local water undertaker is strongly recommended at an early stage to avoid problems of compliance in the design.

1.12 All materials used in the construction of systems referred to in this Health Technical Memorandum must comply with the requirements of the Water Supply (Water Fittings) Regulations 1999 (Regulation 4: "Requirements for water fittings") and be in accordance with relevant British Standards and codes of practice. All materials in contact with wholesome water supplies must be listed in the 'Water Fittings and Materials Directory'.

1.13 Water quality is governed by the Water Supply (Water Fittings) Regulations 1999, building regulations, approved codes of practice and technical standards intended to safeguard quality.

Model Engineering Specification

1.14 Model Engineering Specification C07, which is a procurement specification, supports this Health Technical Memorandum and provides details of the extent of the work required.

Exclusions

1.15 Although many of this Health Technical Memorandum's recommendations will be applicable, it 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 "domestic" 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.

1.16 This Health Technical Memorandum does not cover wet cooling systems such as cooling towers. Guidance on these systems is given in the Health & Safety Commission's Approved Code of Practice and guidance document L8.

1.17 While some guidance on other water-service applications is included, it is not intended to cover them fully. For:

- laundry, see Health Building Note 25 – 'Laundry';
- sterile services departments, see Health Building Note 13 – 'Sterile services department';
- hydrotherapy pools, see the Public Health Laboratory Service's 'Hygiene for hydrotherapy pools';
- spa pools, see the Public Health Laboratory Service's 'Hygiene for spa pools: guidelines for their safe operation. The report of a PHLS spa pools working party';
- Guidance on birthing pools, see Health Building Note 21 – 'Maternity'.

Definitions

1.18 Definition of terms is as those contained in the Water Supply (Water Fittings) Regulations 1999; BS 6100:1984-2000; BS 6700:1997; and BS EN 806-2:2005.

2 Source of supply

General

2.1 Normally, the source of water supply to healthcare premises is by one or more service pipe connections from the mains of a water undertaker. If the quantity and rate of flow is inadequate, or if the cost of providing the service connection appears to be uneconomical, alternative sources of supply such as boreholes or wells may be investigated or other water undertakers may be contacted.

2.2 Where the constraint is only that of inadequacy of the water undertaker's supply, the healthcare building needs could be met by using a private supply as an additional source to the undertaker's supply. In such cases, the undertaker'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 must convey water through a separate pipework system that is clearly labelled. Outlets served by the private supply system should also be appropriately labelled.

2.3 Provision should be included for alternative water supply arrangements to meet an emergency, regardless of the source or sources of supply finally adopted. Alternative arrangements would include a second service connection from the water undertaker or a private supply. In either case the alternative supply should not be vulnerable to the cause of loss of the original supply. Direct physical interconnection of pipework and valves of a water undertaker's supply with any private supply without adequate backflow protection is prohibited by the Water Supply (Water Fittings) Regulations 1999. The water quality requirements applicable to the main supply apply also to any alternative supplies.

2.4 The water undertaker must be advised if it is proposed to use any private supply as well as the water undertaker's supply, and advice should be sought on the limitations imposed in respect of break cisterns and interconnection thereafter as required by the Water Supply (Water Fittings) Regulations 1999.

2.5 In England and Wales all water intended for human consumption is required by legislation to comply with the quality standards laid down in the Water Supply (Water Quality) Regulations 2000 and the Private Water Supplies Regulations 1991. 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.

2.6 The responsibility for enforcing this legislation for public water supplies rests primarily with the Drinking Water Inspectorate, and for private supplies it rests with the local authority. In respect of public water supplies, the water undertaker has a duty to provide a wholesome supply and to demonstrate – by monitoring – that the supplies meet the above standards.

Supplies from a water undertaker

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

a. the water undertaker's 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 there being any contaminated land on site;

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

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

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

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

Note

Regulations require notification to the water undertaker of any proposed changes and additions to the water supply system in the premises.

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

2.9 BS 6700:1997 and BS EN 806-2:2005 give further guidance on the procedures that should be followed when carrying out preliminary investigations in relation to new water supplies.

2.10 During the design stage, close collaboration with the water undertaker should be maintained, and consent must be sought on the final arrangements before proceeding with the installation. These arrangements should include:

- siting of service connection, access chamber, metering, bypassing, flushing out, physical security of service connection, installation and provisions for the fire-fighting service;
- compliance with the Water Supply (Water Fittings) Regulations 1999.

Private supplies

2.11 Private supplies independent of the water undertaker are governed by the Private Water Supplies Regulations 1991 and the Water Industry Act 1991. A licence is required from the Environment Agency (EA) before embarking on any private water supply scheme. If, for reasons of back-up or security of supply, there is a connection to the public supply (regardless of whether, or how often, it is used), the installations must comply with the Water Supply (Water Fittings) Regulations 1999. Private supplies should be registered with the local authority that has the responsibility to monitor the wholesomeness of the supplies where these are used for domestic or food production purposes.

2.12 The quality of water from a private supply is governed by the Private Water Supplies Regulations 1991. The standards are very similar to those for public supplies. Reference should also be made to the Standing Committee of Analysts' (2002) 'The microbiology of drinking water'.

2.13 The EA keeps records and maps of all known sources of private water supply together with details of the geological strata and water-bearing characteristics of the area under its control.

2.14 The feasibility of such a private supply should be decided by comparing 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 undertaker over the predicted life-cycle of the installation. 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.

2.15 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, which is either of proper quality or 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 to a connection from the water undertaker.

3 Water treatment regimens

3.1 Provided water is supplied from the public mains and its quality is preserved by correct design, installation and maintenance, it can be regarded as microbiologically acceptable for use. It is exceptional, however, for a water supply, either public or private, that is wholly 'potable' to be entirely free from aquatic organisms, and consequently it is important that appropriate measures are taken to guard against conditions that may encourage microbial multiplication.

3.2 Reasons for treatment of water from an undertaker in healthcare premises would be for processing for laundries, domestic hot water systems and steam boiler feed water, where either the degree of hardness proves excessive or exceptional softness causes corrosion. Most private supplies, however, are likely to 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.

3.3 Treatment systems that are used in conjunction with potable water systems should be selected with care. Addition of any substance must not cause a breach of any requirements in the Water Supply (Water Quality) Regulations 2000. Any substance should be approved in accordance with those Regulations, for example, by being in the Drinking Water Inspectorate list of approved substances for contact with drinking water, which is included as an appendix in the 'Water Fittings and Materials Directory'.

3.4 Automatic water treatment systems should be fail-safe and have sufficient instrumentation to monitor their operation. The water supply connections to the equipment must be adequately protected against backflow. Monitoring by means of building management systems should be considered.

3.5 In healthcare premises, both hot and cold water are considered to be potable and therefore water treatment supplied to healthcare premises must comply with current legislation on water quality.

3.6 Further details can be found in BSRIA's Application Guide AG 2/93: 'Water treatment for building services systems' (with amendments) and SHTN 2: 'Domestic hot and cold water systems for Scottish health care premises'.

3.7 The continuous chlorination of hot and cold water service systems, after initial disinfection (see Chapter 17), to control the growth of *Legionella* is not recommended because chlorine has a limited ability to penetrate biofilm and inactivate sessile microorganisms.

3.8 Treatment using chlorine dioxide or copper/silver ionisation can be used (see Chapter 15).

4 Water softening

4.1 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.

4.2 Hardness is due to calcium and magnesium salts in the water and is 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 shown in Table 1.

Table 1 Classification of water hardness

Description	**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

4.3 When the temperature of water is raised, 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 lime scale, thus reducing the heat transfer rate.

4.4 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. replacement of calcium and magnesium salts by their more soluble sodium equivalents;

b. removal of all salts, that is, demineralisation;

c. where purer water is required for specialised uses, it can be produced from softened water by reverse osmosis or by demineralisation.

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

4.6 Epidemiological studies have shown that the incidence of cardiovascular disease tends 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 150 mg/L (as $CaCO_3$). The explanation is not known, but it is considered prudent, where possible, not to drink water that 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 children and anyone on strict salt-restricted diets. These concerns can be avoided if water intended for drinking and cooking is not softened.

4.7 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, some water undertakers carry out partial softening.

4.8 The need for softened water in hospitals for domestic purposes other than drinking and cooking should be considered on the merits of each case; if treatment is considered essential, the extent of softening should be the minimum to achieve an acceptable level. A generally acceptable level 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.

4.9 Generally, within healthcare premises, 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 lime scale building up in pipework and plant (see BS 2486:1997);

b. mixing devices and blending valves – to avoid clogging of control ports and showerheads by lime scale;

Note

Problems often occur in thermostatic mixing valves whereby scale is deposited as a result of hard cold water being heated in the blending process.

c. laundries – high maintenance costs and the uneconomic uses of soap or detergents are caused by the presence of hardness (see Health Building Note 25 – 'Laundry').

4.10 The most common water-softening process used for the protection of hot water 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 a raised level of sodium is associated with heart disease.

4.11 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. The efficacy of these water-conditioning measures needs to be considered.

4.12 For further details on processes which control scale formation in hot water services systems, refer to BSRIA's Application Guide AG 2/93: 'Water treatment for building services'.

5 Filtration

General

5.1 Examinations of domestic water systems in a number of Scottish hospitals have revealed significant deposits of sediment and debris in pipework. Such deposits can provide an environment conducive to the development of bacteria as well as biofilms. Filtration may be required to:

a. ensure that the domestic water supply and associated pipework is maintained at a high standard of cleanliness throughout the system;

b. reduce the accumulation of sediments and biofilms that may promote the growth of water-borne organisms.

5.2 Filtration need not be provided for cold water for non-domestic use, for example fire-fighting, boiler-feed or other chemically treated or dosed systems.

Description

5.3 Filtration is normally used to prevent ingress of suspended solids into plant and pipework, and as such may be defined as the process of separating solids from liquids using a porous medium. The medium can consist of granular materials (sand, clay, carbon etc) assisted by chemical and/or bacterial activity, woven meshes and screens made of metals, fabrics, ceramics and polymeric membranes.

5.4 Filtration plant is usually specified by various criteria including minimum particle size retained, expressed in microns (μm). "Absolute filtration" of a given size indicates that the plant can remove 99.9% of all particles above a given size. "Nominal filtration" is normally taken to mean that 95% of all particles above a specified size will be removed.

5.5 As a guide, suspended materials are normally classified according to Table 2.

Table 2 Particle size

Material	Particle diameter	
	mm	μm
Pebbles	>10	–
Gravel	10–2	–
Very coarse sand	2–1	–
Coarse sand	1–0.5	1000–500
Medium sand	0.50–0.25	500–250
Fine sand	0.25–0.10	250–100
Silt	0.10–0.01	100–10
Clay	<0.01	<10
Colloid	$10^{-4} – 10^{-6}$	0.1–0.001

5.6 In practice, water will contain a range of sizes of suspended particulates. The rate of blockage by suspended solids for any given filter will depend on a number of factors such as:

a. throughput;

b. concentration of suspended solids and other fouling debris;

c. size distribution;

d. shape of particles.

5.7 Particles less than 0.1 μm are invisible microscopically. The smallest visible macroparticle is approximately 40 μm. Particles less than 0.001 μm are considered dissolved and in solution.

Capacity

5.8 To accommodate the variation in flow, and to allow for filter changes etc, the equipment should be installed in association with a storage cistern.

Design features

5.9 The level of filtration where thermoplastic pipework systems are installed should be 5 μm absolute.

5.10 The level of filtration where stainless steel pipework systems are installed should be 0.5 μm absolute.

5.11 For small establishments (those with fewer than 100 beds), it will normally be appropriate to use strainer filters with cartridge or membrane elements (see paragraph 5.16).

5.12 In larger establishments (those with more than 100 beds), the filtration equipment plant should be fully automatic in operation and include self-cleaning and back-washing modes so that the filter medium does not become a reservoir for organisms capable of contaminating the service pipework. To allow for servicing of the plant, a bypass line with strainer filter should be provided, complete with isolation valves and non-return valves. The bypass should be provided with drains and vents to facilitate disinfection prior to bringing it into service.

5.13 As an alternative to the installation of a bypass strainer, the provision of two units to operate sequentially with automatic changeover on a regular basis will minimise potential failures and maintenance. Precautions should be taken to minimise stagnation of water in the dead-legs that may occur with this arrangement – weekly flushing of dead-legs should take place.

5.14 All items in contact with water must be of materials that comply with the Water Supply (Water Fittings) Regulations 1999 (for example, materials approved by the Water Regulations Advisory Scheme and listed in the WRAS 'Water Fittings and Materials Directory', having been assessed and shown not to have adverse effects on water quality).

5.15 Parameters essential for the continued performance of the plant should be automatically monitored, for example downstream pressures and automatic cycling of back-washing facilities. These should be relayed to a building management system.

Point-of-use filtration

5.16 Point-of-use filters have been found to provide protection from exposure to *Legionella* by preventing the dispersal of the bacterium from showers and other water outlets. To be effective, the filter membrane needs to have a nominal pore size of no greater than 0.2 μm. Before their use is contemplated, two factors should be considered. First, the filters do not eradicate the organism, but prevent discharge to the environment from the filtered outlet only; secondly, by retaining the organism within the pipework, it may be possible for the organisms to multiply and regressively "seed" other parts of the distribution system. Filters will also need to be changed routinely, depending on usage of the outlets. Their use, therefore, should be considered only as part of an overall regimen of *Legionella* control to be used where the most vulnerable patients are to be treated. Continuous long-term use of point-of-use filters is not recommended, except where there is no effective alternative.

6 Metal contamination

6.1 Analytical results have shown that there can be a serious problem from lead contamination of water supplies. The Water Supply (Water Quality) Regulations 2000 set an upper concentration for lead in drinking water of 0.01 mg/L to be achieved by 2013. This value is likely to be exceeded if lead pipes are present or if copper pipes have been joined with solder containing lead. In general, if hospital drinking water contains more than 0.01 mg/L of lead, remedial action should be taken. The use of lead solder is prohibited on all plumbing installations where water is required to be wholesome.

6.2 Copper concentrations above 1 mg/L may cause staining of laundry and sanitaryware and increase the corrosion of galvanised iron and steel fittings. Whilst the maximum allowable copper concentration in drinking water is 2 mg/L, most supplies will give a level at the tap of less than 1 mg/L.

6.3 Water supplies to certain specialist units such as maternity, neo-natal paediatric, general paediatric and renal dialysis units (see the Renal Association, 2002) should be monitored to ensure that water quality is within acceptable limits. The designer should seek epidemiological advice to ascertain the exact water quality requirements for specialist units.

6.4 Where the water supply is known to dissolve metals (that is, soft water), regular sampling should be carried out 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 independently certified tubes to BS EN 1057:1996 are used. Excessive use of acidic flux in the making of capillary joints can lead to corrosion of copper plumbing, especially if the system is allowed to stagnate after commissioning. WRAS Information and Guidance Note 9-04-02: 'Solder and fluxes' (available on its website http://www.wras.co.uk) gives further information on solders and fluxes.

6.5 If the proposed water supply is likely to take up metals in excess of acceptable limits, it will be necessary to consider treatment of the water such as raising hardness.

7 Water storage

General

7.1 Water is stored in healthcare premises for the following reasons:

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

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 reduce the pressure from that of the distribution system.

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

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 tanks on cold water supplies serving points of use where backflow is, or is likely to be, harmful to health due to a substance representing a serious hazard, for example, supplies to pathology laboratories;

e. feed and expansion for heating service;

f. fire-fighting.

Extent of storage

7.3 Storage should be designed to minimise residence time in the cistern and maximise turnover of water to avoid stagnation and deterioration of water quality. Storage volume should be calculated on the basis 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 affects the storage capacity based on the make-up flow. It also determines the available time for maintenance if twin cisterns are not installed.

7.4 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 (Maver, 1964). Appendix 1 is based on the results of this study. CIBSE's Guide G: 'Public health engineering' gives further guidance on sizing cold water storage. 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 L per bed per day and for a teaching hospital 1350 L per bed per day, excluding provision for the staff residences, laundries and any special storage for fire-fighting purposes.

7.5 It must be borne in mind that the overall pattern of healthcare is changing and the data available now is a best estimate of what is required. The guidance in Appendix 1 is known to overestimate water usage in healthcare premises and, moreover, yields data in litres per second. Reference should be made to SHTN 2: 'Domestic hot and cold water systems for Scottish health care premises'. (As an example, a hospital of between 400 and 600 beds might consume 100,000 m^3 of water annually, that is, about 11 m^3/h over a 24-hour period. Peak hourly demand, however, may reach 50 m^3/h.)

7.6 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.

7.7 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.

7.8 Appendix 1 does not cater for water requirements for staff quarters or such support services as laundries, bulk stores 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 healthcare buildings as well as the premises 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 provides data on typical demands expected from staff residences.

7.9 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

7.10 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. This is achieved by siting cistern rooms at roof level. Where buildings are widely dispersed, it is preferable to install a number of smaller cisterns rather than building a water cistern tower.

7.11 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 footprint may call for much higher buildings to achieve the required accommodation. Depending on the supply water pressure, it may be necessary to install pressurisation equipment to boost the incoming supply. The cost of the supporting structure will have an important bearing on the solution adopted.

7.12 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 an average supply of about four hours if gravity-fed, but if the building structure will economically accept greater tankage 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. The total supply should be based on the average usage over 24 hours. There are some advantages in locating central storage at low level, for example easier access for maintenance, and reduced structural costs.

7.13 Where such storage is located in individual buildings and an adequate supply is available from the water undertaker, a connection in accordance with the Water Supply (Water Fittings) Regulations 1999 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 Supply (Water Fittings) Regulations 1999 and do not result in water stagnating within the storage or distribution system. Where the development is widespread and a water undertaker'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.

7.14 To maintain good water quality, common practice 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 gain in the cold water service en route to points of use.

7.15 Although the final assessment of the capacities of storage cisterns will emerge from the design requirements of Appendix 1, the building's structural design will influence the number of cisterns required and the cistern layout. Standard sizes of tank should be used where possible.

7.16 Cisterns must not be located in any position where there is any likelihood of flooding, excessive heat gain or any other factor that could affect the contents of the cisterns. They should not be installed in any location where access for general inspection or maintenance is restricted.

7.17 Separate systems are recommended for pathology and mortuary departments.

External storage

7.18 The ideal location for external cold water storage cisterns is the roof of the highest building, provided the structural design can support the load. If concrete water cisterns are to be considered, they should be designed to form an integral part of the building structure. The materials of construction, however, must comply with the Water Supply (Water Fittings) Regulations 1999.

7.19 Where storage is below ground, as distinct from being housed within a building, it is essential 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 healthcare building and probable extensions should also be taken into account in this respect.

7.20 Storage below ground should be adopted only as a 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 tank chamber must include provision for a sump to collect drainage water and any piping necessary to pump out tanks to the site drainage. The Water Supply (Water Fittings) Regulations 1999 require any buried concrete reservoir to be designed, constructed and tested in accordance with BS 8007:1987.

7.21 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. If it is found necessary to exceed a depth of 3.3 m, 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

7.22 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.

7.23 It is essential in all cistern installations that a clear working space of not less than 0.5 m – but ideally 1 m – is maintained around the cistern. Minimum clearances of 0.5 m below and 0.75 m above the cisterns are necessary to facilitate erection, inspection and maintenance. A minimum of 0.5 m should be provided between the floor of the catchment basin and the underside of the cistern.

7.24 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

7.25 All storage cisterns should be constructed in accordance with manufacturers' recommendations and should comply with the Water Supply (Water Fittings) Regulations 1999, be WRAS-approved, and comply with BS 6700:1997. Glass-reinforced plastic (GRP) tanks should comply with BS EN 13280:2001. The WRAS Information and Guidance Note 9-04-04: 'Cold water storage systems – design recommendation for mains supply inlets' provides useful advice regarding the design of the inlet arrangements to ensure compliance with the Regulations.

7.26 Depending on size and/or capacity, tankage 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.

7.27 Separate cisterns should also be provided for storage of 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, and it should be noted that isolation by means of shut-off valves between them is not acceptable.

7.28 Normally the materials used for storage cisterns serving healthcare premises are predominantly GRP, but concrete or steel may also be considered. The material selected should comply fully with the Water Supply (Water Fittings) Regulations 1999.

7.29 Sectional cisterns fabricated from GRP or pressed steel provide a convenient means of bulk storage of water at atmospheric 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 base area or, within limits, depth.

7.30 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.

7.31 The Water Supply (Water Fittings) Regulations 1999 lay down the minimum requirements for potable water storage cisterns. Recommendations to comply with these are given in the WRAS 'Water Regulations Guide'. The requirements are indicated in Figure 1.

Note

Cisterns should be sited away from heat sources and be protected from heat gains by insulation. Adequate access should be provided for inspection and maintenance (both internally and externally).

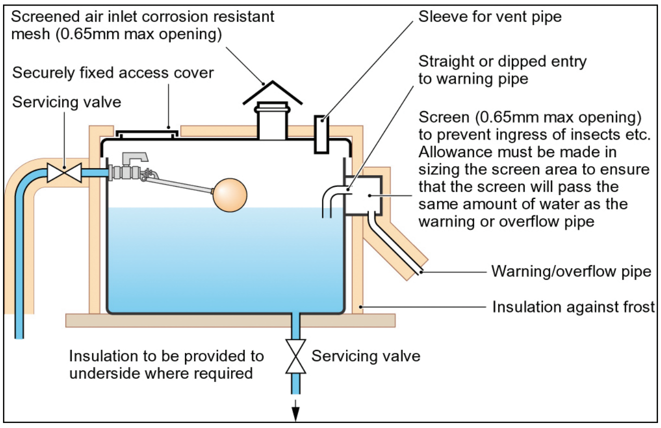
7.32 Each storage cistern or its compartment should also be provided with the following:

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

b. a full-way servicing valve at each inlet and outlet connection, except for cisterns providing water to primary circuits or heating circuits, vent pipes, overflow pipes, and warning pipes. Where practicable, all outlets should be taken from the base of the system and be sited opposite to the inlet;

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.

Figure 1 General potable water storage cistern arrangements



7.33 Cisterns should be adequately supported on bearers placed under the longitudinal or lateral cistern section joints. To avoid distortion, a flat section of marine ply or equivalent should be sited between the support structure and the cistern. Final siting should be in accordance with the manufacturers' recommendations.

7.34 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 drip tray or bund 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 drip tray or bund in the event of cistern leakage. Special requirements apply to the supporting of GRP sectional cisterns on bearers, and manufacturers' recommendations should be observed. The cistern should be provided with a warning pipe or a no less effective device to indicate leakage through the inlet control valve if this should occur.

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

7.36 A consideration 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 building elevation, the duct serving it will be located to suit the internal layout. The pipe route from the system to the service duct will require access for inspection and protection from frost and heat gain.

7.37 A typical potable water storage cistern, piping and valve arrangements, for break-tank operation during normal running and maintenance, is shown in Figure 2. The dotted line indicates that the pipe is disconnected. Supply and draw-off connections should be arranged to facilitate good through-flow and turnover of stored water.

Cistern rooms

7.38 GRP or steel cisterns should be installed in well-ventilated but draught-proof 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.

7.39 Prefabricated GRP housings, protected from extremes of temperature by thermal insulation, can provide an economical and aesthetic solution.

Note

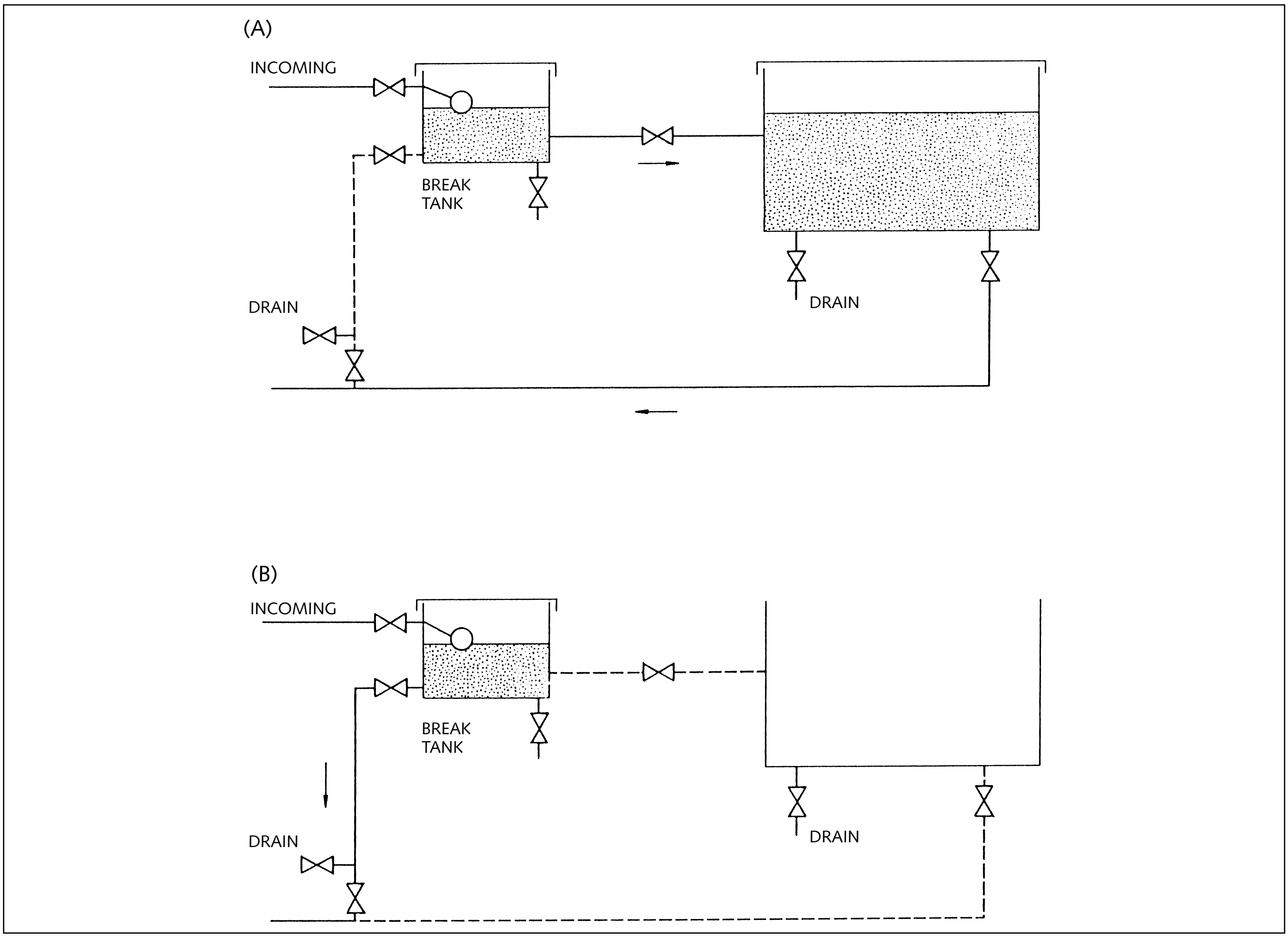
Break tank can be maintained during rundown of the main tank from full. When not in use "dotted" piped sections are removed and stored dry.

7.40 The load-bearing capacity of the main structure will limit the distributed load that the cistern room and its contents can impose, and will ultimately limit capacity. If, however, cisterns can be located above main service ducts or stairwells, this will minimise the effects.

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

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

Figure 2 Piping and valve arrangements for break tank operation. (A) normal running; (B) during maintenance



Ancillary pipework, valves and fittings

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

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

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

7.46 The use of delayed-action ball valves on water storage cisterns should be considered, since these help avoid stagnation of water in the cistern. They may not be suitable when the supply is pumped.

7.47 Strainers should be fitted within the water pipework system to protect thermostatic valves etc against ingress of particulate matter. The installation of these fittings should allow adequate access for maintenance/replacement, and they should be provided with means of upstream and downstream isolation. Strainers can be a source of *Legionella* bacteria and should be included in routine cleaning, maintenance and disinfection procedures (see Chapter 7, Part B).

7.48 Service isolation valves should be fitted to all pipework preceding sanitary tapware and WCs etc for servicing, repair or replacement. Drain-valve provision may also be appropriate for certain installations, for example, service pipework to en-suite facilities etc.

Buffer vessels for cold water boosting sets

7.49 Buffer vessels are typically vertical in orientation and normally have a diaphragm to separate the water from the gas space above. They introduce a potential problem of colonisation by *Legionella*, as the plantroom space temperature will exceed that of the incoming water. They should preferably be of a design such that water flows through the vessel, entering at low level, and discharging at a higher level below the water line. Interconnecting pipework should be kept to a minimum, and the vessel should be insulated to minimise heat gain. All materials in contact with water should be WRAS-approved (see also paragraph 9.41).

Water meters

7.50 BS 6700:1997 gives guidance on the design and installation of water meters.

7.51 Revenue meters are normally supplied and installed by the water undertaker, whereas the consumer may install sub-meters.

7.52 Adequate sub-metering of water supplies should be provided so that supplies can be monitored for individual heavy-use departments. Such monitoring will assist in the detection of leaks or abnormal water demands. Water meters can be connected to a BMS, which can identify anomalous consumption and lead to the early detection of leaks.

7.53 Appropriate bypass arrangements with valves immediately upstream and downstream should be provided; the bypass loop should be as short as practicable and be arranged to be in the horizontal plane.

8 Cold water distribution system

General

8.1 The design and installation of the cold water distribution system should comply with the Water Supply (Water Fittings) Regulations 1999 and relevant parts of BS 6700:1997 and BS EN 806-2: 2005. A simple cold (and hot) water system is shown in Figure 3.

> **Note**
>
> All pipework to be insulated; isolating and control valves not shown; all drains should discharge to waste via a type A "air" gap.

8.2 The installation should be designed to avoid waste, undue consumption, misuse and contamination. Every water fitting through which water is supplied for domestic purposes should be installed in such a manner that no backflow of fluid from any appliance, fitting or process can take place. An assessment of the level of backflow contamination risk (the fluid category) should be made for each fitting, appliance etc. The system should be designed and installed so that each risk is adequately protected against backflow, either by means of the design or by use of backflow prevention devices. Devices are listed in the WRAS 'Water Regulations Guide' together with the degree of backflow protection they provide.

8.3 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, fitting or appliance, whether by back-siphonage or otherwise.

8.4 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 his agent, the water undertaker and all other public and private utilities, highway and local authorities, landowners and others involved. There is a legal duty to notify the water undertaker of proposed installation work and have its consent for the work before installation commences.

8.5 All cold water distribution pipework, mains and cistern down-feeds should be located, as far as is practicable, to minimise heat gains from their environment. Pipework should not be routed through hot ducts or run adjacent to heat sources, such as radiators. Where hot and cold water pipes are run horizontally together, the cold water pipe should be located beneath the hot water pipe to minimise local warming by means of convection.

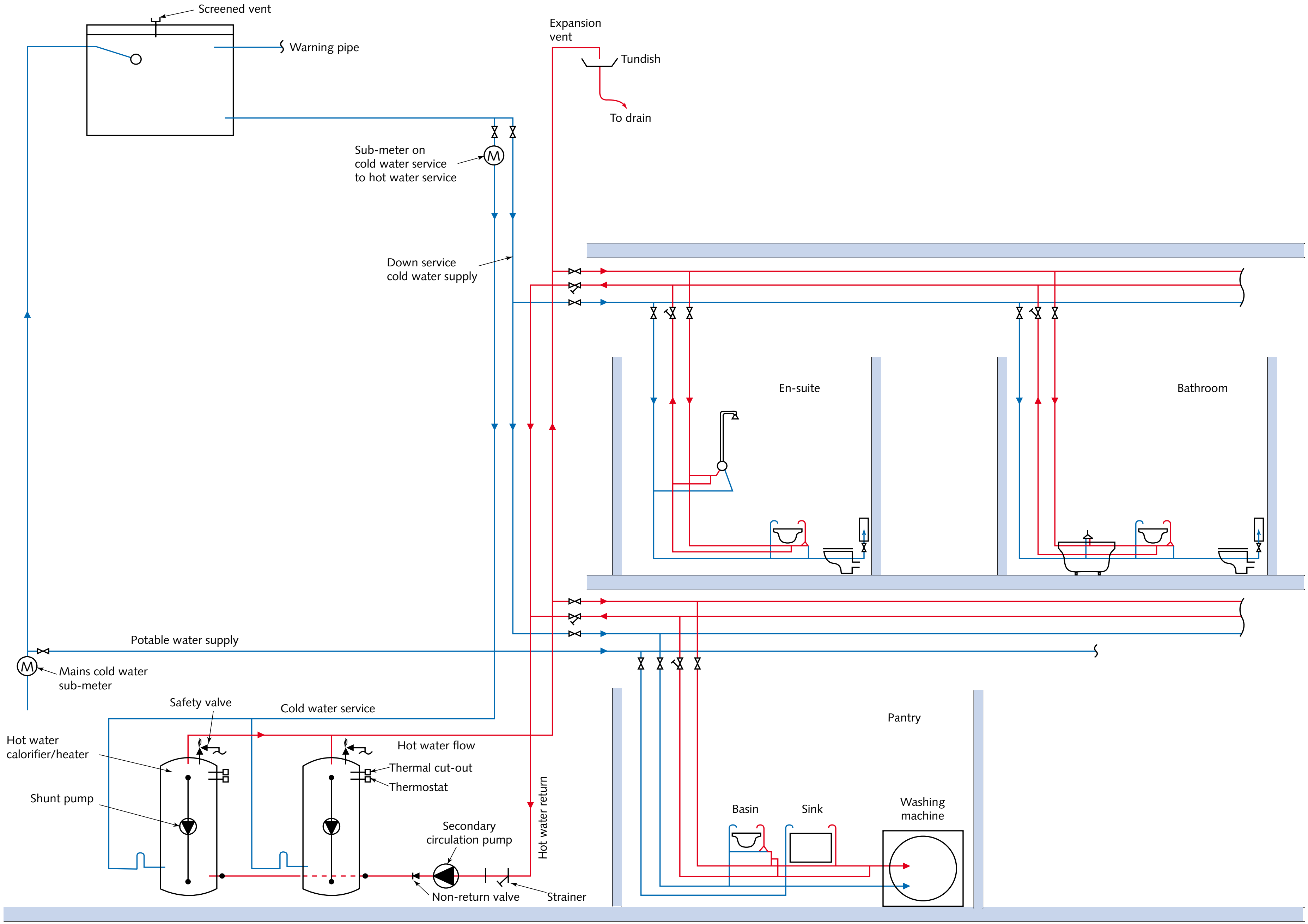
8.6 All pipework should be insulated, except for any exposed final connections to sanitary appliances, and should be arranged to eliminate or minimise dead-legs.

8.7 The Water Supply (Water Quality) Regulations permit cold water to be delivered at temperatures up to 25°C, although in normal circumstances it will be well below 20°C. As far as possible, the objective should be to design the cold water systems to ensure that the inlet, outlet and surface water temperatures of cisterns and cold water feed/header tanks 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 no greater than 2°C above the temperature measured in cistern and cold water header tanks should be reached within two minutes.

> **Note**
>
> For the control of *Legionella* and other water-borne organisms, 20°C is the quoted upper value above which multiplication of *Legionella* in particular begins to take place (see Part B, Chapter 4).

8.8 The control of water temperature in the cold water service, however, will essentially rely on good insulation and water turnover. Cold water services

Figure 3 Schematic layout of a cold (and hot) water service system



should be sized to provide sufficient flow at draw-off points. Stagnation should be avoided.

8.9 Pumped circulation of cold water and refrigeration should only be considered in specialist units where people are at particular risk as a result of immunological deficiency, for example bone marrow transplant units. Such systems require careful design; information may be obtained from NHS Scotland Property and Environment Forum (http://www.show.scot.nhs.uk). For other accommodation, the aim should be to promote turnover of cold water by means of the design of the distribution circuitry.

8.10 In ward areas provided with en-suite facilities, the aim should be to supply sanitary assemblies in series, with the WC connected as the final element. Elsewhere, pipeline routeings should be run so that other outlets are connected with a WC or flushing device, for example sluice hopper or pantry sink, providing the final element at the distal end of the branch – this may require pipe routeing reversal. See Figures 4 and 5.

8.11 In other clinical areas, a similar arrangement for the distribution of cold water should be adopted.

8.12 The cold water distribution system should be designed so that the pressure is the same as that for the hot water service at draw-off points. This may require the inclusion of pressure-reducing valves in the distribution pipework. If unequal pressures exist in the hot and cold water supplies to combination taps where water mixes in the body of the tap, a single check valve is required on each feed pipe to the tap to prevent backflow of water from one to the other.

Drinking water

8.13 When separate drinking-water systems have been provided the policy has normally been to distribute directly from the mains without storage, with stored cold water (down service) being used solely for supplies to WCs, hand-wash basins etc. Providing drinking water without storage may not be appropriate in healthcare premises because of the need to have some security of supply. The advantage of separate drinking and cold water services chiefly lies in the possibility of treating the latter (softening or other forms of treatment) without adulterating the drinking supplies. Softening will avoid the scale problems associated

Figure 4 Piping arrangements for an en-suite facility

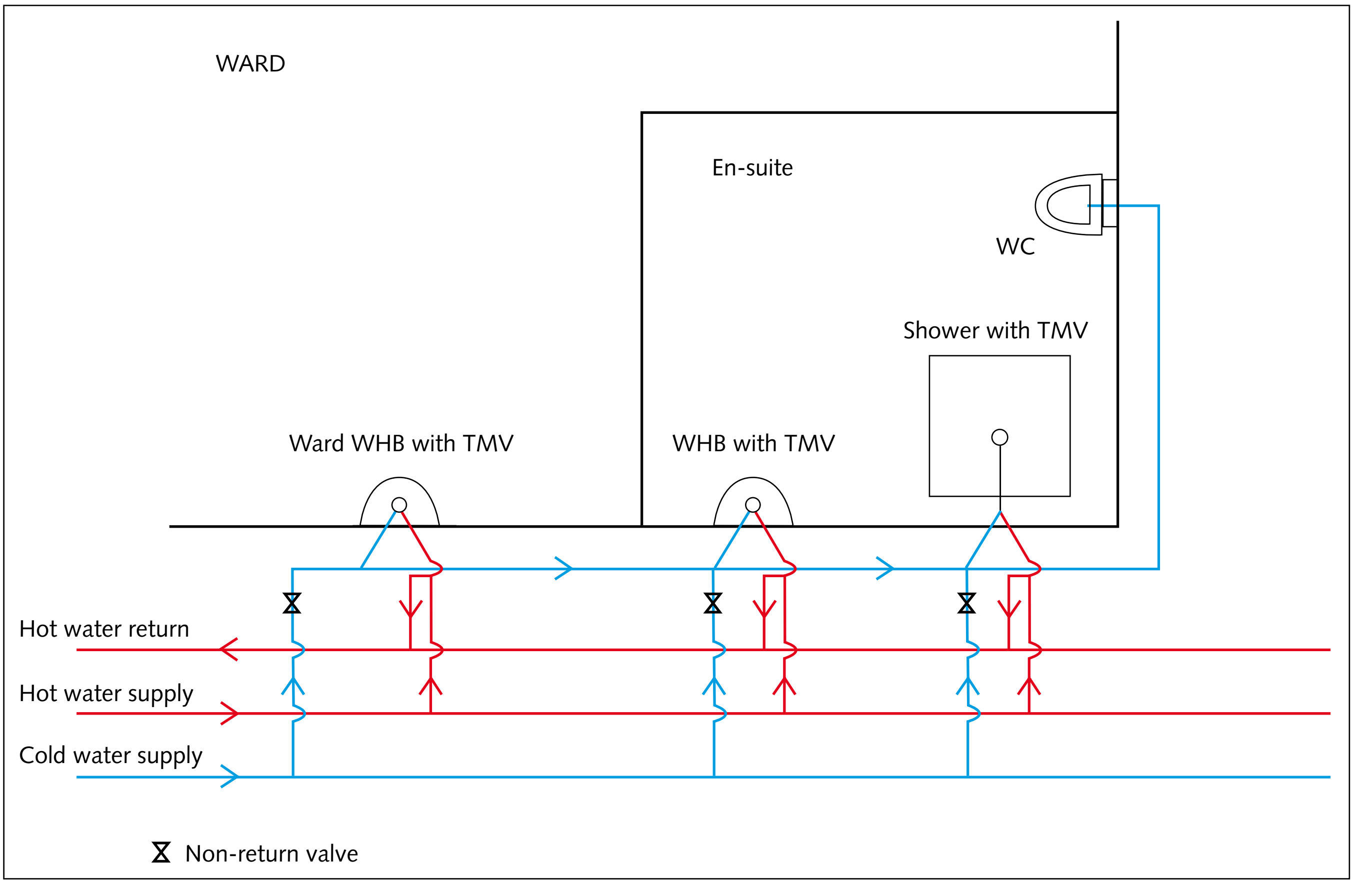
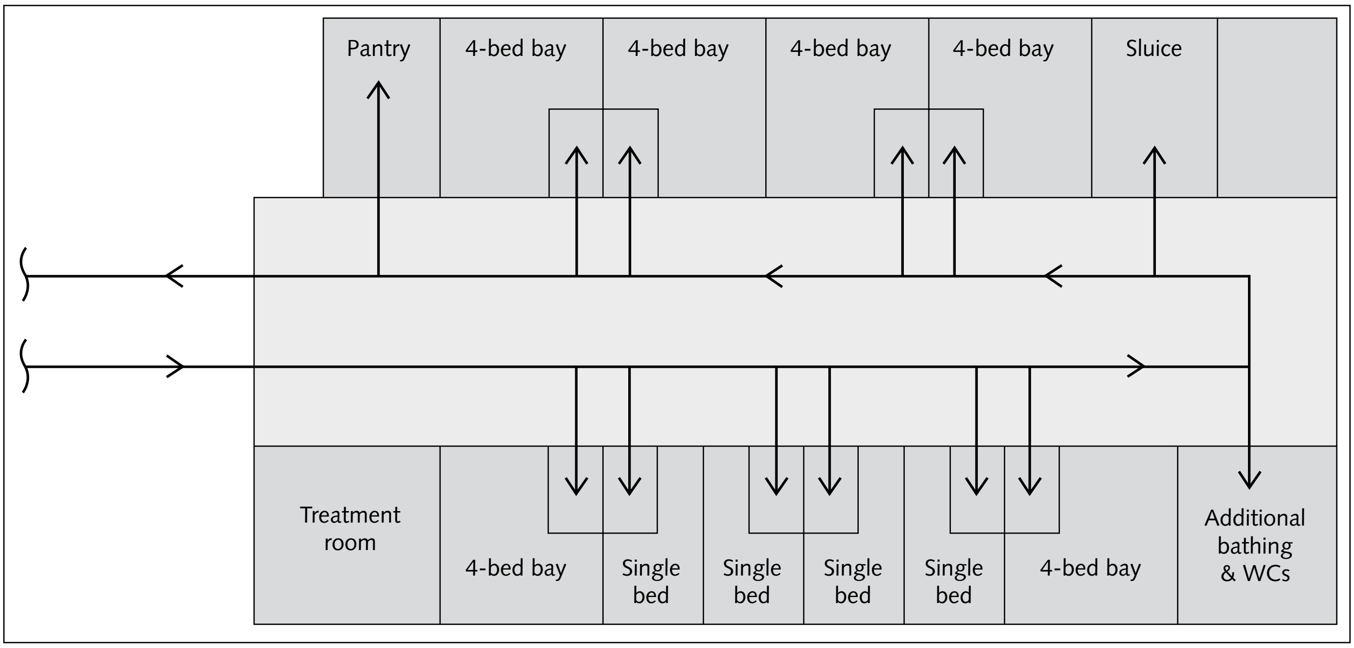


Figure 5 Direction of pipeline routeing in a typical ward



with thermostatic mixing devices. (Problems often occur when scale is deposited as a result of hard cold water being heated in the blending process.) However, this will be wasteful if the cold water supply is to be used for WC flushing.

8.14 A possible strategy, therefore, is to have a drinking water system that also provides WC flushing and, to some extent, this will assist water turnover and the maintenance of water quality. The disadvantage of the concept, apart from installation cost, is that the use of WCs, particularly in en-suite facilities, as the mechanism for achieving good utilisation in the cold water service no longer becomes possible (see paragraph 8.10). The concept for water turnover in en-suite facilities could still be achieved, however, if the cold water service were run in series to en-suite facilities with minimum dead-legs to draw-offs, with the final connection on the system being a highly utilised outlet, for example a sink.

Pumped systems

8.15 Where the pressure of the water undertaker's supply is inadequate, it will be necessary to utilise pressurisation plant. Similarly, pumping or pressurisation may be required for fire-fighting purposes.

8.16 Various arrangements of pumping system are indicated in BS 6700:1997. 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 Water Supply (Water Fittings) Regulations 1999 with regard to prevention of backflow. Any pump delivering more than 12 L/min must be notified to the water undertaker whose consent is required.

8.17 Control of the pump(s) should be fully automatic in operation and controlled by pressure sensors 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.

8.18 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.

8.19 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 also require the pumping equipment to be energised from the emergency electrical service as recommended in Health Technical Memorandum 06-01 – 'Electrical services supply and distribution'.

8.20 Where two or more pumps are installed, the design flow should be achieved with one pump stationary (or out of service). Automatic control should be provided to cyclically and sequentially control all pumps to ensure that each is regularly brought into service.

8.21 The pumping sets for lifting to higher-level storage should be controlled from the level in the high-level tanks 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.

8.22 Pressurisation vessels are typically vertical in orientation and have either a diaphragm or nitrogen fill in the upper space. They introduce a potential problem of colonisation by *Legionella*, as the plantroom space temperature will exceed that of the incoming water. They should be preferably of a design such that water flows through the vessel, entering at low level, and discharging at a higher level below the water line. Interconnecting pipework should be kept to a minimum, and the vessel should be insulated to minimise heat gain. All materials in contact with water should be WRAS-approved. It is important that the expansion vessel is located on the cold feed rather than on the hot water side of the system.

8.23 The plantroom should be constructed with a waterproof and non-dusting type of floor with a slight fall to a drainage trench that 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.

8.24 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 provided.

Specialist systems

8.25 Where water supplies are required for specialist systems such as endoscope cleaning installations, dialysis units 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 undertaker to clarify any special precautions that may be necessary, such as backflow prevention devices. The advice of the water undertaker should also be sought as to any possible variation in the quality of supply or possible change in the source of supply (see also Health Building Note 53 – 'Facilities for renal services: Volume 1 – Satellite dialysis unit'.

Vending, chilled water and ice-making machines

8.26 The water supply to this equipment should be taken from a potable supply via a double check valve to prevent backflow and be upstream of a regularly used outlet with the minimum of intervening pipe-run, that is, less than 3 m. The supply should not be softened. Additionally, it should be established that the usage is sufficient to avoid deterioration in water quality, for example that the inlet water temperature does not exceed 20°C.

8.27 The equipment should be positioned so that the warm air exhaust does not impinge directly on taps or hoses supplying cold water.

8.28 Reference should also be made to the Food Safety (Temperature Control) Regulations 1995 and Food Safety (General Food Hygiene) Regulations 1995. The Automatic Vending Association of Britain (AVAB) codes of practice should be followed regarding hygiene and water quality and hygienic operation of vending machines (http://www.ava-vending.org). Vending machines dispensing carbonated drinks require special materials of construction which should be WRAS-approved.

9 Hot water services

General

9.1 Hot water services should be designed and installed in accordance with the Water Supply (Water Fittings) Regulations 1999 and relevant parts of BS 6700:1997 and BS EN 806-2:2005. The hot water system may be of either the vented or the unvented type.

9.2 The basic components of a hot and cold service system as used within hospitals are shown in Figure 3; most installations will have additional features and components.

9.3 A vented system usually consists of a cold water storage cistern situated above the highest outlets, which feeds a hot water storage vessel (for example a calorifier or direct-fired boiler).

9.4 An unvented system usually has the hot water storage vessel connected to the mains water supply via a backflow prevention device and a pressure-reducing valve. The components of a directly heated unvented hot water system are shown in Figure 6.

9.5 Hot water is taken from the top of the storage vessel, or water heater, and will normally be circulated around the building in a piped distribution system. The flow temperature should be set to 60°C and the minimum temperature of all return legs to the vessel or water heater should be 50°C. In all but domestic systems, if recirculation is not used, some form of trace heating will be required. Such systems, however, should be restricted to areas where backflow contamination is a potential problem, for example pathology laboratories: these should be supplied from separate systems. The individual outlets, taps, mixing valves or other outlet devices will be served from the distribution system; this should be designed such that the minimum temperature at the most distant taps or outlets is 55°C.

Note

The control of *Legionella* requires there to be a minimum temperature of 50°C in hot water service systems (see Part B of this Health Technical Memorandum). A minimum of 55°C may be required for the operation of suitable fail-safe mixing devices required to provide “safe” hot water at the upper limit of the recommended range. Hot water at 55°C is required for many applications such as washing in kitchens and laundries.

9.6 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. The adoption of localised hot water distribution systems will require the provision of local plantrooms.

9.7 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.

9.8 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.

Hot water heater types

9.9 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 too is the open vent, which may or may not be combined. 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. Instantaneous water heaters for distribution systems have similar pipeline connections. All water heaters must be WRAS-approved and listed in the 'Water Fittings and Materials Directory'.

9.10 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. Means should be taken to prevent warm water entering the cold feed line and possibly leading to conditions conducive to colonisation by *Legionella*. A check valve can be provided in the cold feed to prevent such circulation, but this will prevent 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 vent pipe (air vent) over the cistern is no longer permitted by regulations. The vent should be arranged to discharge over a separate tundish arrangement, with visible Type AA air gap, sited at a level that takes account of the hydrostatic head of the system: the tundish should discharge to drain. The calorifier or water heater should be provided with a suitable safety valve of appropriate size and vacuum release arrangement.

9.11 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.

9.12 Where water quality indicates the need, cathodic protection from galvanic action by means of sacrificial anodes should be provided.

9.13 The combined storage capacity and heater output must be sufficient to ensure that the outflow temperature, at continuous design flow (at least 20 minutes) from calorifiers or other heaters, should not be less than 60°C. This applies to both circulating and non-circulating 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.

9.14 There are basically three types of water heater:

a. instantaneous heater;

b. storage calorifier;

c. limited storage calorifier.

Instantaneous water heaters

9.15 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 6700:1997. In essence:

   (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 controlled. 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 that contain modular helical primary coils normally served by steam, medium temperature hot water (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 flat endplates and held together by tie bolts. The plates have ports in all four corners that 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 counter flow 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

9.16 Storage calorifiers are usually cylindrical vessels mounted either vertically or horizontally; the base of a vertical calorifier can be concave or convex, with the vessel being supported on feet. The latter design is preferred, as it avoids the annular space where the base joins the cylinder wall. 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.

9.17 As a result of this, galvanised cylinders are not recommended in new hospital installations or for replacement.

9.18 The following points should be considered during the design process (see also paragraphs 9.28–9.29):

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

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

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

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

Limited storage calorifiers

9.19 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

9.20 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.

9.21 Water storage design estimates are based upon data generated by the Hospital Engineering Research Unit (HERU) in the 1960s (Maver, 1964; see Appendix 1). (But see also CIBSE Guide G: 'Public health engineering', which gives guidance on sizing hot water storage.)

9.22 Since the original study, a review of systems indicates that the overall capacity and consumption predicted is excessive (see paragraphs 7.4–7.5).

9.23 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.

9.24 Some devices are optimistically rated so that, at a continuous demand equal to their design rating, the flow temperature can fall below 60°C. Semi-storage or high-efficiency minimum storage calorifiers and instantaneous heaters are especially prone to this if under-sized.

Connection arrangements for calorifiers and water heaters

9.25 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 (see also paragraph 9.42).

9.26 Installations should not include for series operation of calorifiers.

Stratification in storage vessels

9.27 Stratification will occur in any storage 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 volume of water in the temperature range that encourages maximum growth of *Legionella*.

Note

Water temperatures in the range 20°C–45°C favour growth. It is uncommon to find proliferation below 20°C, and *Legionella* do not survive long above 60°C. The optimum laboratory temperature for the growth of *Legionella* is 37°C, that is, body temperature. *Legionella* may, however, remain dormant in cool water, multiplying only when the temperature reaches a suitable level.

Note

Stratification: in a storage calorifier the upper level, above the heating element, will be at operating temperature (60°C) during normal periods of demand. Below this level will be a volume of water between the feed water temperature and operating temperature. This level will vary as draw-off takes place according to the thermal input and rate of demand.

9.28 Storage and semi-storage calorifiers should be provided with independently pumped circulation from the top to the base of the calorifier; this is referred to as a "shunt pump". The pump should be run continuously for about an hour during periods of minimum demand to raise the entire contents of the calorifier to 60°C. During periods of low draw-off, the temperature will readily achieve 60°C to effect disinfection. Control should be by a timing device that can be adjusted when the profile of demand has been established.

9.29 Some semi-storage/high-efficiency calorifiers are supplied with an integral pump that circulates water in the calorifier; in this case a second shunt pump is not required.

Provisions for maintenance

9.30 There should be adequate access to calorifiers for inspection and cleaning, removal and replacement of tube bundles and removal and replacement of the entire calorifier.

9.31 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. The drain should be of sufficient size to empty the vessel in a reasonable time. A schedule of approximate calorifier emptying times is given in Table 3.

9.32 Drain valves should be of the ball type to avoid clogging, and a drainage gully should be provided of sufficient size to accommodate the flow from the calorifier drain.

Unvented hot water systems

9.33 Hot water storage systems have traditionally been provided with an open vent pipe that 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.

9.34 The use of unvented hot water systems is now permitted in the UK and is covered by section G3 in 'Approved document G: hygiene' of the Building Regulations 1992, which specifies the minimum safety precautions that should be taken when adopting such systems.

9.35 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 undertaker, since they will be required to meet the maximum demand at any time over a 24-hour period.

Table 3 Approximate emptying times for calorifiers

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 (3000)	3 hr 00 min	1 hr 20 min	45 min
		9000 (2000)	2 hr 10 min	1 hr 00 min	30 min
		4500 (1000)	1 hr 10 min	30 min	20 min
		2250 (500)	39 min	17 min	10 min
		1800 (400)	32 min	14 min	8 min
		1400 (300)	25 min	11 min	6 min
Horizontal	1:1.5	13,500 (3000)	3 hr 00 min	1 hr 20 min	45 min
		9000 (2000)	2 hr 10 min	1 hr 00 min	30 min
		4500 (1000)	1 hr 10 min	30 min	20 min
		2250 (500)	39 min	17 min	10 min
		1800 (400)	32 min	14 min	8 min
		1400 (300)	25 min	11 min	6 min
Vertical	1:1.5	13,500 (3000)	2 hr 45 min	1 hr 15 min	40 min
		9000 (2000)	2 hr 00 min	55 min	30 min
		4500 (1000)	1 hr 10 min	30 min	20 min
		2250 (500)	38 min	17 min	9 min
		1800 (400)	31 min	14 min	8 min
		1,400 (300)	25 min	11 min	6 min
			Times assume no hose and simple ball-type valve		

9.36 The design and installation of unvented hot water systems should comply fully with the Building Regulations and the Water Supply (Water Fittings) Regulations 1999.

9.37 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.

9.38 A schematic layout of a typical directly heated unvented hot water system is illustrated in Figure 6 along with a brief description of the main components.

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

9.40 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 on the primary coil must be provided for control of excessive temperature.

Sealed expansion tanks for unvented hot water systems

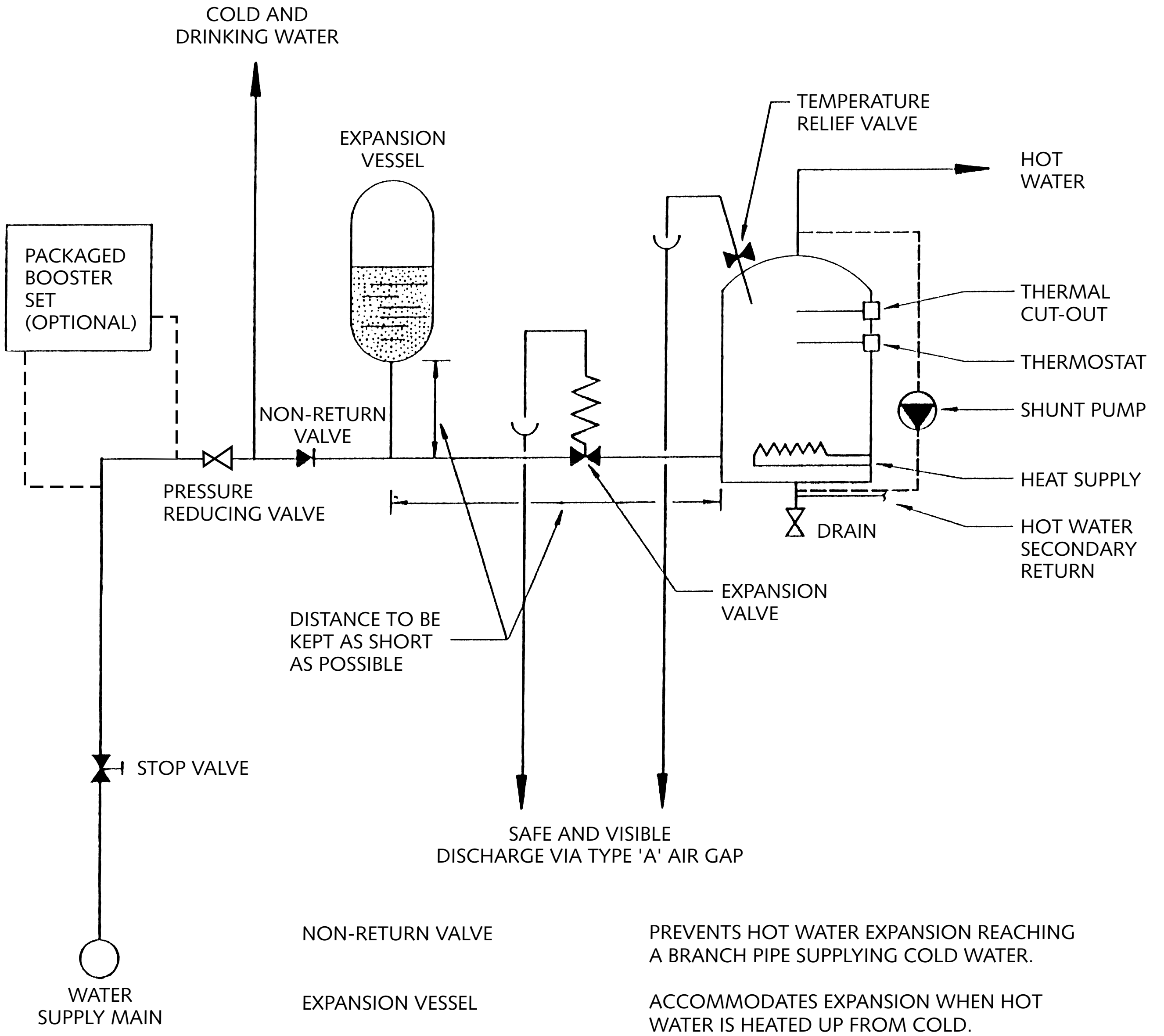
9.41 These vessels are typically vertical in orientation and normally have a diaphragm to separate the water from the gas space above. They introduce a potential problem of colonisation by *Legionella*, as the plantroom space temperature will exceed that of the incoming water. It is important that the expansion vessel is located on the cold feed rather than on the hot water side of the system. All materials in contact with water should be WRAS-approved.

Hot water distribution system

9.42 To control the possible colonisation by *Legionella,* it is essential to maintain the temperature within the hot water circulating system. To some extent, if properly maintained, the calorifier/water heater will provide a form of barrier to *Legionella* and other water-borne organisms.

9.43 The minimum flow temperature of water leaving the calorifier/water heater should be 60°C at all times, and 55°C at the supply to the furthermost draw-off point in the circulating system. The

Figure 6 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-OUT.
THERMAL CUT-OUT	CUTS OFF HEAT SOURCE AT A PREDETERMINED MAXIMUM TEMPERATURE.
THERMOSTAT	CONTROLS THE TEMPERATURE OF STORED WATER AT 60°C ± 2°C.

minimum water temperature of all return legs to the calorifier/water heater should be 50°C.

Note

A minimum of 55°C may be required for the operation of suitable mixing devices required to provide "safe" hot water at the upper limit of the recommended range.

Note

In large, non-recirculating systems, the minimum of 55°C should be maintained by electric trace heating.

9.44 To achieve the required circulating temperatures, it will be necessary to provide some form of regulation to balance the flow to individual pipe branches serving groups of draw-off points, for example each washroom/toilet and en-suite facility etc.

9.45 The means of balancing the hot water circulation can be achieved by either manual or thermostatic regulating valves installed in the return. There should be means of isolation, both upstream and downstream. Adequate access for servicing is also essential.

9.46 In ward accommodation where en-suite facilities are provided, it is recommended that the hot water circulation be extended to draw-off points in series, for example the supply to a basin, bath and/or shower should be run as one circuit (see Figures 4 and 5).

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

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

9.49 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 3 m. The length is measured from the centre line of the circulation pipework to the point of discharge along the centre line of the pipework. The same restriction applies to "communal" blending, that is, where more than one outlet is served by one device. Central blending systems should not be used, since the length of distribution pipework containing water in the temperature range that supports *Legionella* growth would far exceed these maximum permissible lengths.

Electrical trace heating

9.50 A single-pipe distribution system with electrical trace heating can avoid the problems of balancing a hot water service 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.

9.51 Dead-leg lengths should be as short as practicable; that is, the tracing should be taken up to the draw-off or mixing device. The continuity of the trace heating should be monitored to avoid localised failure.

9.52 The trace heating system should be monitored for short-circuit and open-circuit conditions.

9.53 Temperature alarms should be provided (set to 50°C) to warn of a failure of the trace heating system or a deterioration in its performance.

Water temperatures and delivery devices

9.54 The risk of scalding for vulnerable patients (children and young people, older people, and people with disabilities) is a particular problem in healthcare premises caring for such individuals, and therefore thermostatic mixing devices will be needed for many hot water outlets, with different temperatures required for differing toiletry needs. A risk assessment will be necessary to establish the need and type of device to be installed.

9.55 Maintaining strict hygiene in the clinical environment is paramount in the avoidance of healthcare-associated infections. Although the majority of these infections are the result of other factors, basic hand-washing will play an important part in preserving hygiene even with the use of alcohol gels.

9.56 Hand-washing is best performed under running water in basins/sinks without plugs, as they easily become soiled especially where usage is high – this necessitates the installation of a mixing device.

Note

The Water Supply (Water Fittings) Regulations 1999 place limits on the flow of water to draw-offs where plugs are not provided. Spray-type mixer taps are not recommended in healthcare premises; therefore, the type of tap should be carefully selected to minimise the formation of aerosols (see also Health Technical Memorandum 64 – 'Sanitary assemblies'). (With regard to the requirement for plugs, see also the section on baths, sinks, showers and taps in DEFRA's (1999) guidance document to the Regulations.)

9.57 Thermostatic mixing valves should comply with the standards of the MES D08 – 'Thermostatic mixing valves (healthcare premises)'. Thermostatic valves should be tested and accepted by the BuildCert TMV Scheme (http://www.buildcert.com/TMV).

9.58 The types of mixing device are specified in Table 4.

Showers

9.59 Showers with fixed heads are preferred for prevention of backflow. Where flexible hoses and moveable shower outlets are provided, the outlet must not be capable of being accidentally immersed into a drain, WC or other potential source of contamination. Some shower heads are provided with a means for adjusting the flow, for example fine spray, pulsating flow etc, selected by utilising different sets of nozzles. As this will exacerbate possible stagnation problems, they should not be installed in healthcare premises. Taps and showers should be flushed at least twice weekly, or the retained water flushed to waste immediately before use without the generation of aerosols.

Strainers

9.60 Strainers should be fitted within the water pipework system to protect expansion vessels, mechanical backflow protection devices, thermostatic valves etc against ingress of particulate matter. The installation of these fittings should allow adequate access for maintenance/replacement and they should be provided with means of upstream (and downstream where appropriate) isolation. Strainers can be a source of *Legionella* bacteria and should be included in routine cleaning, maintenance and disinfection procedures (see Chapter 7, Part B).

Cold feed cisterns and tanks

9.61 When separate cold feed cisterns are provided for hot water service installations, they should comply with the requirements for cold water systems.

Note

Hot water cylinders with an integral feed and expansion tank are not recommended.

Service isolation valves

9.62 Service isolation valves should be fitted to all pipework preceding sanitary tapware and WCs etc for servicing, repair and replacement. Drain-valve provision may also be appropriate for certain installations, for example service pipework to en-suite facilities etc.

Table 4 Safe water temperatures and delivery devices

Area/activity	Recommended temperature (°C)	Type of device (see MES D08 for explanation of valve types)
Staff bases, ward and consulting rooms etc basins In-patient, out-patient hand-wash basins	41	Type 3 Thermostatic
General areas to which staff and visitors may have access See note 3 below	41	Type 2 Thermostatic
Paediatric baths	40 – to allow for the cold paediatric bath/sink NB: Paediatric nurses should always use a thermometer	Type 3 Thermostatic
General baths	43	Type 3 Thermostatic
Showers	41	Type 3 Thermostatic
Assisted baths	46 – to allow for the cold mass of bath NB: Nurses should always use a thermometer before immersing patients	Type 3 Thermostatic
Hair-wash facilities	41	Type 3 Thermostatic
Bidets	38	Type 3 Thermostatic
All sinks, kitchens, pantries, slop sinks etc	55 – minimum required for food hygiene and decontamination purposes	Separate hot and cold taps or combination tap assembly Type 1; no preceding thermostatic device
Office, staff-only access areas hand-wash basins	43	Type 1

Notes:

1. It is preferable that thermostatic mixing devices are fitted directly to the mixed temperature outlet or be integral with it, and be the method of temperature and flow control, i.e. the mixing device should not be separate and supply water via a second tap or manual mixer since there will be many cases where draw-off of cold water will not occur. If a separate thermostatic device is used, it should be fitted as close to the outlet as possible, which should be a flow only control. Where "T" type mixing valves are installed they will require access for maintenance and consideration should be given to their location behind sanitaryware partitions.
2. In the case of bidets with ascending sprays, or a handheld douche, which may be accidentally immersed in an adjacent WC, water must be supplied via a suitable air gap, normally from a storage cistern.
3. Automatic taps should be considered for general public access washrooms/toilets, surgical scrub sinks and hand-wash basins in main kitchen/food preparation areas; because the temperature is non-user adjustable they should be supplied from a Type 2 TMV set to 41°C. They are not recommended where the frequency of use of sanitary assemblies is low; part of the operational management regimen will necessitate "flushing" of outlets. Such flushing can be time-consuming and is not facilitated by automatic taps that require a continued presence. The proximity detector should include a timer that can be adjusted to take account of the optimum washing time: this is particularly important for scrub sinks.
4. Automatic flushing WCs can also be considered for similar areas.
5. In the case of a dual function delivery device, i.e. shower/bath diverter, a risk assessment will be necessary to establish what temperature setting is required.

10 Building management systems

10.1 The continued safe operation of domestic hot and cold water systems requires a number of routine checks to be made by physical means using separate thermometric equipment. A number of the control parameters can, however, be monitored by building management systems (BMS) continuously, even though routine checks will still be required for "calibration purposes". Parameters that should be monitored are as follows:

a. incoming mains temperature (at the water meter), inlet, outlet, and surface water temperatures of cisterns and cold water feed tanks for hot water calorifiers;

b. calorifier flow and return temperatures;

c. hot water service flow and circulation temperatures at the furthermost outlets in individual wards;

Note

In non-recirculating systems, at least two points, including the furthermost from the entry of the pipe into the department, should be monitored.

In other departments, monitoring should be provided on a similar basis.

d. cold water service at the furthermost point from the pipeline entry to the ward/department.

10.2 In addition to temperature, the BMS should also monitor pressurisation and circulating pumps, and water treatment systems for fault conditions or change of status likely to result in a fault.

11 Materials of construction

General

11.1 Any materials that come into contact with the water in a hot and cold water installation must comply with the requirements of the Water Supply (Water Fittings) Regulations 1999. A list of products and materials that have been assessed for compliance with the requirements of these Regulations is given in the current edition of 'Water Fittings and Materials Directory', which is updated every six months. Further information on the selection of materials can be found in BS 6700:1997, BS EN 806-2:2005 and BS 6920-1: 2000.

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

11.3 Water supplied by the water undertaker, 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. The water undertaker also blends water and accordingly, the character of the water supply may vary from time to time. It will therefore be necessary to consult the water undertaker for advice on what materials should be avoided.

11.4 The choice of materials for piping and fittings should also take into account the nature of the soil in which the piping is to be laid. 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.

11.5 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.

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

11.7 Corrosion may result from galvanic action where dissimilar metals are connected. 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.

11.8 The materials generally used for the conveyance of water in healthcare premises are copper, steel, stainless steel and plastics. Lead is no longer allowed under the Water Supply (Water Fittings) Regulations 1999 for pipework or solders. Lead-free solders are now widely available.

11.9 Substances leached from materials of construction of pipes, cisterns or other water fittings in contact with water must not adversely affect the quality of water stored or drawn for domestic or food production purposes (Water Supply (Water Fittings) Regulations 1999).

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

Steel pipes and fittings

11.11 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, but bitumen is not permitted in contact with water required to be wholesome (that is, to be used for normal domestic or food production purposes).

11.12 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 an epoxy phenolic lining which requires special application techniques.

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

11.14 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.

11.15 Where the soil is of a corrosive nature, the pipes must be additionally protected by means of bitumen and fibreglass cloth wrappings.

11.16 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, should be used according to the manufacturers' instructions. Compounds containing red lead must not be used because of the danger of contamination of the water. Jointing compounds must not support microbial growth, should comply with BS 6920-1:2000, 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

11.17 Stainless steel is being increasingly used in hot and cold water service systems. Reference should be made to SHTN 2: 'Domestic hot and cold water systems for Scottish health care premises'.

Copper pipes and copper/copper alloy fittings

11.18 Copper in general is resistant to corrosion. Unless resistant to dezincification, 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. Dezincification-resistant material must be used for fittings that are concealed or inaccessible, for backflow prevention devices, and for temperature and pressure-relief devices on heating systems. Copper piping should conform to BS EN 1057: 1996 as appropriate for underground or above-ground installations. When soldering copper tube and fittings, refer to WRAS Information and Guidance Note 9-04-02: 'Solder and fluxes'. If wax-based soldering fluxes must be used, they should be used sparingly. They pose a risk of bacterial contamination to the system, which can be difficult to eradicate.

11.19 Fittings should comply with the requirements of BS EN 1254-1–5:1998. 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.

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

Plastics

11.21 Most 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.

11.22 Advantages of plastic include corrosion resistance, lightness of weight and ease of handling.

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

11.24 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 standards are maintained. In the case of plastic materials, this can often be achieved by introducing a suitable "flushing" routine during the commissioning period.

11.25 Materials in common use for plastic pipework are medium-density and high-density polythene, the latter being stronger. Unplasticised polyvinyl chloride (uPVC) is also used. PVC pipes to BS 3505:1986, BS EN 1452:2000 (parts 1–5) and BS 3506:1969 are of a rigid material that has a greater tensile strength than polythene, but is less resistant to fracture. These materials are less susceptible to frost damage than metal pipes. Although freezing is unlikely to damage the pipe, it will result in interruption of supply, and subsequent leakage from joints may occur.

11.26 Polythene pipes are generally not susceptible to corrosion from either the water or the ground in which they are laid. However, they 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. Further advice is available in the WRAS Information and Guidance Note 9-04-03: 'The selection of materials for water supply pipes to be laid in contaminated land'.

11.27 It is essential to consider the locality of exposed plastic pipes to ensure that there is no likelihood of mechanical damage and effects of UV daylight; 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.

11.28 Further advice on flushing regimes is given in SHTN 2: 'Domestic hot and cold water systems for Scottish health care premises'.

11.29 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. A competent fitter who has been trained under an approved scheme should make joints.

Composite materials

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

Iron pipes and fittings

11.31 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.

11.32 In made ground containing ashes and clinker, 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. Water undertakers are using more composite materials in pipework to overcome the risks.

Lead

11.33 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

11.34 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 healthcare premises is very limited.

11.35 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

11.36 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.

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

12 Pipework installations

General

12.1 All hot and cold water pipework should be designed and installed in full accordance with the Water Supply (Water Fittings) Regulations 1999 and relevant parts of BS 6700:1997 and BS EN 806-2:2005.

12.2 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 regulating valves or orifice plates are sited well away from bends or fittings.

Sizing

12.3 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.

12.4 Hot and cold water pipework should be sized using the procedure outlined in CIBSE Guide G: 'Public health engineering'.

Routeing of pipework

12.5 Pipework in buildings should be designed and routed in a manner that will promote good turnover of water, particularly in cold water service systems (see Figure 5). It should be installed so that it is accessible for inspection, maintenance and repair as far as is practicable. Ducts, trenches and chases containing pipework should be large enough to facilitate repairs.

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

12.7 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 the air vent. They should not rise above the hydraulic gradient; that is, there should always be a positive 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.

12.8 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.

12.9 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

12.10 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.

12.11 Automatic air-release valves should be installed where accessible for maintenance. Installation in ceiling voids is not recommended.

12.12 Drain points should not discharge directly into a drain or sewer or into a manhole or chamber connected thereto without a type A air gap. Where a wash-out discharges into a natural watercourse, the discharge should at all times be well above the highest possible water level in the watercourse. Consent for this discharge may be required from the Environment Agency. In some cases it may be necessary for the wash-out to discharge into a watertight sump, which has to be emptied while in use by portable pumping equipment.

12.13 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

12.14 A clear indication should be given on all valves of the direction of rotation needed to close the valve. Normal practice is to have clockwise closing when looking down on the valve.

12.15 Where blending 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 the mixer. This should be located upstream of the mixing valve so as to facilitate flushing out and routine temperature testing of the hot water without having to dismantle the blending valve.

Prevention of contamination

12.16 In all cold water installations it is important that adequate protection be provided to all supplies against backflow. In healthcare facilities, there should be a high degree of protection not only to the water in the undertaker's mains, but also within the installations to protect the patients and staff. In addition to backflow protection at all points of use, the whole installation protection should be provided as required by the Water Supply (Water Fittings) Regulations 1999.

12.17 Healthcare buildings and medical premises have been identified as involving Fluid Category 5 backflow risks (see Schedule 1 "Fluid Categories" from the Water Supply (Water Fittings) Regulations 1999), which are defined as points of use or delivery of water where backflow is likely to involve fluids contaminated with human waste. Within healthcare facilities, water usage covers a wide range of applications, from domestic use by patients and staff to specialised use in operating departments and pathology laboratories, and with equipment such as bedpan washers and haemodialysis machines. In addition, many apparently "commercial" usages may be classed as high-risk because they are for healthcare purposes, such as centralised laundries.

12.18 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, *Legionella* growth etc. The Water Supply (Water Fittings) Regulations 1999 require the identification, by colour-coding or labelling, of all pipework carrying fluids other than wholesome water.

12.19 Comprehensive guidance on the measures required to prevent contamination of the water supply is given in the WRAS 'Water Regulations Guide' and in relevant parts of BS 6700:1997 and BS EN 806-2:2005.

12.20 Certain departments such as pathology laboratories present particular risks of water contamination. Attention is drawn to section G15.24 in the WRAS 'Water Regulations Guide' on supplementing point-of-use protection by zone protection, where the pipes supplying a high-risk area can be given additional protection by installation of a secondary backflow protection device.

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

12.22 Where any doubt exists with regard to the level of protection required against water supply contamination, reference should be made to the Water Supply (Water Fittings) Regulations 1999 and guidance contained in the WRAS 'Water Regulations Guide', or water undertaker.

Frost protection

12.23 The Water Supply (Water Fittings) Regulations 1999 require that all cold water pipework and fittings be adequately protected against damage from freezing.

12.24 In the case of external pipework that is run underground, the Regulations require that consent be sought from the water supplier if pipes are to be run at depths of less than 750 mm or greater than 1350 mm. Permission from the water undertaker must be sought if any deviation is required.

12.25 Particular care is required when routeing pipework externally above ground or through unheated areas within buildings. The WRAS 'Water Regulations Guide' gives guidance on the minimum thickness of thermal insulating materials that should be applied in such cases.

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

12.27 For further guidance on frost protection, refer to the WRAS 'Water Regulations Guide'.

Flushing

12.28 Prior to taking systems into use, they should be subject to a thorough regimen of flushing before disinfection (see paragraph 17.15).

13 Noise and vibration

Pump noise

13.1 Noise generated by centrifugal pumps will not cause problems if water velocity in the pipes and the speed of the pumps are low, for example about 1 m/s and 960 rpm respectively.

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

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

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

13.5 Guidance on recommended noise levels for various locations is given in CIBSE Guide A: 'Environmental design'.

Other forms of system noise

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

a. noise from pipework due 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 from float-operated valves into cisterns;

f. noise caused by thermal movement of pipes;

g. noise due to trapping of air within pipework, particularly on hot water systems.

13.7 Further details on the above sources of noise, including guidance on avoiding such noise problems, are given in the WRAS 'Water Regulations Guide'.

14 Water economy and energy conservation

Water

14.1 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 management system.

14.2 Measures to minimise water consumption that 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. WC pans and flushing cisterns that use more than 6 L per flush are prohibited by Water Supply (Water Fittings) Regulations 1999;

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 – these must not be used in conjunction with thermostatic mixing valves unless approved by the manufacturer of such valves; restrictors or regulators should not be installed at the inlets of thermostatic mixing valves;

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.

14.3 Further guidance on the prevention of wastage of water is given in the WRAS 'Water Regulations Guide'. Reference should also be made to the Audit Commission's (1993) 'Untapped savings: water services in the NHS'.

Energy

14.4 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 for the control of *Legionella*.

14.5 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.

14.6 The practice of pre-heating of the cold feed to calorifiers should not be carried out. 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.

14.7 Further guidance on energy conservation in relation to hot and cold water systems is given in the Department of Health's (2005) Encode (see also the Carbon Trust's website, http://www.carbontrust.co.uk).

15 Water treatment

Chlorine dioxide

15.1 Chlorine dioxide is an oxidising biocide that is capable of reacting with a wide range of organic substances and has been shown to be effective in the control of organisms in water systems. Use of chlorine dioxide as a chemical for drinking water treatment is now subject to a European Standard (BS EN 12671:2000).

15.2 The use of chlorine dioxide as a control measure will depend on the design of the systems in use and, in an existing system, their operational history.

15.3 There are two aspects to be taken into consideration:

a. in the cold water distribution system, chlorine dioxide may be injected into the system upstream of all parts of the distribution, storage and boosting equipment or at the break-tank serving the booster set. There must be close monitoring and control of the dose, which should normally comply with the Water Supply (Water Quality) Regulations 2000 for the equivalent use of chlorine dioxide in the treatment of water supplies by the water undertakers;

b. in the case of hot water distribution systems with calorifiers/water heaters operating conventionally, that is, at 60°C, there will be a tendency for chlorine dioxide to be lost by "gassing off", especially if the retention time in a vented calorifier/water heater is long. In most cases, however, some total oxidant should be found in the hot water, although at levels far less than the 0.5 ppm injected. The calorifier/water heater should act as a barrier to dispersal of any pathogenic material by the hot water system.

15.4 Where copper supply pipes are used, chlorine dioxide can result in high concentrations of copper being measurable in the water supplies.

15.5 Additional information on chlorine dioxide is given in Appendix 4.

Silver/copper ionisation

15.6 Ionisation systems release copper and silver ions into the water stream by means of electrolytic action. Ionisation as a water treatment method is covered in BSRIA's Technical Note TN 6/96 following a study in which it was shown that copper and silver ion concentrations maintained at 400 μg/L and 40 μg/L respectively can be effective against planktonic *Legionella* in hot water systems. In soft waters a silver level as low as 20 μg/L can be effective.

15.7 The use of ionisation as a control measure will depend on the design of the systems and, in an existing system, their operational history.

15.8 The electrodes can be susceptible to accumulation of scale unless effective anti-scaling electrode cells are fitted. The system should be designed to take account of water quality, otherwise additional treatment may be necessary. Copper and silver ion treatment is also sensitive to pH, and thus pH control may be required.

15.9 In hard water areas there have been cases of staining of sanitaryware, but in a properly controlled system where dosing levels of silver are not exceeded, this should not be a major problem.

15.10 The opinion of the Committee on Products and Processes for Use in Public Water Supply concerning the use of silver as a disinfectant in public water supplies can be found on the Drinking Water Inspectorate website: http://www.dwi.gov.uk/cpp/silver.htm.

15.11 Additional information on copper and silver ions is given in Appendix 5.

Ozone and ultraviolet treatment

15.12 Whereas the previous treatments are intended to be dispersive (that is, they result in a residual agent within the system), ozone and ultraviolet are intended to be effective close to the point of application. They are not, therefore, necessarily effective in hot and cold water service systems.

15.13 Ultraviolet and ozone are methods that are suitable for water systems used for dialysis equipment. However, allowance must be made for the aggressive effects of ozone on materials exposed to it, particularly the degradation of rubber compounds and the corrosion of metallic materials.

15.14 The systems should be fail-safe and have adequate instrumentation to monitor operation. For example, UV systems should be preceded by particle filtration to prevent microorganisms being shielded by particles, and incorporate a detector so that any loss of transmission can be corrected immediately. They require appropriate pre-filtration to remove particulate matter that may shield bacteria from the UV rays.

Purging the systems

15.15 When the system is initially dosed, checks should be made at various parts of the system to ensure that satisfactory concentrations of treatment chemicals are being achieved.

16 Testing and commissioning

Introduction

16.1 While testing and commissioning is regarded as a discrete activity, continuous monitoring is required throughout the installation to ensure that:

a. materials and equipment installed comply with the Water Supply (Water Fittings) Regulations 1999 and other British Standards, and are not otherwise unsuitable. Equipment that is listed in the latest edition of the 'Water Fittings and Materials Directory' and installed in accordance with any of its relevant conditions will comply;

b. the work is done entirely within the specification for the scheme;

c. all the requirements of current legislation are met, both during construction of the installation and when it is completed, particularly with regard to the Health and Safety at Work etc Act 1974.

Installation checks

16.2 The system should be regularly checked during installation to ensure that open pipes, valve ends, cylinder connections etc are sealed to prevent the ingress of dust/debris that could cause problems during commissioning and subsequent operation. Checks should also be made to ensure that fittings and materials comply with the Regulations and are those listed in the 'Water Fittings and Materials Directory', and that lead solders are not being used.

Inspection of joints

16.3 Before pressure testing, the site engineer should identify a number of fittings to be cut out for examination to establish whether the quality of the finished joint meets the specification. The exact number to be cut out will vary according to the size of the installation, but as a guide, a ratio of one fitting per 400 installations should be cut out. In any event, a minimum of two, and not normally more than five, fittings should be cut out for examination.

16.4 The fittings cut out should be cut open (quartered longitudinally) and examined. If unacceptable joints are found, adjacent fittings should be cut out until the extent of any faulty workmanship has been established.

16.5 The pipeline should be made good.

16.6 The tube and fitting should be internally clean and free from particulate matter. Some oxidation will be evident when hot "joints" are made.

16.7 When copper pipe and capillary fittings are used, because of the viscosity of the brazing filler, full penetration may not be achieved.

16.8 The minimum penetration at any point must be three times the wall thickness of the tube or 3 mm, whichever is the greater.

Commissioning

16.9 Correct commissioning is vitally important for the satisfactory operation of the hot and cold water systems. The designer should prepare a commissioning brief for use by the contractor's commissioning engineer. 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. number commissioning procedures for thermostatic mixing valves in accordance with specification MES D08;

d. drawings and schematics;

e. a list of test certificates to be provided.

16.10 The designer's attention is drawn to CIBSE Commissioning Code W: 'Water distribution', which provides guidance on information that will be required by the commissioning engineers.

16.11 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 Department of Health's Estates & Facilities Division.

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

16.13 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.

16.14 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.

16.15 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.

16.16 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.

16.17 The supervising officer or project engineer, who should countersign any relevant test record documents, should witness commissioning and testing.

16.18 "As installed" record drawings, schematic diagrams, operating and maintenance instructions must be supplied at the time of handover. Certified records of pressure testing and disinfection should also be made available.

16.19 The whole commissioning procedure should be carried out under the guidance of a single authority, although the involvement of specialists or manufacturers may be required for specific items of plant.

16.20 Valid calibration certificates should be submitted and checked for all measuring equipment to be used by the commissioning engineers prior to commencement of commissioning.

16.21 The commissioning should be carried out in a logical and methodical manner.

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

16.23 Once the system meets the design intent, the final completion record sheet(s) should be completed. In the event of performance not being acceptable, the matter should be dealt with in accordance with the contract requirements.

Commissioning and testing checklists

16.24 The following is a summary of the key activities associated with pre-commissioning and commissioning of hot and cold water storage and distribution systems. The list is not intended to be comprehensive.

Cold water installations

16.25 Pre-commissioning checks can be carried out on completion of the system installation, filling and pressure testing.

16.26 Pre-commissioning checks and tests to be applied are as follows. Check that:

a. systems have been provided and installed in accordance with specification and drawings, and that the systems are charged with water, vented and free from leaks;

b. water storage cisterns are free from distortion and leaks, are properly supported and secured, are provided with correctly fitting covers, and are in accordance with the Water Supply (Water Fittings) Regulations 1999;

c. distribution pipework is rigidly supported, insulated, and incorporates adequate provisions for venting, draining, expansion, isolation and measurement of flow, temperature and pressure;

d. pipework systems have been pressure tested;

e. pipework systems and storage cisterns have been flushed, disinfected, appropriate certification received, and that specified residual chlorine levels are attained;

f. pipework systems and storage/break tanks are correctly identified and marked;

g. regulating valves and flow control devices operate freely;

h. water meter(s) is/are fitted correctly;

j. electrical isolation, cross-bonding and wiring of system components are installed in accordance with the current edition of BS 7671:2001.

16.27 Upon satisfactory completion of the pre-commissioning tests, the commissioning tests can commence.

16.28 Commissioning checks and tests to be applied are as follows. Check that:

a. overflows run freely and discharged water does not cause flooding or damage, and that drain-down points flow when released and are free from leaks when shut;

b. float-operated valves function satisfactorily and are adjusted to give the correct water level;

c. control valves operate correctly and shut-off valves close tightly;

d. all electrical circuits are tested and the pump motor direction of rotation is correct, and that electrical controls and alarms function correctly;

e. operation of any safety or anti-flood device is satisfactory;

f. circulating or lifting pumps are free from excessive noise, vibration and leaks;

g. remote control of pumps (if appropriate) is satisfactory;

h. the installation is vented and regulated;

j. the flow rate into, and out of, storage cisterns is recorded;

k. all taps, mixers and outlets operate satisfactorily, and test and record mass flow from outlets in positions shown on contract drawings. (TMVs require hot and cold water for testing and commissioning. Type 3 TMVs are commissioned in accordance with MES D08.);

m. temperature of water in storage cisterns and at taps is appropriate;

n. full load current of components does not exceed the recommended values;

p. the running current of components does not exceed the recommended values;

q. pump thermal overload trips are set;

r. system schematic is displayed in a frame in the relevant plantroom, complete with valve schedule.

Hot water installations

16.29 Pre-commissioning checks can be carried out upon completion of system installation, filling and pressure testing.

16.30 Pre-commissioning checks and tests to be applied are as follows. Check that:

a. systems have been provided and installed in accordance with the specification and drawings;

b. the system is charged with cold water, vented, and free from leaks;

c. hot water storage vessels are free from leaks and are properly supported and secured;

d. distribution pipework is rigidly supported, insulated, and incorporates adequate provision for venting, drainage, expansion, isolation, and measurement of flow, temperature and pressure;

e. pipework systems, storage cylinders etc have been pressure tested, flushed and disinfected, and appropriate certification has been received, and that specified residual chlorine levels are attained;

f. pipework systems, calorifiers and cisterns are correctly identified and marked;

g. regulating valves and flow control devices operate freely;

h. all control and regulating valves are labelled or marked to correspond with reference numbers on contract drawings;

j. electrical isolation, cross-bonding and wiring of system components is installed in accordance with the current edition of BS 7671:2001;

k. system schematic is displayed in a frame in the relevant plantroom.

16.31 Upon satisfactory completion of the pre-commissioning checks, the commissioning checks and tests can then be started.

16.32 Commissioning checks and tests to be applied are as follows. Check that:

a. drain down points flow when released and are free from leaks when shut, and that air vents and release valves open correctly and are airtight when shut off;

b. all temperature and other controls are adjusted and calibrated to agreed design limits of system performance;

c. all electrical circuits are tested and the pump motor direction of rotation is correct, and that electrical controls and alarms function correctly;

d. control valves operate correctly and shut-off valves close tightly;

e. heat exchangers operate satisfactorily;

f. primary heating circuits are adjusted and regulated, and thermostatic settings are correct; and that bypass circuits and automatic control valves operate correctly;

g. circulating pumps are free from excessive noise, vibration and leaks;

h. remote and automatic control of pumps (if appropriate) is satisfactory, and there are no leaks at joints under maximum flow conditions;

k. secondary circuits are regulated and vented;

m. thermostatic mixing devices and regulating valves are adjusted and set to desired values (TMVs require hot and cold water for testing and commissioning, and should be commissioned in accordance with MES D08);

n. all taps, mixers and outlets operate satisfactorily;

p. water flow quantities at all plant items, regulating valves and flow-measuring valves are recorded;

q. mass flow from taps, main and other outlets in positions shown on contract drawings is satisfactory;

r. pressure drop at heat exchangers at full design demand flow is tested and recorded;

s. hydraulic balancing of hot water secondary circulation system is carried out to ensure that minimum temperatures are achieved in all parts of the circuit;

t. full load current of components does not exceed the recommended values;

u. the running current of components does not exceed the recommended values;

v. pump thermal overload trips are set.

Pressure testing

16.33 Pressure testing must be carried out before disinfection. Except where otherwise specified, testing of underground pipelines should be carried out in accordance with the requirements of the Water Supply (Water Fittings) Regulations 1999.

16.34 Open pipes should be capped and valves closed to avoid contamination.

Temperature testing

16.35 These tests should be performed prior to contractual handover and bringing the system into use. Separate thermostatic measuring and recording equipment should be used, that is, independent of any building management system. It will be necessary to have systems fully operational and to simulate typical draw-off of water.

16.36 Tests should include:

a. measuring the incoming water temperature at the main water meter;

b. testing the inlet, outlet and surface water temperatures of cisterns and cold water feed/header tanks for the hot water calorifiers. The temperature should not be greater than 2°C above that measured at (a);

c. testing the flow and return temperatures at connections to calorifiers and water heaters. These should not be less than 60°C and 50°C respectively;

d. testing the temperature in branches of hot water circulating systems installed in all departments to ensure that the system has been balanced, and that under "no draw-off" conditions 55°C is achieved in the circulating system at outlets furthermost from the calorifier/heater;

e. testing sections of a non-recirculating hot water system at branches to ensure that the trace heating is effective and that under no-flow conditions 55°C is achieved;

f. testing single hot water outlets and inlets to mixing valves to ensure that a minimum of 55°C is achieved within 1 min;

Note

The Health and Safety Commission's (2000) Approved Code of Practice L8 permits a period of 1 min to achieve an equilibrium temperature of 50°C. A minimum of 55°C may be required for the operation of suitable mixing devices required to provide "safe" hot water at the upper limit of the recommended range. Hot water at 55°C is required in many cases for reasons of food hygiene or decontamination requirements, for example in kitchens and sluice rooms. In a properly balanced hot water circulating system, with the circulation taken close to the draw-off point, achieving temperature should be virtually instantaneous. (At a typical flow to a wash-hand basin of 4.5 L/m, 1 min to achieve temperature would indicate a 25 m dead-leg of 15 mm pipe or that the system is out of balance.)

g. testing single cold water outlets and inlets to mixing valves to ensure that temperature equilibrium below 20°C is achieved within 2 min.

Note

The Health and Safety Commission's (2000) Approved Code of Practice L8 permits a period of 2 min to achieve an equilibrium temperature below 20°C. Achieving this minimum requirement would be indicative of an exceptionally under-utilised water system in an unoccupied building. During commissioning, therefore, it is essential to encourage draw-off to simulate normal usage. (At a typical flow to a hand-wash basin of 4.5 L/m, 2 min to achieve temperature would indicate a 50 m dead-leg of 15 mm pipe or that stagnation is occurring.)

h. Testing the temperature at hot water draw-off points to ensure that they comply with the recommended temperatures in Table 4. (Note: the maximum temperatures should not exceed those shown in Table 4 by more than 2°C.)

17 Disinfection

17.1 Guidance on disinfection is given in BSRIA's (2004) Application Guide 1/2001.1: 'Pre-commission cleaning of pipework systems', which contains recommendations for the design, installation, system-flushing and chemical cleaning of pipework systems. Disinfection should be applied to the complete hot and cold water service systems. When considering a contractor to carry out the work, preference should be given to companies/individuals who are members of the Legionella Control Association (formerly, the Code of Conduct Association for the Control of Legionellosis).

17.2 Alternative disinfectants may be used, provided satisfactory disinfection is achieved. The infection control team should be consulted, and advice should also be sought from the Drinking Water Inspectorate.

Note

Disinfection is a requirement of the Water Regulations. Additional advice on the use of alternative disinfectants is given in SHTN 2: 'Domestic hot and cold water systems for Scottish healthcare premises'.

17.3 Proprietary solutions of disinfectant should be used in accordance with the manufacturers' instructions. The COSHH Regulations require that the risks from using the disinfectant for each task be assessed to ensure that the control procedures adopted are suitable for the particular application.

17.4 Disinfection should not be undertaken before materials, for example linings in cisterns, have fully cured. Advice should be sought from equipment manufacturers to ensure that proposed disinfection chemicals will not adversely affect performance. No heat source should be applied during the disinfection procedure, including final flushing.

17.5 Pipework under pressure from the mains should be disinfected through an injection point and the disinfectant residual measured at the end of the pipeline. BS 6700:1997 and the Approved Code of Practice L8 advise 50 mg/L (ppm) for one hour or 20 mg/L (ppm) for two hours; it is usual practice to leave the chlorine solution in the pipes for 24 hours before thoroughly flushing out with fresh water. Junctions that are to be inserted into existing pipelines should be disinfected prior to installation.

17.6 All disinfection of pipework under pressure from the mains must be carried out in accordance with the requirements of the water undertaker. Failure to ensure close liaison between the contractor and the water undertaker during design, construction, pressure testing or commissioning could present a potential risk of back-flow of contaminated materials or chemicals into the public water supply. Site supervision to ensure compliance with any requirements specified by the local water undertaker is recommended.

17.7 All cisterns should be internally cleaned to remove all visible dirt and debris. Cisterns and distributing pipework should be drained, filled with fresh water and then drained completely. The cisterns should then be refilled and the supply servicing valves closed. On re-fitting it is normal practice to add high doses of sodium hypochlorite to the water in the cisterns, for example to give a calculated chlorine concentration of 50 ± 10 mg/L (ppm) in the water, and leave the water to stand for one hour. Whatever disinfection method is used, the concentration should be adjusted if necessary. The use of a high dose ensures an adequate residual concentration to allow proper disinfection of the downstream services. Each tap or fitting should then be opened, progressively away from the cisterns, and water discharged until the disinfectant is detected. Each tap or fitting should then be closed, and the cistern and pipes left charged for a further hour. The tap(s) furthermost from the cisterns should be opened, and the level of disinfectant in the water discharged from the taps measured. If the levels set are not achieved, the disinfection process should be repeated.

17.8 As soon as possible after disinfection, the distribution pipework should be drained and thoroughly flushed through with fresh water and refilled (see paragraphs 17.14 and 17.15). Appropriate hazard warnings should be placed on all taps throughout the building during disinfection procedures.

17.9 After disinfection, microbiological tests for bacteria colony counts at 37°C and coliform bacteria, including *Escherichia coli*, should be carried out under the supervision of the infection control team to establish that the work has been satisfactorily completed. Water samples should be taken from selected areas within the distribution system. The system should not be brought into service until the infection control team certifies that the water is of potable quality.

Discharge of waste water used during disinfection procedures within buildings

17.10 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.

Thermal disinfection (of hot water service systems)

17.11 The process introduces a serious scalding risk, and it is essential that steps are taken to ensure that access is limited to authorised personnel only until such time that the system has returned to normal operating temperature: it is unlikely to be a practicable alternative for a large system. It also requires the removal of thermostatic elements, thus introducing additional practical difficulties.

17.12 This process can be performed by raising the temperature of the entire contents of the calorifier, or hot water heater, followed by circulating the water throughout the system for at least an hour. The calorifier/heater temperature must be sufficiently high to ensure that the temperature in all parts of the circulating system, and at the return connection, does not fall below 60°C. After this period, each tap or draw-off-point should be run sequentially from the nearest point to the furthermost outlet. At branches it will be necessary to draw-off water to at least one outlet, the nearest, to ensure adequate purging. The draw-off at the tap or outlet should be for a period of at least five minutes at full temperature.

17.13 In the case of non-recirculating systems that have trace heating, the whole system should similarly be raised to, and held at, 60°C for at least an hour before draw-off commences.

Maintaining control of systems

17.14 Once disinfection has taken place, it is essential to put in place measures to ensure that hot and cold water temperatures are maintained. This will require regular flushing, at least weekly, and possibly more frequently during periods of hot weather.

17.15 Once filled, systems should not be drained unless full disinfection is to be carried out prior to building occupancy and use. However, allowing water in newly installed capillary-jointed copper plumbing to stagnate can result in serious corrosion of the copper. To reduce the risk of this, it is recommended that flushing should take place on a weekly basis to introduce fresh water throughout the system.

17.16 To prevent the accumulation of biofilm during construction and testing, continuous dosing of water systems with appropriate biocides should be considered. Such treated systems should be regularly flushed to ensure that the biocide reaches all parts of the systems, and particularly outlets. Dosing with an appropriate level of biocide as soon as water hits a pipe or storage vessel, along with regular flushing, can control the accumulation of biofilm more effectively.

18 Documentation

General

18.1 It is essential that a full report of all commissioning and testing activities is compiled and handed over to be incorporated within the operation and maintenance manuals.

18.2 These commissioning and testing records will be required so that subsequent maintenance and periodic checks can be made to ensure that the installation continues to operate as intended. Such information will include results of temperature checks on the cold water supply, hot water circulating systems and trace-heated hot water installations, and commissioning and in-service test data for Type 3 TMVs. The information should also include identification of, and test results for, sentinel taps.

18.3 Where continuous water treatment is installed, the commissioning records should include details of settings of the equipment, dosing rates and requirements for testing.

18.4 Operation and maintenance manuals should be in accordance with BSRIA's (1990) Application Guide 1/87: 'Operation and maintenance manuals for building services installations'.

18.5 As a minimum, for new installations or major refurbishment, the contract should require the following documents and drawings to be supplied:

a. full manufacturing details, including batch numbers of all pipes and fittings;

b. full records and certificates of pressure tests for all sections of pipework;

c. settings of all balancing valves, with readings of flow rates where applicable;

d. full details of each item of plant, including arrangement drawings and appropriate test certificates;

e. as-fitted drawings showing clearly the location of balancing valves, flows and settings, isolation valves, drain valves;

f. schematic drawings for installation in plantrooms showing all valves and items of plant;

g. full details of water treatment parameters and operating modes and settings;

h. full details of maintenance requirements;

j. detailed comfirmation of disinfection procedures to BS 6700:1997, and results of post-disinfection microbiological analysis;

k. full records confirming that all materials and fittings hold WRAS or equivalent accreditation.

Appendix 1 Water consumption for ward units

Ward unit

For the purposes of this study, a ward unit is defined as a combination of all the rooms which make up the working area for patient care, that is, patients' bedrooms, day spaces, treatment, utility and test rooms, bathrooms, showers, WCs, pantry, staff rooms, cleaners' room etc and circulation spaces. Figure A1 shows the average daily consumption of stored water and Figure A2 shows the rate of supply of mains water to cistern.

Figure A1 Average daily consumption of total stored water

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.

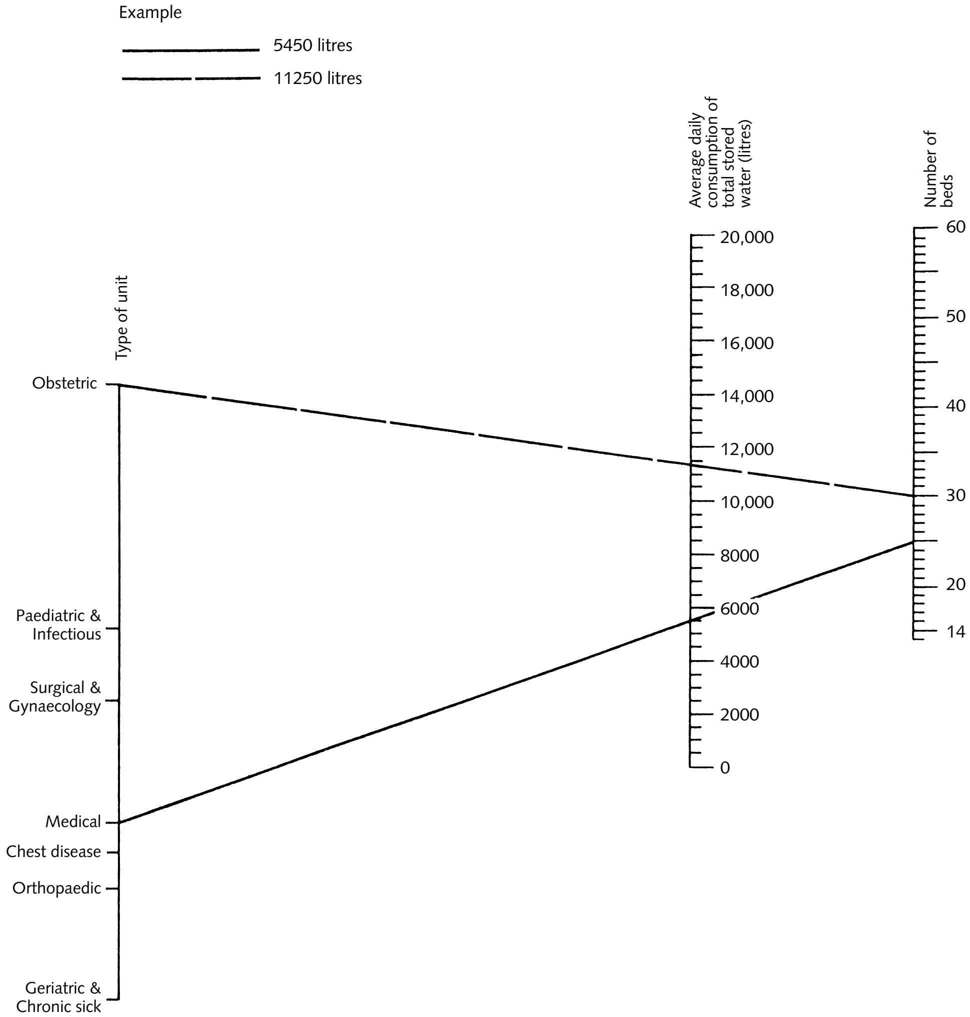
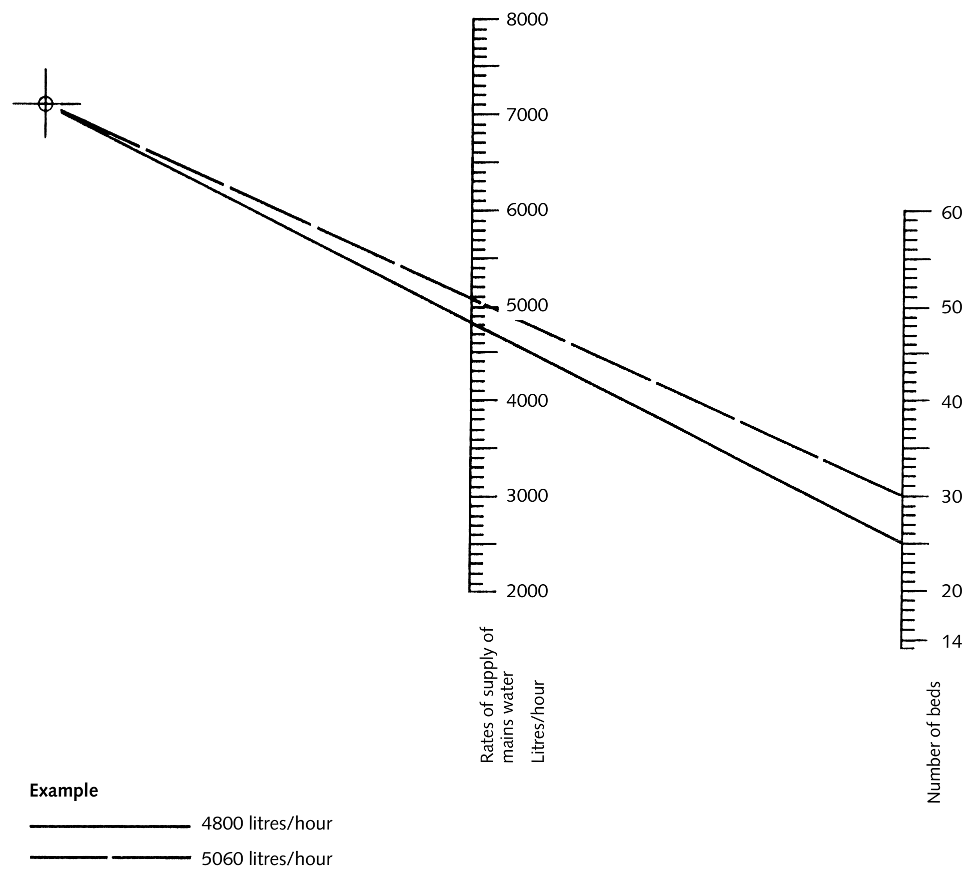


Figure A2 Rate of supply of mains water to cistern

Use of nomogram
Project line from point ⌖ to number of beds. The intersection on 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.



Average water consumption by type and size of hospital

Table A1 (the results of a survey of NHS 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 shown in Table A2. "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).

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 – a graphical presentation of the figures given in Table A1 is presented on a per bed and per floor area basis in Figures A3 and A4.

Table A1 Average water consumption by type and size of hospital

Sire 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
201–300	10	2,300	230	182,617	217
Over 300	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

Table A2 Definition of types of hospital

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 or more of their beds allocated to patients recovering from a disability who no longer require active medical supervision or nursing care in bed though they may need such simple nursing procedures as renewal of dressings or the administration of medicines
Rehabilitation	9	Hospitals with 90 per cent or more 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 functions
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 allocated 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 ENT 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

Figure A3 Average water consumption by type and size of hospital (litres per bed)

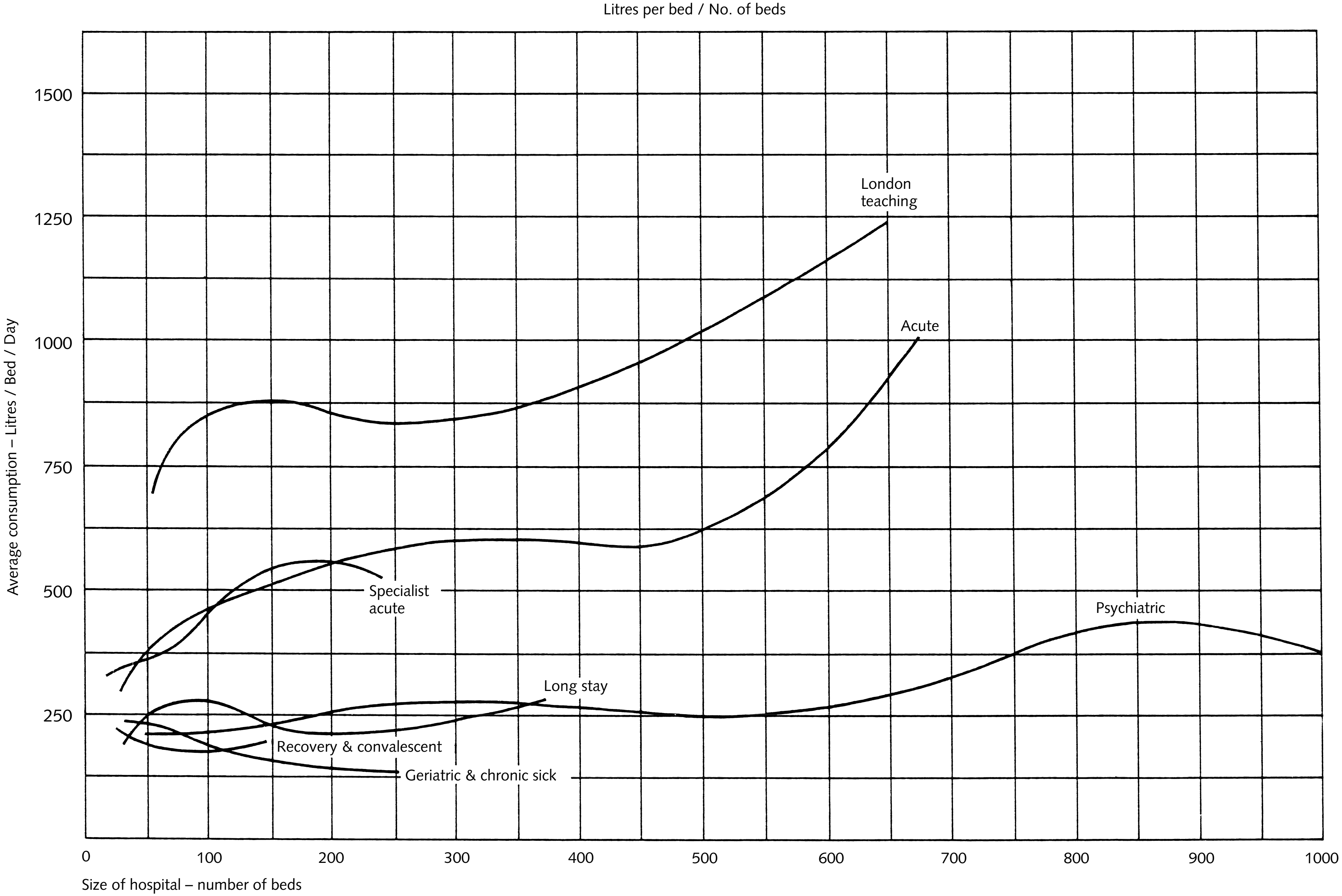


Figure A4 Average water consumption by type and size of hospital (litres per floor area)

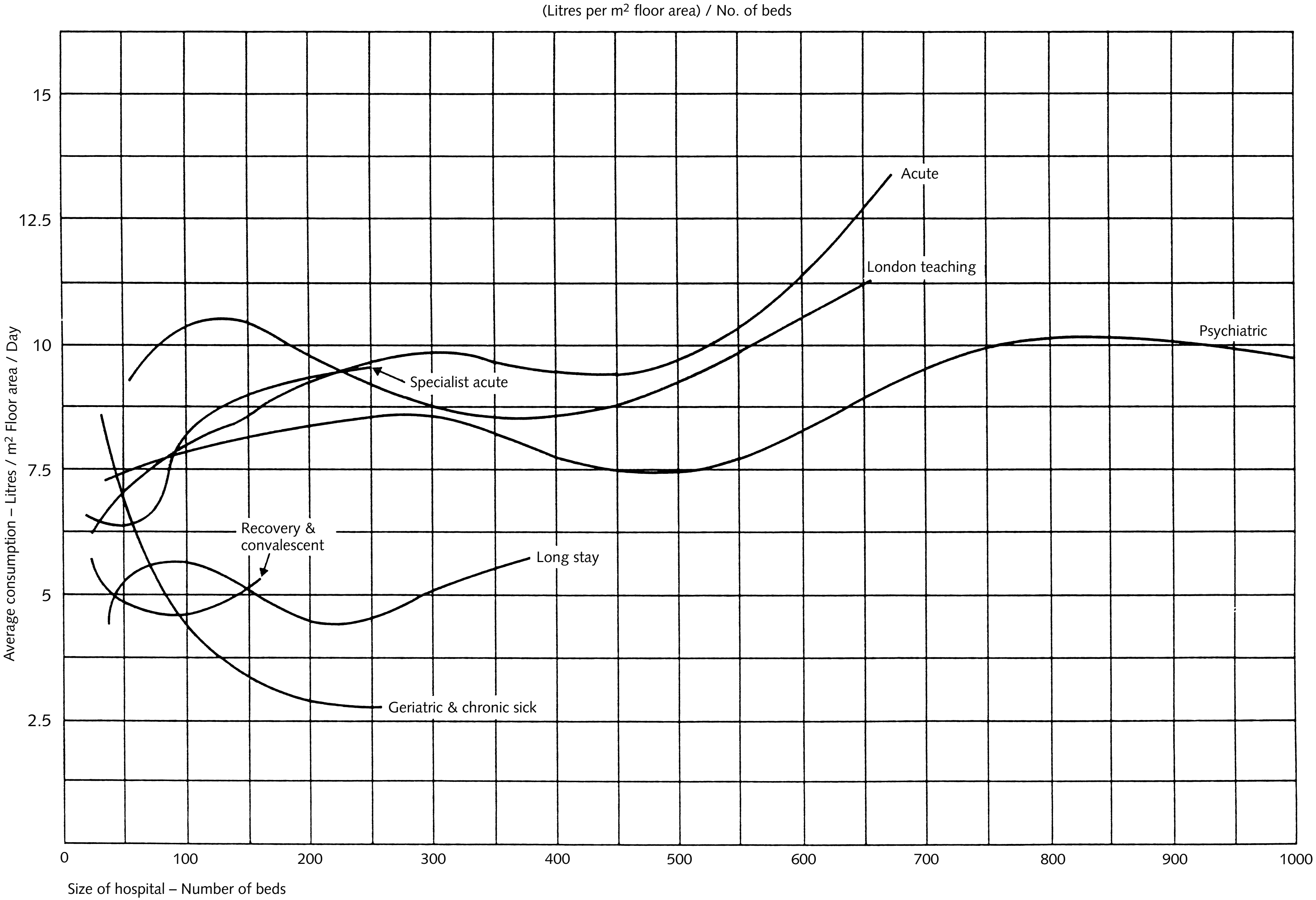
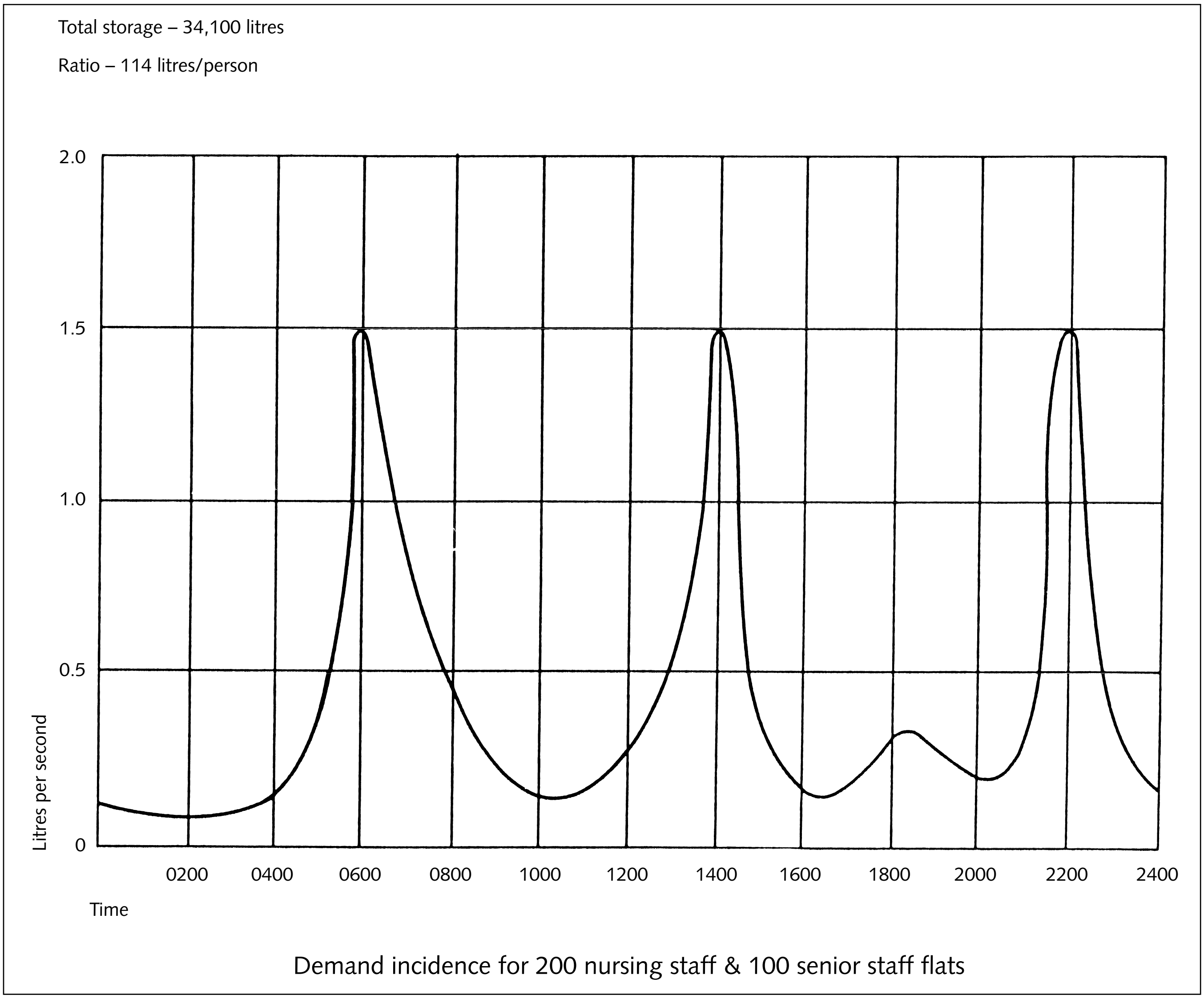


Table A3 and Figure A5 provide a worked example of water consumption by nursing staff in residential accommodation.

Table A3 Example of water consumption by nursing staff in residential accommodation

Residential accommodation for nursing staff			
1. Data			
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 WCs 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	2.5	2	1
WC	20	16	8
Sink	5	4	6
Washing machine	8	–	–
3. Consumption per use			
LB	4.5 litres		
Bath	72 litres		
WC	6 litres		
Sink	6 litres		
Washing machine	114 litres		
4. Estimated daily consumption – 34,090 litres Daily consumption per person – 114 litres			
5. Peak demands – If two-thirds of resident staff work three shifts commencing at 06.00, 14.00 and 22.00 hours, peak demands will occur from 05.00 to 07.00, 13.00 to 15.00 and 21.00 to 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.			

Figure A5 Water consumption for residential accommodation of nursing staff



Appendix 2 Water treatment

General

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

The following sections on water treatment are intended to provide a brief overview only. Further details can be found in BSRIA Application Guide 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.

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.

A supply from a water undertaker 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.

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.

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.

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

For high quality groundwater sources, the only treatment that may be required is disinfection, which is covered in Chapter 17. However, for other water sources, further treatment will be required, and this may be extensive.

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

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

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 tank is part of a flocculation process.

Dissolved air flotation

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

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.

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.

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.

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.

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 (for example manganese dioxide) to oxidise and remove iron and manganese.

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

Iron and manganese removal

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

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

Solids treatment and disposal

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.

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 L of water containing 20 mg/L free chlorine. For water requiring dechlorination, an automated system dosing bisulphite solution or similar solutions can be linked to the BMS.

Appendix 3 Chloramine (and chlorine) in public water supplies

A number of water undertakers are introducing chloramine as a disinfecting agent in water supplies as an alternative to free chlorine. Chloramines tend to be more stable and provide residual antibacterial activity with lower total chlorine levels.

There is evidence that the use of free chlorine as a disinfecting agent in surface water supplies containing natural organic residues can combine to form trihalomethanes (THMs), for example chloroform ($CHCl_3$), bromodichloromethane ($CHCl_2Br$) and other compounds that are carcinogenic. (Free chlorine is still preferred for disinfecting borehole waters.)

The local water undertaker carries out chloramination at the water works by introducing both chlorine (Cl_2) and ammonia (NH_3), which combine in aqueous solution to form monochloramine (NH_2Cl), dichloramine ($NHCl_2$) and a small quantity of trichloramine (NCl_3).

The quantities of these depend upon the ratio of chlorine and ammonia and the acidity of the water; it is important to achieve the correct balance, as dichloramine and trichloramine can lead to problems of taste and odour and their formation needs to be minimised.

In the UK there is no standard for chloramines in water. The WHO recommends a maximum concentration of 3 mg/L. This is based on a tolerable daily intake that is derived from the "no observable adverse effect level" (NOAEL) to which a safety factor of 100 is applied. The levels of chloramine that the UK will use (and dialysis treatments units should be designed to handle) is likely to be in the order of 1 mg/L total chlorine, most of which is present as monochloramine.

Problems associated with aquaria have been reported in the USA, where much higher levels of chemicals are used than is proposed in the UK.

Chloramine is also extensively used in Europe for disinfection of public water supplies.

Implications for healthcare

In systems where free chlorine is rapidly lost, such as typical hot and cold water service systems, chloramines can remain for much longer, posing particular problems for dialysis patients. The effect of chloramine-induced acute haemolytic anaemia and methaemoglobinaemia has been well reported. Little other information is available on chloramine.

Chloramines, and to a lesser extent chlorine, in dialysis water can cause haemolysis – a condition whereby red blood cells are ruptured. In addition, all renal patients suffer from anaemia to some extent because they are lacking in erythropoetin (EPO). This natural hormone, which stimulates bone marrow to produce red blood cells, is not available in sufficient quantities in patients with damaged or diseased kidneys. Synthetic EPO is administered to dialysis patients but, apart from its high cost, can have unpleasant side-effects. Where chlorine or chloramines are present, the need for EPO escalates, and therefore it is imperative to eliminate chlorine and chloramines from water supplies to dialysis equipment to minimise the dosage of EPO.

Dialysis requires a water supply that has the minimum of chemical and bacterial impurities. This requires water treatment – typically reverse osmosis and softening; neither process removes chloramines or chlorine. Some reduction of chloramine occurs in deionisation equipment because of adsorption onto ion-exchange resin molecules, but performance of the ionisation process is unpredictable in this respect and cannot be relied upon. The Renal Association sets limits of 0.1 mg/L and 0.5 mg/L respectively for chloramines and total chlorine in water for dialysis. (The European Pharmacopoeia specifies a maximum limit of 0.1 mg/L for chloramine: studies have shown, however, that levels as low as 0.25 mg/L can cause haemolysis.) Therefore, it can be seen that the margin for error is low. (See also Health Building Note 53 – 'Facilities for renal services', Volumes 1 and 2.)

There remain some concerns about chloramine, but in the main, these are about high concentrations for bathing water disinfection. Further studies are taking place.

Removal of chloramines

The use of granular-activated carbon (GAC; filtration upstream of the reverse osmosis (RO) equipment) is recognised as an effective means of dealing with chloramine. (In hard water areas, water softening will also be required.)

Chemical reduction by use of ascorbic acid (vitamin C), which is capable of neutralising many oxidising agents, is also an effective method. There is some concern about the use of ascorbic acid because of its toxicity for dialysis patients. Management of vitamin C intake has to be carefully monitored in dialysis patients; therefore chemical reduction, particularly for domiciliary patients, is undesirable.

GAC is manufactured from a variety of products, but mostly bituminous coal. The charcoal derived is pulverised and "activated" by exposure to superheated steam. This increases the total surface area for adsorption, which can be as high as 1500 m^2/g. This highly porous substance is formed into disposable cartridges, or used in rechargeable tanks. The material so formed will provide filtration down to typically 0.2 μm.

The critical factor in the selection of the carbon filter is the empty bed contact time (EBCT), which can be calculated as follows:

$$EBCT = \frac{volume(GAC(L))}{flow(water(L/m))} \times 50$$

The aim should be an EBCT of about 6 min.

As a yardstick, the Drinking Water Inspectorate has advised the Renal Association to design water treatment systems, whether domiciliary or hospital-based, to remove up to 1 mg/L total chlorine.

Appendix 4 Chlorine dioxide

Chlorine dioxide is an oxidising biocide that is capable of reacting with a wide range of organic substances. Its effectiveness in the control of organisms in water systems has been demonstrated in a study carried out by BSRIA (see BSRIA's (1998) TN 2/98: 'Chlorine dioxide water treatment – for hot and cold water services').

For hot and cold water services, chlorine dioxide is usually generated by sodium chlorite reacting with gaseous chlorine or hydrochloric acid:

$$5NaClO_2 + 4HCl \longrightarrow 4ClO_2 + 5NaCl + 2H_2O.$$

Alternatively, a number of systems use proprietary solutions that release chlorine dioxide on acidification.

Use of chlorine dioxide as a chemical for drinking water treatment is now subject to a European Standard (BS EN 12671:2000). National conditions of use require that the combined concentration of chlorine dioxide, chlorite and chlorate do not exceed 0.5 mg/L as chlorine dioxide. Chlorine dioxide dissolves unchanged in water, but is very slowly hydrolysed to chloric and chlorous acids. In alkali, chlorate and chlorite are formed:

$$2ClO_2 + 2OH^- \longrightarrow ClO_3^- + ClO_2^- + 2H_2O.$$

It is essential that the maximum amount of chlorine dioxide is available for reaction with organic molecules and not total chlorite or chlorate.

In water, the oxidising properties of chlorine dioxide result from two reactions. Chlorine dioxide gains one electron to form chlorite:

$$ClO_2 + 1e^- \longrightarrow ClO_2^-.$$

If available, the chlorite gains four electrons to form chloride:

$$ClO_2^- + 2H_2O + 4e^- \longrightarrow Cl^- + 4OH^-1.$$

The first of these reactions proceeds readily in the range of pH found in potable water.

The latter reaction, to complete the five-electron transfer, does not always occur.

In the inactivation of microorganisms, the chlorine dioxide molecule acts as a free radical (oxidising biocide) that readily bonds with the amino acids – the basic building blocks of proteins – which form the living cells. This results in their destruction.

Note

The difference between the chlorine dioxide injected into the system and the levels at the furthermost parts of the system, where its presence can be measured, is an indication of the bio-burden oxidised.

Chlorine dioxide is also effective in the destruction and removal of biofilms, which contribute to the nutrients within the systems and provide protection for bacteria against the effects of heat and chlorine.

Appendix 5 Copper and silver ionisation

Ionisation as a water treatment method has been shown to be effective against planktonic *Legionella* in hot and cold water systems at 400 µg/L and 40 µg/L respectively. In soft waters a silver level as low as 20 µg/L can be effective. Ionisation systems release copper and silver ions into the water stream by means of electrolyte action. Copper and silver ionisation involves the release of copper and silver ions by electrolytic generation for use as a water treatment.

Copper and silver ionisation is concerned with releasing silver and copper ions into water by passing an electrical current between two copper electrodes and between two silver electrodes placed in running water.

The copper and silver ions attach, through electrostatic bonds, to negatively charged sites on bacterial cell walls. This distorts and weakens the cell wall, allowing penetration of the silver ions. The silver ions attack the cell by binding at specific sites to DNA, RNA, cellular protein and respiratory enzymes, denying all life support systems to the cell, causing paralysis and death. The copper and silver ions act synergistically to kill bacteria.

Silver/copper ionisation's effectiveness in the control of *Legionella* bacteria in water systems has been demonstrated in a study carried out by BSRIA (1996; TN 6/96: 'Ionisation water treatment for hot and cold water services'). Results show that where silver and copper ion concentrations could be maintained at 0.04 ppm and 0.4 ppm respectively, copper and silver ionisation was effective against *Legionella* bacteria in both cold and hot water systems with reduced water temperatures as low as 35°C. pH levels above 7.6 may affect the efficacy of this technology.

Water analysis certificates-of-analysis results from samples collected from outlets at sites that operate silver/copper ionisation systems in the UK show that where silver and copper ion concentrations are maintained at outlets at between 0.01 and 0.08 ppm and at between 0.2 and 0.8 ppm respectively, *Legionella* contamination is avoided and controlled.

The study carried out by BSRIA also showed that the copper and silver ions not only reduce the biofilm coverage in cisterns and within pipework circuits, they also reduce the number of *Legionella* bacteria present within the biofilm.

Further studies by Walker et al (1997) showed that when copper and silver ionisation was operated at concentrations of 0.04 ppm of silver and 0.4 ppm of copper, it is an effective non-chemical disinfectant for the control of bio-fouling.

References

Acts and regulations

(The) Building Regulations 1992: approved document G: hygiene (1992, as amended 2000). Office of the Deputy Prime Minister, 2000.

(The) Control of Substances Hazardous to Health Regulations 2002, SI 2002 No 2677. HMSO, 2002. http://www.opsi.gov.uk/si/si2002/20022677.htm

(The) Food Safety (General Food Hygiene) Regulations 1995, SI 1995 No 1763. HMSO, 1995. http://www.opsi.gov.uk/si/si1995/Uksi_19951763_en_1.htm

(The) Food Safety (Temperature Control) Regulations 1995, SI 1995 No 2200. HMSO, 1995. http://www.opsi.gov.uk/si/si1995/Uksi_19952200_en_1.htm

(The) Health and Safety at Work etc Act 1974. HMSO, 1974.

(The) Private Water Supplies Regulations 1991, SI 1991 No 2790. HMSO, 1991. http://www.opsi.gov.uk/si/si1991/Uksi_19912790_en_1.htm

(The) Water Act 2003. HMSO, 2003. http://www.opsi.gov.uk/acts/acts2003/20030037.htm

(The) Water Industry Act 1991. HMSO, 1991. http://www.opsi.gov.uk/acts/acts1991/Ukpga_19910056_en_1.htm

(The) Water Resources Act 1991. HMSO, 1991. http://www.opsi.gov.uk/acts/acts1991/Ukpga_19910057_en_1.htm

(The) Water Supply (Water Fittings) Regulations 1999, SI 1999 No 1148. HMSO, 1999. http://www.opsi.gov.uk/si/si1999/19991148.htm

(The) Water Supply (Water Quality) Regulations 2000, SI 2000 No 3184. HMSO, 2000. http://www.opsi.gov.uk/si/si2000/20003184.htm

Department of Health publications

Health Technical Memorandum 07-02 – Encode. The Stationery Office, 2006.

Health Building Notes

Health Building Note 13 – Sterile services department. The Stationery Office, 2004.

Health Building Note 21 – Maternity (forthcoming).

Health Building Note 25 – Laundry. HMSO, 1997.

Health Building Note 53 – Facilities for renal services. Volume 1 – Satellite dialysis unit. The Stationery Office, 2004.

Health Technical Memoranda

Health Technical Memorandum 64 – Sanitary assemblies. The Stationery Office, 2006.

Health Technical Memorandum 06-01 – 'Electrical services supply and distribution'. The Stationery Office, 2006.

Model Engineering Specifications

MES C07 – Heating, hot and cold water systems. HMSO, 1997.

MES D08 – Thermostatic mixing valves (healthcare premises). HMSO, 1997.

Other Government publications

Department for Environment, Food & Rural Affairs (DEFRA) (1999). **Water Supply (Water Fittings) Regulations 1999 guidance document relating to Schedule 1: Fluid Categories and Schedule 2: Requirements for Water Fittings [See Regulation 4(3)].** http://www.defra.gov.uk/environment/water/industry/wsregs99/guide/index.htm

British Standards

BS 2486:1997 Recommendations for treatment of water for steam boilers and water heaters. British Standards Institution, 1997.

BS 3505:1986 Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water. British Standards Institution, 1986.

BS 3506:1969 Specification for unplasticized PVC pipe for industrial uses. British Standards Institution, 1969.

BS 6100:1984–2000 Glossary of building and civil engineering terms. British Standards Institution, 1984–2000.

BS 6700:1997 Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. British Standards Institution, 1997.

BS 6920-1:2000 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. Specification. British Standards Institution, 2000.

BS 7671:2001 Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition. British Standards Institution, 2001.

BS 8007:1987 Code of practice for design of concrete structures for retaining aqueous liquids. British Standards Institution, 1987.

BS EN 806-2:2005 Specifications for installations inside buildings conveying water for human consumption. Design. British Standards Institution, 2005.

BS EN 1057:1996 Copper and copper alloys. Seamless, round copper tubes for water and gas in sanitary and heating applications. British Standards Institution, 1996.

BS EN 1254-1:1998 Copper and copper alloys. Plumbing fittings. Fittings with ends for capillary soldering or capillary brazing to copper tubes. British Standards Institution, 1998.

BS EN 1254-2:1998 Copper and copper alloys. Plumbing fittings. Fittings with compression ends for use with copper tubes. British Standards Institution, 1998.

BS EN 1254-3:1998 Copper and copper alloys. Plumbing fittings. Fittings with compression ends for use with plastics pipes. British Standards Institution, 1998.

BS EN 1254-4:1998 Copper and copper alloys. Plumbing fittings. Fittings combining other end connections with capillary or compression ends. British Standards Institution, 1998.

BS EN 1254-5:1998 Copper and copper alloys. Plumbing fittings. Fittings with short ends for capillary brazing to copper tubes. British Standards Institution, 1998.

BS EN 1452-1:2000 Plastics piping systems for water supply. Unplasticized poly(vinyl chloride) (PVC-U). General. British Standards Institution, 2000.

BS EN 1452-2:2000 Plastics piping systems for water supply. Unplasticized poly(vinyl chloride) (PVC-U). Pipes. British Standards Institution, 2000.

BS EN 1452-3:2000 Plastics piping systems for water supply. Unplasticized poly(vinyl chloride) (PVC-U). Fittings. British Standards Institution, 2000.

BS EN 1452-4:2000 Plastics piping systems for water supply. Unplasticized poly(vinyl chloride) (PVC-U). Valves and ancillary equipment. British Standards Institution, 2000.

BS EN 1452-5:2000 Plastics piping systems for water supply. Unplasticized poly(vinyl chloride) (PVC-U). Fitness for purpose of the system. British Standards Institution, 2000.

BS EN 12671:2000 Chemicals used for treatment of water intended for human consumption. Chlorine dioxide. British Standards Institution, 2000.

BS EN 13280:2001 Specification for glass fibre reinforced cisterns of one-piece and sectional construction, for the storage, above ground, of cold water. British Standards Institution, 2001.

Other publications

Audit Commission (1993). **Untapped savings: water services in the NHS.** NHS Occasional Papers.

BSRIA (1996). **TN 6/96: Ionisation water treatment for hot and cold water services.** BSRIA, 1996.

BSRIA (1998). **TN 2/98: Chlorine dioxide water treatment – for hot and cold water services.** BSRIA, 1998.

BSRIA (1990). **Application Guide 1/87: Operation and maintenance manuals for building services installations.** BSRIA, 1990.

BSRIA (1993). **Application Guide 2/93: Water treatment for building services systems.** BSRIA, 1993.

BSRIA (2004). **Application Guide 1/2001.1: Pre-commission cleaning of pipework systems.** BSRIA, 2004.

CIBSE (2003). **Commissioning Code W: Water distribution.** CIBSE, 2003.

CIBSE (1999). **Guide A: Environmental design.** CIBSE, 1999.

CIBSE (2004). **Guide G: Public health engineering.** CIBSE, 2004.

European Pharmacopoaia 3rd Edition 1997 (Supplement) (2000). **Water for diluting concentrated haemodialysis solutions.** European Directorate for the Quality of Medicines, Council of Europe, Strasbourg, France.

Health and Safety Commission (2000). **Approved Code of Practice, Legionnaires' disease: the control of legionella bacteria in water systems (L8).** Health and Safety Executive, 2000.

Maver, TWA (1964). **Study of water consumption in ward units.** Hospital Engineering Research Unit, University of Glasgow, Glasgow, 1964.

NHS Scotland Property & Environment Forum Executive (1994). **SHTN 2: Domestic hot and cold water systems for Scottish health care premises.** 1994.

Public Health Laboratory Service (1994). **Hygiene for spa pools: guidelines for their safe operation. The report of a PHLS spa pools working party.** PHLS, 1994.
http://www.hpa.org.uk

Public Health Laboratory Service (1999). **Hygiene for hydrotherapy pools.** PHLS, 1999.
http://www.hpa.org.uk

The Renal Association (2002). **Treatment of adults and children with renal failure: standards and audit measures.** The Renal Association and the Royal College of Physicians, London.
http://www.renal.org/Standards/RenalStandards_2002b.pdf

Standing Committee of Analysts (2002). **The Microbiology of Drinking Water.** Environment Agency, 2002.

Walker JT, Ives S, Morales M, West AA and Pavey N (1997), 'Control and monitoring of *Legionella pneumophila* biofouling in a water system treated with silver and copper ions', *Biofilms in the Aquatic Environment*, pp 131–138.

Water Regulations Advisory Scheme (WRAS) (1992). **Information and Guidance Note 9-04-02: Solder and fluxes.** WRAS, 1992.

Water Regulations Advisory Scheme (WRAS) (1993). **WRAS Information and Guidance Note 9-04-03: The selection of materials for water supply pipes to be laid in contaminated land.** WRAS, 1993.

Water Regulations Advisory Scheme (WRAS) (1994). **Information and Guidance Note 9-04-04: Cold water storage systems – design recommendation for mains supply inlets.** WRAS, 1994.
http://www.wras.co.uk/PDF_Files/IGN%209-04-04%20Cisterns.pdf

Water Regulations Advisory Scheme (WRAS) (2004). **Water Regulations Guide.** WRAS, 2004.
http://www.wras.co.uk

Water Regulations Advisory Scheme (WRAS) (2005). **Water Fittings and Materials Directory.** WRAS, 2005.
http://www.wras.co.uk