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BSI Standards Publication

PUBLISHED DOCUMENT

Guide to the flushing and disinfection of services supplying water for domestic use within buildings and their curtilages

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 28, an inside back cover and a back cover.

Foreword

Publishing information

This Published Document is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 September 2015. It was prepared by Technical Committee EH/3, *Water quality*. A list of organizations represented on this committee can be obtained on request to its secretary.

Information about this document

This Published Document has been developed to build on the guidance previously given in BS 8558 on the flushing and disinfection of services supplying water for domestic use within buildings and their curtilages, which was regarded as beyond the scope of that British Standard. The intention is to eventually develop this as a British Standard.

A review of this Published Document will be carried out not later than five years after its publication. Informative annexes about the pH impact of various chlorine doses are planned for inclusion in a future revision of this Published Document or when it is converted to a British Standard. Testing is currently being undertaken by Scottish Water.

Any observations or comments will be welcomed. These should be sent to the Secretary of BSI Technical Committee EH/3 at BSI Head Office, at the address on the back cover. On the basis of the replies received, the responsible BSI Committee will judge whether the Published Document can be converted to a British Standard.

Test laboratory accreditation. Users of this British Standard are advised to consider the desirability of selecting test laboratories that are accredited to BS EN ISO/IEC 17025 by a national or international accreditation body.

Use of this document

As a guide, this Published Document takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This Published Document does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a Published Document cannot confer immunity from legal obligations.

Attention is drawn to the following statutory regulations.

- Health and Safety at Work etc. Act 1974 [1];
- Control of Substances Hazardous to Health (COSHH) Regulations 2002 [2];
- REACH Regulation [3];
- **The Water Fittings Regulations:**
  - The Water Supply (Water Fittings) Regulations 1999, as amended, in England and Wales [4];
  - The Water Supply (Water Fittings) (Scotland) Byelaws 2014, in Scotland [5];
  - The Water Supply (Water Fittings) Regulations (Northern Ireland) 2009, in Northern Ireland [6];

  NOTE 1 These Regulations apply to requirements relating to plumbing systems in premises to which a supply of public water (municipal water supply) has been provided.
- **The Water Quality Regulations:**
  - The Water Supply (Water Quality) Regulations 2000, as amended, in England [7];
  - The Water Supply (Water Quality) Regulations 2010, in Wales [8];
  - The Public Water Supplies (Scotland) Regulations 2014, in Scotland [9];
  - The Water Supply (Water Quality) Regulations (Northern Ireland) 2007, as amended, in Northern Ireland [10];

  NOTE 2 These Regulations apply standards of wholesomeness to water provided from the public supply (municipal supply).
- **The Private Water Supplies Regulations:**
  - The Private Water Supplies Regulations 2009, as amended, in England [11];
  - The Private Water Supplies (Wales) Regulations 2010, as amended, in Wales [12];
  - The Private Water Supplies (Scotland) Regulations 2006, as amended, in Scotland [13];
  - The Private Water Supplies Regulations (Northern Ireland) 2009, as amended, in Northern Ireland [14];

  NOTE 3 These Regulations apply standards of wholesomeness to water provided from private water sources (non-municipal supply).
- **The Water Industry Acts:**
  - Water Industry Act 1991, as amended, in England and Wales [15];
  - Water (Scotland) Act 1980, as amended, in Scotland [16];
  - The Water and Sewerage Services (Northern Ireland) Order 2006, as amended, in Northern Ireland [17].

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1 Scope

This Published Document provides guidance on cleaning, flushing and disinfection of services supplying water for domestic purposes within buildings and their curtilages, including those for the production of foods, but excluding closed systems or other industrial processes.

NOTE 1 See the Water Quality Regulations [7], [8], [9] and [10] and BSRIA Guide 29-2012 [18] for cleaning closed systems. "Domestic purposes" refers to water used for drinking, washing, cooking and sanitation.

The guidance is intended to help prepare new and existing systems for use and control microbiological growth in water systems for supply, storage and distribution, to ensure that:

a) residues of construction are adequately flushed from water distribution systems;

b) appropriate water quality is achieved;

c) appropriate disinfectants and processes are used;

d) construction debris and dust are removed;

e) risk of corrosion and damage to fixtures, fittings and sensitive plant is minimized;

f) adequate records of cleaning are produced;

g) stagnation is avoided or managed; and

h) appropriate tools and personnel are deployed for the relevant tasks.

The guidance applies to:

1) initial commissioning of new or extended systems;

2) maintenance of existing systems;

3) alteration of existing systems;

4) water quality management prior to occupation or as a result of low/no occupancy or usage; and

5) (remedial) response to microbiological problems is identified.

NOTE 2 The techniques set out in this standard are also applicable to the management of premises and systems where water is provided from a private supply.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

BS 1427, *Guide to on-site test methods for the analysis of waters*

BS 8550, *Guide for the auditing of water quality sampling*

BS 8551, *Provision and management of temporary water supplies and distribution networks (not including provisions for statutory emergencies) – Code of practice*

BS 8554:2015, *Code of practice for the sampling and monitoring of hot and cold water services in buildings*

BS 8558:2015, *Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Complementary guidance to BS EN 806*

BS EN 806-4, *Specifications for installations inside buildings conveying water for human consumption – Part 4: Installation*

BS EN 901, *Chemicals used for treatment of water intended for human consumption – Sodium hypochlorite*

BS EN ISO 5667-1, *Water quality – Sampling – Part 1: Guidance on the design of sampling programmes and sampling techniques*

BS ISO 5667-21, *Water quality – Sampling – Part 21: Guidance on sampling of drinking water distributed by tankers or means other than distribution pipes*

Other publications

[N1]UK WATER. Principles of Water Supply Hygiene [1)]

[N2]FOOD STANDARDS AGENCY. *Food Handlers: Fitness to Work*. *Regulatory Guidance and Best Practice Advice for Food Business Operators*. Food Standards Agency. 2009. [2)]

3 Terms and definitions

For the purposes of this Published Document, the following terms and definitions apply.

3.1 cistern
fixed, vented container for holding water at atmospheric pressure

[SOURCE: BS 8558:2015, **3.1.5**]

NOTE A cistern is commonly referred to as a "cold water tank".

3.2 chain of custody
process that ensures the integrity of a sample is maintained and traced from the point of sample collection until the sample reaches the laboratory, so that the sample is accounted for at all times

NOTE A chain-of-custody document accompanies the sample from the time of collection till delivery to the laboratory.

3.3 cleansing flushing
use of water for the removal of:

a) any debris and organic matter that encourage the growth of biofilms and subsequent deterioration of water quality;

b) any excess of flux which can cause corrosion of copper pipes if left in place under conditions of low or no flow; or

c) the residues of all disinfection

NOTE Residues might include materials which could give rise to unacceptable concentrations of endotoxins and/or pyrogens (e.g. for water for haemodialysis, see BS ISO 13959).

1) Available at: http://www.water.org.uk/publications/reports/principles-water-supply-hygiene [viewed: 16 September 2015].
2) Available at: http://www.food.gov.uk/sites/default/files/multimedia/pdfs/publication/foodhandlersireland1009.pdf [viewed: 16 September 2015].

3.4 commissioning
process of bringing a new water system into operation

3.5 CT value
product of the concentration of a disinfectant (e.g. free chlorine) and the contact time with the water being disinfected

NOTE Typically expressed in units of mg-min/L.

3.6 disinfection
process which removes or renders inactive pathogenic microorganisms or parasites

3.7 distribution network
core infrastructure providing water in an area to individual premises or for individual premises to be connected to

3.8 hygiene flushing
drawing off water for the avoidance of stagnation

3.9 physical cleaning
manual removal of physical contaminants or debris, e.g. cleaning of cistern covers

3.10 stagnation
situation where there is no or little flow and in which adverse quality changes can take place over a period of time

3.11 tank
closed vessel holding water at greater than atmospheric pressure

[SOURCE: BS 8558:2015, **3.1.38**]

NOTE This term is often used to describe, incorrectly, a cold water cistern.

3.12 wholesome water
water that is of an acceptable biological, chemical and physical quality for drinking, cooking, food preparation or washing without any potential danger to human health

NOTE National requirements are set out in the Water Quality Regulations [7], [8], [9] and [10] or the Private Water Supplies Regulations [11], [12], [13] and [14], according to how the premises are supplied. These stipulate the criteria that the water needs to meet to protect human health and ensure user acceptability. The parameters include limits on:

- *biological quality, including levels of bacteria and oocysts;*
- *chemical quality, including levels of metals, solvents, pesticides and hydrocarbons; and*
- *physical qualities, including turbidity, colour, taste and odour.*

4 Operational plan

4.1 Only appropriately competent people should work on water systems. Evidence of the competence of individuals undertaking the work should be confirmed, indicating that the knowledge and experience of the operatives is satisfactory for undertaking the proposed work.

4.2 Personnel working on water systems should follow the Water UK *Principles of Water Supply Hygiene* [N1] or the *Food Handlers: Fitness to Work* Guidance [N2] regarding medical screening and suitability to work on water systems, e.g. exclusion from the workplace.

NOTE The Energy & Utility Skills Register (EUSR) administers The National Water Hygiene Card [3] *on behalf of water suppliers using the Principles of Water Supply Hygiene. The WaterSafe Installers Scheme* [4] *operates a register of installers approved under The Water Fittings Regulations [4], [5] and [6] (referred to as "approved contractors" or "approved plumbers").*

4.3 The operational plan should take into account water hygiene considerations. For example, no water system should be filled until the drainage is connected because regular flushing would be impossible.

4.4 Where working on wholesome water systems, dedicated tools and equipment should be used and these should be segregated from tools used for other applications, such as working on drains, macerators or foul pumping systems.

4.5 A risk assessment should be carried out and a safe system of work put in place throughout the cleaning, disinfection, flushing and sampling processes.

4.6 A suitable safe system of work or, for a more complex system, a site-specific method statement should be obtained/prepared before the start of any cleaning and/or disinfection of a water system. The documentation should clearly define the process to be undertaken and should be derived from risk assessments of the hazards typically encountered, which might include:

a) bacteria;

b) access/egress, storage and special site hazards, e.g. asbestos;

c) machinery and equipment isolation;

d) work in confined spaces;

e) manual handling;

f) work at height;

g) slips, trips and falls;

h) electrical equipment;

i) chemical(s) to be used;

j) need for personal protective equipment;

k) a cistern hatch not being sealed and locked after disinfection; or

l) waste disposal and chemical neutralizing process (a discharge permit might be required from the water utility).

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[3] https://www.eusr.co.uk/eusr/the-eusr-card/the-national-water-hygiene-card [viewed: 16 September 2015].

[4] https://www.watersafe.org.uk/ [viewed: 16 September 2015].

4.7 The concentration of disinfectant to be used should be predefined based on the materials, manufacturers' instructions, operation conditions and end use.

NOTE The client ought to have determined if cisterns storing water for domestic purposes are made from, or lined with, material that is verified as suitable for contact with drinking water, such as those listed by WRAS in the Water Fittings and Materials Directory *[19] or with supporting documentation demonstrating conformity to BS 6920-1 and the appropriate corresponding components.*

4.8 If neutralizing agents are used, a process should be implemented to ensure that the water storage cistern is not overdosed and that no residual neutralizing agent is left in the water storage cistern or associated system on completion of the disinfection.

4.9 To ensure that only those parts of the system that are to be disinfected are treated, as-fitted or schematic diagrams of the water system should be consulted.

4.10 Only biocides and materials appearing in the *List of Approved Products for use in Public Water Supply in the United Kingdom* published by the Drinking Water Inspectorate (DWI) [20] should be used in contact with water.

NOTE The only controlled version of this document can be accessed on the DWI Website. [5] *Printed copies of this document, together with electronic copies held on local computers and other storage devices, are uncontrolled. A similar list is published by the Scottish Government* [6] *and the Department for Regional Development in Northern Ireland will eventually publish a list. A treatment system utilizing biocidal copper can only be selected if it is authorized under the appropriate product type within the EU Biocidal Products Regulation [21] and the REACH Regulation [3]. Further advice on appropriate systems can be found on the HSE website.* [7] *The supplier of the disinfectant is required to be registered under the Biocidal Products Regulations [21].*

5 Commissioning or decommissioning

5.1 General

5.1.1 The initial commissioning of a new hot or cold water system is critical to its performance throughout the building's life. In a simpler system (e.g. tenanted housing, individually occupied dwelling or a small office) this could involve simply opening the incoming stopcock, purging air from the system and carrying out a cleansing flush. A larger system requires more complex commissioning procedures, including disinfection, and careful risk assessment and management to avoid bacterial colonization at this initial stage.

5.1.2 Prior to connection to the permanent supply the incoming supply pipe should be pressure-tested, flushed and, if necessary, disinfected.

NOTE Where required by the local water supplier or the contract, or deemed necessary by the service provider, the efficacy of disinfection might need to be demonstrated by microbiological tests, such as those described in ***10.2****.*

5.1.3 Guidance should also be sought from the local water supplier as to any particular requirements that might apply.

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[5] http://www.dwi.gov.uk/drinking-water-products/approved-products/soslistcurrent.pdf [viewed: 16 September 2015].
[6] http://www.gov.scot/Publications/ [viewed: 16 September 2015].
[7] http://www.hse.gov.uk/ [viewed: 16 September 2015].

5.2 Pre-filling planning

5.2.1 In a new development the water supply infrastructure for the premises is also likely to be new, with installation and disinfection immediately prior to use. In a redevelopment the water supply infrastructure could be in poor condition, oversized, underused, etc. If the development is very large the supply might have been isolated during the build process and could remain stagnant until pressure testing is required. The local water supplier should be consulted and a plan agreed for the provision of water for initial flushing and disinfection. Where water needs to be provided from a temporary source, guidance is given in BS 8551.

NOTE The contractor needs to ensure that all connections made to the existing water systems during the construction process meet the requirements of the Water Fittings Regulations [4], [5] and [6] for the avoidance of contamination of the water supply.

5.2.2 Unless precautions are taken, biofilms can re-colonize cisterns and pipework shortly after disinfection, at a speed that depends on the influences of:

a) the temperature and microbiological quality of the incoming supply water;

b) the materials of construction of the cisterns and distribution system;

c) the influence of temperature at specific points in the distribution system;

d) the residual disinfectant concentrations retained in the distribution system on completion of the disinfection process;

e) the frequency of use of outlets; and

f) the physicochemical quality of the water supply, i.e. inherently low disinfection residuals in the water supply affect the rate at which biofilms become re-established.

NOTE Even where materials fully conform to the Water Fittings Regulations [4], [5] and [6] conditions might be present which allow the formation of biofilm to some extent, with growth rates relative to flow rate and temperature.

5.2.3 The risks of contamination and corrosion should be controlled by keeping the water system and the water in it free from nutrients, maintaining cleanliness and preventing stagnation. Hardness scale can trap nutrients, encouraging biofilm formation, and creating a barrier to disinfectants.

5.2.4 It is critical that the first water entering the system is clean and fit for use. Flushing, sampling and, where required, disinfection of the incoming supply should be carried out immediately prior to first fill of the water system(s) for pressure testing. Where contamination is suspected or pipes have an internal diameter greater than 50 mm, they should be disinfected. Typical requirements for flushing, disinfection and testing of below-ground pipes are given in Table 1, but the water undertaker should be consulted for local requirements.

5.2.5 Prior to making a connection to existing pipework for extensions or refurbishment, the existing water quality should be confirmed as satisfactory. If the water quality is not satisfactory then remedial works should be carried out on the existing system before connection of the new pipework, or the building should be flushed and disinfected as a whole when the installation is completed. Where the building is not to be flushed and disinfected as a whole then the new pipework should be filled and flushed through a double-check valve or other appropriate backflow prevention device.

NOTE Water quality in the distribution network might be affected by corrosion, leading to elevated levels of iron, copper, zinc and lead, and biofouling. Disinfection only addresses microbiological problems.

Table 1 **Typical requirements for below-ground pipes**

Description of installation	Method
Pipe ≥25 mm ID [A] (≥32 mm OD [B]) and ≤50 mm ID (≤63 mm OD for medium-density polyethylene pipe) and >50 m in length	Flush, disinfect, microbiological sampling
Pipe >50 mm ID (>63 mm OD for medium-density polyethylene pipe)	Flush, disinfect, pressure-test (if pipe jointed), microbiological sampling

[A] ID = inner diameter

[B] OD = outer diameter

5.2.6 If water turnover is anticipated initially to be low it might be advisable to bypass or reduce the volume of cold water storage cisterns until the building is ready for occupation. This ensures that flushing during low-use periods draws directly on the incoming supply rather than intermediate storage.

5.2.7 If bypassing storage is being considered, the water undertaker should be consulted to ensure conformity to The Water Fittings Regulations [4], [5] and [6] and that no adverse impacts occur.

5.2.8 If a building is to be completed and occupied in stages, the design of the water system should take this into account. Allowance should be made to fill, pressure-test, commission, disinfect and bring into use sections independently without compromising other sections.

5.2.9 Pressure testing using compressed gas is potentially dangerous and should only be carried out according to a written methodology that has been subjected to a full risk assessment and with all necessary risk reduction measures put in place.

NOTE 1 See HSE Guidance Note GS4, Safety requirements for pressure testing *[22]. On-site pressure testing using gases at pressures greater than 0.5 bar is not recommended due to the risk of ballistic projectiles in the event of joint failure.*

NOTE 2 Where a gas system is utilized for pressure testing of water pipework the compressor or gas system should be of an oil-free type or have a filter system that removes all oil, moisture and other pollutants from the gas being used, such as that used for breathing apparatus.

5.2.10 Where there is a long period of time between filling and occupation of a complex system, consideration should be given to dosing water systems proportional to volume consumed with appropriate biocides suitable for drinking water systems, to prevent the growth of biofilm during construction and testing. Such a treated system should be regularly flushed to ensure that the biocide reaches all parts of the system, particularly outlets. Dosing with an appropriate level of biocide as soon as the system is wetted, combined with regular flushing, can control the accumulation of biofilm more effectively than flushing and temperature control alone.

5.2.11 When a hot water system (HWS) has been filled and tested it should not then be allowed to stagnate or maintain temperatures between 20 °C and 50 °C (see HSG274 Part 2 [23]), unless supplementary disinfection is applied. An HWS incorporating a circulatory system should be operated circulating at operational temperatures continuously after commissioning. Low volume (<15 L) point-of-use water heaters should achieve a temperature of 50 °C to 60 °C at the outlet (see HSG274 Part 2, **2.6** [23])].

5.3 Water systems temporarily out of use

5.3.1 If any part of the building water service is temporarily out of use (period equal to or less than 30 days) or is infrequently used, and the system relies on a temperature regime for control of microbiological contaminants (including *Legionella*) then the water system should be flushed after storage vessels have been emptied and filled with water direct from the incoming supply. Flushing should continue until the temperature at the outlet stabilizes and is comparable to the incoming supply. Flushing should be carried out in a manner which minimizes aerosol generation, e.g. removing shower heads prior to flushing, to reduce the risks of *Legionella* transmission.

5.3.2 HWS that are to be left filled need not be heated, but they should be recirculated, temperatures maintained below 20 °C, if possible, and regularly hygiene-flushed. It is accepted that from May to September the risk of ambient temperatures exceeding 20 °C is greater. If the temperature in an unoccupied building is above 20 °C, it is unlikely that it will be possible to maintain temperatures within water pipework below this temperature.

5.3.3 Cold water systems that are to be left filled should be maintained below 20 °C, if possible, and regularly flushed. If the water system relies on a biocide regime for control of microbiological contaminants (including *Legionella*), the levels of biocide should be measured weekly at sentinel points and hygiene-flushed as required to maintain biocide levels.

5.4 Mothballing buildings

5.4.1 Mothballing involves a building being taken out of use for a period greater than 30 days and managed to control microbiological (including *Legionella*) growth within the water systems. The objective is to prevent contamination and colonization of the water system with bacteria and biofilm. Considerations vary according to the length of time the building is out of use and the complexity of the building.

5.4.2 Simple systems, such as those in tenanted housing, individually occupied dwellings and small offices, can be left drained, e.g. for frost risk management purposes.

5.4.3 Mothballing large or complex properties entails more planning and should normally leave the systems filled, as they cannot easily be drained and drying of cistern joints, corrosion in metal pipework and biofilm formation can occur.

5.4.4 If the mothballing process is planned at the outset, a formal process can be put into place. Where the water system remains functional during mothballing a full flushing procedure (see Clause **6**) and disinfection (see Clause **7**) should be completed, and samples taken (see Clause **10**) to prove the disinfection has been successful.

5.4.5 During drought it might not be possible to carry out extensive flushing work over a prolonged period to maintain a temperature control regime. It might be necessary to utilize a biocide in the system to prevent bacterial colonization during the unoccupied period.

5.4.6 All mothballing procedures are a compromise between allowing growth of bacteria in the system, use of water for flushing and potential degradation of the system from prolonged or higher concentrations of biocide use. Biocides should always be selected based on the best possible compromise. The higher biocide concentrations can result in the water no longer being classified as wholesome. If this is the case, water outlets should be clearly marked as unsafe for use and should always be flushed before reuse to leave the system fit for its intended purpose.

5.5 Recommissioning buildings

5.5.1 Recommissioning a building and bringing it back into use is relatively simple, provided the mothballing procedure has been successful in preventing bacteriological contamination and colonization.

5.5.2 If no hot or cold water is used in the building for a period greater than 30 days then the system should be cleaned and disinfected. If the system is complex it should be left filled but managed, with flushing and/or disinfection regimes as set out in Clause **8**. A small, simple water system (e.g. dwelling) may be left drained until ready for reuse, when it should be flushed and brought back into service.

5.5.3 If biocides have been used for microbiological control during mothballing these might need to be flushed from the system and tests completed to ensure the water quality is returned to normal parameters to conform to the Water Quality Regulations [7], [8], [9] and [10] or the Private Water Supplies Regulations [11], [12], [13] and [14], as applicable.

5.5.4 An HWS should be brought up to temperature to ensure the whole content of calorifier(s) is up to temperature.

5.5.5 If there were any problems with maintaining temperatures or biocide levels during mothballing, appropriate microbiological samples should be taken (see Clause **10** and BS 8554).

6 Pre-disinfection cleansing flushing

6.1 Cleansing flushing should be carried out on hot and cold water services in the following situations, in accordance with BS EN 806-4 and BS 8558:

a) on completion of a new water installation or refurbishment of a hot and cold water system;

b) on installation of new components, especially those which have been pressure-tested using water by the manufacturer (see the manufacturer's instructions);

c) where the hot and cold water is not used for a prolonged period and has not been hygiene-flushed as recommended, or the control measures have not been effective for a prolonged period (this could be as little as two or three weeks), depending on the ambient temperature, condition of the water system, potential for exposure to aerosols and the susceptibility of users considered in a site-specific risk assessment; and

d) if the system or part of it has been substantially altered or accessed for maintenance purposes that might introduce contamination.

6.2 All valves should be operated in the fully open position so that any particulate matter can be flushed from the supply pipe. Of particular importance are float-operated or other restrictive valves which need to be induced to fully open to ensure clearing of particulates and prevent fouling of the valve. Where a clearing velocity cannot be achieved, consideration should be given to removal of valves to enable the cleansing flush.

7 Cleaning and disinfection

7.1 Where necessary, hot and cold water services should be cleaned and, in the following situations, disinfected in accordance with BS EN 806-4 and BS 8558:

a) on completion of a new water installation or refurbishment of a hot and cold water system;

b) on installation of new components, especially those which have been pressure-tested using water by the manufacturer (see the manufacturer's instructions);

c) where the hot and cold water is not used for a prolonged period and has not been hygiene-flushed as recommended, or the control measures have not been effective for a prolonged period (this could be as little as two or three weeks), depending on the ambient temperature, condition of the water system, potential for exposure to aerosols and the susceptibility of users considered in a site-specific risk assessment;

d) on routine inspection of the water storage cisterns where there is evidence of significant contamination or stagnation;

e) if the system or part of it has been substantially altered or accessed for maintenance purposes that might introduce contamination;

f) following water sampling results that indicate evidence of microbial contamination of the water system;

g) during or following an outbreak or suspected outbreak of legionellosis linked to the system; or

h) where indicated by the site risk assessment.

7.2 Disinfectants can adversely affect new coatings in cisterns and release chlorinated or other compounds into the water, so coatings should be cured and the manufacturers' instructions and recommendations consulted before disinfection takes place.

7.3 The cistern should be mechanically cleaned using a method that does not damage any coatings (it might not be possible to clean components where there is evidence of corrosion).

7.4 Residual sludge and water should be removed from the cistern, using for example a wet or dry vacuum cleaner, and disposed of in accordance with the cleaning plan.

8 Disinfection

8.1 Post-flush disinfection

*COMMENTARY ON **8.1***

*Flushing and disinfection are not a substitute for a high degree of cleanliness during installation (see also BS 8558:2015, **5.2.1.4**).*

Unless contamination is suspected, flushing alone might be satisfactory for single dwellings and minor extensions or alterations in any premises.

8.1.1 The sequence of disinfection should be: distribution network, service pipes, cisterns and the internal distribution system.

8.1.2 The disinfection of pipework under direct pressure from the incoming supply should only be carried out with adequate backflow protection. If necessary, the water supplier should be consulted prior to any disinfection being undertaken.

8.2 Disinfection prior to occupation

8.2.1 Maintaining an appropriately elevated concentration of oxidizing disinfecting agents prior to occupancy and operational use is effective at controlling biofilm development in larger new building projects (not to be confused with ongoing dosing used at lower levels in operational systems to meet the requirements of the Water Quality Regulations [7], [8], [9] and [10] or the Private Water Supplies Regulations [11], [12], [13] and [14], as applicable).

NOTE Excessive concentrations of oxidizing disinfecting agents promote corrosion in metal systems and embrittlement of plastics and seals.

8.2.2 Where practicable, system disinfection should not be carried out until immediately before occupation. Disinfection should be carried out not more than 30 days before the start of occupancy.

8.3 Method of disinfection

8.3.1 General

8.3.2 Disinfection of the water services when the system is offline may be by:

a) thermal disinfection (see **8.4**); or

b) chemical disinfection (see **8.5**).

NOTE Adding disinfectant or raising the temperature above 60 °C creates a hazard to users by chemical exposure or scalding.

8.3.3 As part of the thermal or chemical disinfection process, a service record should be kept of all work undertaken. Any items that require attention or refurbishment should be noted on the disinfection record.

8.3.4 To confirm effective disinfection, any required microbiological samples should be taken between two and seven days after the system is treated. Samples taken immediately after a disinfection process might give false negative results.

8.4 Thermal disinfection

8.4.1 Thermal disinfection is only applicable to HWS and is commonly used as a rapid response. Thermal disinfection involves raising the HWS temperature to a level at which microorganisms are destroyed, drawing it through to every outlet, and then flushing at a slow flow rate to maintain the high temperature for a suitable period. It might be less effective than chemical disinfection and might not be practicable where the hot water supply is insufficient to maintain a high temperature throughout.

8.4.2 The temperature of the whole contents of the calorifier should be raised to ensure that the temperature at the HWS outlets does not fall below 65 °C and that water is circulated for at least 1 h. Every hot water outlet throughout the system should then be flushed. Each tap and appliance should be run sequentially for at least 5 min at 65 °C (but not necessarily at full flow), and the process should be recorded.

8.4.3 Thermal disinfection might prove to be ineffective where parts of the calorifier or water system fail to reach the required temperature for a long enough period.

8.5 Chemical disinfection

8.5.1 Chemical disinfectants

8.5.1.1 The disinfection of a water system inside a building is normally based on chlorine being dosed at 50 mg/L (50 ppm) for a minimum contact period of one hour, at the end of which the concentration should be not less than 30 mg/L (30 ppm) (or 40% drop in concentration) free residual chlorine. For below-ground pipes, if the drop in chlorine concentration is greater than 5 mg/L (assuming a 50mg/L dose is applied) for 1 h, at the end of this the concentration should be not less than 45 mg/L (45 ppm) (or 10% drop in concentration) free residual chlorine. However, lower concentrations and longer contact times are considered acceptable. Where the level of disinfectant concentrations need to be verified these should be checked using only the appropriate testing equipment.

8.5.1.2 Other disinfectants may be used where they are shown to be effective. Their intended application should take into account the type of system and user profile at the specified concentration levels and contact period. The type and application of disinfection product used need to conform to Section 2.1, Annex 2 of the Drinking Water Inspectorate's *List of Approved Products for use in Public Water Supply in the United Kingdom* [20]. The listing of a specific relevant standard for a particular disinfectant does not imply that this disinfectant is suitable or recommended for the proposed use; fitness for purpose of the chosen disinfectant should be ensured, including its effectiveness in controlling microorganisms in the proposed application.

NOTE Attention is drawn to the Water Industry Acts [15], [16] and [17] for information on contacting the relevant authority before water used to disinfect an installation is discharged into a sewer. Water UK has produced Technical Guidance Note 14 (TGN 14) Disposal of chlorine solutions and chlorinated water *[24] [see also Clause **13**c)].*

8.5.1.3 Sodium hypochlorite solutions deteriorate over time and this deterioration is proportionate to the storage temperature. As a result, material that has exceeded its shelf life recommendations needs to be added in greater quantities to achieve the desired concentration of available chlorine. This can have the undesired effect of increasing the pH of the receiving water to the extent that the efficacy of the dosed chlorine is significantly reduced. 15% sodium hypochlorite used for the cleaning of equipment and plant should not therefore be older than three months after the date of manufacture. Records should be maintained of the date(s) of manufacture, purchase and use of this material in order to ensure adequate rotation of stock and maintain the efficacy of the applied dose. In addition, records of conformity with the required product standard defined in BS EN 901 should also be maintained to ensure that traceability of chemicals in contact with drinking water is achieved.

8.5.1.4 Where possible, sodium hypochlorite solution should be stored below 24 °C, and ideally at or below 20 °C. Where this is not possible, shorter stock rotations of less than 90 days from the date of manufacture should be adopted. A stock rotation of 30 days for storage temperatures above 24 °C is likely to be practical.

8.5.2 Process for chemical disinfection

8.5.2.1 Chemical disinfection involves adding an agent such as chlorine or a similarly effective disinfectant, drawing it through to every outlet, then closing the outlets and allowing the agent to remain in contact for a suitable period (known as the contact time).

NOTE Figure 1 illustrates graphically the more likely practical times and concentrations for chlorine obtained using the following equation, and can be used as a "look-up chart" for practical application (see also BS EN 12671).

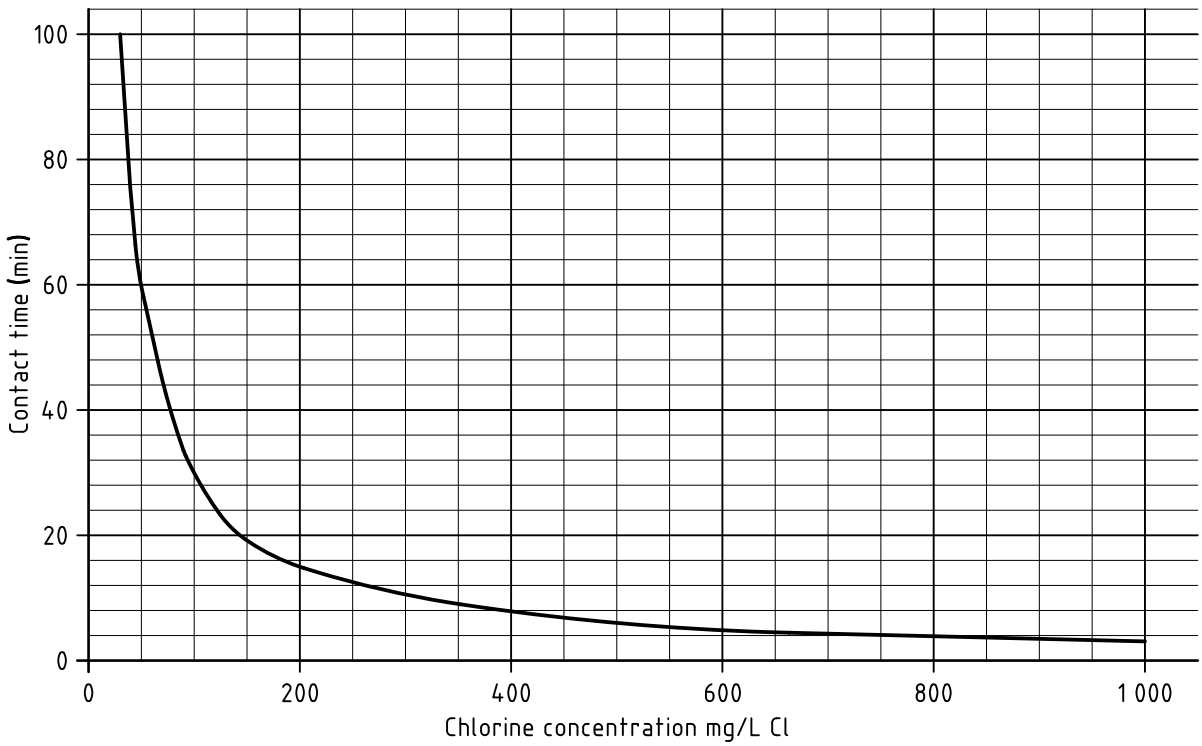
$$\text{contact time} = \frac{3\,000}{\text{free chlorine}}$$

where:

contact time is in min; and

free chlorine is in mg/L.

Figure 1 **Contact time for chlorine at a given concentration time**



NOTE 1 After the allotted contact period, the reduction of free chlorine should not exceed 40%.

NOTE 2 Contact periods of 1 h to 10 h are typically used for offline disinfection in buildings.

NOTE 3 It is necessary to avoid exceeding 50 mg/L to avoid corrosion risks to copper or deterioration of non-metallic materials.

NOTE 4 The contact period commences when the entire volume of the system, including cisterns up to overflow, is full of disinfectant solution at the required initial concentration.

*NOTE 5 Contact time amended according to the pH of the dosed cistern (see **8.5.1.3**).*

8.5.2.2 After supply pipes (including unvented HWSs off the supply pipe) have been flushed, disinfectant solution should be injected through a properly installed injection point at the upstream end of the supply pipe until the disinfectant solution discharged at the downstream end of the pipeline is equal to the initial concentration. The contact period should then commence.

8.5.2.3 Where appropriate, the injection point should be downstream of a double-check valve or other appropriate backflow prevention device. Where this cannot be achieved, the water supplier should be consulted prior to any disinfection being undertaken.

8.5.2.4 Disinfection should be carried out via a temporary connection incorporating the appropriate backflow prevention.

8.5.2.5 The following is a typical chemical-based (chlorine) disinfection procedure:

a) systems, or parts of systems, should not be used during the disinfection procedure;

b) signage and outlet warning labels should be fitted to all areas which might be affected by the disinfection procedure – all outlets should be marked with "DISINFECTION IN PROGRESS, DO NOT USE";

c) to avoid the generation of toxic fumes, no other chemicals, e.g. toilet cleansers, should be added to the water until disinfection is complete and returned to normal service, and all building users, including those not normally in attendance during working hours, i.e. cleaners and security guards, should be informed of the disinfection before it takes place;

d) a pre-disinfection flush (see Clause **6**) should take place if the conditions within the cold water storage cistern are so poor that they could adversely affect the welfare of the operators undertaking the clean;

e) because the efficacy of chlorine as a disinfectant is pH-dependent, pH values in excess of 7.6, measured after the addition of the disinfectant, require an increase in contact time and chlorine should not be used at pH levels above 8.5 without considering alternative disinfectants or pH adjustment;

NOTE 1 Table 2 sets out contact times for pH value of 7.6 and above (see Annex A).

NOTE 2 Further information for specific microbiological problems can be found at http://waterbornepathogens.susana.org/ [viewed: 16 September 2015].

Table 2 **Contact times for pH value of 7.6 and above**

pH	**Contact time** h
7.6	1.00
7.7	1.25
7.85	1.67
8	2.50
8.45	5.00

f) the cistern should be filled with fresh make-up water and the required quantity of disinfectant added during filling so that it is evenly distributed;

NOTE 3 If necessary, a temporary clean, submersible pump can be installed to assist with mixing.

g) the incoming water supply to the cistern should be isolated;

h) the contents of the cistern should be tested to confirm that the required level of disinfection has been achieved, using a quantitative test kit;

i) the disinfecting solution should be drawn through to the water heaters and subsequently to all outlets fed from the system;

j) the key far sentinel outlets should be tested to ensure the required concentration is reached (see, for example, HSG274 [23] for minimum concentration for supplementary disinfection);

k) all other outlets should be subjected to a fast and simple test showing the presence or absence of disinfectant;

l) the cistern should be topped up with fresh water and sufficient disinfectant to bring the concentration back up to target levels, being sure to fill above the top operational water line;

m) the system should be left for the designated contact period appropriate to the pH level and concentration of chlorine dosed;

n) the key outlets should be retested at the end of the contact period to confirm that satisfactory disinfectant levels are achieved;

o) concentration should be checked at intervals during the contact period and the disinfectant levels restored if they decline – if the concentration falls below the minimum residual value, the process should be repeated;

p) for a potable system, a neutralizing agent conforming to the DWI's *List of Approved Products for use in Public Water Supply in the United Kingdom* [20] should be added to the point of discharge to foul sewer (potable systems);

q) there should be no disinfectant remaining before flushing through to the water heaters;

r) signage and outlet warning labels should be removed;

s) if the water is for non-potable applications, e.g. heating or industrial processes, a neutralizing agent can be added at the point of discharge to foul sewer, or to the cistern as long as the subsequent refilling dilutes any neutralizing product to levels acceptable for use within the downstream process; and

NOTE 4 Caution is necessary when using neutralizing agents on sections of the distribution system dedicated to the provision of drinking water, so that these agents are not overdosed and that adequate measures are put in place to check that residues of the agents are not present when the system is handed back for use.

t) if the incoming water supplying the cistern is to be treated, this should be done after the rest of the system is dosed; the incoming supply should then be isolated to ensure that the disinfectant is kept within the system for the required contact time.

8.5.3 Residual disinfection

8.5.3.1 Sampling for chlorine should be conducted in accordance with Clause **10** and BS 8554:2015, Clause **6**, or industry best practices to minimize the chance of any accidental contamination of the sample.

8.5.3.2 After disinfection, a residual free chlorine concentration should be retained to delay the onset of biofilm formation in the system before normal use is allowed. The residual should conform to the following criteria where possible, taking into account the residual in the incoming supply water.

a) The average residual chlorine for the building across all the representative sampling points should be between 0.5 mg/L and 0.1 mg/L free chlorine.

NOTE Where the incoming water has a low disinfection residual (less than 0.1 mg/L Cl) it might not be possible to achieve the recommended residuals. If the system is to be left for more than 72 h without use, it is advisable to give consideration to applying supplemental disinfection dosing in order to avoid complications of stagnation. Where the water provider (public water undertaker or private supplier) uses monochloramine rather than free chlorine as part of its residual disinfection regime, advice should be obtained to decide suitable levels for residual chlorine.

b) The acceptable maximum residual free chlorine concentration of 2 mg/L should not occur in more than 1% of the distribution samples.

c) Cisterns should be left with a residual free chlorine concentration of 0.5 mg/L.

8.5.3.3 Achieving these proportions precisely might not be possible under all circumstances. Therefore, acceptance of the retained residual free chlorine should be left to the professional judgement of the responsible person at the time of completion. This is crucial as, if elevated levels of chlorine are left in the system, copper can become damaged and later "pin-hole".

9 Maintenance or alteration

During routine maintenance or the completion of any alterations to the water supply system, the following should be carried out. These works require detailed planning.

a) For an extension or significant alteration to an existing system, treat as new system and disinfect.

b) For insertion of joints, couplings or fittings used for a localized repair to existing external or internal pipelines, disinfect with a high-strength disinfectant, e.g. by immersion for 15 min in a solution containing 200 mg/L of available chlorine or, if this is not practicable, rinsing with or directly applying a 1 000 mg/L of such solution (wearing appropriate eye protection) or disinfectant with equivalent disinfection capability (BS 8554:2015, Annex F, gives a process for preparing such a chlorine disinfectant solution). Agree the method with the building owner/occupier/operator and product manufacturer.

c) For reconnecting below-ground pipes, ensure the pipes are free from soiling or other contamination, e.g. by wiping and then directly applying a 1 000 mg/L solution of sodium hypochlorite. Where pipes are laid in advance of when they are to be connected to the network, it is important to protect against ingress of potential contamination and debris. This can be achieved by ensuring both ends of the pipe are appropriately sealed until the connection is undertaken.

10 Sampling

10.1 General

10.1.1 Adequate flushing and monitoring is essential to ensure that levels of any biocide employed are achieved at representative sentinel points. Weekly checks and adjustments should be carried out as necessary. Any microbiological samples taken during dosing need to have the biocide neutralized.

10.1.2 Sampling is important for the protection of public health, as well as regulatory and contractual compliance. A responsible person should be appointed to oversee sampling at the time of construction, as well as during the operational use of a water system.

10.1.3 Where more than 30 days elapse between the completion of system disinfection and the start of occupancy, and routine flushing does not take place, the building should be representatively sampled and assessed for microbiological quality and evidence of excessive accumulation in accordance with the sampling scheme and plan (see **10.2** and **10.3**).

10.1.4 Samples should be:

a) appropriate for the specified purpose, i.e. microbiological assessment, chemical analysis or on-site testing;

b) sufficient in number to be fully representative of the distribution system, sub-branches (see Note), tanks and cisterns, as well as the condition to be evaluated, e.g. completion of a cleaning process, efficacy of distribution of disinfectant; and

c) taken at a frequency which is representative of the time series to be demonstrated, e.g. taking into account the growth rate of the organism when designing the monitoring scheme to check for potential microbiological colonization.

NOTE Further guidance on sampling is given in BS EN ISO 5667-3, BS ISO 5667-5, BS EN ISO 19458 and BS 7592. The following are examples of sampling frequencies and distances for distribution networks, where samples would be taken from each branch and at suitable intervals along the run of pipe:

- *1 sample for pipes up to 100 m in length and ≥25 mm inner diameter;*
- *1 sample per 250 m for pipes ≤75 mm inner diameter;*
- *1 sample per 500 m for pipes ≤150 mm inner diameter; and*
- *1 sample per 1 000 m for pipes >150 mm inner diameter.*

These spacing distances can also be used for long uninterrupted runs of aboveground pipework.

10.1.5 Where alternative temporary supplies are used during construction, or at other necessary times of deployment, sampling should be conducted in accordance with BS ISO 5667-21.

10.1.6 Where testing for disinfectant materials, appropriately calibrated test kits should be used in accordance with BS 1427 at the point of sampling. Test kits should be:

a) within the operable shelf life specified by the manufacturer;

b) capable of providing results within the recommended control range of the substance being measured; and

c) assessed and the results documented before use to determine the consequences of any interfering substances, which should be understood by the operator.

10.1.7 Where temporary water supplies have been used for system filling at the time of construction or for supplementary provision when the permanent water supply is not available, the supply should also be monitored in accordance with BS 8551.

10.2 Sampling plan

10.2.1 Sampling should:

a) routinely assess compliance or efficacy and/or the efficiency of a process, e.g. disinfection and thermal performance; and

b) determine change in water quality, both intended, e.g. addition of new items of equipment such as a water softener, and unintended, e.g. colonization by *Legionella* bacteria.

10.2.2 A separate sampling plan should be prepared in accordance with BS EN ISO 5667-1 for each type of assessment, and agreed before the operations begin. A sampling plan should provide sufficient information to satisfy the data user's requirements by establishing compliance with required specifications

and/or identifying the cause of changes in water quality. The sampling plan(s) might need to be varied periodically to achieve this.

10.2.3 The sampling plan should contain agreed sample locations identified on a schematic and documented in a list. This should form the basis for the assessment of:

a) the adequate distribution of disinfection materials at the time of initial application;

b) the efficacy of disinfection demand within the system after the allotted contact time, in particular ensuring there has not been excessive disinfection demand;

c) total viable counts (TVC) measured at 22 °C;

NOTE For testing water to be used in haemodialysis and related therapies in hospitals, see BS ISO 13959.

d) TVC measured at 37 °C;

e) Coliform bacteria;

f) *E. coli*;

g) *Pseudomonas aeruginosa;*

h) *Legionella* (species); and

i) disinfection residuals (taken concurrently with the microbiological samples).

10.2.4 Where the results of sampling/testing indicate that the system has deteriorated, with an increase in microbiological counts, e.g. TVC results in excess of a 2 log (see WHO [25]) difference above that found in incoming water, remedial action should be taken. A pragmatic common sense approach should be adopted, taking into account the need to conserve water, as well as to react to a disinfection need.

10.2.5 Where *Pseudomonas aeruginosa* or Coliform bacteria are present, the sampling point should be cleaned externally, flushed and retested. If positive results persist, investigation into the cause(s) should be extended with a view to repeating the disinfection process.

10.2.6 Where *Legionella* is identified following disinfection, the system should be reassessed as defined in HSG 274 Part 2 [23], Table 2.2, and the disinfection should be repeated if assessed appropriate.

10.3 Sampling and monitoring quality assurance

Regular sampling practice audits should be carried out to ensure that a responsible person can verify the cleaning process or monitoring programme as part of a building water safety plan (see, for example, the WHO's *Water safety in buildings* [25]). Water quality sampling practice should be audited in accordance with BS 8550.

11 Remedial actions after monitoring indicates problem

11.1 The nature and cause of the problem should be fully investigated and understood before appropriate remedial measures are defined. For example, some taste and odour issues might be due to material issues, e.g. copper corrosion or reaction to some disinfection materials.

11.2 Remedial cleaning and disinfection should be appropriate to the nature and cause of the problem. Where system disinfection fails to remove established

biofilm, consideration should be given to removal of affected pipes and fittings for cleaning or for continuous supplementary dosing. In extreme cases, pipes and fittings, etc., should be replaced.

12 Hygiene flushing

The system should be flushed weekly (twice weekly in healthcare premises) to maintain a flow of water. The design of the flushing programme should be in accordance with the HSE's Approved Code of Practice L8 [26], and HSG274 Part 2 [23].

NOTE This is not always possible unless the construction company obtains a derogation from the water undertaker, as it could breach legislation on wasting water.

13 Discharges

Before water is discharged to the environment, the following steps should be taken.

a) Identify suitable methods for safely discharging waters used for remedial cleaning, normally to foul sewer.

b) Establish whether there is an existing discharge consent or whether an additional consent is required, and who is responsible for obtaining the licence.

c) Identify which discharge consent is necessary and the appropriate authority to give this, allowing sufficient time for consent to be granted.

NOTE Water UK has produced Technical Guidance Note 14 (TGN 14) Disposal of chlorinated water *[24]. Consent to discharge a trade effluent to a foul sewer is required under the Water Industry Act 1991 [15], the Water Act 2003 [27], the Environmental Protection Act 1990 [28], the Environment Act 1995 [29] and the Pollution Prevention and Control Act 1999 [30] in England and Wales. For Scotland and Northern Ireland, guidance on obtaining consent is given on the NetRegs website.* [8)]

d) Advise the building owner/occupier that this is being done.

Where water is to be discharged into a water course or into a drain leading to a water course, consent to discharge should be obtained from the appropriate authority, i.e. the Environment Agency in England and Wales, the Scottish Environmental Protection Agency in Scotland or the Department of the Environment for Northern Ireland in Northern Ireland.

14 Water management logbook

On completion of the disinfection process, the following documentation should be made available for use in the water management logbook at the time of occupancy:

a) where the certification is part of a handover procedure, approval of the nominated responsible person from each of the parties involved;

b) a portfolio of supporting information, including as a minimum:

1) copies of chain of custody documents and laboratory scheduling communications;

[8)] http://www.netregs.org.uk/library_of_topics/water/trade_effluent_to_sewer/who_needs_consent_to_discharge.aspx [viewed: 16 September 2015].

2) copies of any sampling audits carried out, together with notes of corrective action taken to mitigate any nonconformity with the sampling plan (see BS 8554);

3) copies of material data safety sheets (MSDS) for the disinfectants used; and

4) any other relevant documentation which might assist in the ongoing management or assessment of water quality in the system, e.g. method statements.

15 Record-keeping requirements for flushing and disinfection

15.1 Individual pipe sections

Where individual pipe sections have been treated, the following should be included in the records:

a) flush time prior to disinfection (min);

b) flush rate prior to disinfection (L/min), where practicable;

c) disinfection dose (mg/L);

d) standing time exposed to elevated disinfectant concentration (h);

e) residual at the end of disinfection time (mg/L);

f) flush time to clear elevated disinfection concentration (h);

g) residual after flushing of disinfectant (mg/L);

h) date of disinfection;

i) disinfectant used with a copy of the MSDS;

j) confirmation that the pipe was capped after disinfection, if necessary; and

k) company or individual who carried out the disinfection.

15.2 Cisterns

Where cisterns have been treated, the following should be included in the records:

a) description of cleaning process prior to filling and disinfection;

b) description of chemicals used in the cleaning process;

c) photograph of the vessel (internal and external) before and after the cleaning process;

d) disinfection dose (mg/L);

e) standing time exposed to elevated disinfectant concentration (h);

f) details of any neutralization applied to the elevated disinfectant concentration, quantities used, an MSDS and reference to required approvals for use in contact with drinking water;

g) residual at the end of disinfection time (mg/L);

h) residual after flushing of disinfectant (mg/L);

i) date of disinfection;

j) company or individual who carried out the disinfection.

15.3 Distribution systems

Where distribution systems have been treated, the following should be included in the records:

a) disinfection dose (mg/L);

b) standing time exposed to elevated disinfectant concentration (h);

c) details of any neutralization applied to the elevated disinfectant concentration, quantities used, an MSDS and reference to required approvals for use in contact with drinking water;

d) a method statement for the tests applied to ensure that all the neutralized water was flushed from the cistern;

e) residual at the end of disinfection time (mg/L);

f) date of disinfection; and

g) company or individual who carried out the disinfection.

15.4 Verification testing records

For the purposes of verification of the efficacy of the cleaning records, the tests required within the water end use specification should be conducted (see examples in Table 3). The precise combination of tests depend on the nature of the water use and the reason the original flushing and disinfection was instigated. For example, the cleaning of a supply cistern feeding hospital renal unit treatment plant requires a more extensive range of tests than that required for a drinking water redistribution cistern in a large office block.

The original laboratory reports should be maintained as records to avoid transcription errors. The sample location identities used on the laboratory reports should be fully traceable to the cleaning and disinfection records.

Table 3 **Example cleaning verification tests that may be required within the water end use specification**

Test	Reporting unit
Colony counts at 37 °C (48 h)	cfu/mL
Colony counts at 22 °C (72 h)	cfu/mL
Total coliforms	cfu/100 mL
E. coli	cfu/100 mL
Legionella	cfu/l
Pseudomonas aeruginosa	cfu/100 mL
Endotoxins (special case for hospital applications)	EU/mL
Colony counts at 22 °C (7 days) [special case for renal units (see BS ISO 13959)]	cfu/mL
Colony counts at 37 °C (48 h)	cfu/100 mL
Washer disinfectors and endoscopy rinse	
Colony counts at 37 °C (72 h)	cfu/100 mL
Washer disinfectors and endoscopy rinse	
Turbidity	ftu
Taste and odour	Description
pH	–
Electrical conductivity	μS/cm
Total chlorine at time of microbiological sampling	mg/L
Free chlorine at time of microbiological sampling	mg/L

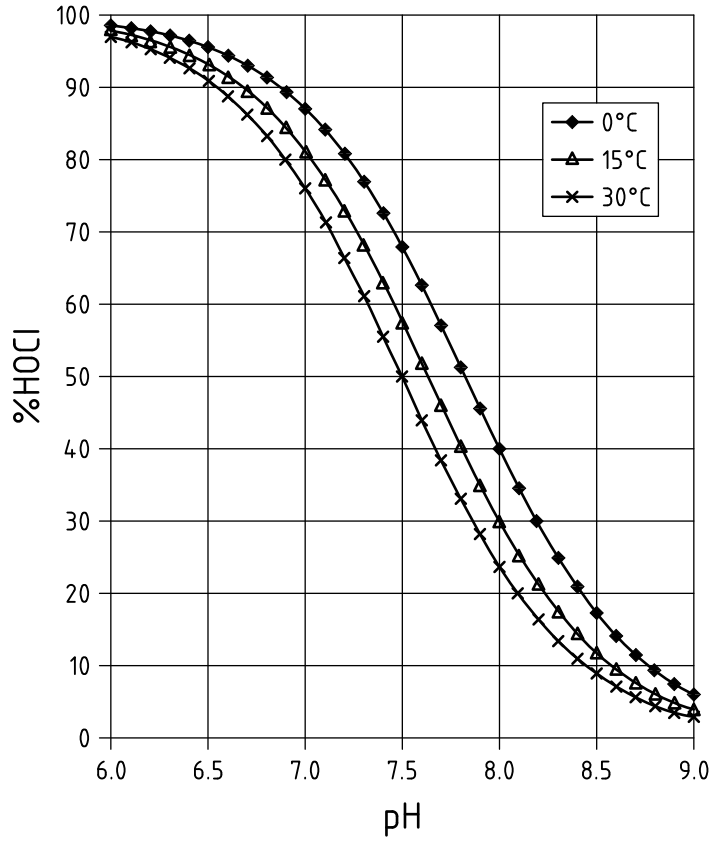
Annex A (informative) Use of 50 mg/L chlorine concentration as a basis for disinfection

The use of 50 mg/L as a basis for disinfection is commonly applied, although the basis for this concentration is not documented in the scientific literature. Most references to efficacy discuss performance of disinfection relative to concentration and time giving rise to CT values as statements of efficacy against a range of microorganisms. However, concentrations of available free chlorine above 50 mg/L might result in corrosion in copper pipes if exposure is uncontrolled.

In order to compensate for the influence of pH on the dissociation of hypochlorite in water most field test kits report "Available free chlorine" by buffering the pH of the test solution to approximately pH 5.5 to facilitate the required colour development. The consequence of this is that chlorine measurements might not accurately reflect the effective disinfection potential in the dosed water because of the resultant pH arising from the use of sodium hypochlorite.

Figure A.1 shows the relationship between pH and the dissociation of hypochlorite relative to disinfection efficacy. This is because the disinfection efficacy of sodium hypochlorite solution depends on the amount of available HOCl. Therefore, the lower the pH, the greater the concentration of HOCl, and the greater the efficacy of disinfections.

Figure A.1 **Percentage of chlorine present as HOCl as a function of pH and temperature** [A)]



[A)] Assuming zero ionic strength and considering HOCl and OCl as the only chlorine species present.

NOTE Reproduced from White's Handbook of Chlorination and Alternative Disinfectants *[31]. Copyright is claimed in Figure A.1. Details of the copyright owner can be found in the Foreword, Information about this document.*

It is generally accepted that in order to achieve effective disinfection a concentration of available free chlorine in the form of HOCl is 25 mg/L. This is achieved with a dose of 50 mg/L available free chlorine at a pH around 7.6. There is a consensus of opinion that concentrations of HOCl below 10 mg/L are less effective against microorganisms such as protozoa which can be refractory to disinfection if ineffectively applied. This is equivalent to a dose of 50 mg/L Cl at a pH in the region of 8.0 to 8.5.

Other factors that affect the dissociation of hypochlorite in addition to pH are temperature and ionic strength. Although important, they are considered less of an influence to the practical considerations required for the disinfection of water distribution systems. This relationship is highly dependent on the temperature of the water. In general terms, contact time can be reduced at lower temperatures but should be increased at higher temperatures. There is an approximate 5% difference in available HOCl between 10 °C and 25 °C, so contact times should be extended by 10% for every 5 °C increment in temperature above 20 °C irrespective of the pH of the dosed water.

Sodium hypochlorite should not be used at pH levels above 8.5 without considering alternative disinfectants, pH adjustment or extending contact times significantly to compensate for these effects.

Alternatively, Table A.1 sets out extensions of contact time required to maintain the efficacy of hypochlorite disinfection at various pHs in the dosed cistern, assuming a dose of 50 mg/L as chlorine.

NOTE 1 Another approach is that, if the chlorine concentration in mg/L (parts per million) is multiplied by the contact time in hours and the product is 50 parts per million hours, the disinfection effect can be considered as equivalent (see TM13: Minimising the risk of Legionnaires' Disease*, 2013, p. 24 [32]).*

NOTE 2 Further information on the efficacy of chlorine at different pH values is given in Treatment and Pathogen Control Process: Efficiency in Achieving Safe Drinking Water *[33].*

NOTE 3 Additional information on the efficacy of chlorine at various pHs is also given in White's Handbook of Chlorination and Alternative Disinfectants *[31].*

Table A.1 **Recommended contact times for various pHs**

pH of water dosed to 50 mg/L Cl using NaOCl solution		**Contact time at 20°C**	
		h	min
6.5	1 h at 50 ppm available free chlorine used		32
6.6			33
6.7			34
6.8			35
6.9			36
7.0			38
7.1			40
7.2			42
7.3			46
7.4			50
7.5			55
7.6	Extensions of contact time required to maintain efficacy	1	1
7.7		1	9
7.8		1	19
7.9		1	32
8.0		1	48
8.1		2	9
8.2		2	34
8.3		3	6
8.4		3	47
8.5		4	38
8.6	Consider alternative disinfectants/ pH adjustments	5	42
8.7		7	3
8.8		8	44
8.9		10	52
9.0		13	33
9.5		42	1

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BS 7592, *Sampling for Legionella bacteria in water systems – Code of practice*

BS EN 12671, *Chemicals used for treatment of water intended for human consumption – Chlorine dioxide generated in situ*

BS EN ISO 5667-3, *Water quality – Sampling – Part 3: Guidance on the preservation and handling of samples*

BS EN ISO 19458, *Water quality – Sampling for microbiological analysis*

BS EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

BS ISO 5667-5, *Water quality – Sampling – Part 5: Guidance on sampling of drinking water from treatment works and piped distribution systems*

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