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BS 7593:2006

BRITISH STANDARD

Code of practice for treatment of water in domestic hot water central heating systems

ICS 13.060.01; 91.140.10

Confirmed
February 2012

BSI
British Standards

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ISBN 0 580 48247 2

The following BSI references relate to the work on this standard:
Committee reference CII/62
Draft for comment 05/30133509 DC

Publication history

First published, December 1992

Amendments issued since publication

Amd. no.	Date	Text affected

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Foreword

Publishing information

This British Standard has been prepared by Technical Committee CII/62, *Treatment of water for boilers*, and supersedes BS 7593:1992, which is withdrawn.

Information about this document

This code gives guidance on the preparation of the primary circuit of wet central heating systems prior to initial commissioning or re-commissioning following major remedial work (e.g. boiler replacement) and ongoing water treatment to ensure continued efficiency in operation. Although intended to cover domestic systems with up to 45 kW heat input, it is recognized that the recommendations are also applicable to similar systems of higher heat output.

The purpose of this standard is to ensure awareness of potential problems, and of the remedies required to maintain efficiency and maximize the life of the system.

Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification, and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

Contractual and legal considerations

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

Compliance with a British Standard cannot confer immunity from legal obligations.

In particular, attention is drawn to the following statutory regulations.

The Water Supply (Water Fittings) Regulations 1999 [1]

The Health and Safety at Work, etc. Act 1974 [2]

The Control of Substances Hazardous to Health Regulations 2002 [3]

The Building Regulations 2000, as amended (particularly Approved Document L1) [4]

The Building (Scotland) Regulations 2004 [5]

The Building Regulations (Northern Ireland) Statutory Rules 2000 [6]

The Trade Effluent (Proscribed Processes and Substances) Regulations 1989 [7]

The Hazardous Waste (England and Wales) Regulations 2005 [8]

The Special Waste (Scotland) Regulations 1996 [9]

The Hazardous Waste (Wales) Regulations 2005 [10]

The Hazardous Waste Regulations (Northern Ireland) 2005 [11]

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1 Scope

This British Standard gives recommendations on best practice for the preparation of the primary circuit of wet central heating systems prior to initial commissioning or re-commissioning following major remedial work (e.g. boiler replacement) and the ongoing water treatment to ensure continued efficiency in operation.

NOTE For specialized systems, such as those containing solar thermal panels and heat pumps, refer to the manufacturer's instructions.

2 Objectives of system water treatment

The objectives of water treatment may be summarized as follows:

a) to minimize corrosion of the system metals;

b) to inhibit the formation of scale and sludge;

c) to inhibit the growth of microbiological organisms;

d) to maintain the engineering design specifications and energy efficiency of the system; and

e) to restore energy efficiency of the system where appropriate.

3 Causes of problems in central heating systems

3.1 Corrosion

Corrosion is generally a process of oxidation of metals which, in a central heating system, can result in restriction of circulation and/or failure of components, for example perforation of radiators. Corrosion in a central heating system is promoted by the following.

a) Poor system design and/or installation, e.g. oxygenation of the circulating water by excessive make-up, pumping over or sucking down at the open vent, incorrect sizing of the cold feed pipe, inadequately sized or incorrectly installed feed and expansion cistern.

b) Ingress of air, e.g. at mechanical or poorly soldered joints. Some plastics pipe allows the ingress of oxygen into the system water (see BS 5955-8).

c) Electrolytic (galvanic) action between dissimilar metals. Metals/alloys which are less noble (more active) are the most susceptible to corrosion (see Table 1). However, the position of some metals (especially aluminium and stainless steels) in Table 1 can change depending on conditions, e.g. pH.

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Table 1 **Electrochemical series**

Metal	Activity
Copper	More noble (less active)
Brass	
Gunmetal	
Stainless steel	
Lead-free solder	
Tin	
Lead	
Steel	
Cast iron	
Galvanized iron	
Aluminium alloys	Less noble (more active)

d) Deleterious materials, e.g. flux residues, jointing compounds, residual cleanser, and/or foreign matter remaining after inadequate cleaning or flushing, or oils and greases left over from the manufacturing process of system components.

e) Certain characteristics of the system supply water. For example, some naturally soft waters with low alkalinity and low pH are generally more corrosive towards system metals. Some artificially softened waters, particularly those from softeners not conforming to BS EN 14743, might contain high levels of aggressive anions (e.g. chloride) that can promote pitting of ferrous and non-ferrous metals, e.g. stainless steel and aluminium.

f) Other sources of chloride, which include fluxes, hydrochloric acid and washing-up liquids.

g) The presence of anaerobic bacteria resulting in acidity.

h) Incorrect, unsuitable or poorly applied or maintained water treatment products.

i) The formation of corrosion products deposited or plated out in the system.

Corrosion is most aggressive when there is a steady source of supporting reactant, e.g. fresh water make-up or re-aeration of the system water.

NOTE Further information on corrosion in re-circulating systems is given in BS EN 14868.

3.2 Scale and sludge

"Hardness" is the term which describes the concentration of calcium and magnesium salts dissolved in water, usually expressed as calcium carbonate ($CaCO_3$) equivalence. Waters may be classified as given in Table 2.

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Table 2 **Classification of waters**

Designation	**Total hardness (as $CaCO_3$)** mg/l
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

The hardness due to bicarbonate is termed "temporary" hardness. When water is heated, temporary hardness forms insoluble calcium carbonate. Scaling is the precipitation of hardness salts and/or corrosion debris to form adherent deposits on surfaces within the system. This reaction is most likely to take place in the hottest part of the system, usually the heat transfer surface in the boiler. Deposited calcium carbonate is usually referred to as lime scale. While it is most likely to form in the boiler heat exchanger, it can also accumulate elsewhere in the system as sludge, often at places of low flow.

Under normal operating conditions non-bicarbonate or "permanent" hardness salts, e.g. calcium sulfate, will remain in solution, but at the higher temperatures of the heat exchanger surfaces their solubility reduces rapidly and precipitation can occur.

The potential for scale formation is greatest in those hard water areas of the United Kingdom where the bicarbonate alkalinity is high. Scale formation will be most pronounced if there is a high rate of water loss.

If calcium carbonate is allowed to form in the heat exchanger this will have a detrimental effect on boiler heat transfer efficiency. Scale and/or sludge can also be responsible for boiler noise.

Corrosion products will usually give rise to sludge, e.g. magnetite, in low flow areas downstream of the point of formation, but small particles can be carried round the system and can deposit, e.g. in the boiler heat exchanger, generating a scale. Where lime scale is formed in the presence of corrosion products a very hard mixed scale might result.

System areas most prone to failure due to fouling by scale or sludge include the boiler heat exchanger and circulator pump. Fouling can also restrict flow through components such as thermostatic radiator valves, zone valves, drain valves, etc., and any parts of the system where there is a low water velocity or small pipe diameters (e.g. in radiators or fan convectors and microbore circuits).

Sludge accumulation will result in poor circulation and a decrease in system efficiency.

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3.3 Microbiological contamination

Microbiological organisms ranging from simple bacteria to fungal and yeast spores can cause problems when they enter a central heating system. Common sources of these organisms include feed and expansion cisterns not installed in accordance with BS 5449 (partially superseded by BS EN 12828, BS EN 12831 and BS EN 14336), the atmosphere, contaminated feed and expansion cisterns, and non-proprietary cistern lids and insulation.

The greatest potential for microbiological proliferation exists in the feed and expansion cistern of open-vented systems. Here the temperature conditions are more favourable for bacterial growth and there is contact with the air. Aerobic bacteria, fungi and slimes which have developed in the cistern can enter the system with the make-up water and produce debris. Such debris can cause blockages and is liable to foul the boiler heat exchanger. Under-floor heating and other systems which operate at lower temperature (below 60 °C) can also be prone to microbiological fouling. Even the high temperature in the boiler heat exchanger might not be sufficient to kill all micro-organisms.

Anaerobic bacteria can thrive in both open and sealed systems fouled with corrosion and other debris, beneath deposits where the temperature might be lower and there is an absence of oxygen. This can give rise to microbiological corrosion of ferrous metals.

4 Treatment of water

4.1 General

In most cases, the quality of the water used in the central heating system is determined by supply to the premises and this will vary across the United Kingdom.

Water treatment should be applied to all primary systems except for single feed indirect hot water cylinders.

Consideration should be given as to whether the water is hard or soft, as this might influence the approach to water treatment and the choice of proprietary product. Refer to the manufacturer's specifications.

4.2 External

Naturally soft waters of low alkalinity or those supplied via a base-exchange resin softener have an increased potential for corrosion and, if they are to be used in any central heating system, a corrosion inhibitor specifically formulated for the purpose[1)] should be added and properly maintained.

[1)] Check inhibitor product specification.

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4.3 Internal

To minimize the likelihood of corrosion, scale and sludge formation, the system water in any system should be treated with an inhibitor. Before the inhibitor is added to the system, the first step should be to render the system in a condition free from foulants. Foulants in new systems can include corrosion debris, flux residues, grease, installation debris, metal swarf, solder pieces, stamping oil and welding rod. Existing systems might also contain black magnetite sludge and scale. If microbiological fouling is found within a system (often detected by the presence of organic slime or a foul odour), the system should be disinfected using a proprietary disinfectant and a biocide added for ongoing protection.

Corrosion inhibitors should not be used as a substitute for correct system design, installation and maintenance.

5 Cleansing

5.1 General considerations

Before cleansing, the system should be examined to determine the system configuration and the age and overall condition of components, in order to ascertain the cleansing regime required. For example, the procedure could remove corrosion debris covering pin-holes in radiators and this could result in leaks.

If there is any doubt as to whether a system will withstand any cleansing methodology, then replacement or repair of relevant components will be necessary before continuing.

A choice of cleansing methodologies is available. In most cases involving major work, e.g. commissioning of new systems or boiler change, this will necessitate a chemical cleanse, followed by a fresh water flush, before an inhibitor is applied. For minor work, e.g. change of a circulator pump or individual radiators, it might be sufficient to isolate and change the component, but always check that the inhibitor protection meets the manufacturer's specification when re-commissioning.

NOTE 1 It is essential that pumped circulation is available throughout the system. A fresh water flush alone, whether hot or cold, is not adequate procedure.

NOTE 2 Filters which collect magnetite may be beneficial as part of the flushing procedure. These should be used with a chemical cleanser to mobilize the magnetite and aid its transport to the filter.

The cleanser manufacturer's specification and usage instructions should be studied and product selection made accordingly. Unless the manufacturer's instructions state otherwise, products from different manufacturers or different products from the same manufacturer should not be mixed.

Adequate time has to be allowed to complete the cleansing procedure.

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5.2 Cleansing and flushing methodologies

There are three cleansing and flushing options, one of which should be applied.

1) Mechanically-assisted powered cleanse and flush (powerflushing) (see **5.3**).
2) Mains pressure cleanse and flush for sealed systems and open-vented systems with the feed and vent temporarily capped-off (see **5.4**).
3) Cleanse and flush using gravity, with the assistance of a circulator pump (see **5.5**).

Powerflushing is most effective as this produces a more thorough clean, but the boiler manufacturer's instructions should be checked to establish whether powerflushing is acceptable. Powerflushing is the most effective method of cleansing existing systems, especially those containing a high level of black magnetite sludge.

With all methodologies, reversing the flow will help to remove debris which might otherwise remain trapped.

An appropriate cleanser should be chosen. (Refer to manufacturers' instructions.) The following factors should be taken into account:

a) the reason for cleaning;
b) the system materials, e.g. aluminium;
c) the age and condition of the system;
d) any specific problems identified;
e) any local restrictions on disposal of the effluent.

Hot flushing is more effective than cold flushing, but the cleanser manufacturer's instructions should be followed.

5.3 Powerflushing

5.3.1 Preparation before powerflushing

a) Turn off all electrical controls and electrically isolate the system.
b) Isolate the cold water supply to the central heating system.
c) Manually close any automatic air vents.
d) For open-vented systems, cap-off or temporarily join together the open vent and cold feed to the feed and expansion cistern.

   NOTE Check for any additional open vents, which will also need capping.

e) Mark the position or note the setting of lockshield or other regulating valves, then fully open all valves. Remove any thermostatic radiator valve (TRV) heads to ensure maximum flow through the valve.
f) Set any diverter or zone valves to their manual, open position.
g) Where practical, anti-gravity and non-return valves should be bridged, by-passed or temporarily removed as failure to do so will prevent flow reversal.

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h) Connect the powerflushing machine to the central heating system following the manufacturer's instructions.

NOTE If a new boiler is being fitted, to prevent damage or contamination, powerflushing should either be carried out before the boiler is installed or with the new boiler isolated from the rest of the system.

5.3.2 Powerflushing procedure

At all times manufacturers' recommended operating procedures should be followed. Chemical cleansing is more effective at increased temperatures and some powerflushing units allow the boiler to be operated during powerflushing.

The powerflushing procedure should include:

a) operation of the unit for at least 10 min (circulation mode) with all radiator and system valves open, reversing the flow regularly;

b) dumping the dirty water to a foul drain whilst mains water is continually added via the powerflushing reservoir tank until the water runs clear;

c) addition of the chosen cleansing chemical to the reservoir of the powerflushing machine and circulating to disperse throughout the system;

d) circulating the cleanser through each radiator for at least 5 min in turn by isolating the other radiators and the hot water circuit, reversing the flow regularly;

NOTE Tapping of the radiator with a rubber hammer will help to remove any loose material.

e) cleansing of the hot water circuit for at least 5 min (circulation mode) by isolating the radiators, reversing the flow regularly;

f) flushing of each radiator in turn for at least 5 min by isolating the other radiators and the hot water circuit, and dumping to foul drain until the water runs clear;

g) flushing of the hot water circuit for at least 5 min by isolating the radiators, and dumping to foul drain until the water runs clear;

h) flushing of the system with all radiator and system valves open for at least 5 min and dumping to foul drain until water runs clear;

i) continual flushing and dumping to foul drain until all of the cleanser and debris have been removed. Refer to the manufacturer's instructions.

After this procedure, re-commissioning should be carried out in accordance with **5.6**.

5.4 Mains pressure cleansing

5.4.1 Preparation for mains pressure cleansing

If possible, run the boiler until normal operating temperature is achieved throughout the system.

a) Turn off all electrical controls and electrically isolate the system.

b) Isolate the cold water supply to the central heating system.

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c) Mark the position or note the setting of lockshield or other regulating valves, then fully open all valves. Remove any thermostatic radiator valve (TRV) heads to ensure maximum flow through the valve.

d) Dump system water to foul drain. (All radiator and other air vents should be opened to ensure complete removal of system water.)

e) Where practical, anti-gravity and non-return valves should be bridged, by-passed or temporarily removed as failure to do so will prevent flow reversal.

5.4.2 Cleansing procedure

a) Dose the system with a cleanser and refill with mains water, bleeding the radiators and any other vent points where necessary.

b) Reinstate the electrical supply.

c) Circulate cleanser in accordance with the manufacturer's instructions.

d) Once the cleanser has circulated within the system for the prescribed period:

   i) turn off all electrical controls and electrically isolate the system;

   ii) isolate the cold water supply to the central heating system;

   iii) manually close any automatic air vents;

   iv) for open-vented systems, cap-off or temporarily join together, the open vent and cold feed to the feed and expansion cistern;

   NOTE Check for any additional open vents, which will also need capping.

   v) connect a mains pressure hose to an appropriate point in the central heating system and a hose from a drain valve to a foul drain.[2)]

NOTE If a new boiler is being fitted, to prevent damage or contamination, mains pressure cleansing should either be carried out before the boiler is installed or with the new boiler isolated from the rest of the system.

5.4.3 Mains pressure flushing procedure

The system should be flushed as follows.

a) Flush each radiator in turn, dumping to foul drain for at least 5 min until the water runs clear, by isolating the other radiators and the hot water circuit.

b) Flush the hot water circuit, dumping to foul drain for at least 5 min until the water runs clear, by isolating the radiators.

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2) Attention is drawn to the Water Supply (Water Fittings) Regulations 1999 [1] and the Scottish Water Bye-laws 2004 [12], which require adequate precautions to be taken to prevent backflow.

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c) Flush the system with all radiator and system valves open, dumping to foul drain, for at least 5 min until the water runs clear.

d) Continue flushing until all of the cleanser and debris have been removed. Refer to the manufacturer's instructions.

After this procedure, re-commissioning should be carried out in accordance with **5.6**.

5.5 Gravity cleansing (with the assistance of a system circulatory pump)

NOTE This method is not appropriate for a system or part of a system that depends on gravity circulation.

5.5.1 Preparation for gravity cleansing

Where the methods of powerflushing or mains pressure cleansing described in **5.3** and **5.4** cannot be used, this procedure might be appropriate, particularly for open-vented systems, but attention is drawn to the need for adequate drain valves at all low points to ensure debris and cleanser can be effectively removed.

If possible, run the boiler until normal operating temperature is achieved throughout the system.

a) Turn off all electrical controls and electrically isolate the system.

b) Isolate the cold water supply to the central heating system.

c) Mark the position or note the setting of lockshield or other regulating valves, then fully open all valves. Remove any thermostatic radiator valve (TRV) heads to ensure maximum flow through the valve.

d) Set any diverter or zone valves to their manual, open position.

e) Dump system water to foul drain using all available drain points. (All radiator and other air vents should be opened to ensure complete removal of system water.)

f) Where necessary, install drain valves at each low point.

5.5.2 Gravity cleansing

a) Dose the system with a cleanser and refill with mains water, bleeding all radiators and any other vent points where necessary.

b) Reinstate the electrical supply.

c) Circulate cleanser in accordance with the manufacturer's instructions.

d) Once the cleanser has circulated within the system for the prescribed period:

   i) turn off all electrical controls and electrically isolate the system; and

   ii) isolate the cold water supply to the central heating system.

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5.5.3 Gravity flushing procedure

a) Dump system water to foul drain using all available drain points. (All radiator and other air vents should be opened to ensure complete removal of system water.)

b) Refill the system, bleeding all radiators and any other vent points where necessary.

c) Reinstate the electrical supply.

d) Circulate the system water.

e) Repeat the draining, refilling, circulating steps a minimum of two further times.

f) Repeat as necessary until the water runs clear at all drain points. Refer to the manufacturer's instructions.

After this procedure, re-commissioning should be carried out in accordance with **5.6**.

5.6 Re-commissioning

The system configuration and all components should be returned to their original settings.

Inhibition devices should be installed in the system pipework after the final flush and before the final fill with fresh water. Chemical inhibitors should be added at the time of final fill with fresh water. Refer to the manufacturer's instructions.

Under no circumstances should the system be left empty for extended periods as this could accelerate corrosion of ferrous components, e.g. radiators.

6 Special treatments – boiler cleansing as a separate process

In certain circumstances, the heat exchanger might need chemical cleansing as a separate process to remove hard water scale or accumulated corrosion debris. The procedure can involve use of a different chemical to that used for the rest of the system. In such cases, the manufacturer's instructions should be closely followed.

Attention is drawn to the need to ensure that all cleanser and debris is flushed from the heat exchanger prior to re-introducing system water.

7 Inhibition

The product selected should be suitable for the system components and water quality and applied in accordance with the manufacturer's instructions.

The system water should be checked at intervals specified by the product manufacturer to ensure adequate ongoing protection. Unless the manufacturer's instructions state otherwise, products from different manufacturers or different products from the same manufacturer should not be mixed.

A record of the work carried out should be left at the premises. A permanent label should be affixed to the system in a prominent position indicating the make and type of the inhibitor used and the date of installation.

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