Water Treatment for Closed Heating and Cooling Systems

Edited by Reginald Brown

A joint venture with ...
ACKNOWLEDGEMENTS

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The treatment of water in modern closed heating and cooling systems is essential for the avoidance of microbiological fouling (biofouling), corrosion and scale. These problems can result in energy wastage, poor system performance, and the need for early replacement of plant and components. The consequences of inappropriate or non-existent water treatment can sometimes be disastrous.

This guide is intended for use by design engineers, installing contractors and the maintenance staff responsible for looking after the completed systems. It provides an introduction to current theory and practice of water treatment in closed systems including minimising the risk of corrosion through system design features and proactive monitoring.

In particular the guide will help facilities managers and others to engage in constructive discussion with water treatment professionals and choose the most appropriate water treatment programme for their systems.

The common causes of water quality and corrosion problems are explained and their implications for closed heating and cooling systems are described. Consideration is given to design, system operation, routine control, treatment and monitoring of water.

The guide partially replaces BSRIA AG 2/93 Water treatment for building services systems in respect of closed system applications. The guidance is consistent with BSRIA BG 29/2012 Pre-commission cleaning of pipework systems, BS 8552:2012 Sampling and monitoring of water from building services closed systems. Code of practice and the European Biocidal products Regulation (528/2012, commonly known as BPR).
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I INTRODUCTION

The scope of this guide is water treatment for the control of corrosion and maintenance of water quality in closed heating and cooling systems in buildings other than individual dwellings. This includes low temperature hot water heating systems, heat pump and chilled water systems and condenser water circuits. It is also relevant to community heating and cooling networks operating at temperatures below 110°C.

The scope does not include the specific requirements for water treatment for medium and high temperature heating systems, for which reference should be made to BS 2486[3].

This scope does not include water treatment for open systems such as cooling towers and steam boilers or for domestic hot and cold water services.

The objectives of a water treatment programme in closed heating and cooling systems are to:

• maintain the system in a clean condition
• assist in maintaining system efficiency
• prolong system life through the control of corrosion and fouling.

This is aided by the following elements:

1. System design
   a. Specification of appropriate materials
   b. Avoidance of dead legs and areas of stagnation
   c. Operating characteristics that minimise the risk of air ingress and problems associated with low flow, such as sedimentation and biofouling

Further information on system design is provided in Section 2.

2. Installation, testing & pre-commission cleaning

Further information on these topics is provided in Section 3 and BSRIA BG 29[1].

3. Application of a correct and appropriate water treatment programme including:
   a. Control of corrosion by:
      i. Application of corrosion inhibitors
      ii. Control of scale, biofouling & other deposits
   b. Control of scale by:
      i. Minimising system losses & make-up
      ii. Use of scale inhibitors
      iii. Pre-treatment of make-up water when necessary
INTRODUCTION

c. Control of biofouling/biofilms by:
   i. Avoidance of low flow
   ii. Use of appropriate biocides
   iii. Control of nutrient ingress
   iv. Pre-treatment of make-up water when necessary
   v. Control of scale, corrosion and sedimentation
d. Control of sedimentation by:
   i. Avoidance of low flow
   ii. Use of dispersants
   iii. Use of side-stream filtration
   iv. Pre-treatment of make-up water when necessary
   v. Control of scale, precipitation, biofouling & corrosion

Further information on these topics is provided in Sections 4 and 5.

4. Management of the programme including:
   a. Knowledge of the system including:
      i. Materials used
      ii. Operational characteristics (temperature, flow rates, etc.)
      iii. Volume
   b. Programme design including
      i. Product selection
      ii. Sampling & testing regime
      iii. Guidelines and action limits etc.
   c. Implementation of programme
   d. Monitoring & control
   e. Training & competence of staff involved
   f. Definition of reporting lines, roles & responsibilities
   g. How to handle/report problems/areas of concern

Further information on these topics is provided in Section 6.

Section 7 briefly summarises the main legislation that is relevant to water treatment activities.

Various technical issues are discussed in detail in the appendices and there is a glossary and bibliography at the end of this guide.
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Pre-commission Cleaning of Pipework Systems

By Reginald Brown and Chris Parsloe

BG 29/2012
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It is not intended that contracts or specifications refer to the guide in its entirety, rather that direct references are made to specific sections to suit the particular circumstances.

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System contaminants such as mill scale, jointing compound and building debris will inevitably be found in newly-fabricated heating and cooling pipework systems. If allowed to remain in the system in sufficient quality, these contaminants will make the system prone to blockage at strainers, control valves and small bore heat exchangers. They may also initiate further corrosion and encourage the growth of micro-organisms.

AG 8/91
The subject of cleaning pipework systems to remove these contaminants prior to commissioning was first addressed in the 1991 BSRIA Application Guide AG 8/91: Pre-Commissioning Cleaning of Water Systems. Many of the recommendations in this guide were considered unconventional at the time. However, in the intervening years, experience has shown that systems that are designed and cleaned following this guidance are far less likely to suffer operating problems. The importance of pre-commission cleaning has also increased as modern heating and cooling systems move towards energy efficient control strategies that result in low flow rates in terminal units with consequently very small orifices in control valves.

AG 1/2001
In 2001, the first revision to AG 8/91 was launched as BSRIA Application Guide AG 1/2001: Pre-Commission Cleaning of Pipework Systems. This guide was intended as a direct replacement for AG 8/91. The preceding recommendations were revised in order to take on board feedback received since 1991, but also to address the growing incidence of bacteria-related problems being reported, particularly Pseudomonas-related problems. For reasons not fully understood, such problems had become more common during the 1990s. AG 1/2001 therefore contained more information on precautionary measures to avoid or address bacteria in systems.

AG 1/2001.1
The guide was updated in 2004. At this time it was recognised that there was a serious contamination risk when new pipework sections were connected to existing systems (such as in shell and core situations). It was decided that additional guidance was required to address these particular situations. BSRIA AG 1/2001.1 therefore contains all of the recommendations provided in AG 1/2001, but also has a completely new stand-alone section which deals with the issues raised when connecting new pipework to existing pipework.

BG 29/2011
This version of the guide incorporated industry feedback from nearly twenty years of flushing and cleaning using the guide. In particular it aimed to clarify the roles and responsibilities of the parties, improve the exchange of information between them and provide consistency between service offerings of the pre-commission cleaning contractors.
PRE-FACE

BG 29/2012
The purpose of the 2012 update is to reflect new British and European standards, correct some minor errors in the 2011 edition, and to clarify certain points that have been raised in the past year. Changes are as follows:

- Figure 2: Amended to clarify location of fill point
- Table 5: Terminology for parameters made consistent with table 4
- Table 6: Pseudomonad guideline for practical completion changed from 10,000 cfu/ml to 10,000 cfu/100 ml (a corrigenda to this effect was issued in October 2011)
- Section 4.1.5: Reference to HVCA COSHH manuals removed
- Section 5.1.1 and table 9: Amended to include internal pipe diameters and revised flushing flow rates
- Figures 10, 11, 12, 13, 15 and 16: The flushing supply valve has been numbered "valve 0"
- Section 5.2.3: Steps 5 and 10 of the example procedure revised to remove reference to temporary flushing pumps
- Section 5.2.4: Steps 6 and 7 of the example procedure revised to remove reference to temporary flushing pumps
- Figures 13, 15 & 16: Path of water flow corrected
- Figure 18: Changed to two separate schematics showing path of water flow during first and second stage of flush
- Appendix C site analysis record sheets: Terminology for parameters made consistent with table 4

Reginald Brown
2012
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<tr>
<td>IV</td>
<td>Isolating valve</td>
</tr>
<tr>
<td>DRV</td>
<td>Double regulating valve</td>
</tr>
<tr>
<td>OP</td>
<td>Orifice plate</td>
</tr>
<tr>
<td>TP</td>
<td>Test point</td>
</tr>
<tr>
<td>STR</td>
<td>Strainer</td>
</tr>
<tr>
<td>MV</td>
<td>Motorised four-port valve</td>
</tr>
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<td>MV</td>
<td>Motorised three-port valve</td>
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<tr>
<td>MV</td>
<td>Motorised two-port valve</td>
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<tr>
<td>DRV</td>
<td>Drain off cock with hose connection</td>
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<td>P</td>
<td>Pressure gauge</td>
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<td>T</td>
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<td>SV</td>
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<td>PICV</td>
<td>Pressure independent control valve</td>
</tr>
<tr>
<td>DOC</td>
<td>Fan coil unit</td>
</tr>
<tr>
<td>DRV</td>
<td>Radiator (with isolating and lockshield valves)</td>
</tr>
<tr>
<td>OP</td>
<td>Gas-fired boiler</td>
</tr>
<tr>
<td>M</td>
<td>Water meter</td>
</tr>
<tr>
<td>AAV</td>
<td>Automatic air vent</td>
</tr>
<tr>
<td>MAV</td>
<td>Manual air vent</td>
</tr>
<tr>
<td>FC</td>
<td>Flexible coupling</td>
</tr>
<tr>
<td>FC</td>
<td>Flexible hose</td>
</tr>
<tr>
<td>M</td>
<td>Pump</td>
</tr>
<tr>
<td>LSV</td>
<td>Lockshield valve</td>
</tr>
<tr>
<td>FP</td>
<td>Fill point</td>
</tr>
<tr>
<td>CFR</td>
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1 INTRODUCTION

Pre-commission cleaning, as it is applied to heating, cooling and other closed pipework systems, is the process of bringing the system to a satisfactory state for commissioning and on-going maintenance of water quality. This means that:

1. The system water should be free of construction debris, dirt and excessive particulate matter
2. Internal surfaces should be free of millscale and appropriately treated to minimise on-going corrosion
3. Pipework, fittings and terminal units should be free from settled solids that could increase the risk of corrosion
4. Residual levels of suspended solids should be low enough not to cause difficulties with commissioning or significant accumulation in low flow areas
5. Biofilm formation should be minimised by appropriate use of biocides and those bacteria associated with microbiologically induced corrosion should be controlled.

This guide is not concerned with the cleaning of domestic hot and cold water services systems in buildings.

Pre-commission cleaning is achieved through a process of flushing and chemical cleaning (where required) followed by the addition of biocides and inhibitors. Since it is not possible to directly examine all the internal surfaces of the system, the success of pre-commission cleaning is inferred from water samples that are analysed for a range of parameters including, but not limited to, suspended solids, iron and bacteria.

These activities should be carried out by trained and experienced operatives working within a management framework that ensures safe and effective working practices and appropriate record keeping at each stage of the process with clear lines of communication to the designer and other parties involved in the project.

The success of pre-commission cleaning and avoidance of subsequent problems will depend on the design and prior history of the system:

- the designer should aim to ensure that the system is amenable to cleaning, and remaining clean, and that appropriate features (such as flushing bypasses and drain points) are included to make this possible. These issues are discussed in Section 2
- manufacturing, storage and assembly methods should aim to minimise residues and the ingress of contamination
- water supplied to the system for pressure testing should be of sufficient quality and suitable measures should be applied to avoid the build-up of corrosion and bacteriological problems prior to pre-commission cleaning. The sequence of system monitoring from initial filling to practical completion is described in section 3.
The processes of pre-commission cleaning are discussed in Sections 4, 5 and 6. The particular issues associated with connecting new and existing systems are discussed in Section 7.

Even where the pre-commission cleaning activity is completely successful it is still possible for the system to deteriorate between conclusion of the clean and practical completion unless the system is properly treated and closely monitored and managed. Recommendations are given in Section 3.2.

This guide is intended to be used in conjunction with BS 8552\(^1\) which describes the requirements for sampling water from buildings. This includes sampling methodology, the selection of locations and frequency of sampling, transport and analysis of samples and interpretation of results according to the guidelines included in this guide.

It is emphasised that the guidelines on water quality contained in this guide relate to pre-commission cleaning activity for new heating and chilled water systems. They are guidelines and are intended to demonstrate that the system has been adequately cleaned and that water quality is under control. The results of water quality analysis should always be subject to interpretation by the appointed cleaning or water treatment specialists in the context of the project and water treatment regime.

A new guide, currently being prepared by a joint working group of the Water management Society (WMS), British Association of Chemical Specialists (BACS), Commissioning Specialists Association (CSA), Institute of Corrosion (ICorr) and BSRIA will provide guidance on reducing corrosion risk and the long term maintenance of water quality after practical completion. That guide is expected to be published in 2013.

Throughout this publication, various legislation is referred to. Only legislation currently applicable in England is stated. In some cases, different legislation applies in different parts of the UK. The full text of all UK legislation can be found at www.legislation.gov.uk Further information can be found in the BSRIA Legislation and Compliance Resource, which can be accessed through the BSRIA website www.bsria.co.uk.
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