Water Treatment for Closed Heating and Cooling Systems

Edited by Reginald Brown

A joint venture with ...
The technical information in this publication was provided by members of a steering group representing BSRIA, the British Association for Chemical Specialities, the Water Management Society, the Commissioning Specialists Association, the Institute of Corrosion and the United Kingdom Water Treatment Association.

The steering group was chaired by Alan Edwards representing the Water Management Society, and the editor for the publication was Reginald Brown of BSRIA. Design and production was carried out by Joanna Smith of BSRIA.

BSRIA wishes to thank all the members of the steering group for their contributions:

- David Bleicher, BSRIA
- Reginald Brown, BSRIA
- Jason Bruce, Commissioning Specialists Association
- Tony Collins, Institute of Corrosion
- Jill Cooper, Water Management Society
- Daniel Davies, United Kingdom Water Treatment Association
- Liz Day, Commissioning Specialists Association
- Alan Edwards, Water Management Society
- Mike Hunter, Water Management Society
- Mike Iddon, Water Management Society
- John Lane, Water Management Society
- Stewart McGillivray, Institute of Corrosion
- Phil Munn, Institute of Corrosion
- Pamela Simpson, Institute of Corrosion
- John Smith, British Association for Chemical Specialities
- Jonathan Usher, Water Management Society
- Geoff Walker, British Association for Chemical Specialities
- Stuart Wilton, Water Management Society

Every opportunity was taken to incorporate the views of the steering group, however final editorial control of the publication rested with BSRIA.

BSRIA acknowledges with thanks the organisations that provided additional images for use in this publication:

- Midland Corrosion Services Ltd.
- Chesterfield WT Consultants Ltd.
- B & V Water Treatment

The guidance given in this publication is correct to the best of BSRIA’s knowledge. However, BSRIA cannot guarantee that it is free of errors. Material in this publication does not constitute any warranty, endorsement or guarantee by BSRIA. Risk associated with the use of material from this publication is assumed entirely by the user.
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).
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>SYSTEM DESIGN AND OPERATION</td>
<td>3</td>
</tr>
<tr>
<td>2.1</td>
<td>Choice of materials</td>
<td>3</td>
</tr>
<tr>
<td>2.2</td>
<td>Flow rates</td>
<td>5</td>
</tr>
<tr>
<td>2.3</td>
<td>Minimising dissolved oxygen</td>
<td>6</td>
</tr>
<tr>
<td>2.4</td>
<td>Design for water treatment</td>
<td>8</td>
</tr>
<tr>
<td>2.5</td>
<td>Pre-commission flushing and cleaning</td>
<td>13</td>
</tr>
<tr>
<td>2.6</td>
<td>Remedial flushing and cleaning</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>CORROSION PROCESSES</td>
<td>21</td>
</tr>
<tr>
<td>3.1</td>
<td>Chemical corrosion processes</td>
<td>21</td>
</tr>
<tr>
<td>3.2</td>
<td>Microbi ally influenced corrosion (MIC)</td>
<td>31</td>
</tr>
<tr>
<td>4</td>
<td>CHEMICAL WATER TREATMENT</td>
<td>35</td>
</tr>
<tr>
<td>4.1</td>
<td>Corrosion inhibition</td>
<td>35</td>
</tr>
<tr>
<td>4.2</td>
<td>Bacteria and biofouling inhibition</td>
<td>44</td>
</tr>
<tr>
<td>4.3</td>
<td>Scale inhibition</td>
<td>49</td>
</tr>
<tr>
<td>5</td>
<td>NON-CHEMICAL WATER TREATMENT</td>
<td>50</td>
</tr>
<tr>
<td>5.1</td>
<td>Filtration</td>
<td>50</td>
</tr>
<tr>
<td>5.2</td>
<td>Deaeration</td>
<td>53</td>
</tr>
<tr>
<td>5.3</td>
<td>Sacrificial anodes</td>
<td>56</td>
</tr>
<tr>
<td>5.4</td>
<td>Other non-chemical treatments</td>
<td>56</td>
</tr>
<tr>
<td>6</td>
<td>MANAGEMENT OF THE WATER TREATMENT PROGRAMME</td>
<td>59</td>
</tr>
<tr>
<td>6.1</td>
<td>Overview</td>
<td>59</td>
</tr>
<tr>
<td>6.2</td>
<td>Water sampling and analysis</td>
<td>60</td>
</tr>
<tr>
<td>6.3</td>
<td>Sampling for water chemistry</td>
<td>61</td>
</tr>
<tr>
<td>6.4</td>
<td>Sampling for microbiology</td>
<td>63</td>
</tr>
<tr>
<td>6.5</td>
<td>Water quality analysis and guidelines</td>
<td>69</td>
</tr>
<tr>
<td>6.6</td>
<td>Corrosion Monitoring</td>
<td>74</td>
</tr>
<tr>
<td>7</td>
<td>REGULATIONS</td>
<td>78</td>
</tr>
<tr>
<td>7.1</td>
<td>Health and safety</td>
<td>78</td>
</tr>
<tr>
<td>7.2</td>
<td>Other regulations</td>
<td>79</td>
</tr>
</tbody>
</table>

WATER TREATMENT FOR CLOSED HEATING AND COOLING SYSTEMS

© BSRIA BG 50/2013
## APPENDICES

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>USE OF TEMPORARY PUMPS</td>
<td>81</td>
</tr>
<tr>
<td>B</td>
<td>CASE STUDIES</td>
<td>83</td>
</tr>
<tr>
<td>C</td>
<td>BIOCIDES</td>
<td>94</td>
</tr>
<tr>
<td>D</td>
<td>QUANTITATIVE MEASUREMENT OF BIOFILM</td>
<td>98</td>
</tr>
<tr>
<td>E</td>
<td>ANTI-FREEZE</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>GLOSSARY</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>REFERENCES AND BIBLIOGRAPHY</td>
<td>103</td>
</tr>
</tbody>
</table>
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
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.
BSRIA — the built environment experts

BSRIA gives you confidence in design, added value in manufacture, competitive advantage in marketing, profitable construction, and efficient buildings

- Testing
- Modelling
- Research
- Consultancy
- Instrument hire, sales and calibration
- Troubleshooting
- Information
- Training
- Publications
- Market research and intelligence

Whatever your building services requirement contact BSRIA:

T: +44 (0)1344 465600
F: +44 (0)1344 465626
E: bsria@bsria.co.uk
W: www.bsria.co.uk

Membership is the foundation of BSRIA’s expertise and independence

Old Bracknell Lane West, Bracknell, Berkshire, RG12 7AH, UK

Offices in Bracknell, Beijing, Dunfermline, Kuala Lumpur, Ottawa, St Helens, Stuttgart and Toulouse. Associates in Armagh