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Sampling and monitoring of water from building services closed systems – Code of practice

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Contents

Foreword *ii*

0	Introduction	1
1	Scope	1
2	Normative references	2
3	Terms and definitions	3
4	Design of the sampling programme	4
5	Sample locations and frequency	11
6	Sampling methodology	15
7	Documentation and reporting of results	22
8	Interpretation of results	23

Annexes

Annex A (normative) Sampling points	24
Annex B (normative) Laboratory analytical methods for water quality sampling	25
Annex C (informative) Method for detecting sulfate reducing bacteria (SRBs)	33
Annex D (informative) Minimum performance requirements for on-site analysis	36
Annex E (normative) Interpretation of results for pre-commission cleaning	36
Bibliography	39

List of figures

Figure A.1 – Binder pressure test point for sampling dissolved oxygen	25
Figure E.1 – Interpretation of guidelines in relation to BSRIA BG29	38

List of tables

Table 1 – Life stages of the closed-circuit water system	5
Table 2 – Suggested analyses	8
Table 2 – Suggested analyses	9
Table 3 – Examples of corrosion and scale inhibitors	10
Table 4 – Examples of analysis for permit to discharge application	11
Table 5 – Number of sample locations between filling/pressure testing and pre-commission cleaning	12
Table 6 – Minimum number of sample locations immediately post-clean and up to practical completion	14
Table A.1 – Selection of sampling points	24
Table B.1 – Reference analytical methods	32
Table C.1 – Probabilities of detecting the presence of SRBs using the five-day test	34
Table D.1 – Minimum performance requirements for on-site analysis of water in building services closed systems	36

Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 40, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under license from The British Standards Institution, and came into effect on 30 November 2012. 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.

Use of this document

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

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its 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 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.

0 Introduction

This British Standard addresses the particular issues of sampling water from closed-circuit heating and cooling systems in buildings and related infrastructure, from construction, pressure testing, pre-commission cleaning and commissioning to routine operation. The purpose of sampling a closed-circuit water system is to provide information about the current condition of that system and/or the water within it. That might include, but is not limited to, water treatment status, water quality, bacteriological contamination and corrosion activity. Confidence in the results obtained, which are crucially dependent on consistent sampling and analysis protocols, is extremely important to industry.

Sampling of water used to fill the system is used to assess whether the water is suitable for unrestricted use or requires pre-treatment.

Sampling of system water between filling and pre-commission cleaning is used to monitor the growth of bacteria that could lead to long-term corrosion and water quality problems.

Sampling of system water on completion of pre-commission cleaning is used to verify the success of the pipework flushing and cleaning procedures. Failure to achieve industry guidelines on system cleanliness can result in expensive remedial work and contractual disputes.

Sampling of system water prior to practical completion is used to demonstrate that the system is fit to be handed over.

Sampling of system water during normal operation is used to establish that the water treatment regime is being correctly applied and is effective in minimizing the risk of corrosion and other water quality issues.

Sampling prior to discharge of water from the system is used to apply for, and establish compliance with, discharge permits.

This standard does not set guidelines for water quality; only the sampling and analysis methods that are recommended to assess whether guidelines set by others have been achieved. These are critical in the commissioning and lifecycle maintenance of closed-circuit system heating and cooling systems in new and renovated buildings to prevent the onset of operational problems and premature failure.

1 Scope

This British Standard gives recommendations and guidance for the sampling of water from closed-circuit heating and cooling systems in buildings and related infrastructure to maintain water quality and the integrity of pipework, plant and fittings, including:

- a) hydronic space heating and cooling systems;
- b) heat pump ground and water loops;
- c) thermal storage systems;
- d) closed-circuit condenser water systems;
- e) low-temperature district heating and cooling mains;
- f) generator cooling systems; and
- g) similar closed-circuit water systems.

The standard gives recommendations for the design of the sampling programme during each phase of the system lifecycle, including the location and suitability of sampling points, frequency of sampling and record keeping, to facilitate the control of closed system water quality throughout the life of the building.

It also gives guidance on:

- 1) procedures for the collection, preservation, handling and storage of samples prior to analysis (by reference to BS EN ISO 5667-3); analytical methods (by reference to other British Standards and approved methods) and the statistical treatment of results; and
- 2) the selection of the analytical parameters appropriate to the sampled system and life stage.

This standard does not provide guidance on the interpretation of results or associated action levels. These matters are discussed in other standards and industry guides, e.g. BSRIA BG29.

This standard is not applicable to sampling water from open circuit systems such as:

- i) cold water services (see BS 7592 and BS ISO 5667-5);
- ii) open circuit cooling towers and cooling ponds;
- iii) steam boiler plant (see BS 6068-6.7 and BS 2486); or
- iv) sprinkler systems.

NOTE Annex A gives recommendations for sampling points. Annex B gives guidance and recommendations for appropriate laboratory analytical methods for water quality sampling, while Annex C describes the application of a statistical method for detecting sulfate reducing bacteria (SRBs). Annex D summarizes the minimum performance requirements for on-site analysis of common parameters using test kits and portable instruments. Guidance on the interpretation of sample results for pre-commission cleaning with respect to the guidelines in BSRIA BG29 is given in Annex E.

2 Normative references

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

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

BS 6068-2.11, *Water quality – Part 2: Physical, chemical and biochemical methods – Section 2.11: Determination of ammonium: manual spectrometric method*

BS 6068-2.34, *Water quality – Part 2: Physical, chemical and biochemical methods – Section 2.34: Method for the determination of the chemical oxygen demand*

BS EN 872, *Water quality – Determination of suspended solids – Method by filtration through glass fibre filters*

BS EN 15216, *Characterization of waste – Determination of total dissolved solids (TDS) in water and eluates*

BS EN 27888, *Water quality – Method for the determination of electrical conductivity*

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

BS EN ISO 9963-1, *Water quality – Determination of alkalinity – Part 1: Determination of total and composite alkalinity*

BS ISO 10523, *Water quality – Determination of pH*

BS ISO 17381, *Water quality – Selection and application of ready-to-use test kit methods in water analysis*

BSRIA BG29, *Pre-commission cleaning of pipework systems*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 back-flushing

process of removing debris from a terminal unit by discharging system water from a convenient drain point such that the direction of flow through the terminal unit is opposite to the normal operating flow

3.2 binder point

self-sealing pressure test point from which fluid can be discharged by insertion of a matching needle probe

3.3 cleaning specialist

person or organization appointed to carry out pre-commission cleaning of a heating, cooling or other closed pipework system and related activities

3.4 fixed sample point

preselected sample point used on every occasion when samples are taken, in order to allow comparison between results for different sampling occasions

NOTE Results for insoluble material reflect the concentration of suspended solids in the circulating water, plus the mobile solids that have accumulated in that location only since the last sampling.

3.5 forward-flushing

process of removing debris from a terminal unit by discharging system water from a convenient drain point such that the direction of flow through the terminal unit is the same as the normal operating flow

3.6 method statement

detailed description of the on-site work activity, including preparatory works and access provisions

3.7 practical completion (PC)

point of issuing a certificate of practical completion of construction works for the relevant system by the responsible person appointed by or on behalf of the client, after which responsibility for that system passes to the client

NOTE All installation, commissioning and remedial works are assumed to have been completed.

3.8 pre-commission cleaning (PCC)

process of bringing a new pipework system to a satisfactory state for commissioning and ongoing maintenance of water quality

3.9 pseudomonad

bacteria from the genera *pseudomonas* and *burkholderia*

3.10 random sample point

point selected at the time of sampling that is not routinely sampled

3.11 representative sample point (for repetitive sampling)

sample point selected at the time of sampling and used to demonstrate water quality at that location at the time of sampling

NOTE Results for insoluble material reflect the concentration of suspended solids in the circulating water plus the mobile solids that have accumulated in that location since the system was last filled or flushed.

3.12 sampling and analysis plan

detailed description of the objectives of sampling, numbers and locations of samples, and the analyses to be carried out for each sample and applicable guidelines for the result

NOTE A different sampling and analysis plan is required for each life stage of the building or system.

3.13 water quality specialist

person or organization appointed to maintain the water quality and manage the corrosion risk within a heating, cooling or other closed pipework system

4 Design of the sampling programme

4.1 Life stages of the building and system

The objective of sampling a closed-circuit water system in a building or related infrastructure is to provide information about the current condition of that system and/or the water within it.

The objective and requirements for sampling and analysis vary according to the life stage of the system and buildings may contain multiple systems. The applicable sample locations, frequency of sampling and parameters should be selected from Table 1.

A detailed sampling and analysis plan to achieve these objectives for each life stage of the system should be prepared by the cleaning or water quality specialist in accordance with 4.2 to 4.5 and Clause 5.

Table 1 Life stages of the closed-circuit water system (1 of 2)

Life stage	Samples	Objective	Timing and frequency	(Sub) Clause
Design	Proposed fill water	Evaluate suitability of water supply and any treatment measures that might be required	As soon as water source is identified (if sufficient information is not already available from water undertaker)	—
Installation of pipework	No sampling required	NA	NA	NA
Filling and pressure testing ^{A)}	Supplied water at point of connection	Assess quality of supplied water and whether treatment is required	Before initial fill and pressure test	
	System water after filling and treatment	Monitor water quality and concentration of water treatment chemicals	On completion of fill and system treatment At suitable intervals, the final samples being taken within 14 days of the start of pre-commission cleaning ^{B)}	5.1
Pre-commission cleaning (PCC)	System water during chemical cleaning ^{C)}	Verify concentration and distribution of cleaning chemicals	On completion of addition of chemicals	5.3.1
			During cleaning	—
			On completion of clean	5.3.2
	System water on completion of flushing	Verify removal of cleaning chemicals and debris	On completion of flushing	5.3.2
	System water after PCC and treatment	Verify success of pre-commission cleaning and monitor ongoing condition of system, including chemical and microbiological parameters throughout the system	Seven days after completion of pre-commission cleaning and system treatment	5.4.1
Commissioning	System water	Monitor and maintain water quality	At least every 14 days until practical completion and handover	5.4.2
Practical completion (PC) and handover	System water at practical completion	Verify condition of system water and concentration of treatment chemicals	At practical completion	5.4.3
Minor modifications to existing system	System water	Monitor and maintain water quality	Before and after modification	—

Table 1 Life stages of the closed-circuit water system (2 of 2)

Life stage	Samples	Objective	Timing and frequency	(Sub) Clause
Significant additions to existing systems, including shell and core fit out projects	Base build water and new system water before connection	Verify acceptable condition of water quality in additional pipework prior to connection to base build Assess water quality in base build prior to connection and identify any measures required	On completion of pre-commission cleaning and treatment of additional system, before connection to base build	5.4.1
Normal operation	System water	Monitor and maintain water quality	Periodically through the life of the system At least every three months ^{D)}	5.5
Drain-down at any time	See note	Information required for discharge permit or other disposal method	Before drain-down of system water	—
Demolition	System water	Information required for discharge permit or other disposal method	Before drain-down of system water	5.6

A) Pressure testing of prefabricated pipework modules may be carried out off site.

B) At this stage the system is filled but not pressurized or circulated. The impact of loss of volume due to system sampling should be considered and kept to a minimum to avoid air ingress.

C) At this stage the main plant and terminal units is not open to the system.

D) Some business critical or process critical systems might require more frequent monitoring.

NOTE See Clause 5 for detailed recommendations on sampling frequency.

4.2 Sampling

Sampling should be carried out using appropriate methodologies and equipment to ensure that the results obtained from subsequent analyses are accurate and meaningful. Samples should be taken at a sufficient number of locations to provide an overall view of the system condition and, where possible, to allow for statistical assessment of the significance of the results. Guidance on the minimum number of samples required is given in Clause 5.

4.3 Sampling points

Provisions for sampling should be considered as early as possible at the design stage of the building. Suitable sampling points should be made available at sufficient locations to provide a representative view of the condition of the water within the system.

All sampling points should be capable of being operated safely, with issues such as the following considered:

- pressure and temperature of the system to be sampled;
- alternative means of isolation in the event of sampling valve failure;
- local hazards such as sharp edges, hot pipes and live electrical equipment; and
- general access including the need for ladders, staging or access to confined spaces.

Flushing and drain points of not less than 15 mm nominal bore with quarter turn valves may be used as general purpose sampling points provided the dead leg is less than 100 mm.

Samples should not be taken from chemical dosing pots as there is a risk that residual chemical in the pots could affect the result.

Drain cocks conforming to BS 2879 should not be used as general purpose sampling points as they are not suitable for this.

Where no suitable sampling points exist in the functional design of the system, dedicated sampling points of not less than 15 mm nominal bore should be installed in accordance with Annex A.

Pressure test points may be used as sampling points for planktonic microorganisms and dissolved components only.

NOTE 1 Dissolved components include total dissolved solids, soluble ions (including hydrogen ion), glycols and soluble biocides.

Pressure test points should not be used as sampling points for settled solids, suspended solids or "total" analysis of inorganic components as they are not suitable for this.

NOTE 2 Pressure test points are not suitable as sample points for suspended material as the samples obtained would under-represent the concentration of solids in system water due to hydrodynamic effects around the sample point.

Sampling locations in individual systems within typical buildings should include pumps (delivery side), risers, distribution circuits and other sampling locations as set out in the sampling and analysis plan. These other sampling locations may include, but are not limited to:

- 1) air handling units;
- 2) fan coils;
- 3) chilled beams;
- 4) underfloor heating manifold;
- 5) domestic hot water calorifier primary;
- 6) heat store;
- 7) heat exchanger primary and/or secondary;
- 8) condenser and chilled water at chiller;
- 9) heating boilers;
- 10) dry coolers;
- 11) pressurization sets;
- 12) standby generator cooling; and
- 13) district heating and cooling supply.

Proposed sampling points should be documented in the sampling and analysis plan and cross-referenced to system schematics.

NOTE 3 Representative sample points are to be selected at the time of sampling.

4.4 Types of sample

The types of sample to be taken depend on the objectives of sampling and the proposed analyses. These factors define the acceptable sampling points and sampling methodology, the types and volumes of containers and subsequent sample handling. These details should be included in the sampling and analysis plan.

4.5 Analysis

4.5.1 Analysis for water quality

The proposed scope of analysis for water quality should be documented in the sampling and analysis plan.

NOTE Table 2 suggests the scope of analyses (excluding water treatment chemicals) that might be required to assess water quality during the life of the system. Other analyses may be proposed by the cleaning or water quality specialist, e.g. suspicion of excessive corrosion, severe biofouling or investigation of anomalous results. Water source sampling and analysis ought to be repeated prior to any works on the system that involve significant water replacement. Appropriate analytical methods are referenced in Annex B.

Table 2 Suggested analyses (1 of 2)

Parameter	Life stage						
	Before filling (source water)	Post pressure testing	After pre-commission cleaning	Between pre-commission cleaning and practical completion	Practical completion and handover	Routine operation	Pre-discharge
Suspended solids (see 4.5.2)	W		P	P	P	P	P ^{A)}
Settled solids (see 4.5.2)			R	R	R	Z	
Total dissolved solids: gravimetric			R		R	Z	Z
Conductivity	W	R	R	P	R	P	
pH	W	R	P	P	P	P	P
Visual appearance	W	R	R	R	R	P	
Odour	W	R	R	R	R	P	
Dissolved oxygen				Z	Z	Z	
Chemical oxygen demand							P
Total organic carbon							P ^{B)}
Total alkalinity	W				P	P	
p alkalinity (pH 8.3)	W		Z	Z	Z	Z	
Total hardness	W		P		P	P	
Ammonia			Z		Z	Z	P
Nitrite			R	P	P	P	P
Nitrate				Z	Z	Z	
Sulfate	W		P	P	P	P	P
Chloride	W		P		P	P	P
Total iron			R	R	R	R	
Dissolved iron			R	R	R	R	
Total copper				R	R	R	P
Dissolved copper				Z	Z	Z	Z
Aluminium				Z	Z	Z	Z
Total zinc			Z	Z	P	Z	Z

Table 2 Suggested analyses (2 of 2)

Parameter	Life stage						
	Before filling (source water)	Post pressure testing	After pre-commission cleaning	Between pre-commission cleaning and practical completion	Practical completion and handover	Routine operation	Pre-discharge
Scale and corrosion inhibitors (see 4.5.3)		Z ^{C)}	Z	Z	Z	Z	Z
Biocides (see 4.5.4)		Z	Z	Z	Z	Z	Z
Antifreeze			Z ^{D)}	Z ^{D)}	Z ^{D)}	Z ^{D)}	Z ^{D)}
Total viable count at 22 °C	W	R	R	R	R	R	
Total viable count at 37 °C ^{E)}	Z			Z	Z	Z	
Pseudomonads 30 °C	W	R	R	R	R	R	
Sulfate reducing bacteria	W	R	R	R	R	R	
Nitrite/nitrate reducing bacteria				Z	Z	Z	
Nitrite oxidizing bacteria					Z	Z	
<i>Legionella</i> bacteria	Z ^{F)}	Z ^{F)}					

Key to sample locations

W = Source water supply point

P = Circulating pump (delivery side)

R = Representative points for the relevant life stage of the building (including circulating pump) as detailed in the sampling and analysis plan.

Z = If advised, at the locations advised, by the cleaning or water quality specialist.

^{A)} Suspended solids are usually acceptable to the sewerage undertaker as an alternative to "settled solids" for the purpose of the discharge application.^{B)} If required by sewerage undertaker (see Table 4).^{C)} If corrosion inhibitor is used at this stage.^{D)} For chilled water circuits, e.g. ethylene glycol or propylene glycol. At circulating pump.^{E)} TVC at 37 °C is not required for pre-commission cleaning activity but might be relevant in the routine operation of some plant.^{F)} If required by *Legionella* risk assessment. Locations to be advised by the *Legionella* risk assessor.

Where on-site analysis is used, methods should be traceable and the reagents used within manufacturer's declared shelf life. Where instruments are used, these should be calibrated in accordance with manufacturer's recommendations and service interval. Records should be maintained of all time-sensitive field equipment.

Chemical sampling after inhibitor dosing should not be undertaken until full circulation has been assured.

Microbiological samples should not be taken until seven days after biocide dosing.

4.5.2 Analysis for solids

Sampling for solids should be carried out in accordance with 6.3 and the analyses described in B.2.

NOTE Both suspended and settled solids are important in the assessment of water quality for closed systems. In this standard they are differentiated by the method of sampling, not by the method of analysis.

4.5.3 Analysis for corrosion and scale inhibitors

The analyses to be used to quantify the levels of active inhibitors in the system and control limits to be maintained should be confirmed with the chemical supplier. The proposed scope of analysis should be clearly documented in the sampling and analysis plan and handover information.

NOTE Proprietary water treatment products often employ a blend of inhibitors, for example nitrite, molybdate and azoles. All major inhibitor components ought to be included in the analyses where they are used in the inhibitor product. Table 3 lists inhibitors that might be found in water treatment products. Appropriate analytical methods are referenced in Annex B.

Table 3 Examples of corrosion and scale inhibitors

Component	Function
Nitrite	Corrosion inhibitor
Molybdate	Corrosion inhibitor
Borate	pH buffer, biocide, corrosion inhibitor
Sulfite	Oxygen scavenger
Tannin	Corrosion inhibitor
Phosphonate	Scale inhibitor, corrosion inhibitor
Phosphate	Corrosion inhibitor for steel
Polymers	Scale inhibitor
Silicate	Corrosion inhibitor for steel
Azoles	Corrosion inhibitors for copper

Checks should be made that the product data sheet expresses the control limits for the product using the same units of measurement as the laboratory or converted by the appropriate factor.

Any deviations from control limits should be reported to the relevant person for use in determining appropriate corrective action.

4.5.4 Analysis for biocides

Sampling and analysis for biocides when required, including the use of appropriate sample containers and preservatives, should be carried out in accordance with the biocide supplier's recommendations.

Test kits may be used where these are recommended by the biocide supplier. Copies of the instructions, calibration charts and material safety data sheets should be included with the method statement.

NOTE Biocide analysis is not usually carried out in closed systems unless there are specific queries in relation to biocide persistence and effectiveness.

4.5.5 Analysis during cleaning processes

Additional sampling and analysis may be conducted during pre-commission cleaning or pre-cleaning procedures to verify active concentrations of cleaning chemicals and residues of those chemicals or their reaction products after flushing. The cleaning or water quality specialist should consult with the chemical supplier regarding the appropriate analyses and concentrations of chemical to be achieved.