ICOM Energy Association

Water Treatment and Conditioning of Commercial Heating Systems Guide

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INDEX

Appendix

Figures & Tables

1 Introduction

ICOM Energy Association is a not-for-profit members' organisation, representing the UK commercial and industrial heating equipment manufacturers. ICOM members are manufacturers of commercial and industrial boilers, water heaters, air heaters, radiant heaters, water treatment, burners and industrial process equipment.

This guide was started because the commercial boiler manufacturers raised the issue of poor water treatment and conditioning in commercial heating systems, which in turn caused problems with the appliance and ancillary components.

The guide has been written from the boiler and heating system point of view and, as is evident from the acknowledgements, many of the leading commercial boiler manufacturers have had their input into writing this guide.

The treatment of water in closed and open heating systems is essential for the avoidance of fouling, biofouling, corrosion and scale. These problems can result in energy wastage, poor system performance and the need for early replacement of heating system components.

The consequences of inappropriate or non-existent water treatment can prove costly to rectify.

Any installation must be thoroughly flushed and cleaned before it can be filled and used.

Under no circumstances should boilers be fired **before** the system water has been treated. If an installation is not flushed and/or if the system water is not of the right quality, it may invalidate the manufacturer's warranty.

Due to the presence of dissimilar metals in heating systems and to avoid problems with the heating system components and installation, a suitable inhibitor and biocide must be applied to protect all metals present in the system.

Accordingly the advice of a water treatment specialist is recommended to establish and maintain the limiting values and to control the composition of the heating system water.

It is therefore essential that the heating system water is treated by a suitably competent person/ operative i.e. someone who has undergone education and training on the subject matter and can demonstrate experience in applying that knowledge - refer to Appendix B.

About this guide

This comprehensive guide deals with all aspects of water treatment for commercial heating systems. We trust that by studying the contents and following the freely given advice your heating systems will operate trouble free, safely and more efficiently.

Having considered who is responsible for looking after and managing the safe operation of commercial heating systems, ICOM agreed to write this guide, with the help of our respective members.

It is aimed as a document that can be read and understood by plant operators, engineers and personnel with limited or no knowledge of water treatment chemistry. It is also intended to help them understand what effect any water and its subsequent treatment will have on their heating system.

Naturally, we cannot accept any liability for the information provided in this guide. However, be assured that we have consulted widely with our member companies during the compilation of the guide.

Acknowledgements

Our thanks go to those people listed below in compiling this document, who have given their time freely during the process and to all other members of ICOM who have been consulted and have contributed to this guide.

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Pete Mills	Bosch Commercial and Industrial Heating
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Roger Williams	Spirotech UK Ltd
Bob Walsh	ICOM Energy Association
Ross Anderson	ICOM Energy Association
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2 Scope:

Low temperature commercial heating systems above 45kW.

3 Exclusions:

Heating systems with operating temperatures greater than 105ºC, domestic hot water supplies, steam or process heating & industrial systems

4 Regulations

4.1 The **Health and Safety at Work 1974** requires that the following regulations (as amended) must be taken into account by all operatives:

- Management of Health and Safety at Work Regulations 1999
- Personal Protective Equipment at Work Regulations 1992
- Control of Substances Hazardous To Health Regulations 2002
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995
- Confined Spaces Regulations 1997
- Electricity at Work Regulations 1989
- The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009

4.2 Attention is drawn to the following documents for best practice:

- BG04 ICOM & CEA Industrial Boiler Water Treatment Guide
- BSRIA documents: BG29/2012 (Pre-commission cleaning of pipe work systems) & BG50/2013 (Water treatment for closed heating and cooling systems)
- BS 6798 - Specification for selection, installation, inspection, commissioning, servicing and maintenance of gas-fired boilers-not exceeding 70kW net input (for reference only)
- BS 7593 Code of practice for treatment of water in domestic hot water central heating systems (for reference only)
- BS 8552 (Sampling and monitoring of water from building services closed systems)
- BS EN12828 (Heating systems in buildings. Design for water-based heating systems)
- BS EN14743 (Water conditioning equipment inside buildings. Softeners. Requirements for performance, safety and testing)
- BEAMA Code of Practice for Chemical Cleaning and Inhibiting of Domestic Hot Water Central Heating Systems

Note: The ICOM Water Treatment guide acknowledges the existence of the German guidance VDI 2035 (Prevention of damage in water heating installations) and that many European appliance manufacturers may base their own water treatment guidance upon this document. However VDI 2035 is not a recognised UK guideline and since there is concern from UK water treatment specialists that the methods describe in VDI 2035 may not be suited to UK systems, the ICOM Water Treatment guide will reference only recognised UK standards and guidance documents for the basis of the methods contained within this document.

With some European equipment manufacturers referring to the VDI document, it would be prudent to discuss any water quality matters with the equipment manufacturer.

5 Water Quality

5.1 Analysis

All heating systems maintain efficiency with clean, good quality system water. The most prevalent factors influencing the quality of heating system water are: oxygen content, total hardness, conductivity, suspended solids, total metals, chlorides, settled sludge, sulphate, micro-biological activity and pH.

Chemical analysis of the heating system and make-up water will determine the quality of the water by identifying the composition and concentration of the above factors. A plan to implement the appropriate corrective actions can then be formulated.

A detailed analysis of make-up water is essential prior to any cleaning/treatment programme, and a detailed assessment of system design & volume, materials of construction and mode of operation must be carried out before a suitable programme can be developed. Pre-treatment of the make-up water may be required to achieve the desired system water quality.

Note: As the formative period of the heating system operation is dynamic, monitoring should be carried out until stable conditions are present, thus validating the condition of the heating system water quality.

When using non-metallic pipes and fittings, these must be compliant with BS7291 to prevent oxygen diffusion.

When an installation is regularly topped up with significant quantities of fresh untreated water, more oxygen and other compounds (including calcium hardness) may be introduced to the heating system. Avoidance of regular make-up of heating systems requires the resolution of any leaks and monitoring of make-up water usage. To monitor the volume of make-up water entering the system, it is recommended that a water meter should be fitted and readings recorded in a Water Treatment Log Book to be retained onsite (paper or electronic copy).

Note: Well-designed systems may still require make-up water. However this should be monitored and corrected so as to minimise the impact of the make-up water. Water treatment specialists may give additional guidance on the volume of permitted un-treated water which may be used within a heating system.

5.2 Initial Fill/ Make-up/ Supply Water

Pre-treatment of fill, make-up and supply water may be required to achieve the desired make-up water quality which may then affect the system water quality - refer to equipment manufacturer’s instructions.

If borehole water is to be used, its quality should be ascertained and advice be sought from the water treatment specialist.

Base Exchange (softened), Reverse Osmosis (RO) or De-mineralised (de-ionised) water are all possible types of pre-treated water. Advice should be sought on the water treatment appropriate for each type of water quality.

De-mineralised water treatment is suitable for all kinds of heating system with all types of metals. With this pre-treatment, when corrected for pH, not only are all substances which cause scale formation removed from the fill and top up water, but corrosive agents such as chloride and sulphate are also removed.

It is important to remember that de-mineralised water has no pH buffering capacity and may suffer excursions in pH due to contamination. It is recommended that systems filled with de-mineralised water be treated with an appropriate additive to stabilise pH within a suitable range. Modern corrosion and scale inhibitor formulations often contain components to stabilise pH to different ranges.

BS EN12828 provides guidance for water treatment for heating systems which do not exceed 105ºC.

The use of de-mineralised, RO or softened water treatment are three of the preferred methods for controlling water quality in heating systems under the proviso that;

- all system & cleaning contaminants have been flushed out, as this may increase the alkalinity of the fill water
- a suitable corrosion inhibitor is added
- an additive is added to stabilise pH
- a suitable biocide is added

Where softened water is used, equipment manufacturer's instructions should be followed.

After flushing, the heating system should be filled with suitably treated water as determined by the water treatment specialist and on a case by case basis.

5.3 Methods of System Fill

A water meter should be installed on all heating systems greater than 45kW output, immediately after any pressure maintenance equipment.

5.3.1 Base Exchange

Plant must be suitably specified, preferably incorporating an automatic regeneration function, with sufficient flow to avoid channelling or tracking (short cut by water flow through the resin bed due to inadequate flow rate).

Onsite resin systems should be plumbed in before the system pressure maintenance equipment, usually with flexible connections that allow easy exchange of the resin container. The sizing of the resin system must be suitable to provide the initial system fill within a reasonable time period.

Replacement resin kegs are available which means containers can be flushed out and reused. Used resin can be disposed as normal non-hazardous solid waste.

5.3.2 De-mineralised Water

De-mineralised water is available for delivery to site in IBC containers or can be produced onsite via ion exchange resin systems. For containerised initial filling, a temporary pump arrangement will be required. The entire system should be pressure tested and flushed prior to final system fill with demineralised water. A suitably sized resin system will still be required for the system top up and pressure maintenance equipment, to ensure adequate water quality.

As detailed in BG29, the guidelines for water quality at practical completion represent the minimum requirements for system water quality and must be considered on a case by case basis. It is important to stress that while the specified requirements are applicable to many closed heating systems some of the parameters (particularly the guidelines for soluble metals) are dependent on the specific water treatment products being employed. As a bare minimum, water samples of supply and system water should be taken and sent for analysis and report, by a water treatment specialist. It is the responsibility of the water treatment provider to declare the acceptable range of each parameter in relation to the correct application of their products. For more detailed information refer to BG 29.

Figure 5.4: What does your system water look like?

5.4 Water Treatment

Any water treatment product must be appropriate for all materials used in the heating system, consult a water treatment specialist or the supplier of the water treatment product for further details. Always comply strictly with the guidelines and operating instructions provided by the supplier of the water treatment product. This will involve periodic checks and possibly additional dosing to ensure chemical concentrations are maintained at a suitable level.

The objectives of water treatment (and pre-treatment) are to minimise the corrosion of system metals, to inhibit the formation of mineral scale and inhibit the growth of microbiological organisms. In this way, not only the physical integrity of the system, but its long term efficiency and effectiveness are preserved. Major problems of corrosion, scale and microbiological fouling can be avoided by correct system design and installation to minimise ingress of air into system water, excessive requirement for make-up water, electro-galvanic couplings and use of municipal potable supply water. Account should be taken of long term static periods during times of heating shut down, as these conditions will promote corrosion and micro-biological fouling.

The presence of oxygen is a major factor in the corrosion of ferrous metals on the water side of heating systems. The effects of oxygen can be controlled by several types of additives. It is also necessary to control microbiological activity that could lead to microbiologically induced corrosion (MIC.)

Historically, closed loop heating systems have often been dosed with an electrochemical inhibitor only. This approach is incorrect and a comprehensive treatment regime should be used. A microbiological induced control product should be considered in all cases to minimise microbiologically induced corrosion especially if the temperature is below 70ºC.

Note: Nitrite based inhibitors can be used as a food source by bacteria, in systems not correctly treated with a biocide. This in turn can affect system pH.

- The water quality of a heating installation should be checked at least quarterly. Larger systems may require more frequent checks.
- The user/operator of the installation is responsible for ensuring the installation water is always of a suitable quality. If the user wishes to obtain the required water quality by using water treatment products, they must take responsibility for the treatment.
- All records relating to water treatment products and dosing must be recorded in the log book retained onsite by a suitably trained and competent person. Any work started or completed on the heating installation should also be recorded in the log book (paper or electronic copy).
- It is considered best practice that records include ‘pre-commission cleaning & flushing’ or existing system ‘remediation’ documents which evidence the efficacy of the cleaning process and final water quality on completion which should also include details of flow rates achieved, sample locations and independent analysis of results together with ‘witnessing’ of water quality on completion.

WARNING

Applying water treatments requires great care and attention. If the instructions for the water treatment method are not followed in full, interpreted incorrectly and/or if the method is not implemented properly, this may result in health risks, damage to the environment or damage to the heating system.

pH value at 25ºC	pH Scale units	6.5 to 9.5 * (6.5 to 8.5 where aluminium is present)
Sulphite	ppm	30 to 70
Nitrite	ppm	1000 min
or Tannin	ppm	120 to 160
or Ascorbic Acid	ppm	15 to 30
or Diethyl Hydroxylamine	ppm	0.1 to 1.0
Molybdate	ppm	200 min steel 300 min aluminium refer to water treatment specialists
Suspended solids	ppm	30 max.
Total Dissolved solids	ppm	3500 max Dependent on type of make-up water and system inhibitor used
Total bacteriological activity	Cfu/ml	<1000
NRB's/SRB's/Pseudomonas(Sp)	Cfu/ml	Nil

Table 1: Typical water treatment test parameters for hot water boiler systems

Note: The parameters and values detailed are indicative and should be considered on a case by case basis in consultation with the water treatment specialist.

5.5 System Design

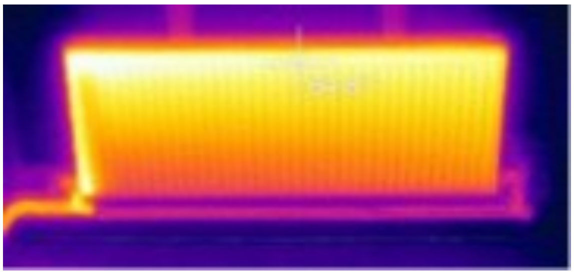
It is important that water treatment is considered at the design stage of a project and that the design intent is effectively communicated to the installer. System designers have an opportunity to assess suitable water treatment methods at the outset, based on the specified mechanical equipment and pipe work for a project. Advice from water treatment specialists and manufacturers can be incorporated into the written specification for the project to ensure the design intent is not lost.

For the purpose of clarity and so as to avoid confusion in the terminology used, all commercial heating systems are closed (as defined by water treatment specialists), even the open vented systems. However in heating systems, the term closed refers to sealed (pressurised) systems, with no open vent.

Within the UK Commercial Heating sector, due to the maturity of the market, **open vented** systems are prevalent. However with the replacement of old boilers with modern condensing or high efficiency boilers, **closed** systems are becoming the norm. Accordingly a greater emphasis must be placed on existing systems from a water quality perspective, as there are more unknowns due to the age of the system.

The requirements for a new system may not be as onerous but the same processes should be applied. Before commencing flushing and cleaning, adequately sized flushing points must be installed (if not already installed) on the flow and return pipe-work or headers to ensure the required flushing velocities are obtainable - refer to table 2 section 5.6.1.

A thorough system clean not only restores system efficiency and effectiveness, but is critical in preparing interior surfaces for effective corrosion and scale inhibition. Before cleaning, the system should be examined to determine the system configuration, the age and overall condition of components and the nature of the contamination that needs to be cleaned in order to decide the most appropriate cleaning agent and cleaning method.



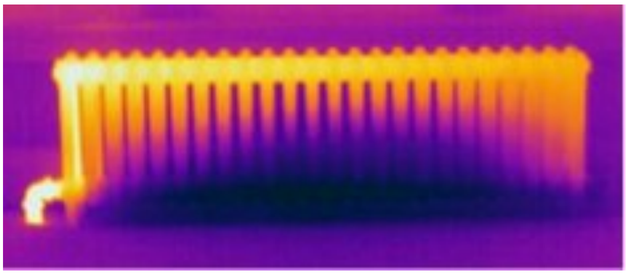


Figure 5.5: Clean Radiator (L) and Blocked Radiator (R)

For more details on system design and equipment, refer to Appendix A of this document.

5.5.1 Existing Systems

It is important to establish the water volume of the system so that the correct proportions of treatment can be formulated.

Flush the heating system thoroughly (either by balanced flushing or power flushing, as appropriate) to remove dirt and sludge deposits before connecting any new equipment to an existing heating system. Otherwise, dirt and sludge will be deposited and can lead to local overheating, noise and corrosion. Equipment damage caused by such deposits may be excluded from manufacturers' warranties.

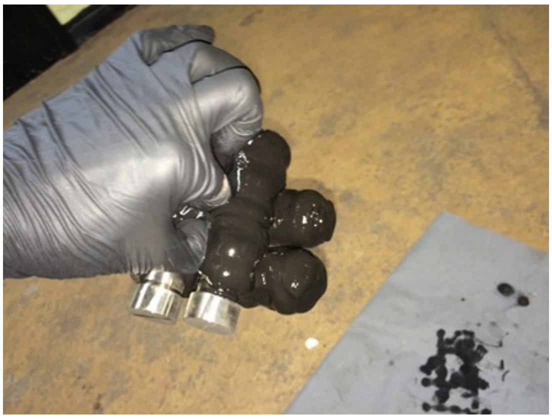


Figure 5.5.1: Contamination by High Levels of Suspended Solids

Install filters & dirt separators to protect the system. Systems with high levels of suspended solids should be treated with appropriate filtration device(s), with or without chemical assistance. Notwithstanding the above, under no circumstances should the fitting of such devices be a substitute for a suitable clean and thorough flush of the heating system. In some instances, it may be necessary to separate the boiler plant from the system using a separating (plate) heat exchanger.

The presence of ‘dead legs’ or idle sections of the heating system must be identified and consideration given to re-design of the system to manage system temperatures to be above 70ºC or by the application of an appropriate biocide to the system water.

Figure 5.5.2: Separating Plate Heat Exchanger (with isolation valves)

A system schematic diagram detailing the complete hydraulic circuit should be available and updated with any changes to the system.

5.5.2 New Systems

Although new systems may not suffer the accumulated fouling experienced in existing systems, nevertheless regimented cleaning, flushing and dosing regimes are required to ensure the integrity of the system and to deal with new equipment production and installation residues present in the new system. Passivation can also be carried out to ensure a good anti-corrosive film is laid down at the outset.

Preferably, cleaning of new systems should utilise chemical cleaners specifically formulated for new systems and which provide metal passivation or other means of corrosion protection to limit the effects of flash corrosion due to temporarily high levels of dissolved oxygen entering the system. Otherwise, flushing should be carried out as appropriate to the system.

A system schematic diagram detailing the complete hydraulic circuit should be provided and updated with any changes to the system.

5.5.3 Pressurisation

Pressurisation equipment is installed in order to manage the differences in volume of the heating system water occurring due to changes in temperature. The pressurisation unit provides system warning indicators and interlocks and can be applicable to open or closed central heating systems.

For all closed systems, the use of a pressurisation unit is recommended - refer to Appendix A4.

5.5.4 De-aeration

The presence of air in heating systems is undesirable but unfortunately also unavoidable. It occurs in 3 forms: free air, micro-bubbles and dissolved air; each requiring a dedicated mechanism for removal.

For all systems, the use of de-aeration devices is recommended - refer to Appendix A5.

5.5.5 Filtration

Contamination of the system water can never be fully prevented. The dirt (contamination) largely consists of corrosion particles which may be magnetic and seek out the magnetic fields in pumps, valves and control valves. Other dirt particles will be pumped round the system and will eventually collect in critical components or areas. This will result in unnecessary energy consumption, reduced efficiency, faults and failure, and recurring complaints.

There are a number of devices used to remove contamination from the system; strainers, filters, magnetic filters, dirt separators, combined air & dirt separators & side stream filtration.

Figure 5.5.5: Contamination of Butterfly Valve

For all systems, the use of filtration devices is recommended - refer to Appendix A6.

5.5.6 Dosing

The chemical dosing system should be sized relative to the system volume to allow sufficient quantities of treatment chemicals to be added.

For small systems, a dosing pot, or solid feeder may be used for maintenance treatments. It is important that the dosing pot or solid feeder remains open to the system, with the flow through it to avoid any potential microbiological growths or a dead leg of system water occurring within the dosing pot and it's connecting pipe work.

Note: Dead legs can encourage corrosion of the pipe and vessel components and any bacteria or corrosion debris will be introduced into the main system when the dosing pot is opened to the system. For initial dosing or maintenance dosing of larger systems, treatment can be achieved by dosing pumps or solid chemical feeder systems.

For all systems, the use of dosing devices is recommended - refer to Appendix A7.

5.6 Flushing

At each stage of flushing, a consent to discharge should be sought from the local water utility.

Primary heating circuits should be thoroughly flushed prior to commissioning, re-commissioning following major remedial works or if known or suspected to be affected by corrosion, settled sludge, deposits, build-up of scale on heat transfer surfaces, gassing or cold spots.

Guidance from a water treatment specialist should be sought in choosing a flushing process appropriate to the system.

Prior to carrying out any flushing, reference must be made to system equipment manufacturers so as not to invalidate any warranties. Equipment damage caused by system debris may be excluded from manufacturer's warranty.

After each stage of the flushing process, representative water samples should be taken, witnessed by the client representative and signed off on a service/work sheet. Duplicate water samples should be retained. A certificate to confirm the water condition should be attached to the work completion certificate, and accepted with a counter signature by the client representative.

Figure 5.6: Dirty Strainer

5.6.1 Flushing and Sampling Points

Sampling during flushing and cleaning should be carried out around the system, in particular at its extremities and any terminal units, to ensure adequate flushing throughout the system. The location of sampling points and sampling methodology should be in accordance with the requirements of BS8552. Install suitable sampling points on the make-up supply and heating system to ensure;

- consistency of the location of drawn samples irrespective of who takes the sample
- the sample point locations are representative of the whole system
- the sample points are clearly identified

The water velocity for flushing and cleaning should be sufficient to penetrate, dislodge, suspend and transport insoluble debris from the system. It should also ensure even temperature around the system for optimum effectiveness of the chemical cleaner. Flushing velocity should be based on the largest pipe diameter in the system or zone to be flushed. Effective minimum flush velocities for horizontal pipe provide sufficient turbulent flow (Reynolds number > 4000) and are listed in Table 2.

Nominal Pipe Size (mm)	Flushing Velocity (m/s)	Flushing Volume (l/s)
20	1.00	0.37
30	1.05	0.96
40	1.08	1.50
50	1.11	2.45
80	1.17	6.00
100	1.22	10.50

Table 2: Flushing Velocities (boiler isolated)

It may be difficult to attain sufficient flushing velocities in primary circuits having pipe bores more than 100mm and in such circumstances it is advisable to adopt alternative cleaning protocols such as the addition of chemical dispersants to help suspend particulate debris or as a last resort, direct access for physical cleaning.

5.6.2 Looping out Sensitive Equipment

Consideration must be given to looping out all sensitive equipment having small bore pipework and/or low lift valves to ensure they do not become blocked during the flushing /cleaning procedures. In this regard, it is important that the system equipment manufacturers' instructions be carefully followed prior to cleaning.

5.6.3 Static Flushing

The system should be filled with mains water and where appropriate a suitable biocide added, then fully circulated and drained rapidly from the system low points/flushing points.

For closed systems, consideration of the pre-charge pressure of the expansion vessel must be taken to avoid overpressure and damage to the diaphragm.

5.6.4 Dynamic Pre-clean Flushing

Dynamic pre-clean flushing can be carried out with or without a chemical cleaner, as stipulated by a water treatment specialist.

An initial dynamic flushing procedure may be performed by pumping in fresh water, and if required using a suitable temporary pump and tank set. Prior to a chemical dynamic flush a pre-flush will remove significant amounts of loose corrosion or installation debris and reduce subsequent system demand for cleaning chemical.

The system pumps should be operational during this procedure (where possible) to help achieve flushing velocities as noted in Table 2, or at least 10% above flow rate design whichever is greater. This procedure helps to remove larger particles of corrosion debris from the system. As noted above, in some cases, due to the size of the primary pipework, it may be difficult to achieve the flushing velocities required in this loop; therefore advance use of a suitable chemical dispersant product prior to flushing can assist the dynamic flush process by encouraging suspension of the loose material.

To help maximise flushing velocities, larger circuits should be divided into individual zones or sections and cleaned separately. Each section of the system being cleaned should be isolated from the rest of the circuit during the flushing process.

The duration of the dynamic flush depends on flush velocity, section size and initial extent and nature of deposits but should be sufficient to achieve an appropriate level of cleanliness. In any case, it should be followed immediately by drain down to ensure optimum removal of the suspended debris. System strainers or filters should be inspected and cleaned throughout the flushing process.

Flush out water cleanliness can be estimated by use of a TDS meter or graduated turbidity tubes.

5.6.5 Choice of Cleaning Chemical

Before cleaning, the system should be examined to determine the system configuration, the age, overall condition of components and the nature of the contamination that needs to be cleaned in order to decide the most appropriate cleaning agent and cleaning method. Water samples should be taken to determine the appropriate water treatment.

The choice of cleaning agent should be under the direction of a water treatment specialist and appropriate for the materials of construction of the system, the type of contamination to be removed, the cleaning method employed and any discharge limitations.

There are many different cleaning and sanitising chemicals available. These range from mild detergent cleaners, which may be designed for cleaning newly installed systems, through cleaners formulated to penetrate, lift and remove sludge and accretions in older systems to strong acid based cleaners, specifically designed to remove high levels of hardened scale deposits and corrosion. Other cleaners are formulated with biocidal ingredients to target and destroy microbiological activity.

Special consideration should be given to systems containing dissimilar metals which are vulnerable to attack. Manufacturer’s recommendations and guidelines regarding the choice / use of chemicals and recommended operating parameters should **always** be followed.

5.6.6 Dynamic Chemical Flushing

Following the initial dynamic flush, the procedure should be repeated with the inclusion of an appropriate chemical cleaner to the system water to dissolve or dislodge and remove adherent iron oxides, sludge, greases, fluxes and scales.

The type and extent of debris, dirt and fouling commonly found inside central heating circuits largely depends on the age and nature of the system and how well or poorly it has been maintained. New systems invariably contain contaminants and debris from component manufacture or from the system installation work itself, whilst older, even well maintained installations may have accumulations of sludge and scale. Microbiological slimes and contamination may be found in all systems regardless of age. The use of inappropriate chemical cleaners on existing systems should be avoided if possible. At the end of the cleaning process, the cleaning chemicals must be flushed from the system which should then be re-treated with inhibitors and biocides.

Water treatment chemical cleaning products should be added via dosing equipment, a solid chemical feeder, pot feeder or flushing pump.

The duration of chemical cleaner circulation in the system or system sub-circuit depends on several factors including the type and thickness of deposits, the temperature and concentration of the cleaning solution, the flow velocity and agitation and its compatibility with materials of construction. Chemical cleaner suppliers' instructions must be followed.

If possible, heating the circulating cleaner solution will enhance the effectiveness of the clean and may shorten the cleaning cycle. The duration of the dynamic chemical clean depends on temperature, flush velocity, section size and initial extent and nature of deposits, and the nature and concentration of the cleaning chemical employed. In all cases, the supplier's instructions must be followed, especially with regard to material compatibility.

Monitoring of the progress of the dynamic chemical clean according to the supplier's instructions may be possible and will indicate when the chemical clean is complete.

Highly acidic or alkaline cleaning solutions must be adjusted to a neutral or near neutral pH (6.0 – 8.5) before discharge to drain. In any case, discharge to drain of the cleaning solution must occur immediately after dynamic chemical flushing in order that solid suspended matter is removed with the cleaning solution and not allowed to resettle in the system. System strainers and filters should be inspected and cleaned throughout the flushing process.

It is often possible to discharge spent cleaning solution directly to foul drain, but permission must be sought from the local municipal water authority, and must be within the requirements of prevailing standards. Such effluent should **never** be discharged to surface drains.

5.7 Cleaning

At each stage of cleaning, a consent to discharge should be sought from the local water utility. Advice should be sought from the water treatment specialist. Reference should be made to section 5.6.6 for contaminants commonly found in heating systems.

After each stage of the cleaning process, representative water samples should be taken, witnessed by the client representative and signed off on a service/work sheet. Duplicate water samples should be retained.

A certificate to confirm the water condition should be attached to the work completion certificate, and accepted with a counter signature by the client.

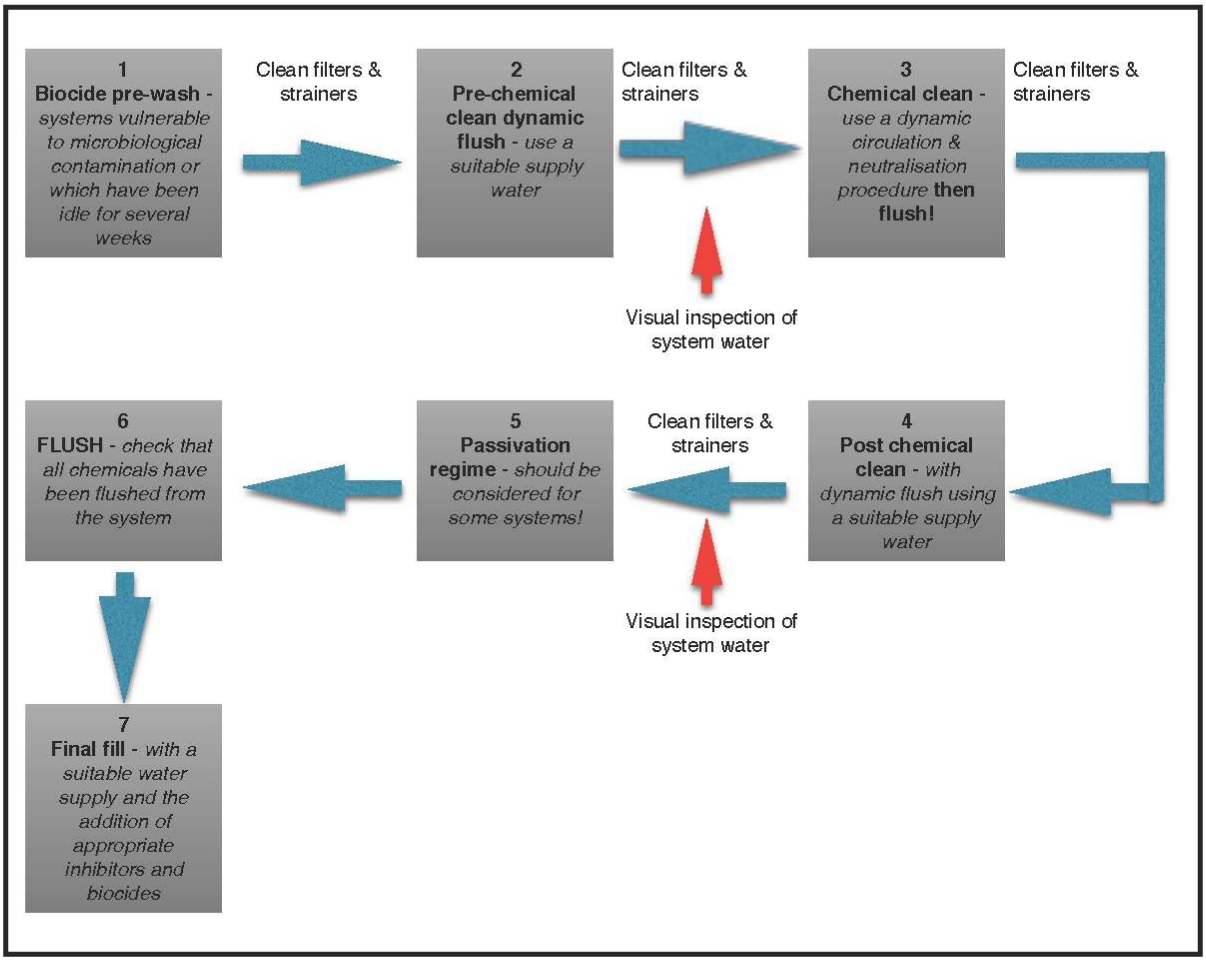


Figure 5.7: Typical Cleaning Programme

5.7.1 Cleaning Programme

A typical cleaning programme for either the entire system or isolated sections of it is detailed in the flow chart and may include temporary pumping facilities and cleaning of filters and strainers.

To aid the cleaning process filtration should be considered. This may be side stream or in line filtration using magnetic filters, dirt separators or strainers. This will aid the cleaning process by continual removal of dirt particles during the programme.

Visual inspection methods for onsite quantitative estimation of water clarity, such as a graduated turbidity tubes or similar should be employed. Some stages may have to be repeated several times to attain satisfactory conditions.

Extra stages may be required in special circumstances, e.g. to effect the removal of greases, neutralise acidic cleaning solution or pre-passivate system metal surfaces and these should be incorporated into the cleaning programme in the appropriate sequence.

5.7.2 Cleaning Methodologies

The type of cleaning method adopted will depend on the system size and complexity, system materials and sensitivity or obstruction of plant items (regulating valves, plate heat exchangers etc.) to the cleaning process. In all cases, the technical requirements for the system cleaning protocol should be prescribed by the system designer and the protocol undertaken by trained and experienced personnel under the auspices of management procedures that ensure safe and effective working practices and adequate record keeping. The specification for cleaning of a system should at least include drawings of the system layout as installed in relation to the building, schedules of materials of construction, system equipment and system components, details of system sectional volumes, the main steps in the cleaning process to be employed and the method of achieving the required flushing velocities to effect an adequate removal of contaminants.

In larger systems, the larger-bore primary distribution sections should be isolated, bypass circuits closed off and the primary section dynamically flushed first. Where the bore diameter makes it difficult to obtain adequate flow velocity, the addition of a chemical dispersant may aid debris suspension or it may need to be accessed and physically cleaned. In systems served by a large bore distribution section, consideration should be given to providing suitable filtration devices to protect system components.

The secondary main pipework sub-circuits should be isolated and cleaned after opening all valves and isolating sensitive equipment.

5.8 Final Full System Flush

Individual, isolated sections may be dynamically flushed with mains supply water. To ensure adequate water quality throughout, the entire system should be finally flushed simultaneously until the quality of the effluent is acceptable. A consent to discharge may be required.

System strainers or filters should be inspected and cleaned throughout the flushing process and any looped out equipment should be back flushed prior to reinstatement.

After the final flushing is complete a chemical corrosion and scale inhibitor product and a biocide additive, should be dosed during, or immediately after the final refilling of the system in order to prevent system deterioration. Inhibitors should be added via a dosing pot, a solid chemical feeder, dosing pump or flushing pump at a concentration recommended by the water treatment specialist or chemical supplier.

6 System Water Treatment

After the final flushing, action must be taken to passivate the cleaned surfaces to prevent system deterioration. The usual practice is to treat the system with inhibitor during or immediately after final re-filling with increased levels of inhibitor sometimes being applied to achieve passivation, since systems often exhibit an increased initial chemical demand, in order to correctly form the passivation film.

A biocide treatment should always be undertaken at this time. Advice should be taken from the water treatment specialist in conjunction with the recommendations of the boiler manufacturer to make sure the correct water treatment approach is followed.

The effectiveness of inhibitors relies on the cleanliness of the system, and hence on the thoroughness of the pre-commission cleaning operation. A corrosion inhibitor should have the following attributes:

- Soluble or easily dispersible in order that it can be evenly distributed and afford protection throughout the system
- Stable and effective across the entire temperature range experienced in the system
- Effective in the system fill water in regard to its quality or hardness. Where fill water is pre-treated by base-exchange softening, reverse osmosis or demineralisation, it is critical that any corrosion inhibitor added is suitable for such waters.
- Inhibits corrosion of all the different metal types in the system
- Non foaming
- For all systems, it is critical that he additive should buffer and stabilise the pH of the system water strictly between pH 6.5 up to pH 9.5
- If the system contains aluminium components, it is critical that the additive should buffer and stabilise the pH of the system water strictly between pH 6.5 and 8.5
- Compatible with all water-facing materials in the system
- Preferable to be able to perform onsite testing for concentration level in the system
- Some inhibitors may have discharge considerations subject to local constraints

Chemical corrosion inhibitors should be added during the final fill of the system at a concentration recommended by the inhibitor manufacturer. It is important that full circulation and homogenous distribution of the additive is achieved before sampling system water to confirm the correct inhibitor concentration, and subsequent adjustment if necessary.

The volume of system water make-up should be monitored, preferably by incorporation of a water meter immediately after any pressure maintenance equipment, so that water treatment chemical losses due to leaks or partial drainage for maintenance work can be replenished. In any case, the concentration of corrosion inhibitor additive and bacterial activity in the system should be checked periodically – at least quarterly for all systems. Larger systems may require more frequent checks.

If antifreeze is used then ensure that a compatible inhibitor and biocide are used, and the effectiveness of each should be measured periodically, at least quarterly. However, if inhibited antifreeze is used, then ensure that the concentration is not lower than the minimum concentration recommended by the supplier, to ensure good corrosion protection.

It is common that chemical scale inhibitors, chemical corrosion inhibitors and pH stabilisers are formulated together in a single product. If added separately, similar precautions should be taken to maintain minimum concentration in the event of replenishment of water losses, as noted above for corrosion inhibitors.

If conditions are favourable, microbiological organisms can proliferate in closed circuit systems. If water temperatures in any part of the circuit never exceed pasteurisation conditions of 70ºC, then it is possible that micro-organisms can thrive.

Systems prone to microbiological fouling should first be cleaned and sanitised as part of a commissioning or periodic cleaning programme, followed by the application of an appropriate biocide to the system water for long term protection. Subsequently routine biocide applications should always be considered.

Note: In the event of any remedial works or change of maintenance operator, which involves a change to the installed water treatment, it is imperative that any change of water treatment programme is compatible with the current treatment regime and that any flushing and drain down regime has been confirmed as successful by the new water treatment supplier. In cases where this is not possible and a new formula is to be added, the building owner should be notified and the system either be flushed, or proof of compatibility provided by the new water treatment supplier, which details the test method and assurance that adding the new treatment formula does not impact the accuracy when testing active reserve levels or the effectiveness of both combined products.

6.1 System Water Treatment Written Control Scheme

This is a scheme arising from the findings of the System Water Treatment Risk Assessment, that records the various control measures to be employed and how to use and carry out those measures. It should describe the water treatment regime in place and the correct operation of the water system plant. The scheme should be both site and boiler/system specific, relating only to water treatment of the boiler plant and so therefore specifically tailored to the boiler plant covered by the System Water Treatment Risk Assessment.

The following list summarises the information that must be included in a System Water Treatment Written Control Scheme.

- Purpose
- Scope
- System Water Treatment Risk Assessment
- Management Structure:
    - Statutory Duty Holder
    - Responsible Person(s) and communication pathways
    - Training records
    - Allocation of responsibilities

- Up to date system schematic diagram including incoming water and system layout
- Correct and safe operation of the system
- Precautions in place to prevent or minimise risks associated with the water treatment of the system
- Analytical tests, other operational checks, inspections and calibrations to be carried out, their frequency and the resulting corrective actions
- Remedial action to be taken in the event that the System Water Treatment Written Control Scheme is shown not to be effective, including Written Control Scheme reviews and any changes made
- Health and safety information, including details on storage, handling, use and disposal of any water treatment chemical products used in both the treatment of the system and its testing
- Incident plan designed to cover the following situations:
    - Plant failure such as complete boiler failure or catastrophic system leak
    - Dosing and control equipment failure
    - Monitoring and data recording equipment or systems failure

7 Commissioning and Handover

Water treatment should form a part of commissioning of the system as a whole. Special consideration should be given to water treatment during the commissioning of boilers or other heat generating plant (CHP, heat pumps etc.) in relation to potential scale deposition on hot surfaces. Whatever form of water treatment has been carried out prior to startup of heat generating plant, the sequence of commissioning should be such that multiple heat generators are bought into operation at low fire rate to increase the total surface area being heated and therefore reduce the risk for any remaining scaling potential building up in concentration. Elevated flow rates during initial startup may help to reduce further the potential for scale formation on the heated surfaces.

Reference to manufacturers commissioning guidance should be made, to ensure their requirements for water treatment and start up procedures are followed.

System water quality tests are recommended after commissioning for all systems, to ensure the values are within those recommended by the equipment manufacturers.

Copies of equipment commissioning sheets and water quality certificates should be kept with the Water Treatment Log Book to be retained onsite or saved on electronic systems.

NOTE: Filters, dirt traps and other separating facilities in the heating system must be checked, cleaned and activated more frequently after commissioning or re-commissioning.

8 Maintenance

System water quality is an important factor for the efficient functioning of a system and should be regarded as a system component and treated as such. Therefore, it should not only be carefully selected but also properly maintained in order to prevent the presence of air and dirt from causing problems, such as;

- Noise in radiators, heat exchangers, pipes and pumps
- Difficult and prolonged commissioning of systems
- The need for frequent manual venting
- Reduced pump performance
- Constrictions and blockages in pipes and boiler components
- Radiators which only heat up partially or not at all
- Premature wear to system components such as heat exchangers, control components, valves and pumps
- Corrosion of pipes and system components
- System malfunctions or even complete system failure
- Complaints from users/residents and the necessary follow-up action
- Unnecessarily high energy consumption
- Increased usage of chemical treatments
- Increased frequency of chemical treatments

It is recommended that the pre-charge pressure of the diaphragm expansion vessel be checked at least during the annual service.

9 Monitoring

Fill water, including water that is treated for use in the system, should be sampled at the supply point at the following frequencies:

- Within 14 days of first fill & pressure test
- Within 14 days of pre-commissioning cleaning
- Whenever the make-up supply water quality is changed
- At other times, locations and frequencies recommended by the water treatment expert

- The water quality of a heating installation should be checked at least quarterly. Larger systems may require more frequent checks.
- Records of all tests, procedures and results should be filed with the Water Treatment Log Book (paper or electronic copy)
- In carrying out any tests, reference should be made to Table 1 for typical water quality conditions, accepting that each installation should be considered on a case by case basis.

System samples should be taken 24 hours after dosing to allow for thorough mixing so as to ensure that samples are representative.

Monitoring should be carried out after a suitable period to ensure that full circulation and homogenous distribution of the additive is achieved to the correct dose level and samples should be taken for laboratory analysis.

It is important that corrosion inhibitor level and bacterial activity checks are performed two weeks after the addition, as this helps to ensure there are no losses from the circuits that have been treated and also acts as a confirmation that the initial inhibitor and biocide levels are being maintained. A further check should be performed after three months and levels adjusted as necessary.

A copy of the analyses and recommendations may be communicated to the customer.

Corrosion monitoring should be considered as part of an on-going maintenance program.

10 Operator Training

During the handover process, the client representative should be instructed on the checks and routines necessary to maintain the equipment and system integrity. The level of training for operatives should be tailored to the equipment an individual is expected to operate and the duties that they are expected to perform whilst operating that equipment, either normally or under exceptional circumstances.

It is advised that all Heating systems have a “Water Treatment Log Book”, which may be paper or electronic and should contain:

- Asset information (including system volume /working pressure/ specified final treatment), along with details of appointed and competent persons (Building Owner/ Operator responsible to ensure the Log Book is kept up to date)
- Pre commissioning cleaning documentation and sample results.
- Method statement for sampling, maintenance visits and tasks, chemicals that are specified for use, as well as protocols for non-conformities and a schedule of “Pass/Failure Criteria”.
- Site Inspection report and analysis (including any laboratory sample results)
- Details of operative carrying out any work

LPHW water test sheet						
Parameter	Control Limits	January	April	June	September	
	Enter date:	4/1/16	4/4/16	206/16	14/9/16	
Test 1 pH	6.5 – 9.5 [6.5 – 8.5 for aluminium]	7.0	7.0	7.0	7.5	
Test 2 TDS	Max 3500ppm	1400	1450	1100	550	
Test 3 P Alkalinity	Min 50ppm Unless Aluminium based	Nil	Nil	Nil	Nil	
Test 4 Inhibitor	Molybdate Min 330ppm	420	420	350	20	
Test 5 Visual	Clear / Hazy / Opaque	Clear	Clear	Clear	Clear	
Test 6 Colour	No colour					
Test 7 Iron						
Test 5 Bacteria	Take Dipslide	$<10^3$	$<10^3$	$<10^3$	$<10^3$	
Notes:		None	None	None	Major leak System needs complete redose	
Chemicals in use:						
Chemical 1						
Chemical 2						
Chemical 3						

Figure 9: Example of System Water Test Sheet

Appendix A - Design

A1 - Open Vented / Closed System

Open vented systems evolved due to the inherent safety of an open system not being able to exceed the maximum water temperature determined by the static head exerted by the open feed tank on the system. This was proliferated by system design criteria at the time, sizing heat emitters for a ΔT11ºC (82/71ºC), resulting in boilers with a low hydraulic pressure drop to accommodate the location of the cold feed and open vent.

However with the impact of European legislation on product design, modern boilers operate at ΔT20ºC with a move to even higher temperature differentials to maximise the application to different system designs and as a result are designed for closed (sealed) systems only. Closed systems are closed to atmosphere (pressurised) and utilise a diaphragm expansion vessel to accommodate temperature effects on the system with the system pressure managed by a pressurisation unit. The benefits of sealed systems are recognised; it eliminates the issues associated with cold feed and vent locations, make up water & gross oxygen ingress.

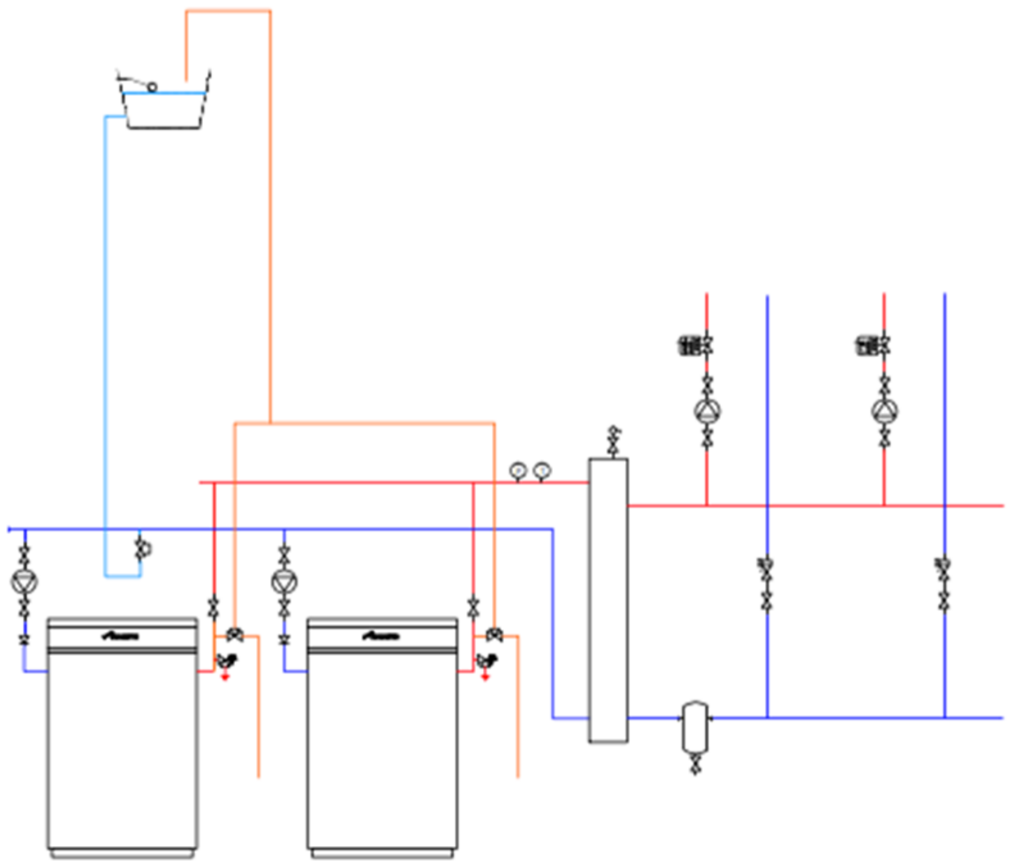


Figure A1.1: Typical Open Vented System

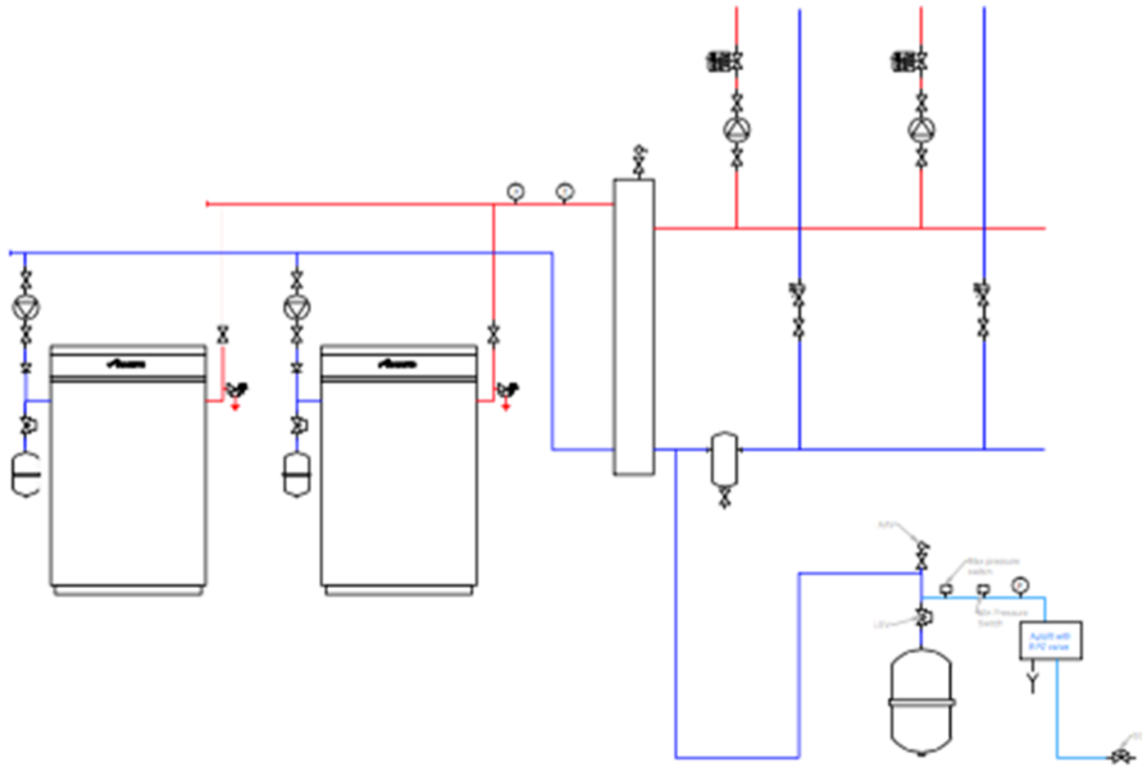


Figure A1.2: Typical Sealed (Un-Vented) System

A2 - Location of Circulating Pump

Consideration must be given at the design stage to the positioning of pumps in relation to the neutral point within the system. The goal should be to ensure that all parts of the system are always subjected to a positive pressure and that negative pressure situations, which could lead to oxygen ingress, are avoided.

General advice for system arrangement can be found in BS 7074 and BS EN 12828.

A3 - Static Head

For open vented systems in particular, static head and the relationship of the open vent and cold feed pipes with pump position, is a crucial design consideration. It should also be carefully considered before alterations or retro fits are carried out which might affect this relationship. It is imperative that there is no potential for pump over into the expansion tank or air ingress through negative pressures under all operating conditions.

Sufficient static head should be ensured to avoid problems with open vented systems and where this is not possible, the system should be closed and pressurised. Particular attention should be made to the equipment manufactures requirements for heat generating plant such as boilers.

A4 - Pressurisation

Many of the problems within large heating systems are closely related to poor pressurisation. Often these issues are overlooked during design, installation and maintenance. As a result, the quality of the system fluid is seriously compromised and a costly and inconvenient series of events can occur. This dramatically reduces the efficiency of the system and also causes premature failure of major system components. Often it ends up in high operating costs for the plant and considerable expense for the owner and annoying inconveniences for the end user.

A poorly designed, installed and/or maintained pressurisation system can lead to negative pressures around the circuit. Air can be drawn in through automatic air vents, gaskets and micro leaks. High pressure situations can lead to water being emitted through the safety valves and then the subsequent frequent addition of further raw, highly oxygenated, make-up water. The introduction of fresh oxygen rich water depletes any level of corrosion inhibitors that may be present. The onset of corrosion is then inevitable, and the cycle continues:

- Air constantly gets into the system
- Corrosion starts to occur
- Dirt & sludge begin to build up

Furthermore, corrosion inhibitors do not affect the content of certain gases, such as nitrogen and carbon dioxide that are present in large volumes and reduce the operating efficiency of the system.

A good pressurisation regime is necessary because it creates the conditions for a system to operate efficiently and reliably and ensures that the required minimum pressures are achieved across the whole system.

Good pressurisation doesn’t solve and prevent all the problems. It doesn’t make other measures redundant. Other factors like air (dissolved oxygen), dirt, chemical composition and treatment are also of importance. For instance, if any make-up water is to be added, it is preferable to remove free and dissolved air before the make-up water is fed into the system.

As systems can vary so greatly further specific guidance on design is not possible but in all cases BSEN12828 should be followed. However the following points should be noted:

- Wherever possible open type expansion systems should be avoided as these can lead to a very high ingress of air into the system.
- Account should be taken of the mandatory regular checks of fixed gas vessels which can be quite costly and time consuming. Also, when doing these, the vessel needs to be disconnected from the system. This might lead to system shutdown, which is sometimes unwanted or impossible.
- It is preferable when using fixed gas systems, to use only one vessel. This can lead to having to use one very large vessel, which might give problems due to space constraints. In these systems it is wise to consider a high quality spill type pressurisation system, as these tend to need less floor space and can control the pressure in a narrower band than fixed gas systems, and the storage tanks that are of a closed type are essentially pressure-less vessels that do not require the same

amount of checks as fixed gas vessels, and the checks that are required can be done during operation (not requiring a system shutdown).

According to BSEN12828, the pressurisation system has to maintain at least + 0.2 bar at the highest point of the system under static conditions, ensuring positive pressure at all points in the system at all times.

Based on the above mentioned it is recommended to seek expert advice. An expert pressurisation specialist should be involved at the design stage to deliver a solution compliant with current standards. This expert will explore all possible methodologies of pressure control to determine the optimal solution for the system(s) in question. As mentioned earlier, all advice should be compliant with BSEN12828.

Figure A4: Combined Vacuum De-gasser and Pressurisation Unit

A5 - De-aeration

When filling, starting up and commissioning new and often complex systems, air can cause undesirable conditions and unnecessary delays. In addition, many modern system components, are particularly sensitive to the presence of air in the system water.

The main reasons for air being present in a system are: the (re)filling of the system, modifications and maintenance, incorrect expansion volume due to faulty design, incorrect or modified pre-pressure and **Henry's law of physics** - *"The amount of gas, dissolved in water, is in direct proportion to the partial pressure of the gas"* i.e. temperature and pressure influence the property which allows water to absorb or emit air.

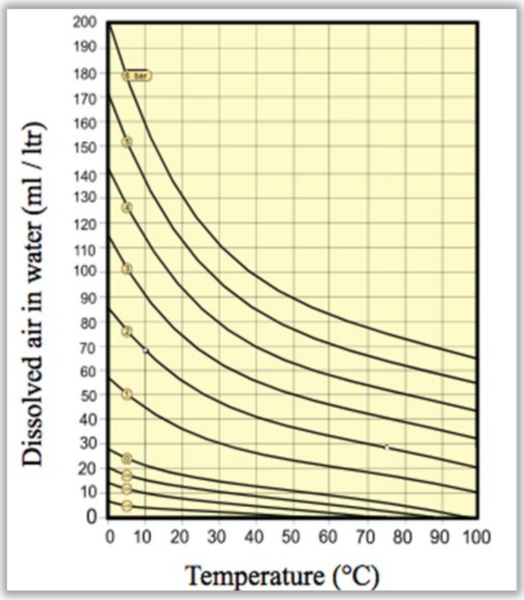


Figure A5.1: Henry's Law

A5.1 Free Air

After filling a system, air can become trapped in radiators and pipe bends. In free-flowing pipes, this air will be carried along by the flow but in low flow areas, the air will remain.

Trapped amounts of free air (air pockets) cause the biggest problems. They can stop radiators from heating up all over and can even cause a blockage in part of a circuit.

The heating system must be designed and operated so that gross oxygen ingress into the heating system is prevented.

Air in water occurs in 3 forms: free air, micro-bubbles and dissolved air.

During operation, oxygen can enter into the system due to:

Closed System

- Open expansion vessels receiving flow
- Negative pressure in the system
- Presence of gas permeable components in the system
- Poor jointing
- System leaks and no make-up water controls
- Poor maintenance regimes

Open System

- Poor location or sizing of the cold feed and vent pipes
- Static head
- Excessive pump head
- Poor jointing
- System leaks and no make-up water controls
- Poor maintenance regimes

Therefore, it is important to prevent air inclusion. A means of removing trapped air should be provided at all high points in the system. This can done by installing automatic air vents where they are needed. It is better to prevent the formation of air pockets wherever possible by ensuring micro-bubbles and dissolved air are removed quickly and efficiently.

A5.2 Micro-bubbles and Dissolved Air

If the solubility of air in water is reduced due to the lowering of pressure or an increase in temperature, that air will be emitted in the form of a myriad of small micro-bubbles with various bubble sizes.

Designers, consultants and installers should be aware of the importance of effective system de-aeration. Not only to ensure problem-free start-up and commissioning but also to prevent any cause for complaints regarding the system.

A5.3 Air Removal

An automatic air vent only removes “large” bubbles of air from a system (and will usually only do so when the system is not running).

A micro-bubble de-aerator separates both large and small air bubbles from the water and then removes these from the system (two functions in one device). Air is released via another system component, e.g. the boiler, so de-aerators should normally be placed at the hottest point in the system.

A vacuum de-gasser creates free air, in the form of micro-bubbles (separated from a dissolved state and converted into a gaseous state) and then removes it from the system.

Note – the requirements of BS 6644 for all expansion vessels (including individual boiler vessels) must be followed. This is especially important when a vacuum de-gasser is used.

A5.3.1 Automatic Air Vent

In a system, air and other gases collect at the highest point or in ‘dead legs’. However, a system will often have several collection points where the trapped air can disrupt the flow or even stop it altogether. A good automatic air vent will continuously remove the air present at these collection points.

When a system has to be filled, an automatic air vent ensures that all the air bubbles which will rise themselves are removed. Finally, when the system is drained, it also ensures that aeration occurs.

A good automatic air vent will not need to be isolated. Isolating means stopping air removal. In addition, automatic air vents are often mounted in places which are not easily accessible which makes regular opening and closing an endless task.

An automatic air vent should be installed at the highest point within the system and at any point where air can gather. It should be installed vertically, with the connection at the bottom.

A5.3.2 Micro-bubble De-aerator

If air is not sufficiently removed from the system water, many hindrances and problems arise. Every now and then, manual venting is not enough as small air bubbles are carried along with the flow and are not collected in standard de-aerators. The fast and effective removal of micro bubbles stops the formation of larger air bubbles which can cause overloading.

There are two factors which determine the efficiency of a de-aerator: the efficiency of the separating element and the pressure drop which a separator causes.

A good separating element ensures that as many micro bubbles as possible are trapped and that these are removed effectively from the heating system. In addition, the separating element must not form an obstruction which blocks the flow in the system.

A micro-bubble de-aerator should preferably be installed at the hottest point within a system where the micro bubbles are released. In the case of a heating system, this is the point where the water exits the boiler or the separation plate heat exchanger. Some manufacturers offer the same function as a side stream operation.

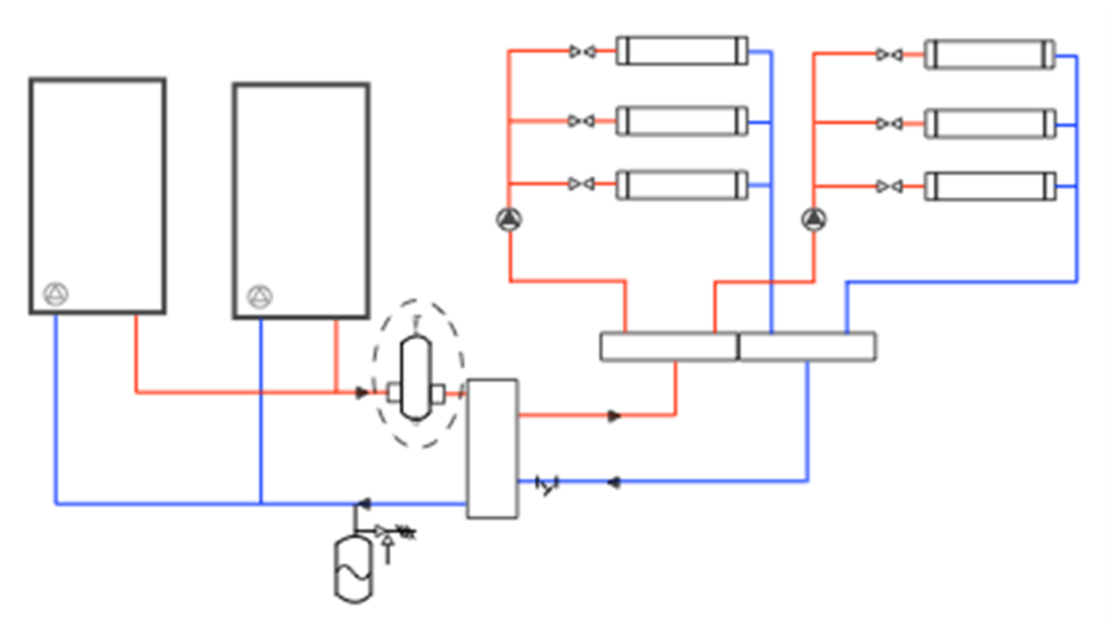


Figure A5.2: De-aerator on a Large System

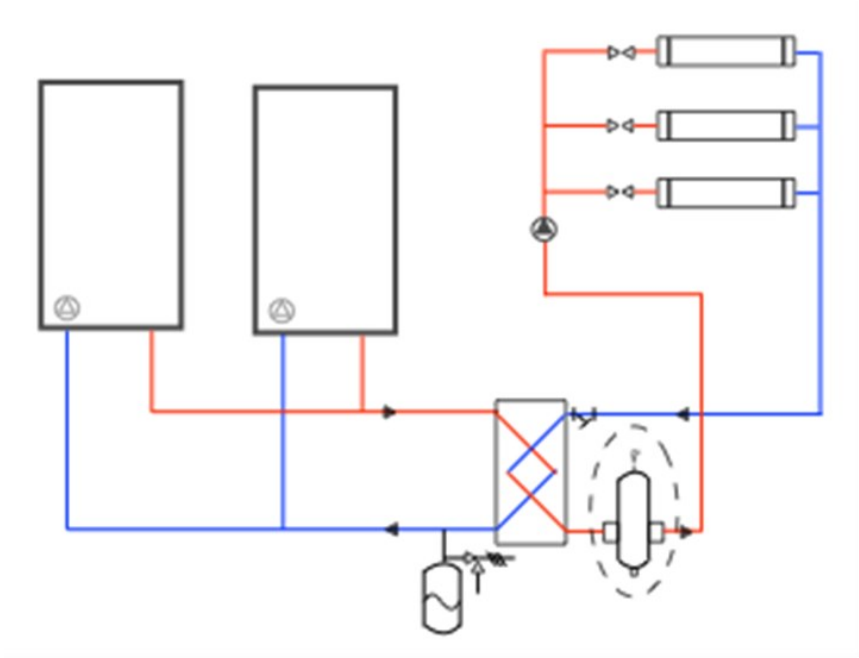


Figure A5.3: De-aerator on a Large System with a Separating Plate Heat Exchanger

A5.3.3 Vacuum De-gasser

With vacuum de-gassing, part of the system fluid is temporarily subjected to a vacuum. The gases dissolved in the fluid are released, separated and removed from the system. The degassed and absorptive fluid is then pumped back into the system and can start absorbing freely circulating gases again. In this way problems can also be rectified in places where the flow is poor and overpressure is limited.

Vacuum de-gasser devices should be used;

- For systems with many branches and a low flow velocity.
- If there are small differences in temperature between supply and return. A vacuum de-gasser is not dependent on the fluid temperature.
- If an inline de-gasser cannot be mounted on the system for practical reasons. A vacuum de-gasser can be connected to virtually any point within a system.

Note - Vacuum de-gasser equipment is temperature limited at the point of connection to the system. Seek advice from the equipment manufacturer, as incorrectly selecting the equipment can lead to 'steam' being evacuated due to the fact that water boils at a lower temperature under a vacuum state (in some cases as low as 40ºC), creating further system water losses, make up of untreated water and depleted inhibitor levels.

A6 - Filtration

The key to the effectiveness of a corrosion inhibitor within a closed system is complete contact of the inhibitor with all metal surfaces. The build-up of bio-film and other detritus will not only affect water flow but will also prevent film forming corrosion inhibitors from working effectively with possible catastrophic results.

As a result there are numerous types of filtration devices to deal with heating system detritus.

A6.1 - Strainer

All systems are fitted with strainers to protect equipment. Strainers are intended to capture large debris that might cause blockage or damage for example foreign objects, metal fragments, jointing tape and large corrosion flakes. (None of these should be present in a previously cleaned system). However, strainers do not retain fine particles of metal oxides, scale and precipitates that contribute to the suspended solids resident in the system. Typically the element in the common in-line "Y" pattern strainer will be either a perforated screen (available hole sizes 0.8 – 3.2 mm) or a mesh screen (available hole sizes down to 0.08 mm)

It is counterproductive to specify a smaller mesh than is actually needed as this will increase the pressure drop and the risk of blockage of the strainer itself if not regularly inspected.

Figure A6.1.1: Contaminated Lateral Strainer

Figure A6.1.2: System Iron Oxide on Magnet

Figure A6.1.3 :Blocked (scale) Pipe

Figure A6.1.4 : Contaminated Pipes

Figure A6.1.5: 'Y' strainer

Figure A6.1.6: Blocked Mesh Strainer

A6.2 – Filter

Mesh filters in the return line will have a tendency to limit flow rates as they block and can reduce the efficacy of the flushing process. A filter should be sized in line with the recommendations of BG 29 such that in a 24hr period, the equivalent of the system volume passes through the filter, which will significantly speed up the cleaning process. Side stream filtration is therefore generally recommended.

The application of filtration is made more manageable by incorporating fine media filtration (@ 5micron - 0.005mm), as these collect the much finer ferrous and nonferrous silt like deposits that pass through conventional dirt separators and as a result, reduce the potential for bacterial growth.

The use of filtration can either be full bore or side stream, with side stream being the most common approach as it offers reduced pressure losses in the system.

All filters should be fitted in combination with devices which indicate if a filter has or is becoming blocked (ideally pressure transducers linked to the BMS) and the pipe work system designed so that they can be easily cleaned and maintained.

If filters are not maintained or replaced they become blocked, acting as a bacterial load on the system. In all cases refer to the manufacturer's instructions.

Figure A6.2.1: Side Stream Filter Cartridge

Figure A6.2.2: Sludge Contaminated (new/old) Filter Cartridge

Figure A6.2.3: Water Samples after using Side Stream Filtration

A6.3 - Magnetic Filtration

Magnetic filters incorporate permanent magnets to trap magnetic debris (magnetite). They generally contain powerful rare earth magnets with high magnetic strength which can actively remove suspended magnetic particles from the system water. Magnetic filters may be fitted in line on the main system flow or on side stream bypass dependant on the design of the filter and pressure loss. Some designs are very effective in removing debris in a single pass, down to sub-micron particle size, which prevents sludge circulating around the system and building up in heat exchangers, pumps and radiators. Therefore they are ideally and commonly installed on the return to the boiler. Magnetic filters should be checked at regular intervals dependant on the state and age of the system and at least annually.

Figure A6.3.1: Demonstration of Magnet Effect on Magnetite

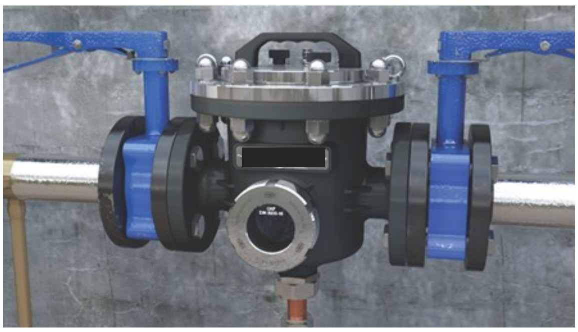


Figure A6.3.2: Commercial Magnetic Filter DN50 Path

Figure A6.3.3: Light Commercial Dual Magnetic filter DN42

A6.4 Optimum Dirt Separation

Many of the components within and mounted on systems are getting smaller. Not only the pipes but for example, the bore of thermostatic valves and three-way valves. Over the past few decades, on-going developments have led to the ever-increasing efficiency of heating boilers. One of the results of this is that water capacity has been reduced significantly. This has increased the load on the exchanger and brought about a relative increase in the effect of the air and dirt particles present.

The separating element is extremely important. It must be able to trap the smallest particles without forming an obstruction in the flow and without any risk of a blockage.

If absolute dirt separation is required from the outset, a filter is the only solution. In all other cases, it is preferable to use a dirt separator, as over a period of time the circulation through the dirt separator will reduce the system detritus. However, if a filter is used, a dirt separator will provide ideal protection for the filter and will extend maintenance intervals and service life considerably.

A dirt separator should preferably be installed in the main return pipe of a heating system.

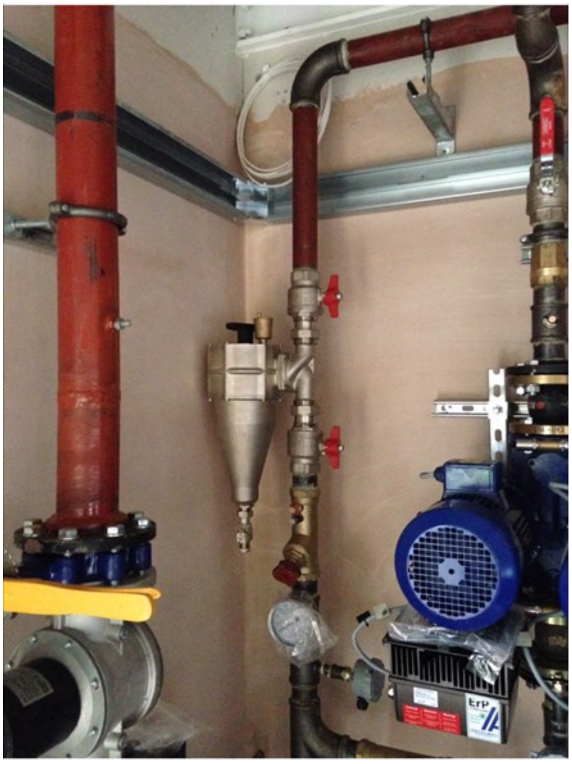


Figure A6.3.4: Hydro-cyclone Dirt Separator (1)

Figure A6.3.5: Hydro-cyclone Dirt Separator (2)

A6.5 Combined Air and Dirt Separation in a Single Device

Free air, micro bubbles and dirt particles are continually removed from system water. Air should preferably be removed from system water at the hottest point. A dirt separator is preferably to be installed in the main return pipe. In the first instance, that makes a combined unit an extremely reliable solution for heating systems.

A combined air and dirt separator should preferably be installed in the main flow pipe of a heating system, close to the boiler.

Some manufacturers provide side stream dirt & air separators. These work by removing the dirt through a set of filter stages, with micro bubbles being removed by a matrix.

Figure A6.4: Air & Dirt Separator and Magnetic Air & Dirt Separator

A6.6 Low Loss Header with Integrated Air and Dirt Separation

A good water-side balance is of paramount importance to heating systems with separate circuits or multiple groups and pumps. With hydraulic balancing, the differences between a primary circuit and a secondary circuit are absorbed in an open separator. Hydraulic separators with integrated air and dirt separators also condition the system water by removing the circulating air and micro bubbles and circulating dirt.

The correct application of pressurisation solutions, de-aeration and filtration equipment will provide a stable, efficient system, and should reduce the total amount of maintenance required over the lifetime of the system, and also extend the intervals between treatments.

A7 - Dosing System

A typical dosing pot is shown in figure A7.1 and is a flow through container, plumbed in parallel to part of the heating system. It is fitted with isolating valves to allow draining and safe filling of the chemicals at atmospheric pressure into the system. Once the filling of the container is complete, it can be reconnected to the heating system using the isolating valves. Care should be taken in siting the pot to make access and dosing of chemicals as safe as possible.

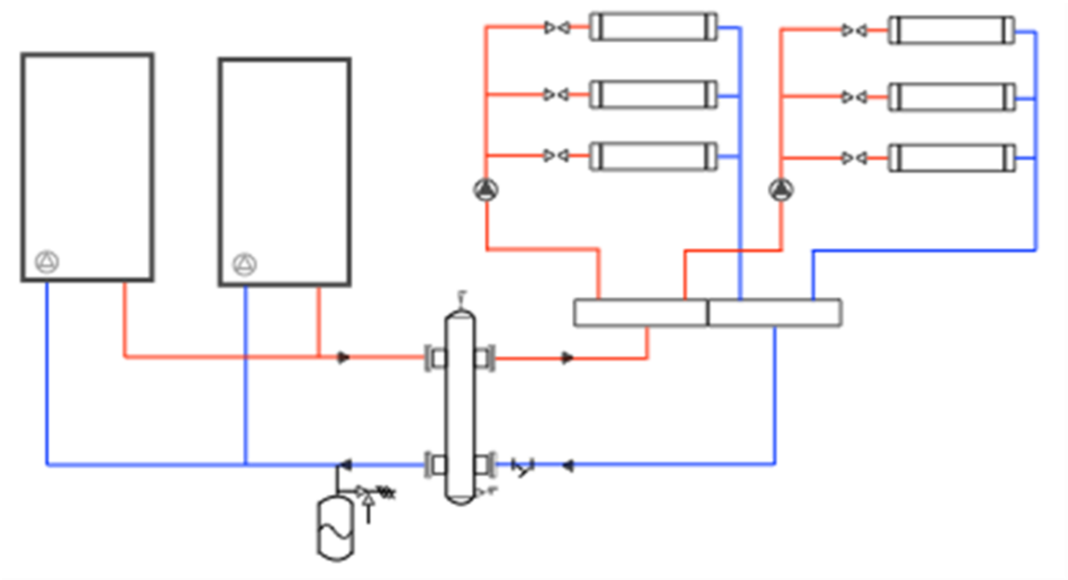


Figure A6.5 - Low Loss Header with Integrated Air and Dirt Separation

Designers should carefully consider the dosing arrangement and safe storage of chemicals near to the dosing point. Due to the hazardous nature of the chemicals and the potential effects on operatives, a risk assessment should be carried out on the system and the chemicals. If necessary monitoring arrangements for persons exposure to them should be put in place and personal protective equipment stipulated and provided.

As the dosing pot should be left open to the system flow as outlined above, it can also be utilised as an optional side stream filter, refer to the schematic below for the optimal installation of a dosing pot.

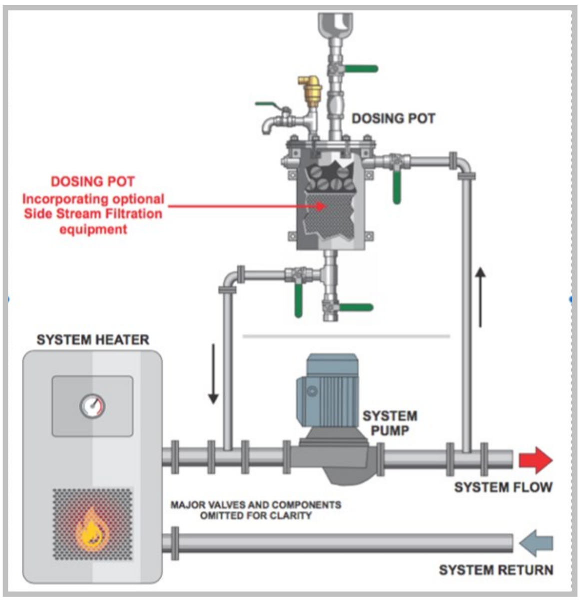


Figure A7.1 - Typical Installation of a Dosing Pot

Figure A7.2 - Typical Liquid Chemical Dosing

Figure A7.3 - Typical Solid/Liquid Chemical Feeder Pot

A8 - System Design

For a heating system in excess of 600kW the total hardness of the fill and make-up water should ideally be less that 2ppm which is the accepted upper limit from a base - exchange water softener. Better quality water should always be considered, such as reverse osmosis or demineralised water. However, in using these methods of fill and make-up water, consideration must be given to the pH buffering required to achieve the levels detailed in Table 1. Provided a water softener is included in the design of the reverse osmosis plant, both these options will meet the control limit of less than 2ppm total hardness. The water treatment specialist must be consulted on the best water treatment approach to meet the make-up water selected.

A8.1 - System Volume

If there is no system schematic diagram detailing the complete hydraulic circuit allowing a calculated system volume, the system volume should be estimated from a consideration of pipe bore and length, together with nominal waterside volumes of all components. If this is not feasible, a very approximate minimum system volume for a commercial installation may be estimated from:

Boiler kW x 12 = System volume (litres)

A system used by water treatment companies (when system volume is unknown) is to calculate the system volume using the combined boiler kW output of the boilers (using the above formula). The chemical dose rate (adopting the chemical manufacturer’s guidance) is then used and the treatment is applied as follows:

Note: Whenever adding water treatment chemicals it is important to check they are compatible with any previous treatment within the system and are compatible with system materials and operating temperatures. Other chemical methods for assessing system volume are available

- A sample of the system water is taken (before dosing) and its conductivity measured (after cooling the sample to room temp) using a conductivity sensor (available from on-line distributors), or using a manufacturers test kit to identify active reserve levels.

- The same sample is then treated at the recommended % v/v and conductivity re-measured. This then provides the operative with the anticipated target range for a correctly dosed system, at this point a test kit can also be used to check it is performing correctly.

- Using the anticipated system volume, 50% of the total dose rate is added and circulated for 2-3 hours (ensuring BMS is driven to include 100% of the system circuits).

- After 2-3 hours circulation a re-sample is carried out, from the results it can then be determined what volume of treatment is required to achieve the manufacturers recommended dose rate, the system dosing is then adjusted accordingly.

- After a further 2-3 hours "full" circulation, a final sample is taken and tested (including using a test kit). From the final volume of chemical added and the manufacturer's %v/v, the system water volume can then be determined. This should then be documented within the Site O&M document and the Water Treatment Log Book.

Figure A8.1 - Test Kit

Figure A8.2 - Test Reagents

A8.2 Separating plate heat exchanger - In some instances, it may be necessary to separate the boiler plant from the system using a separating (plate) heat exchanger. This may be necessary as many modern condensing boilers are not suitable for connection to open vented systems. It may also be a wise precaution where effective flushing of an older system is in doubt. This generally means that any protection measures such as filters should be located in the secondary return to protect the heat exchanger (Side Steam filtration is also a recognised and effective solution). Additional care is necessary in the location of the open vent and cold feed, which will be moved from the boiler to the secondary side of the plate heat exchanger, to ensure there is no chance of 'pump over' at the expansion tank.

A8.3 Stagnation- Areas of stagnation within a system's design and operating maintenance regime should be avoided at all costs, as these will encourage bacterial load and also lead to ineffective chemical treatment, leading to corrosion, bacterial fouling and further contamination of the wider system. Therefore during seasonal periods when the system is not required to run, it is recommended to set the BMS (out of hours) to run all parts of the system (Boilers off) for 1 hour every 24 hours. This will ensure the water is passed through any dirt & air separation and side stream filtration, as well as fresh levels of film forming inhibitors being laid down. Good application and design of three or four port valves is recommended to maintain good system circulation (for example at the ends of lateral runs).

Appendix B - Training & Competency

B.1 - Training

Employers must ensure that all personnel possess sufficient knowledge of the boiler systems on which they work to perform their duties properly. This is a legal requirement under the Management of Health & Safety at work Regulations.

Any training should form part of a structured scheme taking into account the particular types of equipment onsite and the full range of maintenance tasks required for safe operation of the equipment. All training should be a structured on-going process which is updated to keep pace with developing technology, equipment and legislation. The level of competence required (and corresponding training requirements) should be reviewed when a system is modified, e.g. increased automation/remote supervision. The training should be delivered by personnel possessing the appropriate practical experience, assessment skills, and knowledge of the working environment.

The employer should ensure that all operatives and other relevant personnel are regularly assessed through work audits. Training should also be reassessed periodically, or at least once every three years. All of these items should be recorded and records retained for at least 5 years.

B1.1 - Training Record

Employers should ensure that all relevant training and assessment records are maintained and kept securely, including details of content and results of courses and any re-assessments. Appropriate audit records should be maintained and kept securely. Such evidence of training may be required to be viewed by enforcing authorities.

You **MUST** be able to demonstrate that the people operating and maintaining your equipment are suitably trained and competent.

B2 - Competence

Employers have a duty to ensure that any person who carries out a task as part of his/her employment is competent. If a person is being trained, a competent person must supervise that person until he can carry out his/her work effectively and safely.

This duty also extends to people who employ contractors. A Duty Holder must be able to show that his/her organisation has done enough to reassure itself that the contractors it has engaged are competent.

Definition - A person who is deemed competent requires three main attributes:

The ability to carry out and complete tasks effectively;

The ability to work safely alone and/or with others;

The knowledge of his/her limitations.

For many positions in the water treatment industry and other related disciplines (risk assessors, consultants, water treatment chemists etc.), the person must also have the ability to communicate well.

B2.1 - Recognising Competence

The qualities sought when establishing an individual's competence (as defined above) include that the person:

Has undergone appropriate training;

Is sufficiently experienced to carry out the activity effectively and safely;

Possesses the ability to communicate verbally and in writing;

Has the ability to use his/her experience to work safely in unfamiliar situations (e.g. when carrying out risk assessments);

Has demonstrated the ability to manage time (their own and other people's time);

Is able to meet deadlines without compromising safety.

Competence is recognised in a practical way. This means that on-the-job assessment is required in order to show that the employee/sub-contractor has the ability to work in a safe manner.

Competence cannot be totally assessed in the classroom. On-the-job training can be of use as long as the person delivering that training is competent to do so. It is not suitable or sufficient to simply pass knowledge along from, for example, one operator to another. This typically results in parts of the required training or information being missed or forgotten and errors being made.

There are, however, many people who work effectively and safely and have no formal qualifications at all. However, it is most unlikely that water treatment specialists, risk assessors, engineers etc., will have no formal qualifications, as most will be professional people (most commonly scientists and engineers) and possibly members of professional bodies or learned associations. Even these people, however, will need to be able to show they are able to work safely and effectively.

B2.2 - Proving Competence

A formal strategy must be put in place in order to demonstrate that individuals are competent, or that competent people are being employed. This will vary depending on whether the person is a contractor, or a direct employee.

Competence is defined in law as Education, Training and Experience.

This would also apply to a contractor who wished to be able to prove his/her competence to a client. The basic requirements will be:

1. Onsite references from customers (for contractors). For direct employees of a contractor, line managers within that business should be able to provide reassurance of a person's ability to

work safely. For the self-employed, their present customers could be used as verifiers.

2. On-the-job checking on a regular basis. When first employing a contractor their ability should be checked when introducing them to the site and ensuring they can work safely. For direct employees, a supervisor should check his/her work frequently and keep a record of the findings.

B2.3 - Recording Competence

Proof of competency may be required by enforcing bodies that everything practicable has been done to allow managers to believe the person was competent. This will require records which need to be kept up to date (dated and signed), on a regular basis, at least annually or better every 3-6 months and whenever there are changes to personnel or their work**. Formal refresher training, both classroom and practical, should take place every three years, as a minimum.**

Competence is a continuous process!

Appendix C - Glossary of Commonly Used Terms in Heating System Water Treatment

Alarm Relay: An electric circuit, that when triggered will active an alarm – this could be internal or external to the boiler house, or at a remote monitoring station.

Alkalinity: An expression of the total basic anions, including hydroxyl, carbonate and bicarbonate in a solution.

Alkalinity Booster: A chemical used in water treatment to raise pH and alkalinity.

Allowable working pressure: The maximum pressure for which the boiler was designed and constructed; the maximum gauge pressure on a complete boiler and the basis for the setting on the pressure relieving devices protecting the boiler.

Anion: A negatively charged ion.

Anode: The positive electrode of an electrochemical cell where electrons are donated and oxidation occurs.

Backwash: A stage in the regeneration cycle of a softener or other ion-exchange equipment, during which water flow through the unit is directed upwards through the resin bed. This is done to clean and reclassify the bed following exhaustion.

Balanced dynamic flush: A stage in the flushing of closed circuit systems, such as hot water boiler systems, whereby the incoming fresh water flushing flow rate is “balanced” against the dirty water leaving the system to drain.

Biocide: A solid or liquid water treatment chemical added to closed loop circuits, such as hot water boiler systems, to control bacteria levels and reduce the propensity for the set-up of microbiologically Induced Corrosion (MIC).

Biocide wash: A stage in a closed loop hot water boiler system clean whereby specific solid or liquid biocidal water treatment chemicals are added, recirculated and then flushed from the circuit in order to control initial bacteria levels and reduce the propensity for the set-up of microbiologically Induced Corrosion (MIC).

BMS System: Building Management System, (automated control system) managing the operation of the equipment within the building.

Buffer Solution: A solution with a specific pH value, used as a control in calibrating sensors or hand held meters.

Calibration: A procedure to match the values read by sensors against a known standard.

Calorific Value MJ/m^3 : the energy content by volume of a gas expressed as ‘gross’ (including the latent heat content) or ‘net’ (excluding the latent heat content)

Calorifier: An apparatus used for the transfer of heat to water in a vessel by indirect means, the source of heat being contained within a pipe or a coil immersed in the water.

Cathode: The negative electrode of an electrochemical cell where electrons are accepted and reduction occurs.

Cation: A positively charged ion.

Caustic: A concentrated alkali used in boiler water treatment to raise pH.

Caustic embrittlement: Cracking of stressed steel in contact with concentrated alkali.

Chelant: An organic compound that forms soluble complexes with certain metallic ions, especially calcium, magnesium, iron and copper.

Chemical Feed Pump: A relay or proportionally controlled pump that disperses chemical into the system.

Chloride: Soluble ionic form of the element chlorine, useful as a means of determining system volume by excess salt method.

Closed loop system: A term used to describe any system that is closed to atmosphere (not airtight) and recirculates water on a continuous basis.

Commissioning: The process of initially setting up the water treatment plant, control equipment and chemical treatment programme for any heating system.

Condensing Boiler: A heating boiler which cools the flue gases releasing the latent heat within the flue gases and improving the thermal performance of the boiler.

Condensate: The water that is formed when flue gases cool and changes from a gas to a liquid (water).

Conductivity: Represents the electrical current carrying capacity of a water. It is used as a means of indirectly measuring the total dissolved solids concentration of a water. Conductivity can be converted to TDS by a simple calculation.

Corrosion: The destructive disintegration of metals (e.g. steel or copper) by electrochemical means; measured in mils (mils = one thousandth of an inch) per year (mpy). See Oxygen attack or pitting corrosion.

De-aerator: A device that physically removes one or all of the following free air, micro-bubbles and dissolved air.

De-alkaliser: An ion exchange unit designed to remove alkalinity from water. Alkalinity removal is performed with either a cation resin using sulphuric acid as the regenerant or an anion resin using sodium chloride for regeneration.

Deionisation: The removal of all anions and cations from a water by ion exchange.

Demineralisation: Equivalent to deionisation.

Deposit: Accumulation of mineral or organic matter laid down on heat transfer surfaces.

Deposition/ Deposit Formation: The process by which mineral or organic matter is laid down on heat transfer surfaces.

De-sludging chemical: A liquid or solid water treatment chemical, specifically formulated to act as a mild system cleaner. These types of products are normally used to de-sludge existing heating systems where flows have reduced over time.

Dip slide: A simple and easy to use method of measuring general bacteria counts in closed loop hot water boiler systems. Dip slides are non-specific and can only read total viable counts of bacteria. They are useful in closed loop monitoring.

Dissolved gases: Gases that are in solution in water.

Dissolved solids: Solids in true solution in ionic form in water that cannot be removed by filtration (expressed as Total Dissolved Solids (TDS)). Their presence is due to the solvent action of water in contact with minerals in the earth.

Dosing pot: An apparatus used to dose liquid water treatment chemical to a closed loop heating system.

Dynamic flush: A stage in the flushing of closed circuit systems, such as heating systems, whereby the incoming fresh water at high pressure is used to flush dirty system water to drain.

End point: In water testing, the point at which titration reactions are completed and the indicator changes colour.

Erosion: The physical wearing of metal by the action of a liquid or gas.

Filming amine: An organic chemical that forms a water repellent film on system metal. The film controls corrosion in the entire boiler system.

Foaming: The formation of bubbles that have sufficiently high surface tension to remain as bubbles beyond the disengaging surface.

Fouling: The obstructing of the flow of water by matter that accumulates on pipe walls or in water-using equipment.

Galvanic corrosion: Generally results from the juxtaposition of two dissimilar metals, e.g. copper and steel, in an electrolyte. It is characterised by an electron movement from the metal of higher potential (anode) to the metal of lower potential (cathode) resulting in corrosion of the anodic metal.

Grains per gallon (gpg): A unit of concentration equivalent to 17.14 parts per million (ppm).

Hardness: The total of a water’s calcium and magnesium ion content. The total concentration is reported as calcium carbonate. Hardness is sometimes referred to as carbonate and non-carbonate hardness. Carbonate, also referred to as temporary hardness is that portion of the total hardness that combines with carbonate and bicarbonate ions. The remainder of the hardness is that which combines with sulphate or other anions and is known as non-carbonate or permanent hardness.

Incubator: An apparatus used to grow bacterial cultures on dip slides.

Independent set point: This is a controller feature that allows the user to independently set the high and low alarm levels.

Indicator: In water testing, a substance that undergoes a colour change when the end-point of a titration has been reached. The indicator does not enter into the reaction.

Inhibitor: A substance that selectively slows down a chemical action, such as scaling or corrosion.

Ion: A negatively or positively charged atom or radical.

Ion exchange: A reversible process in which ions that are chemically attached to resin beads are exchanged for other ions that are in solution in a water. For example, in an ion exchange softener sodium ions on the resin beads are exchanged for calcium and magnesium ions in the water passing through the softener.

kW: The rate of transfer of energy with respect to time

LPHW: Low pressure hot water - a term used to describe hot water boiler systems.

Magnetite: an impervious layer of fully formed iron oxide that is black in colour and cannot be oxidised any further. Formed within boilers by allowing normal internal rusting to take place but in a pH controlled and oxygen negative environment. Requires an excess of hydroxyl ions to allow correct formation of this layer. The formation of magnetite prevents oxygen pitting or low pH corrosion attack taking place.

M-Alkalinity: Also called total alkalinity or methyl orange alkalinity. This is the measure of the total of bicarbonate, carbonate and hydroxyl ions in a water.

Make-up: The water added to a heating system to compensate for that lost through leakage to atmosphere, etc.

Monitoring Tool: A monitoring tool is a system or process used to undertake the regular observation and recording of activities taking place in a system, project or programme. This tool could, for example, be web or paper based. The tool is used to implement and subsequently monitor the process of routinely gathering information on all aspects of the system, project or programme. To monitor is to check on how the system, project or programme activities are progressing. It is observation; systematic and purposeful observation. Monitoring also involves giving feedback about the progress of the project to the donors, implementers and beneficiaries of the project. Reporting enables the gathered information to be used in making decisions for improving system, project or programme performance.

Neutralising amine: An alkaline organic chemical that neutralises acidity to control corrosion.

Open Vented System: A heating system open to atmosphere via a ‘high level’ cold feed tank providing a static head on the system and limiting the temperature and pressure achievable within the system.

Oxygen scavenger: A chemical added to the system to remove dissolved oxygen.

P-Alkalinity: A measure of half the carbonate and all of the hydroxyl ions in a solution. It is determined through titration using phenolphthalein indicator.

Passivation: The process of laying down a corrosion resistant surface by using increased inhibitor levels or a passivating additive by the creation of a protective layer or film.

pH: The hydrogen ion concentration of a water stated on a logarithmic scale from 0 to 14 used to indicate the water’s relative acidity or alkalinity; pH7 is neutral - pH below 7 indicates an acidic solution and pH above 7 indicates an alkaline solution.

Phosphonate: An organic compound used to inhibit scale in boilers by distorting the crystalline structure of sludge particles, preventing them from agglomerating and forming a hard scale - also called organo-phosphonate.

Pitting: A concentration attack by oxygen or otherwise corrosive agents producing a localised depression in the metal surface.

Plate failure: A term used to describe when a heat exchanger plate fails.

Polymer: An organic compound used primarily to control scale and deposition in boilers by dispersing sludge particles.

ppm: Abbreviation of parts per million. It is used in chemical determinations as a measure of the concentration of dissolved impurities in water.

Precipitate: To separate materials from a solution through the formation of insoluble matter by chemical reaction.

Precipitation: The chemical process by which materials are separated from a solution through the formation of insoluble matter by chemical reaction.

Pre-treatment: Term frequently used to define mechanical treatment of water, e.g. softening, reverse osmosis or de-alkalisation, prior to its use in a process – also called external treatment.

Rated capacity: The manufacturer’s stated capacity rating for mechanical equipment, e.g., the maximum continuous capacity in kW for which a boiler is designed.

Raw water: The water supplied to a plant or facility before external or internal treatment is applied.

Resin: Synthetic organic ion exchange material, such as the cation exchange resin used in water softeners. Formerly made of zeolite.

Responsible Person (RP): The Responsible Person is defined as the person who will take day-to-day responsibility for managing the control of any identified risk from the boiler and associated system. Anyone can be appointed as the Responsible Person as long as they have sufficient authority, competence, skills and knowledge about their specific installation to ensure that all operational procedures are carried out in a timely and effective manner, and they implement the pre-defined control measures and strategies, i.e. they are suitably informed, instructed, trained and assessed. They should be able to ensure that tasks are carried out in a safe and technically competent manner.

If a Statutory Duty Holder is self-employed or a member of a partnership and is competent, they may appoint themselves as the Responsible Person. The Responsible Person should be suitably informed, instructed and trained and their suitability assessed. They should also have a clear understanding of their duties and the overall health and safety management structure and policy in the organisation.

Both the Statutory Duty Holder and the Responsible Person must have undertaken site specific boiler water treatment training in order to effectively carry out their role, and this training needs to be refreshed at least once every three years.

Reynolds number: This is a dimensionless quantity that can be used on a predictive basis in order to assesses flow patterns, and is named after Osborne Reynolds**.** The Reynolds Number, the non-dimensional velocity, can be defined as the ratio of

- the inertia force *(ρ u L),* and
- the viscous or friction force *(μ)*

Safety valve: A spring-loaded valve that automatically opens when pressure reaches the valve setting. Used to prevent excessive pressure from building up in a boiler/heating system.

Sample point, **sample cock** or **sample valve**: A sample point allowing the user to draw off water for analysis.

Sample cooler: A small heat exchanger designed to cool a small flow of boiler water to a temperature where it can exist in its liquid state at standard atmospheric pressure.

Scale: A dense, crystalline deposit form by precipitated material. It usually formed on boiler tube surfaces where heat transfer occurs.

Section failure: A term used to describe when a heat exchanger element (section) of a heating boiler fails.

Sealed (un-vented) System: A heating system sealed to atmosphere and incorporating a device (pressurisation unit) to maintain the system pressure in conjunction with a diaphragm expansion vessel to manage the pressure fluctuations due to the changes in heating system water temperature.

Sequester: To separate and hold potential scale-forming materials in solution or suspension.

Set point: The user-determined value input to a controller that initiates action of the controller.

Set point differential or **hysteresis**: Also known as the "dead band" is the offset applied to a set point to stop the controller from "bouncing" too frequently around that point.

Side Stream Filter: A device, which either uses it's own pump or uses the system pumps to filter approx. 4-5% of the system water continuously (or the total system volume in a 24 hour period). It should remove both magnetic and non-magnetic material. The particles in the filtered water should be a minimum of 5micron or less when re-introduced back into the system water.

Sludge: A soft, water-formed sedimentary deposit.

Sludge Deposition: The process by which a soft, water-formed sedimentary deposit is formed within a heating boiler that can usually be removed by dynamic/balanced flushing (if a hot water boiler).

Softened water: Water containing relatively low concentrations of calcium and magnesium ions (typically less than 5ppm).

Softener: A device for removing hardness from water. Ion exchange softeners operate by exchanging sodium ions (from salt) for calcium and magnesium ions. Ion exchange softeners do a very complete job of hardness removal and modern units are now very capable of producing a consistent supply of commercial zero hardness (less than 2ppm) water.

Solid Chemical Feeder: An apparatus used to dose liquid or solid water treatment chemical to a closed loop hot water boiler system.

Statutory Duty Holder/Duty Holder (SDH): The Statutory Duty Holder/Duty Holder is the person who has ultimate responsibility for all company/site Health and Safety related matters, including initiation of the Boiler Water Treatment Risk Assessment and completion of its findings. The Statutory Duty Holder would normally be a company director or similar and have sufficient authority and influence within the company such that the boiler water treatment regime and system could be correctly implemented and managed. The Statutory Duty Holder should appoint a Responsible Person (RP) to take over the operational management of this function for them. The Responsible Person (RP) would then normally action this by utilising input or assistance from various sources such as water treatment companies, specialising in boiler water treatment, boiler manufacturers and control system experts, or have the entire risk assessment carried out on his/her behalf by someone competent to do so. It is the responsibility of the RP to access and assure himself/herself of this competent help.

It is the responsibility of the Duty Holder to formally appoint the Responsible Person with, for example, a letter of appointment, including scope of role. This letter should be signed off by both parties as accepted, and similarly a deputy RP should also be appointed to cover periods of illness or annual leave, using the same formal process of engagement.

Both the Statutory Duty Holder and the Responsible Person must have undertaken site specific boiler water treatment training in order to effectively carry out their role, and this training needs to be refreshed at least once every three years.

Strainer: A coarse (usually in-line) filter used to protect vital components from gross debris.

Sulphite: An oxygen scavenger used in boiler systems. It comes in numerous forms and "Sulphite" is a generic term for this type of product.

Suspended solids: Solids not in true solution in water, rather in particulate from capable of being removed through filtration.

Test kit: A collection of test reagents, meters etc., usually contained in a bespoke case, used to test waterside balance in systems.

Test reagent: A specific indicator chemical used to test waterside balance in systems.

Threshold treatment: A technique of treating water by the addition of very low levels of chemicals, usually phosphonates and/or polymers that will temporarily inhibit the formation of scale.

Total Dissolved Solids (TDS): The total of all substances dissolved in ionic form in a water.

Tuberculation: Irregular, protruding mounds of corrosion product that form over corrosion sites on steel and cast iron that has been exposed to oxygenated water. The tubercle height may be as much as 30 times the metal loss depth below.

Turbidity: Cloudy appearance of water imparted by the presence of suspended or colloidal particles.

Under deposit corrosion: The destructive disintegration of metal by electrochemical means under a covering deposit of scale for example.

Notes:

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Whilst every care has been taken in the preparation of this booklet by **ICOM Energy Association** and its members, no liability can be accepted for the consequences of any inaccuracies or misstatements.

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