ICOM Energy Association

Water Quality Consideration of Domestic Hot Water Systems for Commercial Applications

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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.

The treatment of hot water systems in non-domestic premises may be required for the avoidance of scale, corrosion and bio-fouling (including legionella). These problems may result in energy wastage, poor system performance, potential health issues and the need for early replacement of system components.

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

Due to the diversity of water sources there are significant variations in the quality of UK mains cold water supplies - Refer to Appendix E. The Regulations governing the supply and quality of water are concerned with its condition in regard to health and safety issues ("Wholesomeness") rather than the engineering aspects of water quality. As a result total hardness is not a parameter considered by the Regulations, despite the use of different geological sources through which rain water must pass to enter the supply system such as reservoirs, rivers, aquifers, bore holes etc. In addition, blending of water supplies is common practice and as a result hardness levels may vary daily.

Hardness can result in scale formation and this is the major cause of engineering issues in hot water systems- (Refer to Appendices C & F). If water hardness is likely to cause scale formation, then treatment of the water supply may be required; - refer to equipment manufacturers for guidance.

Under no circumstances should water heating equipment be fired before the cold water supply to the equipment has been checked and treated, where required. All installations of hot and cold water supplies shall be thoroughly flushed and cleaned before being filled and used. If an installation is not flushed and/or if the water is not of the right quality, it may invalidate the manufacturer's warranty.

Due to the presence of dissimilar metals in hot water systems (- Refer to Appendix F) and to avoid problems with corrosion, consideration should be given to materials in the system, quality of the water and mechanisms for controlling corrosion.

Due to the potential presence of micro-biological organisms within a hot water system, consideration shall be given to the Health and Safety at Work Act and the Control of Substances Hazardous to Health Regulations, with particular reference to Technical Guidance document HSG274.

It is the responsibility of the 'statutory duty holder' or 'responsible person' to determine the risks associated with the hot water system. If treatment of the water supply or hot water system is required, the services of a suitably competent person/ operative should be used i.e. Someone who has undergone education and training on the subject matter and can demonstrate experience in applying that knowledge - refer to Appendix G.

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

About this guide

This comprehensive guide deals with all aspects of water treatment of domestic hot water systems for commercial applications. We trust that by studying the contents and following the freely given advice your hot water systems should operate reliably, safely and more efficiently.

Having considered who is responsible for looking after and managing the safe operation of non domestic hot water installations, ICOM members have compiled this guide to promote best practice for the management and safe operation of hot water installations.

It is aimed as a document that can be read and understood by personnel with limited or no knowledge of water treatment chemistry. It is also intended to aid the understanding of the impact of water and its subsequent treatment on hot water systems.

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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2 Scope:

Domestic hot water (dhw) systems (open vented & unvented) for commercial applications including:

- Storage direct fired
- Circulating direct fired
- Instantaneous direct fired
- Storage indirect (calorifiers)
- Storage electrical
- Plate heat exchangers
- Renewables - solar thermal, chp & heat pump

This guide relates specifically to the mainland UK and deals with scale, corrosion (metallic) and bio-fouling (including legionella).

3 Exclusions:

Heating systems and individual household installations

Point of use water heaters

Water boiling heaters

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:

Statutory Instruments

Water Supply (Water Quality England & Wales) Regulations 2016 - as amended The Public Water Supplies (Scotland) Regulations 2014 - as amended

The Water Supply (Water Fittings) Regulation (Northern Ireland) 2009 - as amended

The Health and Safety Commission (HSC) approved code of practice and guidance document L8 - HSG274: Legionnaires disease. Technical Guidance.

Note: - due to the scope of HSG274, all non domestic premises shall implement some form monitoring regime and should implement, if necessary, some form of water treatment.

CIBSE Publications -

- **CIBSE Guide G Public Health Engineering**
- **CIBSE TM13:** Minimising the risk of Legionnaires' disease.
- **CIBSE Guide H** Building Control Systems.
- **CIBSE Guide Energy Efficiency in Buildings.**
- **CIBSE Commissioning Code B:** 2002.

Department of Health

Health Technical Memorandum (HTM) 04-01: The control of Legionella, hygiene, 'safe' hot water, cold water and drinking water systems.

- Part A Design, installation and testing.
- Part B Operational Management Department of Health (DH). Addendum
- Pseudonomas aeruginosa - advice for augmented care units.

HTM 04-04 The Control of Legionella in Health Care Premises- Code of Practice:2006

British Standards - a comprehensive list of relevant standards is detailed in Appendix A

General Requirements

All connections to the local water main shall comply with Water Supply (Water Fittings) Regulations 1999 (as amended). Compliance with the Regulations can be demonstrated by certification from notified body organisations such as WRAS or KIWA.

Unvented Systems

Building Regulations - use of unvented hot water storage systems with volumes exceeding 15 litres. **G3** (England & Wales), **P3** (Scotland) & **P5** (Northern Ireland)

The unvented system components allows the storage vessel to be fed directly from the mains cold water supply, or from a booster pump set, without the need for feed and expansion tanks. The unvented system components should be approved and comply with the Water Supply (Water Fittings) Regulations 1999 (as amended), including a suitably sized temperature or temperature and pressure (T&P) relief valve, which locates directly into the top portion of the storage vessel.

5 Water Quality

Prior to distribution into the cold water mains network the water is treated in accordance with the Regulations so as to be "wholesome". This water quality, which is suitable for human consumption, may not be suitable for some types of water heating equipment or associated accessories. - refer to manufacturers for guidance.

The most significant variation is the total hardness of the water which may impact scale formation. In addition, conductivity may vary resulting in potential corrosion issues.

WARNING: Always verify the manufacturers water quality recommendations for the equipment used in the hot water system. These can usually be found in the technical manual of the equipment. Never exceed the manufactures recommendations. When in doubt contact the manufacturer.

Incorrect water quality can damage and or shorten the life expectancy of the equipment.

Fig. 5a. Scaled up cold water supply pipe

Fig. 5b. Scaled up direct fired water heater

A map showing typical regional variations in total hardness is provided in Appendix E. However it is strongly recommended that contact is made with the Local Water Authority to establish the actual hardness for the installation.

Note: - Due consideration of the duty and volumetric flow of water through equipment should be undertaken as the cumulative effect of scale deposition could impact the performance of the equipment. Refer to the equipment manufacturer for guidance against the system water quality results prior to recommendations for any water treatment!

Fig. 5c. Scaled up Water pipe

5.1 Analysis

All hot water systems maintain efficiency with a clean, good quality cold water supply and all water supplies shall conform to the Regulations from a health and safety perspective. However, the most prevalent factors influencing the performance of hot water systems are: total hardness, conductivity, chlorides, chlorine content and pH; all determined by the water source.

A detailed analysis of the supply water is recommended prior to any treatment programme, and a detailed assessment of system design, materials of construction and mode of operation must be carried out before a suitable programme can be developed.

Chemical analysis of the cold water supply to the hot water system 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.

Note: - Local Water Authorities will frequently vary treatment of the cold water supply so as to maintain the 'wholesomeness' of the water. This should be considered in the formulation of any on-site water treatment programme.

- Chloride levels can impact the corrosion of some stainless steels. Refer to equipment manufacturer.

- Conductivity is invariably linked to the level of dissolved solids, including hardness.

Fig. 5.1.1 Failed welds in stainless steel tanks

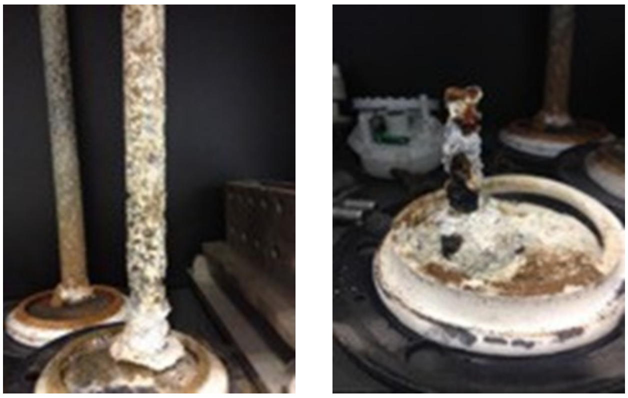

Fig. 5.1.2 Part & Fully Corroded Sacrificial Anode

5.2 Treatment of Cold Water Supply

Pre-treatment of the cold water supply to the hot water equipment may be required to achieve the desired system water quality and appropriate measures shall be taken to protect the drinking water quality. Any base exchange water treatment equipment shall be fitted downstream of the cold water supply to taps and upstream of the water heating equipment, so as to protect the equipment but not influence drinking water quality - Refer to Appendix A. Other forms of water treatment such as polyphosphate dosing, electrolytic zinc and full demineralisation are suitable for drinking water.

Further advice should be sought from the equipment manufacturer before any decision on water treatment is taken.

Note: due to the legacy of UK water distribution infrastructure, lead pipes may still be in use and accordingly the Local Water Authority may vary the dosing of phosphates so as to manage local water quality.

Water quality should be ascertained and advice be sought from the water treatment specialist.

Proven technologies are available to control water quality such as filters, electrolytic devices and polyphosphate dosing. Refer to Appendix D for details. Other devices are available and advice should be sought from the water treatment specialist as to effectiveness.

Where softened water is to be used, reference should be made to the Water Supply Regulations and Local Water Authority. The equipment manufacturer’s instructions should be followed.

WARNING

Any person applying water treatments should be competent in that field. 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 hot water system or environment.

5.3 System Design

Refer to section 4.2 & Appendix B for guidance documents

Point of use mixing valves are recommended at each outlet to ensure high water temperatures are not discharged.

All circulation pipework shall be lagged to prevent heat loss and possible freezing, especially where pipes run through roof spaces and ventilated cavities. Tanks situated in areas that may be exposed to freezing conditions should also be insulated and header tanks fitted with an appropriate cover (Water Supply Regulations - Bylaw 30 kit)

Dead legs to both cold and hot water draw off points should be avoided, and where this is not possible, should not exceed the lengths laid down in the Water Supply Regulations.

Drain valves shall be located in accessible positions to permit the draining of the complete secondary water storage system and pipework.

5.3.1 Open Vented Systems

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. Refer to Appendix B

However with the impact of European legislation on product design and health and safety issues with cold water storage tanks, unvented systems (with the appropriate safety controls) are becoming very popular.

Any storage system should consider the potential for corrosion of the storage vessel and implement procedures & equipment to address the problem (sacrificial anodes or powered- impressed current anodes).

5.3.2 Unvented Systems

As mentioned above, unvented systems are growing in popularity utilising the cold water main or boosted cold water supply to distribute both hot and cold water services throughout the installation. Due to the fact that the system is unvented, there is the potential for water temperatures to become elevated above 100°C due to the resultant system pressure and as a result enhanced safety features are required to mitigate this occurrence. Refer to Appendix B.

All unvented systems shall comply with the Building Regulations. General advice for system arrangement can be found in BS 7074.

Any storage system should consider the potential for corrosion of the storage vessel and implement procedures & equipment to address the problem (sacrificial anodes or powered- impressed current anodes).

5.3.2.1 Unvented Systems—Boosted Supply

The attraction of the unvented system relies on there being sufficient cold water supply pressure available to distribute both hot and cold water services throughout the installation. In some instances (such as high rise buildings) this is not achievable. In which case, a booster pump takes cold water from a storage tank, increasing the pressure of the distribution system throughout the installation. Refer to Appendix B

All unvented systems shall comply with the Building Regulations.

General advice for system arrangement can be found in BS 7074

Any storage system shall consider the potential for corrosion of the storage vessel and implement procedures & equipment to address the problem (sacrificial anodes or powered - impressed current anodes).

5.3.3 Strainers

Reference should be made to BS EN 806 for the fitting of strainers to cold water supplies. In normal operation these devices are not required. However if the system or equipment is intolerant to suspended solids, guidance should be sought from equipment manufacturers' as the presence of any debris may invalidate manufacturers warranties.

5.3.4 Corrosion

Corrosion takes place in all systems and some systems may require treatment based upon the materials present. Refer to Appendices C & F for information on metallic materials frequently present in a hot water system.

Corrosion can largely be controlled by the adoption of good system design and operating conditions (such as pipe layout and flow velocities) together with good installation practices and correct ongoing maintenance and system control. Should corrosion be a concern, there are various chemical treatments available for drinking water systems comprising, orthophosphate, polyphosphate (typically, blended polyphosphates) and sodium silicate, each with or without zinc.

Advice should be sought from the equipment manufacturer and a water treatment specialist before any decision on water treatment is taken.

5.3.5 Scale

Scale formation is the most prevalent problem in UK hot water systems and if not addressed will ultimately result in the failure of the system or equipment. In selecting a suitable treatment, consideration must be given to the duty and volumetric flow of water and the maintenance regime required to manage the cleaning and removal of scale formation in equipment and distribution pipe work.

Fig. 5.3.5. Scale formation on taps and shower head

The graph (fig. 5.3.5.2) shows the correlation between calcium carbonate with temperature. As the solubility decreases with increasing temperature (unlike most other compounds which become more soluble at higher temperatures) more scale forming salts will be present in the water.

This phenomenon of **increasing scale** forming compounds with **increasing temperature** affects all types of water heaters and an illustration of the typical levels of deposition in a water heater is shown in fig 5.3.5.1.

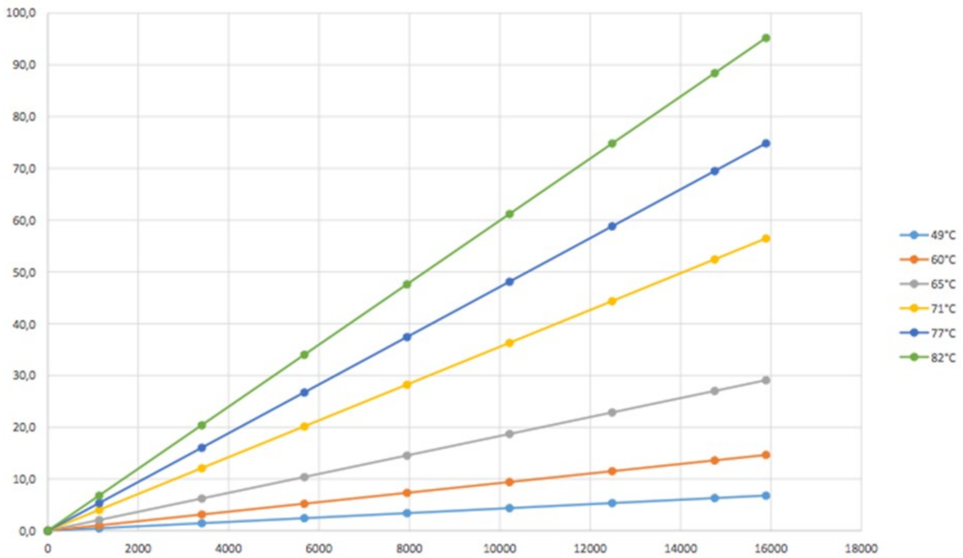

Fig 5.3.5.1 - Typical levels of lime scale deposition

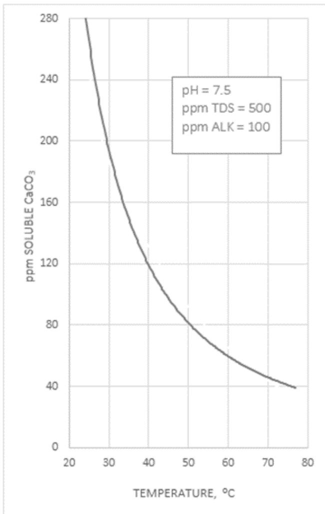

Fig 5.3.5.2—Calcium Carbonate Solubility v~v Temperature

5.3.6 Bio-fouling

This is the most critical health consideration of hot water system design and is subject to Health and Safety legislation and associated guidance documents. As a result mandatory compliance is required. Refer to HSG274 document.

5.4 Cleaning

At each stage of the cleaning process, a consent to discharge may be required from the Local Water Authority. Advice should be sought from the water treatment specialist.

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

System strainers or filters should be inspected and cleaned throughout the cleaning process.

For unvented systems, consideration of the pre-charge pressure of the expansion vessel should be undertaken to avoid overpressure and damage to the diaphragm during cleaning.

5.4.1 Looping out sensitive equipment

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

5.4.2 Descale

At regular intervals, heat transfer surfaces should be inspected to ensure that they are free from scale and debris in accordance with section 7. Should they be contaminated, the advice of a water treatment specialist should be sought, together with the equipment manufacturer with a view to carrying out a descale procedure. Due to the hazardous nature of the aggressive chemicals used in descale, this operation should be carried out by a competent person.

5.4.3 Disinfection

Refer to HSG274 for the specific commissioning process which is applicable to both new and old systems.

Directly after installation the complete system should be available and filled with a disinfectant chemical, held for a suitable period of time to thoroughly clean all materials in contact with the water, then the whole system should be neutralised if necessary and flushed through several times until all disinfectant traces are removed.

Any storage vessel or cold water storage tank should be physically cleaned before disinfection, if possible and flushed through several times until all disinfectant traces are removed.

Further advice should be sought from the water heater manufacturer before any decision on water treatment is taken.

5.4.4 Sampling

At each stage of the cleaning process, representative water samples should be taken, witnessed and signed off on a service/work sheet. A certificate to confirm the water condition should be attached to the work completion certificate. Sampling during flushing should be carried out at any terminal units, to ensure adequate flushing throughout the system. Allow water to flow for circa 10 seconds before sampling to ensure a representative sample.

5.4.5 Choice of Cleaning Chemical

Advice should be sought from the water treatment specialist and the equipment manufacturer.

5.5 Final Full System Flush

Individual, isolated sections may be 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 and a consent to discharge may be required. The advice of a water treatment specialist should be sought to determine the acceptability of the effluent.

In completing the cleaning process the inspection of heat transfer surfaces should be undertaken, where possible, to ensure that they are free from scale and debris.

Once the final system flush has been satisfactorily undertaken, it is often prudent to take bacteriological samples, from across the system, in order to provide an indication of the bacteriological water quality within the system.

These samples should not be taken immediately after disinfection, as this can lead to erroneous results. Instead it is good practice to take these one week after disinfection has been completed.

Samples should be taken from across the system and should comprise ten per cent of the total number of system outlets in number.

Certification of analysis should be provided from a UKAS accredited laboratory or similar and commentary made, by the analyst, with respect to system water quality.

If the sample results show the system to be bacteriologically fouled, then the disinfection process should be repeated and fresh samples taken, until such a point as the efficacy of the disinfection process is proven.

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 or 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 Commissioning and Handover

Where fitted, water treatment equipment should form a part of commissioning of the system as a whole. Special consideration should be given to water treatment during the commissioning of water heating plant in relation to potential scale deposition on hot surfaces.

Reference to manufacturers commissioning guidance should be made, to ensure that the 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. Should the situation occur where different equipment manufacturers have different water quality guidance, then a consensus must be agreed between the manufacturers.

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

7 Maintenance

System water quality is an important factor for the efficient functioning of equipment in a hot water system. It should be regarded as a system component and treated in the same manner as equipment. Therefore, it should not only be carefully selected but also properly maintained in order to prevent problems.

Any testing regime implemented should be a response to the outcome of Risk Assessment and the advice of a water treatment specialist.

For unvented systems, it is recommended that the pre-charge pressure of the diaphragm expansion vessel be checked at least during the annual service.

7.1 Storage Type Systems

Water side maintenance for storage water heaters and storage tanks:

The water side maintenance interval of a storage system is strongly influenced by the water quality and the amount of water used daily.

It is advised that after 3 months from initial use of the storage system, the inside of the tank is inspected for scale deposits and the condition of sacrificial anodes, where fitted, are inspected.

Based on the outcome of the inspection, a maintenance schedule can be formulated, with a minimum of once per year.

Scale needs to be removed from the unit to ensure the efficiency and longevity of the unit. Removal of scale can be done manually or for example using a vacuum cleaner suitable for water to remove the loose scale deposits.

For the scale that cannot be removed with the vacuum cleaner and or by hand we advise using a descale solution that will dissolve the remaining scale deposit.

Never use tools to get the scale out of the unit as this can damage the protective coating on the inside of the tank, where relevant.

Note: Before using any descale solution for the removal of scale deposits always consult the manufacturer of the equipment. Sacrificial anodes, where fitted, should be replaced when they are dissolved more than 60% of their original volume.

7.2 Circulating Type Water Heater

Water side maintenance for circulating/instantaneous type water heaters using internal heat exchangers or external plate heat exchangers:

The water side maintenance interval of this type of water heater is strongly influenced by the water quality and the amount of water used daily.

It is advised that after 3 months from initial use of the water heater, checks are made to the condition of the heat exchanger/plate, such as checking the ΔT across the heat exchanger/ plate against commissioning figures, or if possible measure the flow rate across the heat exchanger/plate. A build-up of scale may cause a higher ΔT or slower flow rate than those recorded at commissioning stage.

Based on the outcome of the inspection, a maintenance schedule can be formulated, with a minimum of once per year.

Scale needs to be removed from the heat exchanger to ensure the efficiency and longevity of the unit. Removal of scale is best done using a power flush device, this should be connected to the inlet and outlet of the heat exchanger/plate. A chemical descale solution should then be circulated around the heat exchanger/plate for a prescribed time. The advice of a water treatment specialist should be sought to determine the type of descale solution and exposure time.

Note: Before using any descale solution for the removal of scale deposits always consult with the manufacturer of the Water Heater.

7.3 Instantaneous Type Water Heater

Continuous flow/instantaneous water heaters, unlike storage water heaters, do not have inspection flanges. However to manage the water temperatures in the appliance at varying flow rates, they are equipped with a controller and thermistor sensors. These may be used to determine the condition of the heat exchanger. For specific guidance on the detection and removal of lime scale, which may involve carrying out a periodic flushing routine contact the manufacturer of the water heater.

7.4 Water Treatment Equipment

Where such equipment is installed, reference should be made to the equipment manufacturer and the advice of a water treatment specialist for maintenance requirements.

8 Monitoring

The cold water supply should be periodically sampled at the supply point. Refer to HSG274 and the advice of a water treatment specialist.

Monitoring should be carried out after a suitable period to ensure the effectiveness of the treatment and samples should be taken for laboratory analysis. In particular, with the impact of potential scale formation, heat transfer surfaces should be periodically monitored for cleanliness by inspection where possible. Any fundamental changes to the system should require further monitoring so as to demonstrate the effectiveness of the changes.

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

Monitoring of water quality and all equipment should be considered as part of an on-going maintenance program.

9. 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 are expected to be performed while operating that equipment, either normally or under exceptional circumstances. Specific attention is drawn to HSG274 document, detailing the responsibilities of personnel.

It is recommended that all Hot Water systems subject to water treatment, should have a “Water Treatment Log Book”, which may be paper or electronic and should contain:

- Asset information (including system components / working pressure / specified water 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

Appendices

A - British Standards

BS 6880 Part 1, 2 & 3 Code of Practice for low temperature hot water heating systems of output greater than 45kW.

BS 7074 Part 1: Application, selection and installation of expansion vessels and ancillary equipment for sealed water systems.

Part 2: Code of Practice for low and medium temperature hot water heating systems.

BS 7671 Requirements for electrical installations. IET Wiring Regulations. 17th edition.

BS 8550 Guide for the auditing of water quality sampling.

BS 8558 Guide to the design, installation, and maintenance of services supplying water for domestic use within buildings. **Note:** this document is complimentary to BS EN 806.

BS 14743 Water conditioning equipment inside buildings. Softeners. Requirements for performance, safety and testing.

BS EN ISO 4126-1 Safety devices for protection against excessive pressure. Safety valves.

BS EN 806 Specification for installations inside buildings conveying water for human consumption.

Note: - BS6700 - The Design, Installation, Testing and Maintenance of Services supplying water for domestic use within buildings; is still referred to. However this document has been superseded by BS EN 806.

BS EN 1717 Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by back-flow.

Electrical Standards:- BS 3456 Part 201, EN 60335 Part 1.

CP 342-2 Code of practice for centralised hot water supply. Buildings other than individual dwellings.

B - Design

Note - the following schematics are illustrative of the different types of systems and equipment.

B1—Typical Open Vented System

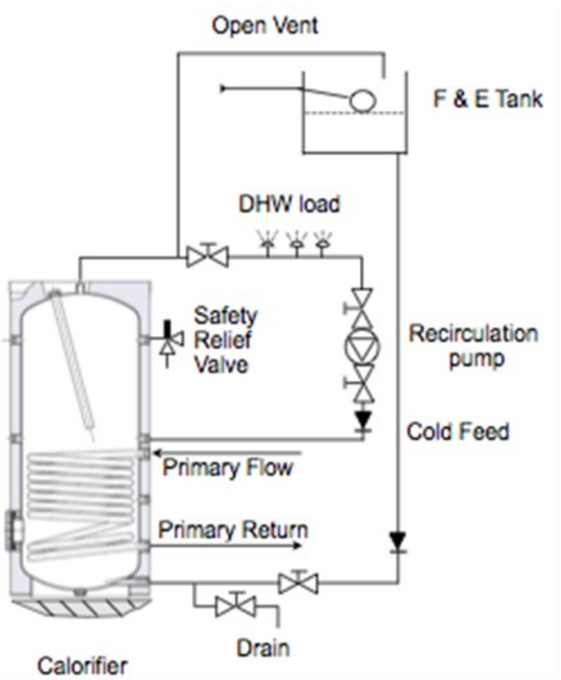

Fig B1.1—Calorifier on open vented system

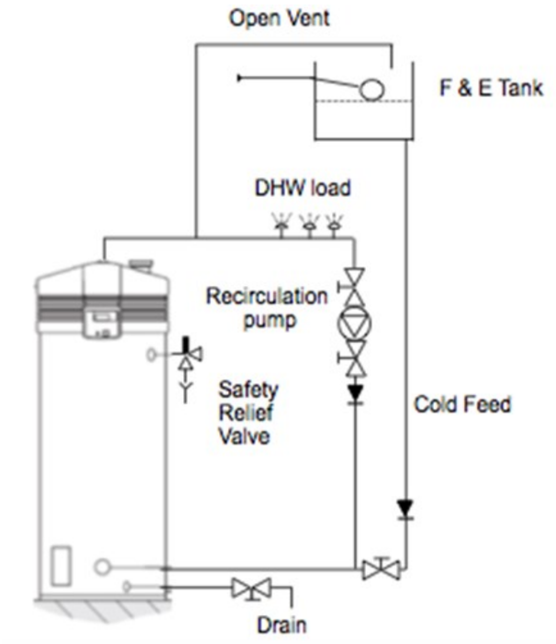

Fig B1.2—Storage Water Heater on open vented system

B1.3 Typical Unvented System

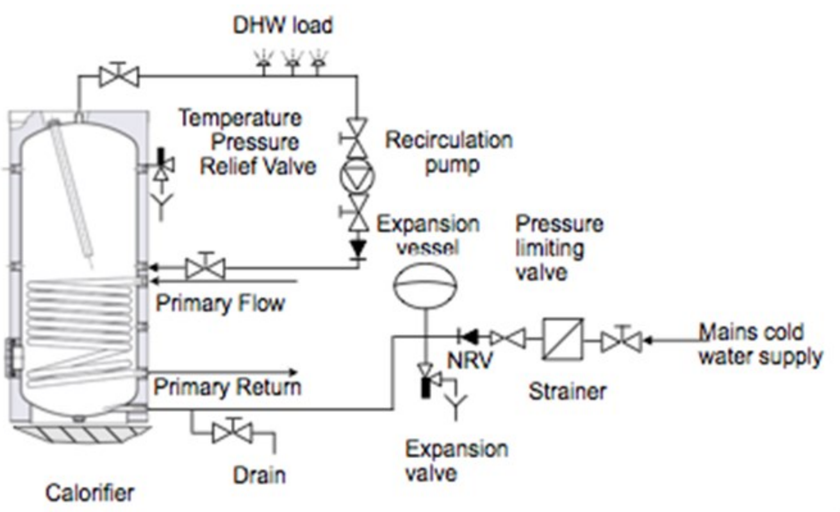

Fig B1.3 Calorifier on unvented system

B1.4 Typical Unvented System (Boosted Supply)

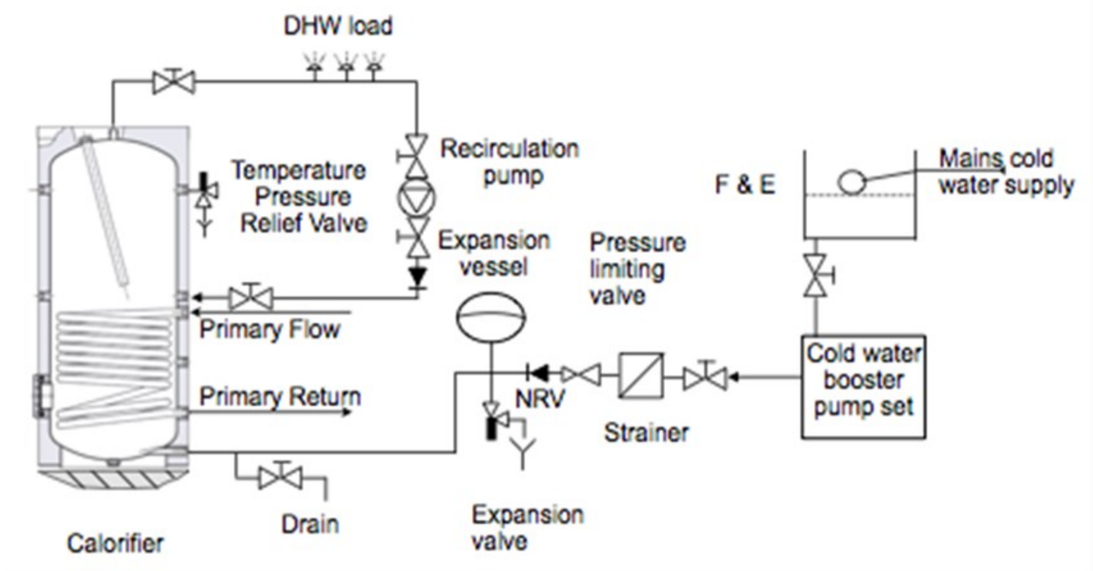

Fig. B1.4—Calorifier on unvented (Boosted Supply) system

B2—Appliance types

B2.1 Storage Direct Fired

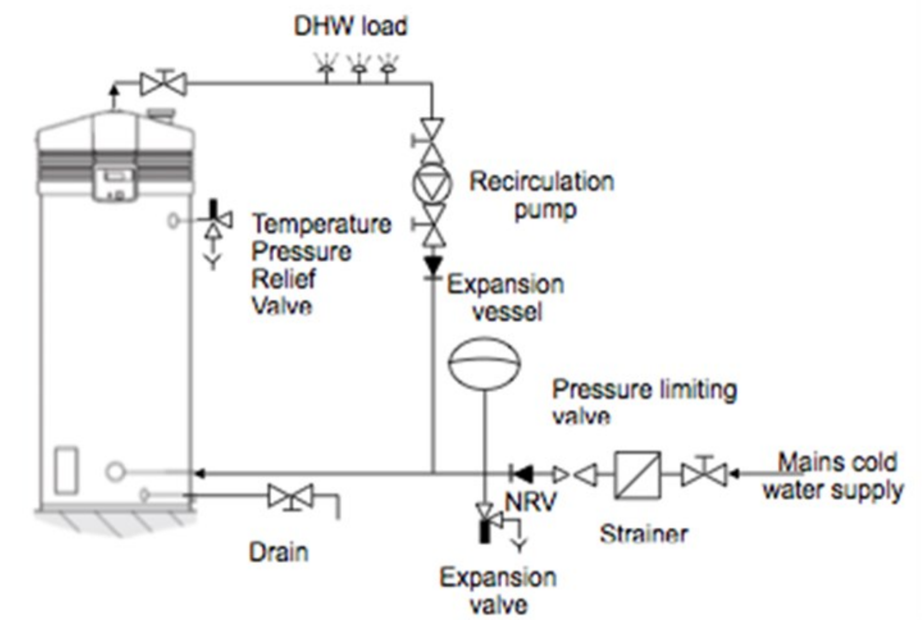

Fig B2.1 Storage Direct Fired on unvented system

B2.2 Circulating Direct Fired

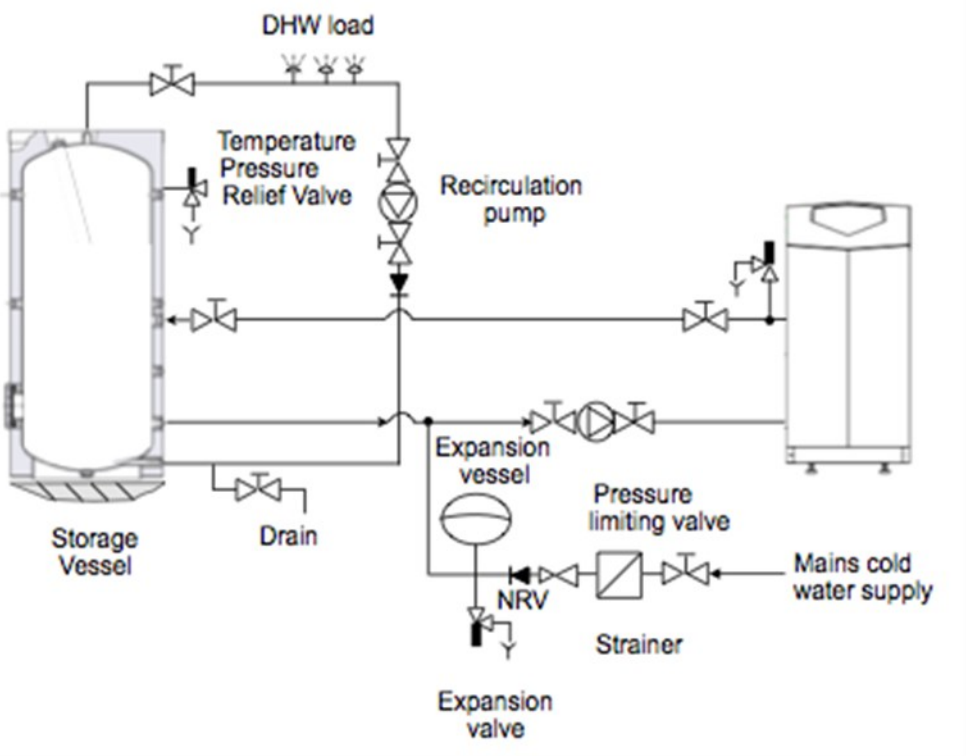

Fig B2.2 Circulating Direct Fired on unvented system

B2.3 Instantaneous Direct Fired

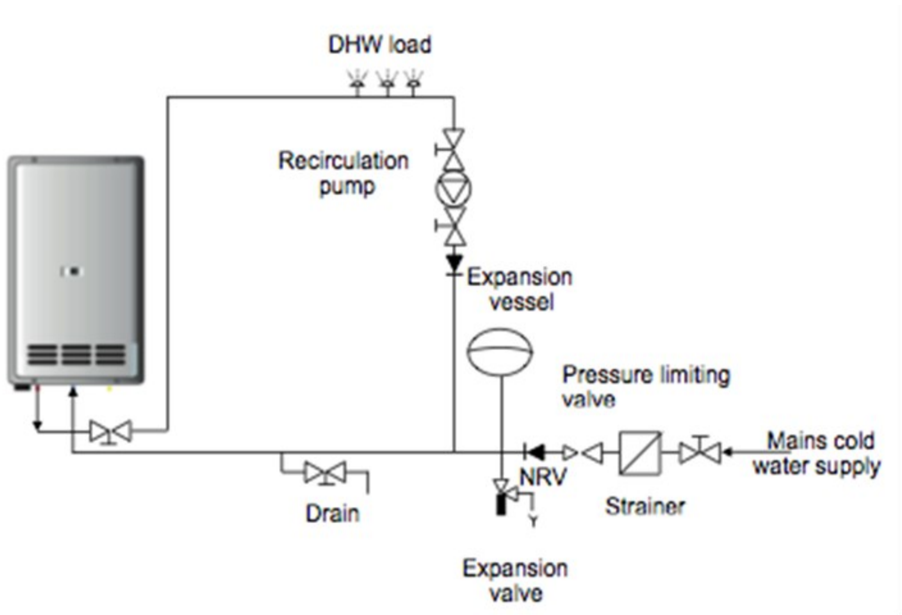

Fig B2.3—Instantaneous Direct Fired on unvented system

B2.4 Storage Indirect

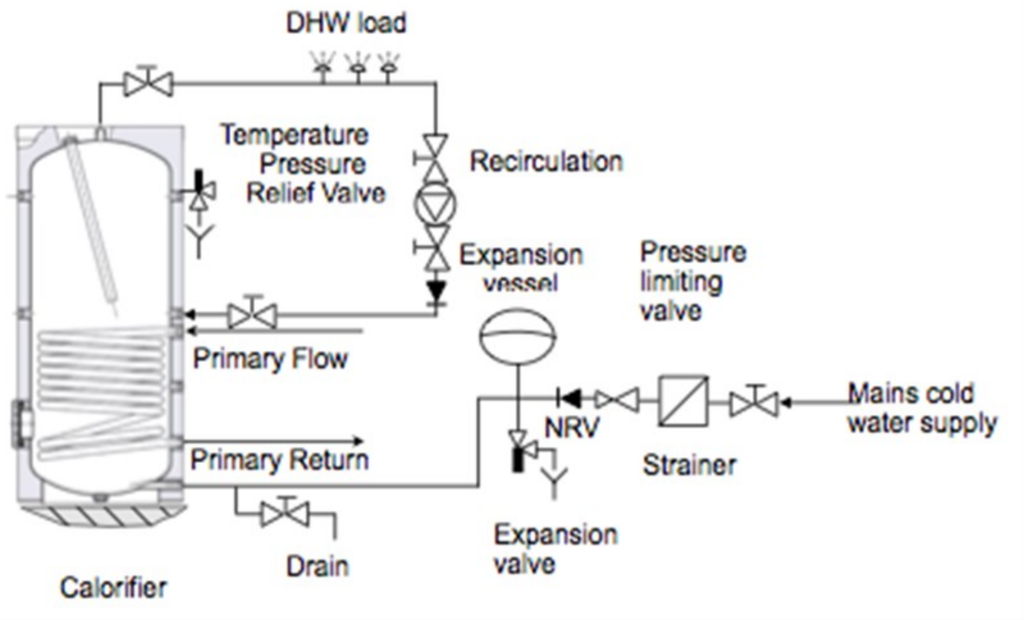

Fig B2.4 Storage Calorifier on unvented system

B2.5 Storage Electrical

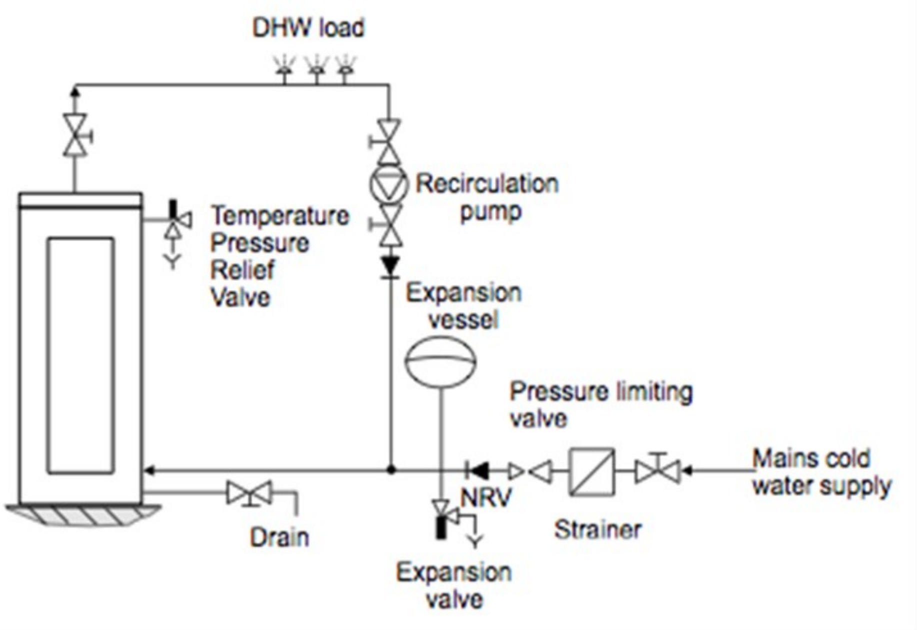

Fig B2.5 Storage Electrical on unvented system

B2.6 Plate Heat Exchanger

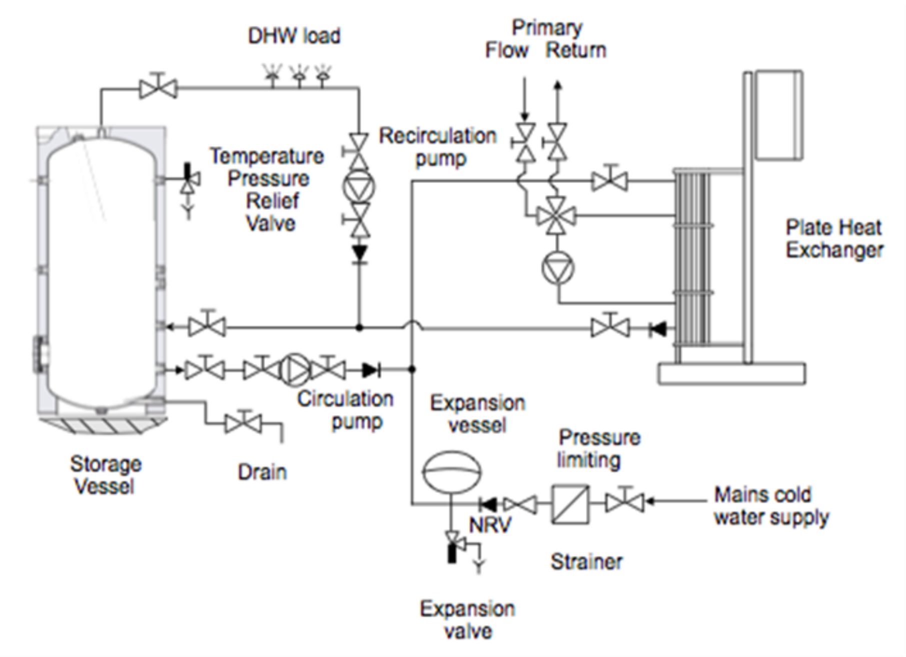

Fig B2.6 Plate Heat Exchanger on Unvented System

B2.7 Renewables—CHP

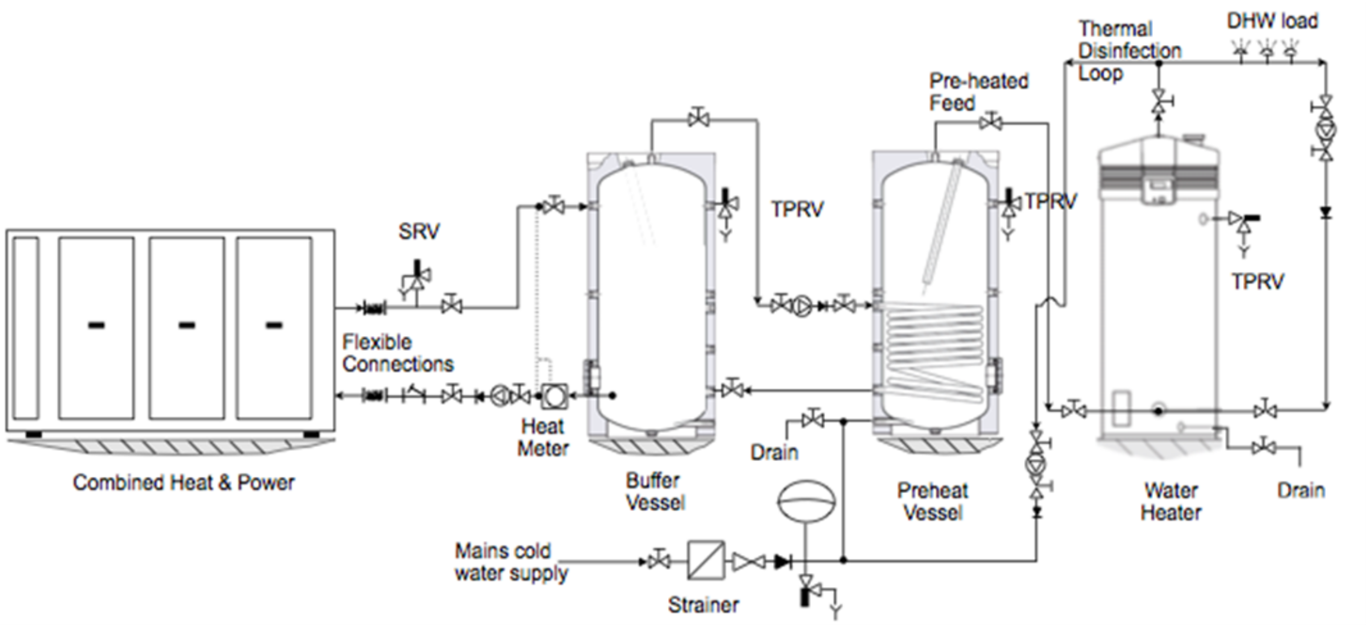

Fig B2.7 Renewables—CHP

C - Corrosion

The destructive disintegration of metals (e.g. steel or copper) by electrochemical means. Any metal in contact with water containing even a very small amount of oxygen has the potential to corrode. The conductivity of the water will also be an influencing factor in corrosion. Refer to Appendix F.

The six most frequently occurring types of corrosion are;

General corrosion - the whole surface corrodes at an approximately even rate. Pipe failures usually take several years.

Pitting corrosion - a localised form of attack occurring randomly around and along the inside of the pipe.

Erosion corrosion - a combined action of wear, caused by fluid or particulates in the pipe, and corrosion.

Stress corrosion cracking - occurs in highly stressed areas, characterised by the formation of fine cracks, which propagate through the material. Stainless steels are vulnerable to this type of corrosion.

Bimetallic/ Galvanic corrosion - there are two possible mechanisms. The first is small amounts of a dissolved metal in one part of a system causing corrosion of a different metal downstream. Alternatively, the presence and contact of two dissimilar metals, e.g. copper and steel, in an electrolyte. The more reactive metal will corrode and the rate of corrosion of the less reactive metal will be reduced - refer to Appendix F. It is this principle which supports the use of sacrificial anodes in certain applications. An alternative is the use of powered anodes, so as to minimise maintenance interventions. Refer to the equipment manufacturer for guidance.

Micro-biological corrosion - the result of the action of a bacteria and it's metabolic products such as hydrogen sulphide.

Advice should always be taken from a water treatment specialist to establish the prevention and management of any corrosion present.

D - Water Treatment

D1 - Water treatment technologies

In large areas of the UK (see map Appendix E) the mains water hardness will exceed the maximum limit and provision should be made to control the rate of scale formation. Installing a water softener (with isolation of the potable supply) or a Reverse Osmosis cartridge system can achieve this by reducing the water hardness to almost zero but some blending of raw water may be advisable for enhanced corrosion protection. Alternatively, an electrolytic scale reducer or a polyphosphate dosing system may be installed. Nevertheless, in the UK, the majority of systems will not require any further ongoing water treatment for mains water sources. Advice should always be taken from a water treatment specialist and full risk assessment carried out before they are used. Refer to BS EN806 and The Health and Safety Executive (HSE) approved code of practice and guidance document L8 - HSG274 for guidance.

Sacrificial and powered anodes can also be used for corrosion protection. Refer to Appendix C and equipment manufacturer.

Routine biocide additions should not be necessary for hot water systems, especially those on mains water. If bacterial contamination is an issue then physical forms of treatment such ultra violet light or ultra-filtration can be considered as no residual biocide is left in the water. Electrolysis is also an option. Any biocide additions should only be off-line disinfections during pre-commissioning and before returning systems to service after routine maintenance. Refer to BS EN806 and The Health and Safety Executive (HSE) approved code of practice and guidance document L8 - HSG274 for guidance.

D2.1 Base Exchange Equipment

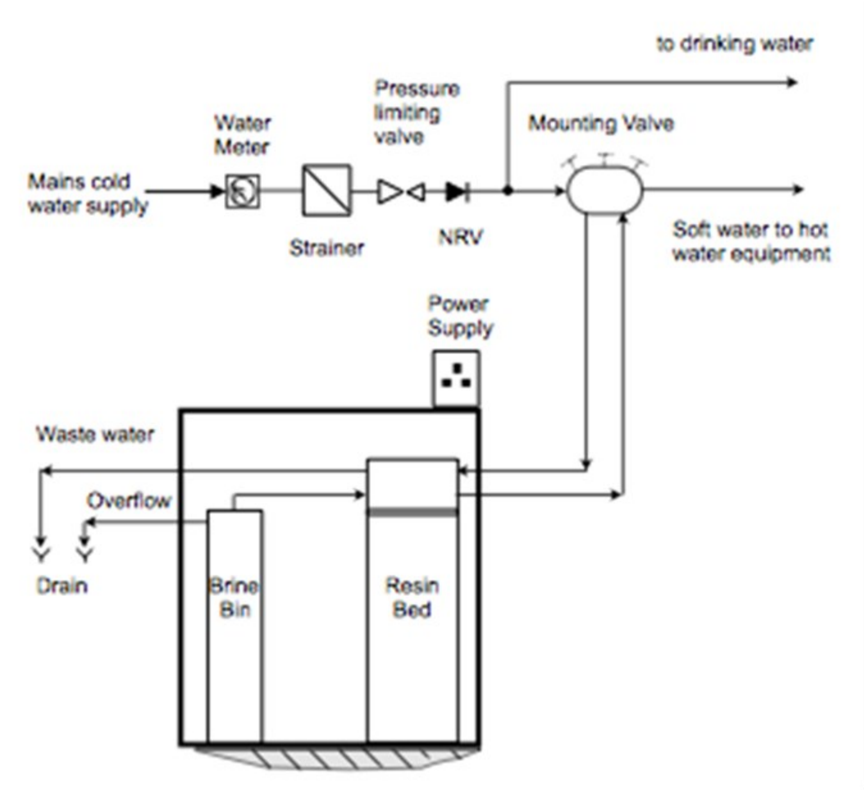

Fig D2.1 Base Exchange Installation

Fig D2.2 Base Exchange Equipment

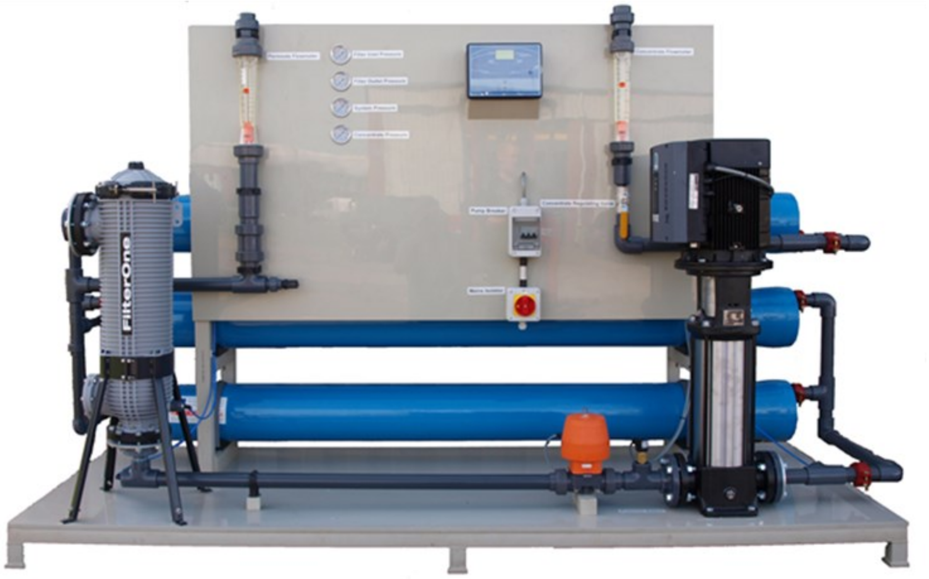

Fig D2.3 Reverse Osmosis Equipment

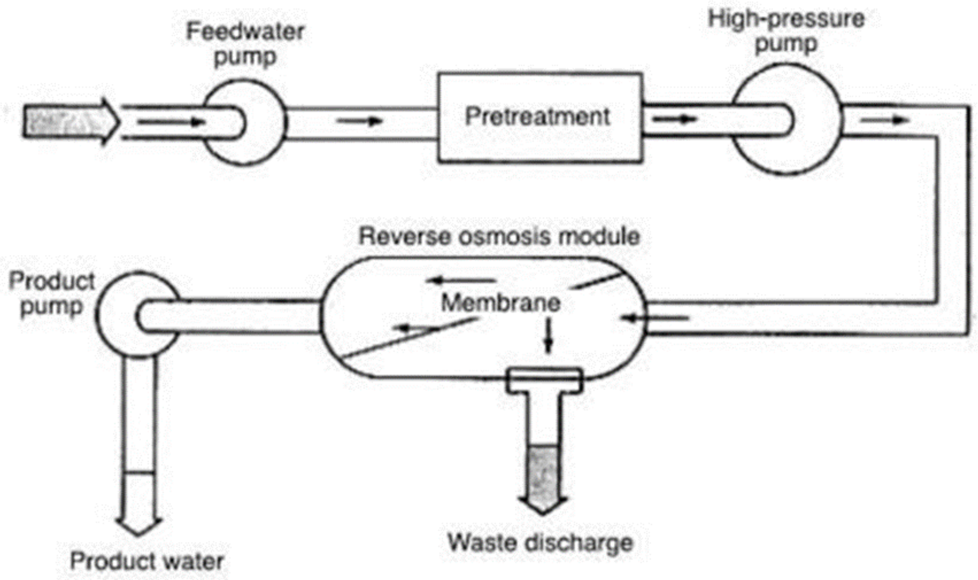

Fig D2.4 Reverse Osmosis Principles of Operation

Fig D2.5 Electrolytic Scale Control Equipment showing range of ‘inline anode units’

E—Water Hardness Map

This map shows typical hardness levels (mg/litre) by region. However the advice of the Local Water Authority should be sought to establish the actual hardness for the area of the installation.

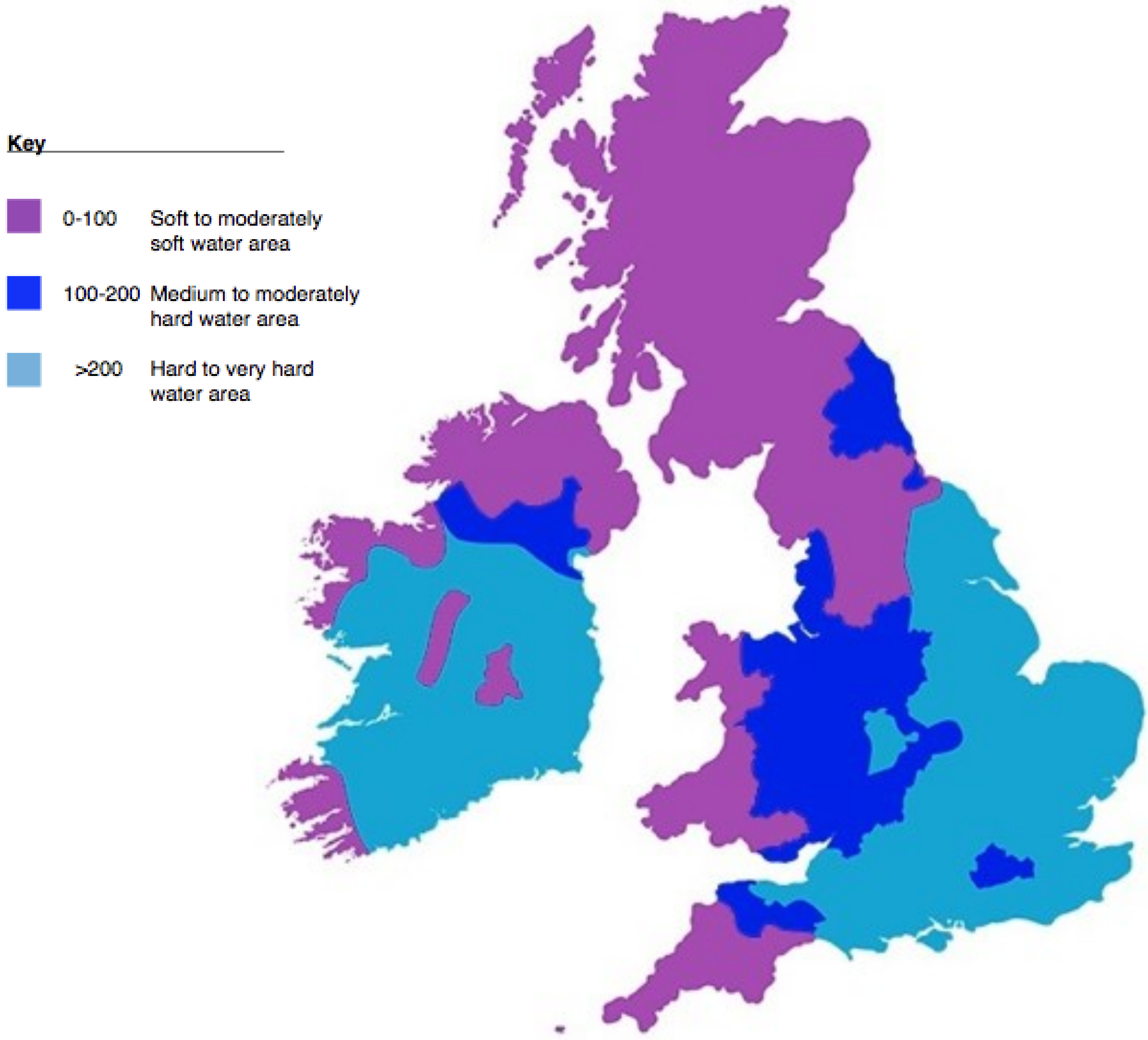

Fig E. Water Hardness Map

F—Galvanic Table based on Standard Calomel Electrode

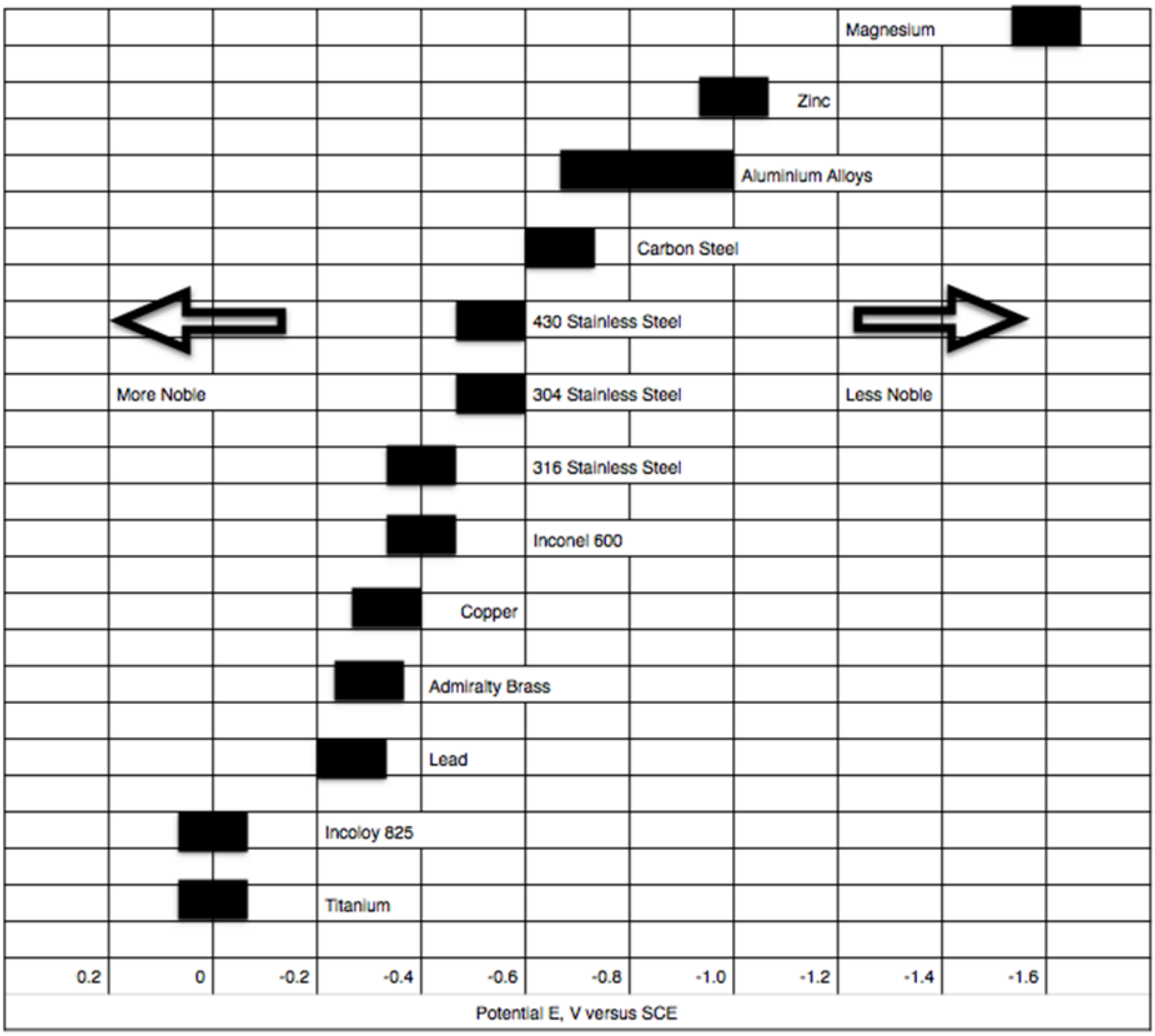

Fig F—Galvanic Table

The above table represents the potential difference between dissimilar metals expressed against the Standard Calomel Electrode. The greater the horizontal difference in potential (volts) between metals, the greater the risk of corrosion, with the 'more noble' being less likely to corrode and the 'less noble' being more likely to corrode. It is this characteristic which determines that sacrificial anodes are manufactured from Magnesium.

A factor in the corrosion of sacrificial anodes is the conductivity of the water. In areas where water conductivity is very low, there may be an issue with anodic protection of storage tanks. Refer to the equipment manufacturer for guidance.

Dissimilar metals in a system must be considered so as to avoid corrosion and premature equipment failure.

Appendix G - Training & Competency

G1 - Training

Employers shall 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 Management of Health & Safety at work Regulations.

Any training should form part of a structured scheme taking into account the particular types of equipment on-site 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.

G1.1 - 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.

G2 - Competence

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

This duty also extends to people who employ contractors. A Duty Holder must be able to show that his or 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.

G2.1 - 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.

G2.2 - Proving Competence

A formal strategy shall 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:

- On site 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.
- 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.

G2.3 - 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 H - Glossary of Commonly Used Terms in Hot Water Systems Treatment

Alarm Relay: An electric circuit, that when triggered will activate an alarm, which 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.

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

Anion: A negatively charged ion.

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

Sacrificial Anode: An anode made from a metal alloy with a more "active" voltage (more negative electrochemical potential) than the metal of the structure it is protecting (the cathode). A typical material for sacrificial anodes in hot water systems is magnesium.

Powered (impressed current) Anode: Powered anodes, or impressed current anodes, are non-sacrificial. Powered anodes use an electrical supply to produce a very low current into the water to replace the electrolytic current produced by sacrificial anodes. The metal of the anode is titanium and theoretically will last the lifetime of the hot water cylinder. It is good practice to remove the sacrificial anode (if already installed) from the hot water cylinder to maximise protection.

Electrolytic Anode: Water treatment unit installed on water pipes to generate electrolytic zinc for the control of scale.

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.

Biocide: Any substance or mixture, in the form in which it is supplied to the user, consisting of, containing or generating one or more active substances, with the intention of destroying, deterring, rendering harmless, preventing the action of, or otherwise exerting a controlling effect on, any harmful organism by any means other than mere physical or mechanical action.

Biocide wash: A stage in a hot water 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 microbiological activity.

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.

Non return (check) valve: A valve which allows fluid flow in one direction only, preventing cross circuit contamination.

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

Chloride: Soluble ionic form of the element chlorine.

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

Cold Water Booster Pump: A pump connected to a feed tank, installed in the cold water supply and used to increase the static pressure to a value controlled by a pressure reducing (limiting) valve.

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.

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.

DHW: Domestic hot water - a term used to describe hot water for distribution from taps/showers.

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.

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.

Expansion vessel: A vessel used in unvented (sealed) hot water systems with a flexible membrane to accommodate the expansion/contraction of water as it heats/cools preventing significant pressure increases and resultant evacuation of water to drain.

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.

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

Maximum allowable working pressure: Is the maximum allowable working pressure which a system/component can sustain in normal operation, less than the maximum operating pressure, typically expressed in bar.

Maximum operating pressure: Is the maximum pressure which a system can sustain in a fault condition, typically expressed in bar.

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.

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. Reporting enables the gathered information to be used in making decisions for improving system, project or programme performance.

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.

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.

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.

Pitting: A concentrated 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.

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

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

Pressure relief valve: A pre-set safety device (spring loaded) to automatically limit the water pressure within a system and is sized to suit the heat input capability of the system.

Pressure reducing (limiting) valve: An adjustable safety device (spring loaded) to protect hot water systems from excessive pressure regardless of cold water mains pressure fluctuations.

Rated capacity: The manufacturer's stated capacity rating for mechanical equipment, e.g., the maximum continuous capacity in kW for which a water heater 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 hot water system. The Responsible Person must have undertaken site specific hot water system water treatment training in order to effectively carry out their role, and this training needs to be refreshed at least once every three years.

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

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.

Soft 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.

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 Hot Water System Water Treatment Risk Assessment and completion of its findings.

The Statutory Duty Holder must have undertaken site specific hot water system 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.

Static pressure: The pressure exerted in a hot water system can be as a result of a header tank or connection to a cold water main or booster pump. Typically it is expressed in bar but can also be expressed in metres head (10m = 1 bar)

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

Temperature relief valve: A pre-set safety device to automatically limit the water temperature within a system and is sized to suit the heat input capability of the system.

Temperature & Pressure relief valve: A pre-set combined safety device to automatically limit the water temperature and pressure within a system and is sized to suit the heat input capability of the system.

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.

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

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.

Un-vented System: A hot water system sealed to atmosphere and incorporating a device to limit the system temperature and pressure in conjunction with a diaphragm expansion vessel to manage the pressure fluctuations due to the changes in hot water system temperature.

Notes (Page Left Intentionally Blank) **:**

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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