Guidance on Safe Operation of Electrically Powered Steam Boilers

Ref: BG13

CEA
Combustion Engineering Association

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Cover image courtesy of Fulton Boilers

4 x EU300kW skid mounted electric immersion boiler system
Fulton Boilerworks (GB) limited

Collins Walker skid mounted electrode boiler.

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Foreword

This document, Guidance on the Safe Operation of electrically powered Steam Boilers (BG13) has been developed and written by the Combustion Engineering Association (CEA) in consultation with other stakeholders within the boiler industry to help designers, managers and operators of new and existing boiler systems make health and safety and environmental improvements in the industry.

This document incorporates up-to-date information and best practices relating to the operation of electrically powered steam boiler plant.

This publication should not be regarded as an authoritative interpretation of the law, nor a mandatory legal requirement. However, if the guidance provided is followed, it will normally be regarded as sufficient to comply with the relevant health and safety duties.

These Guidelines, which are based on the collective experience of the Combustion Engineering Association and Member companies, should only be adopted after proper consideration has been given to the individual circumstances pertaining to each system. The CEA will not be held liable or responsible for any loss howsoever caused arising directly or indirectly from reliance on the information supplied or contained within this document. The primary responsibility for compliance with all legal duties rests with the employer or duty holder.

Acknowledgements

The Combustion Engineering Association (CEA) is an educational charity which promotes the science of combustion engineering in the commercial and industrial sector. The CEA is concerned with industry good practice and the safe and efficient operation of related plant and equipment. This guide for electrically powered steam boilers incorporates all of the same safety, legislative and regulatory features that are relevant to traditional combustion activities.

In this document the following words convey specific meaning:

Should: Compliance with this clause is not essential where supported by risk assessments and/or design calculation.

Shall: Compliance with this clause is required in order to claim compliance with this document.

Must: Compliance with this clause is a legal requirement within the United Kingdom.

His: The use of his in health and safety legislation includes male and female genders

Unless otherwise stated, all pressures refer to gauge pressure.

Skidded 2 boiler Europack 300kW steam boiler – Fulton Boilerworks (GB) limited

Typical electrode boiler with fittings and mountings – Parat/Babcock Wanson

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1 INTRODUCTION

Guidance on Safe Operation of Electrically Powered Steam Boilers (Ref: BG13) is a document intended to assist the designers, managers, operators, maintenance personnel and Competent Persons (CP) of new and existing steam boiler systems in addressing the following issues:

- Consideration of all the necessary design and installation aspects relating to an electrically powered steam boiler installation;
- The safe and efficient use and operation of the boiler installation;
- Determining adequate supervision and maintenance requirements (levels and competence) that are consistent with the installed plant and its location;
- Reducing the likelihood of other dangers from events such as:
    - Loss of feed water or low water level;
    - Over-pressure;
    - Overheating;
    - Electrical safety issues;
    - The effects of Hydrogen gas possibly arising during operation;
- Using efficient boiler operation to avoid excessive pressure or thermal cycles and load swings which can accelerate boiler fatigue or failure;
- Having proper treatment and monitoring of the feed water, boiler water, and condensate to:
    - minimise corrosion and scale of the vessel and electrical elements or electrodes;
    - treat the boiler water in order to protect the steam distribution system as well as the boiler shell and components; and
    - avoid carry-over of water with the steam which in turn can cause water-hammer and other issues;
- Compliance with the various legal requirements, in particular that for periodic examination by a Competent Person (CP) in accordance with a Written Scheme of Examination (WSE).

Electrically powered steam boilers are available in a wide range of sizes and types, and in this document the size of equipment is classified as small (<100kW), medium (100kW to 500kW), and large (above 500kW). This is an arbitrary grading simply used herein to differentiate between the different types and features of different sizes of boilers, and may not apply in every case or to every manufacturer.

There are essentially two types of boiler that use electrical power in order to raise steam, electric boilers and electrode boilers. In this document:

- the term ‘electric boiler’ means an unfired pressure vessel with a visible water level and fully immersed electrically powered heating elements, used to generate steam by indirectly heating the water; and
- the term ‘electrode boiler’ means an unfired pressure vessel with a visible water level and with immersed electrically powered conducting probes or electrodes, used to generate steam by directly heating the water through the passage of an electric current through the water.

2 SCOPE

This document applies to all industrial & commercial electrically powered steam boiler plant operating at a working pressure up to 32 bar gauge. Several types of electrically powered steam boilers are available and are included in scope, particularly:

- Boilers with electric immersion heating elements (electric boilers);
- Boilers with submerged electrodes in the water (electrode boilers);
- Hybrid boilers designed for use with electrical power and a conventional fossil fuel, either simultaneously or separately;
- Boilers converted from conventional fossil fuel operation to use electrical power.

The following boilers are **specifically excluded** from the scope of this Guidance Document:

- Steam boilers either:
  - exceeding 37 MW nett rated thermal input, or
  - above 32 bar gauge working pressure;
- Coffee boilers for commercial catering needs;
- Jet type electrode boilers;
- Hot water boilers (whether or not covered by the Pressure Systems Safety Regulations).

However, just because these boilers are outside the scope of BG13, this does not mean that the regulations and general principles in this document should not be applied where suitable and applicable.

Small 24 kW 'resistance' boiler – Babcock Wanson

3 DESIGN AND INSTALLATION

3.1 Conceptual design, and advantages of electric boilers

Fossil fuel fired steam boilers are well known and well understood. Fuel supplies for such boilers come from traditional sources and the principles are well established. However, in our drive to 'decarbonise' and find more environmentally friendly ways to run our factories, schools and hospitals, many steam boiler users and boiler manufacturers are turning to electricity as the fuel source.

Electrically powered boilers are generally classified as "low water volume unfired pressure vessels". Some of the regulations that apply to pressure systems are therefore still applicable, but equally some of the significant advantages of electric boilers include:

- Faster start up and shutdown;
- Efficiency at point of use close to 100%;
- Less operational involvement;
- Inherently fail—safe operation;
- Limited residual heat in the pressure envelope when the heating source is removed;
- Familiar control and safety devices for operation compared to fire tube steam boilers (gauge glasses, safety valves, level control, blowdown etc.);
- No requirement to meet MCPD or Clean Air Regulations;
- Generally smaller water volume for a given output;
- No CO_2 emissions on the user's site.

However, there are some important points to consider in relation to electrically powered boilers, mainly to ensure good water quality at all times, and having an adequately rated electrical supply close to the point of connection.

Water Quality

Water quality in electrically powered boilers is a specialist area and it is strongly advised that the services of a suitably qualified steam boiler water treatment chemist are used at the planning stages, since it is easy to have water conditions in any boiler that are unsuitable for the materials of construction, the steam system, and the extended life of the overall plant. Some of the water quality issues are discussed in later paragraphs.

As a general rule, electric boilers predominantly using fully immersed electrically powered elements that indirectly heat the water will require similar water treatment regimes compared with their fossil fuel fired 'furnace tube' equivalents.

Electrode boilers that generally rely on the conductivity of the water and heat the water directly have a very different set of water treatment requirements, often presenting the boiler owner/operator and their water treatment specialist with some challenges. The 'low solids chemistry' that applies to electrode boilers of most types is still not particularly well or widely understood, and it is essential that the boiler manufacturer is consulted at an early stage in the boiler procurement process.

It is also important to consider two further water quality related issues – the quality of the steam being delivered to the steam distribution system, and the operating regime of the boiler.

Water, and therefore steam, that is suitable for the materials of construction of the boiler must also be suitable for all the components in the steam distribution and condensate return system, and the individual steam users. This may require some advanced water treatment techniques.

Boilers that have a water quality regime that is well matched to their normal operating condition must also contain water that is suitable for the 'cold' condition when they are shut down. Intermittently used electrode boilers will need particularly careful assessment since the 'off' state of the boiler is often the highest corrosive state.

Electricity Supplies

It is often found that the size and characteristics of the available electrical supply on a site are inadequate to be able to support an electrically powered steam boiler without some infrastructure changes. Apart from a need to supply a very large electrical load, there may be other constraints due to electrical fault levels existing on site or nearby, and the possibility of harmonic disturbances or load shedding requirements, all of which need to be addressed by suitably qualified electrical engineers before the use of an electrically powered boiler is contemplated.

In a simple example, a small 300kW electric boiler which will give a steam output of around 450kg/h @ 10bar will require electrical switchgear rated at around 450 Amps per phase, 3 phase 400V, with cabling and other facilities to match. This may be unachievable on the site without some electrical system upgrades, and for larger electrically powered boilers, depending on the capability of the local infrastructure in the area, connection to the electricity grid may be impossible without extensive electrical distribution infrastructure being enhanced by the network operator, a lengthy and potentially costly exercise.

In very general terms, the electrical supply requirements for different 3 phase supply voltages will be in the ranges below for steam boilers (working pressure 10.3 barg (150 psig)):

Steam output	approx. kW rating	415V supply	690V supply	3,300V supply	11,000V supply
100 kg/h	64	88 A/phase	55 A/phase	-	-
1000 kg/h	628	875 A/phase	525 A/phase	-	-
10000 kg/h	6,534	-	5500 A/phase	1150 A/phase	350 A/phase
25000 kg/h	15,685	-	-	2750 A/phase	825 A/phase

Significant structures may be required to contain transformers, switchgear and cables, so a primary consideration must therefore be to conduct an electrical survey at the chosen location to ensure that the required boiler power can be provided, and the timescales and costs for any electrical system upgrades are within acceptable limits. The results of these investigations will determine the success or otherwise of the proposed scheme.

A connection agreement for the new installation may need to be obtained from the Distribution Network Operator (DNO). DNOs are licensed companies that own and operate the network of towers, transformers, cables and meters that carry electricity from the national transmission system and distribute it throughout Britain. There are currently 14 licensed DNOs owned by six different groups that cover specific geographically defined UK regions.

A further consideration may be related to the reliability of the electricity supply in the area. Traditionally the UK has benefitted from a reliable electricity grid that suffers few failures. However, some more rural operations may be disconnected for periods of time if storms or other events cause electrical distribution problems, and the addition of a significant new electrical load in an area might be subject to voluntary disconnection in times of local power shortages.

Processes or heat/steam consumers that require fail safe access to some form of steam generation may need to be designed with back-up systems in mind, and as the electricity grid moves ever closer to more renewable sources, some new challenges may present themselves. Hiring a standby generator large enough for example to provide electrical power to a 4MW steam boiler may be a significant challenge.

All the remaining parts of this guidance note will therefore presume that the conceptual design phase has gone well and sufficient fuel supplies and acceptable water quality can be achieved.

3.2 Hybrid boilers and hybrid boiler houses

There will be situations where a wholly electrically powered steam raising facility is not achievable or desirable, potentially leading to a hybrid solution, and there are emerging techniques where existing furnace tube boilers are being converted to run either as a fully electrically powered boiler or as a hybrid boiler capable of 'dual fuel' operation, electricity and a fossil fuel both being utilised.

In each case, wherever the fossil fuelled alternative is still available for use, the requirements of relevant legislation and the recommendations in guidance notes such as INDG436 and CEA BG01 should be followed, as well as the relevant parts of this guidance document.

3.3 Electrically powered boiler types

Electrically powered boilers generally fall into two main categories, those with fully submerged immersion heating elements and those with movable electrodes or electrode shields suspended in the water. Other types of electric boiler are in use and being further developed, but are presently less common in the UK.

All electrically powered boilers may be described as inherently 'fail safe'. There is very little residual heat in the pressure envelope after the electrical supply is disconnected, and there will be automatic disconnection of the heating elements or electrodes if low water conditions persist. In the electrode boiler, no water means no conductive path, since air is a very poor conductor of electricity, even if steam laden.

However, larger electric boilers and most electrode boilers will require local manning to some extent to ensure that the steam load is matching the boiler capability, not tending to over fill and carry over wet steam, or to under deliver and risk exposing the submerged elements.

Electric boilers

In general terms, electric immersion boilers are smaller (typically from around 10kW, equivalent to 15kg/h steam approximately, up to 4MW equivalent to over 6000kg/h steam output). They operate predominantly at low voltage (less than 1000V a.c.) for smaller sizes, and have multiple electrical elements each individually switched on and off in order to provide control of steam output – turndown ratios are therefore very good, often better than 10:1. It is common practice to rotate the operation of the elements to even out wear and exercise the relevant switchgear.

Immersion heater elements are typically made from incoloy or stainless steel, designed to allow quick start-up and quick steam production, while protecting the heaters from excessive stresses. Operating (surface) temperatures are in the region of 400 ^{0}C compared to fossil fuel fired furnace tubes which may approach 1000 ^{0}C surface temperature.

Electric boilers will require a pump for feed water, and either an ‘on skid’ feed tank or a separate tank for the feed water with tank level control devices. They may frequently be fitted with high pressure alarms and lockouts, pressure sensing devices for element sequencing, and chemical dosing controls. Feed water is frequently cold treated mains water, especially if there is no, or limited, condense return – pre-heating of the feed water tank can be offered.

As soon as one of the elements is exposed it should trip the water supply on thermal protection as the element would go over temperature due to not being cooled. Level limiters are supplied but not often required, as the element would usually trip before the low water limit is triggered.

One method of level control and heating inhibition is achieved through micro-switches associated with a single float level switch. The heater is inhibited by the float switch when the water is at low level, and heating is reinstated when the level rises to a suitable point. Some manufacturers may also protect against extreme low level with an over temperature thermostat.

Electric boilers can also offer a more controlled electrical load regulation than Electrode boilers which can be improved further via the use of semi-conductor devices to switch the elements rather than via staged contactors – almost infinite turndown may then be possible.

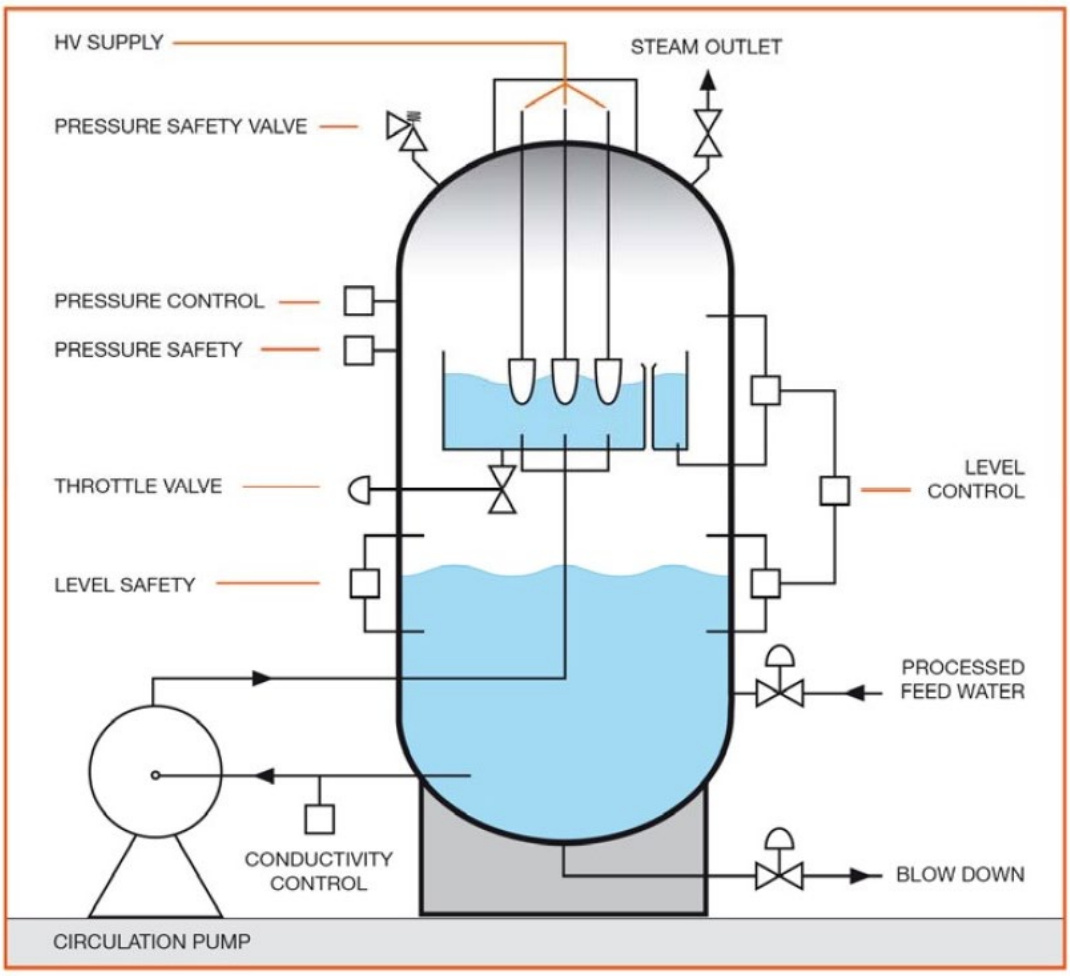
Collins Walker small electric boiler skid assembly

Electrode boilers

Electrode boilers are more usually operated at higher voltages (from 690V to well above 1000V a.c.) and many regulate the steam output either by varying the water level in the boiler or by raising and lowering the electrodes or shields around the suspended electrodes in the water whilst relying on the conductivity of the water to convert the electrical energy. Other types are controlled by pumping water into a tray that the electrodes sit in, and they can be started with very low water and switch from nothing to full output in a few minutes.

Electrode boilers use the conductive properties of water to carry electric current and generate steam – sizes up to 50MW or more are available, operating at high voltages of 25kV or more and requiring significant electrical infrastructure such as switchgear, cabling and transformers.

An alternating current flows from an electrode of one phase to earth using the water as a conductor. Since chemicals in the water provide conductivity, the current flow generates heat directly in the water itself. The more current that flows, the more heat is generated, and the more steam produced. Almost 100% of the electrical energy is converted into heat with no 'stack losses' and minimal heat transfer loss. The conductivity of the water has to be supervised on a constant basis in order to maintain output and avoid exceeding the MW capacity of the boiler.



Typical electrode boiler for steam – Parat/Babcock Wanson

3.4 Boiler House Design considerations

Many trades and professions are involved in the design, construction, operation and maintenance of a boiler system, so it is essential that all equipment, instrumentation and controls are designed and installed by suitably qualified and experienced personnel in accordance with the manufacturers' instructions.

All new and substantially modified steam raising boilers must be designed to satisfy all relevant requirements of the Pressure Equipment (Safety) Regulations (PE(S)R).

When repairs or modifications, including changes to control systems or commissioning of a new system are undertaken, the risk assessments must be reviewed with a view to eliminating the risks or reducing them to a level as low as reasonably practicable (ALARP).

The design shall be based on the results of risk assessments and relevant information from the appropriate design standards which provide further detail on the construction of electric boilers and their equipment.

Boiler system designs shall address the following safety issues as a minimum:

- The source of the boiler feed water, its effective treatment, and means for efficient monitoring of the water treatment plant, all in accordance with CEA BG04, BS 2486:1997, BS EN 12953-10 or the manufacturer's instructions;
- Electrical installation - designs to comply with BS 7671 IET Wiring Regulations for low voltage installations <1000Vac and appropriate design standards for High Voltage equipment;
- Boiler house ventilation – to ensure adequate air supply for ambient temperature control, not greater than 35^0C for operator comfort and long component life cycles;
- Boilers shall fail-safe, i.e. ensure boilers remain in or go to a safe mode under automatic control without requiring manual intervention. They shall also have a control integrity appropriate to their mode of operation;
- Critical alarms relating to plant safety shall default to lock-out and require manual reset as defined by BS EN 12953-6;
- Interruption of the electrical supply to water level equipment shall cut off the boiler automatically. Restart shall only be possible if the normal requirements for start-up are met and the boiler system has been designed to do so.

Other considerations in boiler design include:

- Appropriate types of controls and safety-related systems;
- Site manning levels & competency;
- Testing and maintenance requirements;
- Normal, extreme and transient conditions including safe start-up and shut-down and management of boiler blowdown (see CEA BG03);
- Emergency procedures;
- Access for operation and maintenance (overhead and sideways in some instances);
- Relevant aspects of the Construction Design and Management Regulations (CDM), where applicable.

3.5 Electrical Installations

All electrical work associated with the installation and operation of an electric boiler must comply with The Electricity At Work Regulations 1989 as well as various British Standards and other legislation for specific electrical components and equipment including, but not limited to:

- BS7671 IET Wiring Regulations for all parts of the installation operating at less than 1000V a.c.;
- IET Guidance notes on the application of the Wiring Regulations;
- The Electrical Equipment (Safety) Regulations 2016;
- The Electricity Safety, Quality and Continuity Regulations 2002.

The main risk arising from the electrical installation will be exposing personnel to electric shocks, so all necessary precautions must be taken to eliminate this risk, including earthing of the installation, correct selection of all protective devices, correct cable sizing and correctly installed insulation and barriers. Supplementary electrical risks of fire, electrical explosion and other effects will be adequately mitigated if all relevant design codes and standards are followed.

Small electric boilers will probably be supplied from a nearby electrical distribution board where there is spare capacity for the new equipment. Other larger boilers may need new dedicated electrical supplies from main distribution boards within the premises. Very large electric boilers and most electrode boilers will require a more significant upgrade of the electrical infrastructure, possibly including new transformers and local switchgear for HV and LV components, and in some cases an upgrade of the network connection to the grid.

High Voltage electrical installations and the associated switchgear and transformers can take up significant space. Transformers and some HV switchgear may be left outside in suitably protected and locked enclosures, but a dry indoor location will provide more suitable operating and maintenance space and may allow less costly switchgear. The HV switchgear, the transformer, and the LV switchgear will all need their own segregated lockable enclosures.

The load of the electrically powered boiler will be mostly resistive, so should not impact on the power factor of the installation in any significant way, and where the boiler load is a significant percentage of the overall site load, may tend to slightly improve the overall power factor on site during operation.

Some electrically powered boiler controllers use semi-conductor based electronic switching devices and these can give rise to harmonic disturbances on the local electrical network. Care must be taken to ensure that any electrical disturbance is minimised. The switching of large loads in quick succession or the potential sudden disconnection of a large load may need to be discussed with the site's electricity supply company or DNO in order to meet their network requirements.

Consideration should be given to the operating environment, ensuring that cable type, size, routing and connections will guard against erroneous operation and maintain the required integrity of the control system.

3.6 Water treatment plant

A Boiler Water Treatment Risk Assessment (see BG04) should always be undertaken early in the design process to fully understand the nature and source of the incoming raw water, the treatment regime that may be required to meet the boiler manufacturer's requirements (contained in a Boiler Water Treatment Written Control Scheme), any special considerations for emergencies such as low water pressure or low volume, water treatment plant maintenance outages and possible failure, and the monitoring of new or changed incoming water supplies.

The following issues should be identified and recorded:

- Means required for treating incoming water, such as filtration and base exchange or reverse osmosis (RO);
- Measurement and control devices to confirm that water flow is maintained, softened water or RO is provided within the correct parameters, brine tanks are kept full of salt, and equipment is properly serviced and maintained to a defined service schedule;
- Devices required to record feed tank temperatures and levels, and alarm on deviation; small units may not have feed tank alarms;
- Devices for monitoring condensate quality and potential contamination;
- Co-ordination of the water quality required in the boiler and the water quality needed in the steam distribution system and the steam users;
- Means for safely collecting boiler water samples from appropriate locations (such as from inside the boiler, from the feed tank, in the condensate return line, and from the softener outlet) – note that very small boilers may not have this facility due to the small volumes of water in the boiler;
- Means for delivering water treatment chemicals at appropriate points in the system with measurement and control devices to alarm if chemical dosing is low or out of specification, chemical stocks are low, or chemical dosing plant has failed (dosing pump faults, leaks, etc.);
- Equipment for on-site measurement and testing of boiler water parameters;
- Suitably trained and qualified staff on site to proactively manage water quality, especially where electrode boilers are to be used and the knowledge required of appropriate water chemistry is significantly greater than for other boiler types.

Increasing time between boiler house visits will increase the quantity and quality of the feed water and condensate monitoring and alarm equipment that is required. However, adding equipment to monitor water quality it is not a substitute for regular manual checking of water samples. Manufacturers should supply a detailed list of the recommended water parameters and will put the onus on the operators to ensure their water quality complies.

3.7 Control systems

Safe and efficient operation depends on the boiler remaining within its safe parameters during operation. A wide range of additional equipment can be fitted to electrically powered boilers which is available to help ensure this. Smaller electric boilers will frequently have limited local control features, relying on the necessary safety devices and occasional manual intervention.

Control equipment includes the various level sensors, limiters, control devices, relief devices and gauges as well as the communication and alarm systems. The level of control and monitoring will depend on a variety of factors. In general, boilers with automatic control and remote monitoring systems will require more monitoring and control equipment than a locally manned boiler system.

New safety-related systems shall be designed, documented and applied according to the requirements of BS EN 61508 so that safety functions are determined, i.e. the Safety Integrity Level (SIL) of each safety function is specified and the measures used to achieve the specified SIL for each safety function are described. BS EN 50156, *Electrical Equipment for Furnaces and Ancillary Equipment,* provides information on the application, design and installation of electrical equipment.

Every employer shall ensure that, where appropriate, work equipment is provided with one or more readily accessible emergency stop control device (PUWER Reg 16 refers).

In all circumstances refer to the manufacturer's guidance and applicable designated standards. Risk assessments may demonstrate that some control solutions are not satisfactory for unmanned (remotely operated) boiler systems and additional safety systems and monitoring may be required.

3.7.1 Level sensing devices

Electrically powered boilers should be fitted with devices to detect and alarm the level of water in any feed tank and the level of water in the boiler.

Traditional gauge glasses are usually fitted to the boiler shell in all but the smallest sizes of electric boiler, and these must always have a minimum connection point 25mm dia at the top and the bottom, be fitted with three suitable cocks for level testing and draining, and must show the actual level of the water across the whole range of normal operating conditions.

Water level indication should never disappear from the top or the bottom of the visible part of the glass, and the lowest level of water in the boiler must be above the heated surfaces.

Skidded single boiler Europack 300kW steam boiler – Fulton Boilerworks (GB) limited

3.7.2 Pressure and temperature devices

Heat input must be controlled automatically by pressure controls; limiting devices that lock-out the boiler must be fitted to prevent excessive pressure or temperature.

Users/owners shall ensure that an adequate test regime for all pressure and temperature limiters is incorporated into the operating procedures for the boilers as recommended by the boiler manufacturer.

3.7.3 Heat input Control devices

A means of accurately controlling the amount of electrical energy supplied to the elements or electrodes and therefore to the water must be provided. This is typically achieved by the use of thermal cut out devices.

If the system fails due to power outage, refer to the manufacturer's instructions to restart the equipment. A competent operator must be present for a restart.

Electrical disturbances and power surges should be prevented from causing damage to the boiler and the control system by inbuilt devices within the control function and power supply connections.

3.7.4 TDS and Blowdown

A means of blowing down the boiler shall be provided to enable any sludge and other deposits to be safely removed from the bottom of the boiler. Total Dissolved Solids (TDS) controllers and the associated TDS auto-blowdown systems are frequently not supplied on smaller boilers rated less than approximately 100kW.

Where a high TDS alarm is fitted to the boiler system this will normally be through a shell mounted probe and not a probe in the blowdown line. Smaller boilers may have TDS alarms fitted in other suitable locations as manufacturers' specifications.

CEA BG03 - *Blowdown Systems, Guidance for Industrial Steam Boilers* is applicable to both new and existing installations of all steam boilers and addresses the following issues:

- The safe discharge of blowdown from boilers;
- The safe use and operation of blowdown vessels;
- The safe use and operation of blowdown pits;
- Proper maintenance and inspection of blowdown vessels and pits including requirements for regular inspection.

Electrode boilers operating with 'low solids chemistry' water treatment regimes will require a different approach to the blowdown procedure.

3.7.5 Water samples

A means of safely taking water samples from the boiler and other locations such as the main water supply and the condensate return shall be provided for all but the smallest boilers. It is highly recommended that samples are taken frequently to give confidence that the water supply characteristics are stable, the water treatment regime is effective, and the overall water treatment equipment is operating as planned.

As soon as a reading is taken that is out of specification, a more frequent testing regime should be reinstated until conditions stabilise. It is helpful therefore to analyse every deviation of water quality and try to find the cause to prevent the same situations arising in the future.

3.7.6 Communications and alarms

The number and type of alarms will depend on a number of variables, and a review of the design and risk assessments must be undertaken to validate any decisions. Boiler systems shall be designed such that boilers will always remain in a safe condition and will shut themselves down upon critical alarm without manual intervention.

A lock-out condition requires that the boiler be attended and can only be reset locally.

Risk assessment is likely to indicate that there is benefit in also relaying alarms and providing an emergency shut-down facility at a remote location e.g. for boilers that are left unattended for a defined period of time.

The following should be considered:

- The response time for personnel to investigate and rectify alarm conditions shall be considered as part of the design of the control system; where a competent boiler operator is unable to attend the boiler within a reasonable time, a remotely activated shut-down and lockout facility shall be provided;
- Alarms shall be clearly audible and visible at a permanently manned location where persons who are competent to take the appropriate action can always hear or see them;
- It shall be possible to ascertain the current status of the boiler from the remote location; this may be as simple as a green light to indicate a ‘no-faults’ condition, or as complex as full boiler telemetry. The level of information required at the remote location shall reflect the level of knowledge of individuals at that location; e.g. it is unlikely to be appropriate to provide full boiler telemetry in a gate-house or reception area while the more detailed information could be of use to those in, say, an engineers’ office;
- The integrity and testing of communication links between the boiler house and remote locations, and the action to be taken by the automated system on the loss of that communication, shall be considered as part of the design of the control system. An “auto-dialler” is not considered a robust means of monitoring a boiler unless it is capable of also checking the integrity of the communications system, or taking action in the event of a loss of communication, or incorporates a means of remotely determining the boiler status and remotely shutting it down.

It is recommended that emergency ‘STOP’ push buttons or provision for an external emergency stop device is included within the electrical control panel to isolate power to the boiler in an emergency; it is a requirement of the PUWER Regs that a means of safely stopping plant is provided.

Low Voltage Electric Boiler Up to 10 MW in one unit –

Electric steam boiler with typical fittings and mountings – Babcock Wanson

4 BOILER OPERATION

This section details the requirements for operating the boiler and the various regular checks and procedures that should be carried out on boiler systems.

Employers must ensure that system-specific risk assessments are carried out for each boiler and site to determine:

- the appropriate types of controls and limiters; and
- the particular site manning and supervision levels

to ensure that all safety related risks remain as low as reasonably practicable. Additionally, the boilers must be examined and tested by the Competent Person before first use (PSSR Reg 8 (3) c) and then in accordance with the periodicity in the Written Scheme of Examination.

Employers should also consider business risk in their assessments. Safety comes first, but business critical risks such as equipment breakdown and failure, maintenance shortcomings or lack of spare parts, loss of steam to processes, inadequate alternative steam or fuel supplies, the potential for power cuts and a number of other considerations may need to be taken into account.

4.1 Boiler instructions

Boiler instructions shall as a minimum include the following:

- Instructions for the safe operation of steam boiler systems;
- The recommended daily checks required including water treatment plant performance and water quality test results;
- How to start the boiler from cold in a controlled manner, and add boilers to the range. Steam boilers shall be manned throughout the start-up period, and the water levels corrected to allow for expansion and guard against carry-over. The controls and limiters shall be tested prior to the boiler entering service;
- Information on the safe systems of work, including appropriate standards of isolation that should be implemented for any work on the boiler systems;
- How to protect off-line boilers against corrosion, freezing and sudden thermal shocks;
- The requirement to notify any significant planned change in boiler operating conditions (e.g. reduction in operating pressure or increase in cyclic operation) to the Competent Person prior to making such change, so that the Written Scheme of Examination can be reviewed and, if necessary, amended to reflect the new operating regime.

System re-starts following lock-out must only be made by a suitably experienced and competent boiler operator. Repeated attempts to re-start boiler plants must not be made except as part of a controlled fault identification process.

4.2 Recording of controls, limiters and water quality tests

Clear, written instructions describing how and when to carry out routine tests must be kept on-site and be followed by suitably competent boiler operators.

Where the boiler controls may be operated off-site, under IEC 61508, these instructions must also be available at the point of control and operated by a person competent to do so.

Routine testing of controls, limiters and water quality is essential to ensure continued safe, reliable and efficient operation. It can help prevent the following occurrences:

- Low water level issues;
- High water level which can lead to priming of the boiler or carry-over of water, causing water-hammer, damage to valves and pipework as well as sudden steam leaks;
- Scale, excessive sludge deposits and dissolved solids which can quickly build up in a boiler through inadequate blowdown or ineffective water treatment regimes. These can cause boiler overheating or water carry-over which can ultimately cause boiler or system failure;

The tests and their frequency shall be based upon:

- Risk assessment of the plant and boiler system;
- Manufacturers or modifiers' instructions; and
- The controls and manning levels.

A record of such tests shall be maintained to keep an audit trail of the boiler operation. Daily and weekly boiler log books, hard bound, will be supplied by some manufacturers.

Examples of the type of records and documents that shall be kept and made available for scrutiny include:

- Risk assessments;
- Boiler log book;
- Water treatment test records;
- Manufacturer's records and instructions;
- Standard Operating Procedures;
- Emergency Procedures;
- Written Scheme of Examination (WSE);
- WSE Examination reports;
- Record of periodic tests (e.g. If applicable, Non Destructive Testing (NDT), Hydraulic test);
- Certificates of thorough examination;
- Records of servicing & modifications;
- Maintenance of controls;
- Training records for boiler operators, supervisors and managers;
- Audit reports for boiler operators.

The use of loose-leaf log books is not recommended. Paper logs shall be securely bound, while electronic logs must comply with the requirements of BS 10008:2014: *Evidential weight and legal admissibility of electronic information. Specification.*

Careful consideration of where logbooks are stored is required. While it is useful for information flow between operators to keep the current logbook in the boiler house, there is a risk that the log itself could be lost in the event of a catastrophic incident. For that reason, only the current log should be stored near the boiler. Verified copies and older logbooks should be stored away from the boiler house.

Logbook entries shall be reviewed regularly by a senior manager within the organisation; this may be a useful time to make appropriate copies for remote storage and prompt a review of the procedures and risk assessment.

4.3 Water level controls and limiters

The testing regime for water level controls needs to be specific to the type of equipment employed. As a minimum it shall verify the functionality of the water level controls and the associated alarms & limiters. This shall form part of the operating instructions for the boiler system.

The following need to be considered when drawing up instructions:

- The manufacturer's recommended test methods must be carried out as a minimum;
- Any departure from the test frequencies outlined in the arrangements must be supported by the risk assessment;
- Only a competent boiler operator shall carry out the tests;
- At no time during a test shall the water be lowered to the extent that it disappears from the gauge glass;
- If a boiler fails a functional test of the level limiting devices it must be shut down and not brought back into service until such time as the fault has been repaired and the level limiting devices successfully re-tested;
- Test results shall be logged (either electronically or manually) with boiler operator's name, date of test plus any corrective action taken;
- Corrective action following alarms shall always be taken by the competent boiler operator;
- After tests have been completed, ensure that the water level is restored and that all valves are in the correct operating position. The boiler shall not be left until it is operating correctly.

Further details of tests can be found in BS EN 12953 Part 6 Annex C. While the recommended tests are useful for all boilers, the recommended frequency is only appropriate to boilers designed to this BS EN standard; risk assessment may demonstrate that some tests should be carried out more frequently. As a minimum, the level limiters shall be proven by test on a weekly basis unless risk assessment demonstrates otherwise. It is unlikely that a lower frequency will be suitable for a boiler that does not possess systems for limiting the water level in accordance with the relevant parts of EN 12953.

It is strongly recommended that gauge glasses if fitted on steam boilers are always left open to the boiler during normal operation and the connections to the gauge glasses should be fitted with auto shut off devices for safety of boiler operatives.

4.4 Feed water and boiler water checks

Unless the Boiler Water Treatment Risk Assessment and Written Control Scheme demonstrate otherwise, the minimum frequency of checks on the feed and boiler water shall be the same as the minimum attendance requirement on the boiler under all operating conditions – the boiler is at its highest risk point when it is 'off' but full of water, or when used intermittently, or when being commissioned.

A water treatment chemist with specialist knowledge of the plant to be tested and competency to take action shall undertake regular checks on the water treatment plant and test the

- make-up water;
- feed water;
- boiler water;
- condensate quality.

If scale or corrosion or any other water treatment related deterioration is found in boilers, the water treatment management system should be checked for correct operation and appropriate corrective action taken immediately.

In addition, a suitably competent employee or the boiler operator shall make the following checks, usually on a daily basis unless suitable automatic testing/monitoring and a supporting risk assessment is in place, in which case extended periods of testing according to manufacturers' advice may be acceptable:

- That the feed tank level is adequate and there are no contaminants;
- That the feed tank temperature is above the required level for the chemical water treatment dosing levels specified by the water treatment specialist for complete oxygen scavenging;
- That any chemical dosing metering device is functioning and there are adequate chemical stocks, both in the tanks and elsewhere on site;
- That in-house routine sample results dictated by the Water Treatment Written Control Scheme are within their given parameters provided by the water treatment specialist and/or any recognised standard including BG04, BS 2486:1997, BS EN 12953-10 or the manufacturer's instructions, and take remedial action when and where necessary. In-house routine testing is expected to include at least the following:
    - oxygen scavenger reserve;
    - alkalinity tests;
    - pH;
    - hardness checks of softening plant, feed tank, and boiler;
    - total dissolved solids level within the boiler;
    - appropriate tests of the condensate;
    - that the temperature is above the required level for the chemical water treatment dosing levels, specified by the water treatment specialist, for complete oxygen scavenging;
    - other tests as determined by risk assessment.

For more detailed and specific guidance please see manufacturer's instructions on water supply parameters and BG04, BS 2486:1997, BS EN 12953-10. Special consideration shall be given to the water treatment requirements for standby boilers and boilers that are to be left unused for any period.

A pair of Babcock VAP-EL units installed within a group of 4

for a total installed power of 720 kW.

5 PERSONNEL AND RESPONSIBILITIES

5.1 User/owner

These legal terms are defined later in section 10.3. The distinction between these terms is important as it will determine the duty holder responsible for ensuring compliance with certain regulations under PSSR. Similarly, the duties have been outlined in sections above.

In general, the legal responsibilities of the user/owner cannot be transferred e.g. by an employer to an employee. In situations where more than one employer or self-employed person may have an interest in the operation of a plant, para 46 of the ACoP to the PSSR provides guidance as to who is the user. It may however be prudent to take legal advice on the matter in this type of situation as it must be clear to all parties who is responsible under the Regulations.

5.2 Competent Person (CP)

A Competent Person (CP) is defined in Regulation 2, PSSR as "a competent individual person (other than an employee) or a competent body of persons corporate or unincorporate; and accordingly any reference in these Regulations to a CP performing a function includes a reference to his performing it through his employees."

From para 10 of the PSSR ACoP this term refers to the organisation employing the person who carries out these duties. Therefore, the legal duty to comply rests with a CP's employer, and not with an individual, unless that person is self-employed.

A CP is required to undertake two distinct functions under PSSR:

- To draw up, certify or review the written scheme of examination; and
- To carry out the examinations in accordance with the scheme and to produce a report after each examination.

These roles may be undertaken by the same or more than one organisation. The user/owner remains responsible for selecting a CP who possesses sufficient expertise in the particular system and is capable of carrying out the duties in a proper manner. A CP is also able to act in an advisory role and advise on other aspects of PSSR such as the scope of the written scheme and establishing the safe operating limits of pressure systems.

In addition to the above legally defined personnel, there are also a number of other personnel involved in the day-to-day safe operation of boilers. These are discussed below but it should be borne in mind, these may not be terms that have a legal definition.

5.3 Employers

Under the Health & Safety at Work etc Act 1974 (HSWA), employers have general duties, amongst other things, to provide safe places of work and adequate training for staff. This general duty on employers is also required under other legislation such as such as MHSWR and PUWER. **This legal responsibility cannot be transferred to employees or third parties.**

5.4 Employees managing the operation of boiler plant

Employers must appoint sufficient suitably competent persons to be responsible for the safe management and operation of boiler systems. These supervisors or managers must be adequately competent to carry out all the duties they are expected to perform at each specific site. The authority of a person in a management position should be commensurate with the duties and responsibilities of that person.

The duties of boiler house managers may include but are not limited to:

- Ensuring compliance with relevant law (PSSR is specifically noted);
- Risk assessments and risk management;
- Ensuring that manning levels are sufficient;
- Ensuring that plant is maintained correctly;
- Oversight on boiler operators;
- Oversight on sub-contractors;
- Defining and maintaining competencies;
- Management of personnel;
- Record keeping.

5.5 Competent Boiler Operator

It is a legal requirement for the user/owner to appoint sufficient competent persons to be responsible for the daily safe operation of the boiler system. Competence is frequently described as having relevant education, training and experience. Boiler operators must be competent to carry out all the duties they are expected to perform at each specific site. The training should enable the operators to recognise when the limits of their own expertise are reached and when to call for assistance.

The duties of the boiler operator should be determined as a logical outcome of a site specific risk assessment. These may include, but are not limited to:

- Shutdown of a boiler in an emergency or if it is unsafe;
- Implementing the boiler manufacturer's instructions, especially with regard to attendance when starting up from cold, and for all the other aspects of boiler operation, use, maintenance and cleaning etc.
- Carrying out all functional tests of limiters & controls where required, before the boiler is left unattended and at all specified frequencies and in the specified manner. Records of all these tests must be maintained;
- Carrying out the recommended water quality tests, routine water treatment, recording the results and making adjustments where necessary in accordance with established standards and guidance (BG04, BS 2486:1997, BS EN 12953-10 or the manufacturer's instructions). This should be in addition to any testing contracted out to a water treatment specialist; note that the user/owner remains responsible, and the water treatment specialist contractor shall have specific and demonstrated expertise in the treatment of water for steam and systems;
- Tests on ancillary equipment;
- Responding to alarms and taking appropriate action;
- Identification of maintenance requirements and faults;
- Investigation of abnormal operating conditions;
- Appropriate supervision of contractors;
- Recording the results of checks and tests and boiler house visits.

5.6 Electrically qualified staff

Apart from the duties allocated to a competent boiler operator, a competent electrician and/or electrical engineer will be required to manage any electrical issues associated with the boiler.

At the simplest level, a small electric boiler with a normal industrial power supply from a 400V 3 phase distribution board should not present any significant challenges to a qualified electrician. Staff with suitable experience and qualifications in industrial electrical work who are trained and assessed to the current edition of the IET Wiring Regulations and associated guidance notes should be capable of demonstrating their competence.

The installation can be treated as any other industrial electrical load with, for example, facilities for isolation, locking off, overcurrent or earth fault tripping, and resetting of the load. All abnormal operation of the electrical elements and the control modules should be protected by the correct selection and sizing of any protective devices, and the earthing of the equipment shall be maintained at all operational times for safety of personnel nearby.

As soon as the size of the boiler dictates a high voltage supply is required (above 1000V a.c.) a greater degree of care and training is required, and all operations and maintenance personnel involved with the electrically powered HV boiler should be trained in the safe application and management of an HV electrical permit to work system.

Such systems frequently include HV Authorising Engineers (who oversee the electrical safety processes), HV Authorised Persons (who write and supervise work permits and other related procedures), and HV Competent Persons (who accept permits and carry out tasks).

The application of Permit procedures is more fully described in CEA BG10 – *The Safe Isolation of Plant and Equipment*, especially written for the boiler industry in general. Several organisations have their own HV operating procedures and HV AP training is readily available. HV switchgear and the associated transformers and related equipment require segregation from all other activities at the installation, and require a rigorous safety regime to be followed at all times.

5.7 Personnel monitoring boiler alarms from on-site and off-site locations

All such persons must possess sufficient training and information to take the appropriate action in the event of an alarm condition before calling for the assistance of a boiler operator. In some cases, this may involve the emergency shutdown of the system.

Persons whose function is to monitor alarms shall ensure that the boiler is safe in response to an alarm condition, or shut it down in response to a site emergency from a location deemed appropriate by a risk assessment.

Untrained persons and persons whose only function is to monitor alarms shall not enter a boiler house during an emergency unless there is a system or procedure in place to ensure that access is safe. Only competent persons should enter during an emergency and this entry process should include a dynamic risk assessment to ensure their personal safety.

Untrained persons and persons whose only function is to monitor alarms shall not reset a boiler following a trip or a lockout.

5.8 Maintenance personnel

All maintenance personnel must possess sufficient knowledge and training to be able to carry out their expected duties. Maintenance personnel must only carry out the maintenance work for which they have been trained and are deemed competent. Suitable training courses and maintenance services for maintenance personnel can usually be provided or recommended by manufacturers of boilers, fittings or control equipment.

5.9 Sub-contractors

Sub-contractors are employed on many sites to perform specific specialist tasks or manage the day to day operation of the steam raising plant.

The contracting out party (normally the user/owner) shall ensure that the chosen sub-contractor is competent to perform the required tasks. Suitable and sufficient oversight should be exercised on sub-contractors to ensure that:

- legal requirements and legally imposed duties are met;
- works are undertaken in a safe manner;
- plant is left in a safe condition (whether usable or otherwise) during and after works;
- relevant tests and checks are performed on the plant before it is returned to service.

5.10 Manning and supervision of boiler houses

Manning and supervision levels in boiler houses shall be established as a result of a detailed boiler house technical risk assessment and a Boiler Water Treatment Risk Assessment supported by a Boiler Water Treatment Written Control Scheme as per BG04, firstly at the design stage and then revised later as the operation of the boiler house evolves.

In simple terms, the more automation, measurement and control that is installed the lower the manning requirements might be, BUT this has to be taken in context with other issues such as the location of the boilers, the likelihood of water quality issues, the possibility of contaminated condensate, risks associated with a loss of steam to process and the risks associated with actually getting competent operators to attend the boilers in adverse weather, as just a few examples.

Furthermore, different operating scenarios may dictate different supervision levels for the same level of automation. A boiler needs to be fully manned whenever it is in a vulnerable state, such as during start up, but it may be assessed as safe for daily visits during production periods and safe to leave for the weekend when the site is out of production but alarms are still monitored.

For all levels of manning, electric boilers shall not be started from cold or reset after a lockout without the competent boiler operator present to observe all limiters and alarms, and take the necessary actions.

Boiler plants which incorporate systems which significantly exceed the minimum requirements of the law and include the highest level of automation and monitoring may in certain circumstances still need to be fully manned, and this may be for reasons of steam security to process or other considerations.

Note the definitions used in this section and elsewhere:

Competent Boiler Operator - Someone appointed by their employer who has attended a training course with assessment, is familiar with the boiler system on site, and has sufficient knowledge & experience to operate the boiler and system safely.

Suitably competent and Instructed Person – Someone who has been trained to respond to specific boiler house alarms by taking agreed actions which include contacting the duty Competent Boiler Operator.

Check the boiler - carry out all documented tests and inspections relating to the boiler and ancillary plant according to local procedures, recording all necessary readings and actions, and making reports of actions and interventions as appropriate.

Local control and alarms

Where the risk assessment determines that the boilers cannot be left alone, a competent boiler operator shall be notified and available such that action can be taken in a timely manner. They shall remain in the vicinity of the boilers at all times whilst the boilers are operating. They shall be within earshot and sight of alarms at all times, and able to attend the boilers immediately.

This type of supervision is required when the boiler controls are extremely basic or the boiler is in a vulnerable state, e.g. on start-up or after an unexpected alarm.

Fail safe and alarm

If the boilers can, and actually do, automatically shut down safely as a result of any malfunction or incident, a competent boiler operator shall be on site at all times whilst the boilers are operating;

The risk assessment will determine if the operator shall be able to hear or see if the boiler is in alarm. Electronic call devices may be used if accepted by risk assessment.

The boiler operator may have other duties at the site, but they will be present for starting and stopping the boiler, and shall have specific boiler operational duties such as testing alarms and water quality tests.

Automatic shut down on limiters with alarms

Where the boilers automatically shut down safely as a result of any limiting device activating (low water for instance), or a malfunction or an incident, a competent boiler operator shall check the boilers at least on a daily basis – they might not be based on site. Speed of response to alarms might be a critical part of the risk assessment. Risk assessments and manufacturer's instructions will determine how the system needs to be operated. Auto TDS and bottom blowdown could be installed on any boiler left unattended for a period of time as determined by risk assessment.

However, a competent person on site shall be able to respond to an alarm in the absence of a competent boiler operator to ensure that the boilers shut down, and be able to summon a competent boiler operator. The competent person may need do no more than respond to an alarm (which can be as simple as "If this light comes on press this button and contact the duty boiler operator") but they shall be on site at all times to carry out that action if it is required.

Remotely monitored fail safe with alarms

If the boilers are monitored from a remote monitoring location all the time they are operating then a competent boiler operator shall attend the boilers on a daily basis or as determined by risk assessment; they might not be based on site. Also, a suitably competent and instructed person at the remote monitoring location shall have the ability to respond to an alarm and summon a competent boiler operator.

The boilers may have advanced controls and monitoring, such as high integrity water level probes on certain size boilers, pressure control and limiter. The boilers shall automatically shut down safely as a result of a limiting device activating (low water for instance), or a malfunction or an incident.

If retransmission devices are fitted all the main boiler operational data and alarms shall be visible and/or audible at the remote location at all times. This could be a manned control room, either on site or off site, or a contracted monitoring centre where the suitably competent and instructed person has the ability to confirm the boiler has shut down and can summon a competent boiler operator. In the event that the system monitoring the boiler status fails or loses its capability to communicate, the system shall sound an alarm.

A high level of supervision will typically suit sites with multiple boiler houses where operations are centrally monitored, for example, or energy management contractors who operate many sites from one central location. Speed and type of response to alarms and how to deal with each a situation will be a critical part of the risk assessments.

Remotely continuously monitored on limiters

Where automation on the boilers is such that the boilers self-monitor all operational parameters and have the proven ability to shut themselves down safely in the event of any limiting device activating or a malfunction or an incident, a competent boiler operator shall attend the boilers as determined by the risk assessment - they might not be based on site. Speed of response and type of response to alarms might be a critical part of the risk assessment.

The boilers must have advanced controls and monitoring, such as high integrity water level probes and pressure control and limiters, and indication that the main circuit breaker is energized i.e. fuel is available. The boiler water, feed water and condensate return chemistry must be checked by a competent operator at a periodicity identified through risk assessments.

Continuous monitoring of the water treatment plant and TDS levels in the boiler and feed tank shall be provided, along with any other checks and alarm systems identified in the risk assessment. All of the above must send out an alarm condition if they go out of set parameters, and shut the boiler down safely.

The boiler must be continuously observed all the time it is operating from an external monitoring location. This could be a manned control room, either on site or off site, or a contracted monitoring centre where the suitably competent and instructed person has the ability to confirm the boiler has shut down and can summon a competent boiler operator. In the event that the system monitoring the boiler status fails or loses its capability to communicate, the boiler shall automatically shut down and sound an alarm.

It is worth taking note that this level of automation and remote supervision is extremely rare, normally due to the boiler house technical risk assessments identifying unforeseen risks and the resulting high cost of the installation and maintenance of the monitoring equipment.

6 TRAINING

Employers must ensure that all personnel possess sufficient knowledge of the boiler systems on which they work to perform their duties properly. Every employer shall ensure that any of his employees who supervises or manages the use of work equipment has received adequate training for purposes of health and safety (PUWER Reg 9).

Any training shall form part of a structured scheme taking into account the particular types of boiler on site and the full range of maintenance tasks required for safe operation of the boiler. All training (including that for boiler systems) 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 the corresponding training requirements) must be reviewed when a system is modified, e.g. increased automation or remote supervision. The training shall be delivered by personnel possessing the appropriate practical experience, assessment skills, and knowledge of the working environment.

The employer must ensure that all managers and operators and other relevant personnel are regularly assessed through work audits. Training must also be reassessed periodically. All training shall be validated by assessment (written and/or oral) and the results of the assessment recorded.

The Boiler Operation Accreditation Scheme (BOAS) is recognised by the Health and Safety Executive, the UK insurance industry, the Safety Assessment Federation (SAFed) and industry members through the Combustion Engineering Association. Training providers accredited under the Boiler Operation Accreditation Scheme (BOAS) are accredited to the industry standards.

As part of any boiler house training programme, an essential element is to train all staff associated with the boilers to understand Steam Boiler Water Treatment (SBWT) with a suitable training course and assessment. This will allow monitoring and correction of any treatment parameters to ensure the water stays within specification as dictated by the Boiler Water Treatment Risk Assessment and Written Control Scheme.

6.1 Training courses

There are a number of courses available at various levels. It is recommended that operators and managers achieve the national industry standards for:

- Certified Industrial Boiler Operator (CertIBO) for operators; or
- Diploma in Boiler Plant Operation Management (DipBOM) for managers; and
- Steam Boiler Water Treatment Training (SBWTT)

These qualifications form part of the CEA suite of approved training courses which cover various types of steam boiler plant.

The level of training for operatives and managers 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.

Generic boiler system training courses can be used to provide basic information at varying levels. All training courses should involve site-specific elements. Courses should include the following topics:

- Boiler operation including start-up and shut-down;
- Boiler controls and failure modes;
- Feed water/boiler water analysis;
- Condensate drainage and water-hammer;
- Electrical safety;
- Actions to be taken in an emergency, and the consequences of inappropriate action;
- Responsibilities of all parties involved and legal aspects;
- Site specific training plus documented written and oral examination on completion of the course.

For shell boiler systems operators and managers, Category 2 BOAS courses cover the following in more detail:

- Basic heat & heat transfer concepts
- Draught & combustion
- Feed water & boiler water analysis
- Control & instrumentation
- Safety & legal requirements
- Energy efficiency
- Environment
- Boilers & auxiliaries
- Operation
- Fuel concepts

BOAS courses cover these basic requirements for boiler operators and managers in general terms, but further training for specific activities is highly recommended. In particular, boiler house operators and managers should be encouraged to undertake enhanced training in steam boiler water testing (in accordance with BG04), manufacturer specific training and bespoke training for the operation and daily maintenance of any other plant items provided in their boiler house, and specific electrical system training to include safe isolation of the boiler in normal and abnormal circumstances.

6.2 Training records

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

7 MAINTENANCE, REPAIR AND MODIFICATION

7.1 Maintenance

Boiler systems must be properly maintained and in good repair, so as to prevent danger, and must take account of manufacturers' instructions in accordance with PSSR Regulation 12 and PUWER Regulation 5.

All maintenance requirements and activities shall be fully documented, including the frequency that maintenance should take place, and maintenance logs must be kept up to date.

The use of high current, and sometimes high voltage, cables and connections lends itself to the use of infra-red thermography as a tool in the maintenance of the electrical circuits and components. The most likely faults will come from cable connections that are not sufficiently tightened and electrical components that are operating at too high temperatures. Building up a portfolio of thermal images will greatly assist maintenance activities on electrically powered boilers.

7.2 Modification & repairs

Prior to any changes or modifications, a risk assessment should be undertaken, and the effects of any modifications, repairs or adjustments to the pressure equipment must be assessed by the CP to determine whether a review of the WSE will be required; this assessment shall take place prior to the work being undertaken. The WSE itself must be reviewed at appropriate intervals (PSSR Reg 8) and it is recommended it is reviewed by the CP at each examination (PSSR ACoP para 117).

Modifications and repairs to pressure systems must comply with PSSR Regulation 13. For significant repairs, the following points must be addressed:

- All alterations to the boiler must be documented and reports or records kept for the life of the boiler;
- Repairs and modifications may in and of themselves only address the symptom. The underlying causal factors which necessitated the repairs or modification must themselves also be addressed;
- Design of the repair must make reference to the original design code and other suitable guidance and achieve an equivalent standard;
- Materials must be suitable and closely match the properties of the original equipment;
- Workmanship must be in accordance with suitable standards including non-destructive examination where applicable;
- Significant repairs or modifications to boiler systems, changes in their operating pressure or changes in cyclic operation must be notified to the CP, the WSE reviewed and the system thoroughly examined prior to coming back into use;
- Any alterations to the original specification of either the boiler system or the boiler house will require consideration and approval by the manufacturer and CP/s before instigating;
- Steam leaks are dangerous and will waste energy. Identified leaks should be cordoned off and repaired as soon as practicable;
- It may be necessary to carry out modifications or repairs. Significant modifications and repairs, where they affect integrity and/or safety of the system, its controls & software, shall be properly considered and the CP shall be kept fully informed of proposals.

7.3 Responsibility

The importance of adequate maintenance on boiler control and alarm systems cannot be over-emphasised. It is imperative that the limits of responsibility of each organisation involved in the maintenance regime are clearly defined in writing and understood by all parties.

In particular, it is important that the following points are noted:

- The user/owner is responsible for ensuring that all persons working on or with a boiler are competent to do so, including directly employed staff, agency staff, and sub-contractors;
- Boiler operators must ensure that they hand over the boiler to maintenance personnel in a safe condition;
- On completion of maintenance, the checking of all controls, limiters and alarms shall be verified by the boiler operator in the presence of the maintenance personnel before the boiler is placed on line;
- If the maintenance is carried out at the same time as the boiler examination, the controls, limiters and alarms will also be verified by the CP.

6MW electric steam boiler – Babcock Wanson

8 PERIODIC EXAMINATION OF BOILERS

The boiler must be examined in accordance with a WSE which will specify the parts to be examined, the types of examination required and the intervals between them. Depending on the circumstances and degree of expertise available the WSE may be:

- Written and certified by an independent CP; or
- Written and certified by the in-house CP (so long as they are sufficiently independent from the operating function); or
- Written in house by staff with sufficient technical capability, but certified by an independent CP.

The overall examination consists of two parts, firstly with the boiler and its fittings stripped down ("out of service") and then after it has been returned to operation ("in service" examination). The second part of the examination includes verifying the protective devices are functioning correctly and it must be performed as soon as reasonably practicable after the out of service examination. In any event, pre-checks on the functionality of controls and protective devices should have already been performed by the user/owner as soon as the boiler was returned to operation.

The protective devices that must be checked and/or tested include:

- Pressure gauge;
- Pressure / temperature protection limit switch (manufacturer's choice - depending on size of boiler)
- Pressure controller;
- Safety relief valve;
- Water level controls/limiters;
- Other protective devices fitted by the manufacturer.

The user/owner must ensure that any necessary preparatory work is completed so that the CP can carry out the examination safely. After the examination, the CP will issue a report of examination and all recommendations contained in the report shall be implemented.

Other devices or controls not classed as protective devices in PSSR but should still be checked and tested include:

- Control system power failure;
- Mains power failure;
- Critical alarms (including temperature alarms where fitted);
- TDS alarm.

9 ENERGY AND ENVIRONMENT

9.1 Energy management

Energy management of boilers is sensible to minimise operating costs to facilitate safe operation and to prolong plant life. Expert advice should be sought before any change in the operating parameters of a boiler which may affect the safety, environmental impact and efficient operation. This may include the following:

- Metering to monitor boiler efficiency;
- Water treatment;
- Energy improvement devices such as variable speed drives, auto TDS control etc;
- Plant scheduling and boiler optimisation to maximise plant efficiency.

The ability to carry out measurement is recommended to demonstrate efficient operation.

It should be noted that reducing steam pressure may not necessarily improve efficiency.

Certain large organisations (ones that employ at least 250 people, or have an annual turnover in excess of €50 million and a balance sheet in excess of €43 million) will also have to comply with the Energy Saving Opportunities Scheme (ESOS); most public sector bodies are excluded.

9.2 Environmental issues

Electrically powered boilers themselves are not subject to any emissions or other environmental legislation. There are always considerations in boiler houses where, for example, noise, fumes, waste streams and light pollution may be an issue, but these can be easily remedied by careful design and considerate operation.

Water discharged to drains must comply with water utility restrictions, and a discharge temperature of greater than 43°C is not allowed under the terms of the Water industry Act 1991.

Legislation and guidance can be downloaded from gov.uk, hse.gov.uk, or the CEA and SAFed web sites.

10 LEGISLATION

Boiler systems are required to comply with a number of health and safety and environmental regulations which are aimed at ensuring that new and existing boiler systems are continually designed, installed, operated and maintained in a safe manner.

The principal sets of health and safety legislation that support the Health and Safety at Work etc. Act 1974 and apply to the use of boiler systems covered by this guidance are:

- The Management of Health & Safety at Work Regulations (MHSWR);
- The Pressure Equipment (Safety) Regulations (PER);
- The Pressure Systems Safety Regulations (PSSR);
- The Provision and Use of Work Equipment Regulations (PUWER);
- IET Wiring Regulations BS7671 for installations operating at less than 1000Vac;

Many of the regulations listed above are supported by Approved Codes of Practice (ACoP) and Guidance produced by the Health and Safety Executive (HSE), and available as free downloads from www.hse.gov.uk.

Refer to Appendix 1 for a list of currently applicable legislation. It is the reader's responsibility to ensure that they refer to the latest available version of any legislation or guidance.

10.1 The Management of Health and Safety at Work Regulations (MHSWR)

The Management of Health and Safety at Work Approved Code of Practice (ACoP – L21) has been withdrawn and is no longer available. For those looking for information on how to manage risks in their business, HSE has a suite of guidance that will be able to help. Each level of guidance on HSE's website offers appropriately targeted information, focussed on making compliance as straightforward as possible.

If you need basic information or are getting started in managing for health and safety, then the best place to look is *Health and safety made simple: The basics for your business* (INDG449). You should also consult: *Safe management of industrial steam and Hot water boilers. A guide for owners, managers and supervisors of boilers, boiler houses and boiler plant* (INDG436).

MHSWR apply to every employer and self-employed person who carries out any work activity whether or not they own or use a pressure system (all future references to employers in this guidance should be read to include self-employed persons).

They impose a duty to manage all risks from any work activity, not only within the workplace itself, but also any risks to all persons (including any non-employees) who may be affected by the activity in question.

Regulation 3 requires the completion of a suitable and sufficient risk assessment of the work activity in order to properly identify and adequately manage any risks. This is of central importance. The risk assessment must identify sensible measures to control identified risks that may otherwise result in injury or danger.

10.2 The Pressure Equipment (Safety) Regulations (PE(S)R)

PE(S)R applies to the design, manufacture and conformity assessment of pressure equipment and assemblies of pressure equipment with a maximum allowable pressure >0.5 bar, although there are a number of exclusions which are set out in regulation 4 and Schedule 1 to the Regulations.

All items of new and substantially modified pressure equipment (including steam raising plant) comes within the scope of PE(S)R and they must comply with its requirements before they may be supplied for use.

The Directive on Pressure Equipment (PED - 2014/68/EU) was adopted on 15 May 2014 and all of its provisions entered into force on 19 July 2016, replacing the previous Directive 97/23/EC. The Directive was implemented into UK law by The Pressure Equipment (Safety) Regulations 2016 (SI 2016 No.1105).

The PED provides a legal structure whereby pressure equipment can be manufactured and sold throughout the European Union without having to go through a local approval regime in every member state. The means by which this is achieved is to ensure common standards of safety in all pressure equipment sold within the European Economic Area. Manufacturers are therefore able to meet the requirements for approval in any member state of the EU, and do not have to repeat the process when selling goods in any other state.

“Pressure equipment” means vessels, piping, safety accessories and pressure accessories. “Assembly” means several pieces of pressure equipment assembled to form an integrated, functional whole. These regulations do not apply to pressure equipment placed on the market before 8 December 2016.

10.3 Pressure Systems Safety Regulations (PSSR)

PSSR set out the main legislative requirements to ensure the continued safety of pressure systems in use, which includes all steam boilers. PSSR applies to two clearly defined categories of people (**duty holders**). These are the

- ‘**Owner’** – an employer or self-employed person who owns a pressure system. Where the employer who owns the system does not have a place of business in Great Britain, or an agent in Great Britain who would take responsibility, then the user (see below) will be responsible; and the
- ‘**User’** – the employer or self-employed person who has control of the operation of the pressure system.

The distinction between ‘**Owner’** and ‘**User’** can be important in certain circumstances in determining the duty holder responsible for ensuring compliance with certain regulations under PSSR. However, in general, owners carry more responsibility in relation to mobile systems (but see “Temporary Boiler Plant” below), while users have responsibilities in relation to installed systems. Electric boilers including electrically heated shell boilers are considered to be ‘installed systems’ for the purposes of the regulations.

The user/owner of the boiler is responsible for complying with the following requirements of PSSR:

- Safe Operating Limits (SOL) have been set and are not adjusted without informing the Competent Person (CP) and manufacturer where appropriate;
- The system is never operated unless a current Written Scheme of Examination (WSE) is in place. Any requirements of this scheme e.g. a report of the last examination, must also be satisfied (Regulations 8 & 9);
- The items identified in the WSE must be examined by a CP in accordance with the requirements of the scheme;
- The results of all tests and examinations must be recorded by the CP (Reg 9) and retained by the user/owner for a suitable period (see Log Sheets, Appendix 4). A period of at least two years is recommended for retention of records of routine tests (see section 8);
- All repairs and modifications shall be carried out by people suitably competent in such work (Regulation 13, PSSR, ACoP Para 176). You must discuss and agree any changes with the “Competent Person” and include any changes within your written scheme of examination (WSE) (ACoP Para 116,117). The details of such work shall be retained for the life of the plant;
- The statutory technical documentation and other records must be kept and where required, be made available for examination.

All records may be kept on-site or at a designated central location but wherever they are kept, they must be secure and easily accessible, and records must be transferred when the ownership of a system changes (Regulation14, PSSR).

The user must give operational employees adequate instruction so that the boiler can be operated safely (Reg 11 and para 145 ACoP). For a steam boiler these should include instructions covering:

- start-up instructions;
- water treatment; (see BG04)
- safe blowdown of the boiler (see BG03);
- precautions to be taken when emptying the boiler;
- precautions to ensure positive isolation and depressurisation of one boiler from a common header and blowdown system if internal access is required;
- precautions to be taken before carrying out maintenance operations;
- procedures to be followed in the event of a shortage of water, or other event requiring the boiler to be shut down.

10.4 Temporary Boiler Plant:

Companies who hire out steam boilers are usually hiring out a pressure system. Para 39 of the PSSR ACoP says that a steam boiler [fitted with skids] may be installed temporarily to maintain steam or supply to the site during the replacement of an existing boiler, but such an installation should not be treated as a mobile system.

Mobile steam boilers are not in fact mobile plant for the purposes of PSSR, and where a person supplies an installed system by way of lease or hire and agrees in writing to be responsible for discharging the duties of the user, all the provisions of regulations 8(1) and (2), 9(1), 11(1), 12 and 14 must be followed (Reg3(5)) and the requirements of PSSR Schedule 2 must be followed.

CEA BG08 Guidance on Temporary Steam and Hot water Boiler Plant contains detailed information regarding the safe use of temporary boiler plant.

10.5 Provision and Use of Work Equipment Regulations (PUWER)

Any employer who either provides equipment for use at work (including boiler systems) or has control over the way and manner in which equipment is used at work has a legal responsibility to comply with the relevant provisions of these regulations. An important, often overlooked, requirement under PUWER is that a maintenance logbook, when provided, must be kept up to date.

Under PUWER, all employees required to use equipment at work must be competent to do so (Reg 9). This will therefore extend to the competence assessment and training of operators and managers of boilers, all ancillary plant, and any feed water treatment plant used for the boilers.

Other parts of PUWER of relevance to boiler systems cover such topics as equipment suitability, maintenance, inspection, information & instructions, and control systems. This is not an exhaustive list.

10.6 The Construction (Design and Management) Regulations (CDM)

Although installing or replacing a steam boiler might not be a large enough project on its own to be notifiable under CDM, the principles of the regulations should still be followed, and if the steam boiler is part of a major installation the regulations will apply in full and must be considered at every stage of the project from conceptual design through installation to maintenance and ultimate demolition.

Clients must appoint a Principal Designer and a Principal Contractor to ensure that the CDM Regulations are properly followed.

10.7 The Electrical Equipment (Safety) Regulations 2016

The Electrical Equipment (Safety) Regulations 2016 implemented EU Directive (2014/35/EU) on electrical equipment designed for use within certain voltage limits (commonly called the Low Voltage Directive). The EU Withdrawal Act 2018 preserved the Regulations and enabled them to be amended so as to continue to function effectively.

The Regulations apply to all electrical equipment that is designed or adapted for use between 50 and 1,000 volts (in the case of alternating current) and 75 and 1,500 volts (in the case of direct current). The Regulations apply to equipment that is intended for use in the workplace.

Before placing electrical equipment on the GB market, the manufacturer must ensure that the equipment has been designed and manufactured in accordance with the principal elements of the safety objectives. These are set out in Schedule 1 to the Regulations. The manufacturer must also have a relevant conformity assessment procedure carried out and technical documentation drawn up.

Manufacturers have the choice to use either the CE marking or other recognised EU markings (where permitted), or the UKCA marking to supply products to Great Britain. For products that can use a UKCA marking in Great Britain, these must meet EU rules in Northern Ireland, including a CE marking.

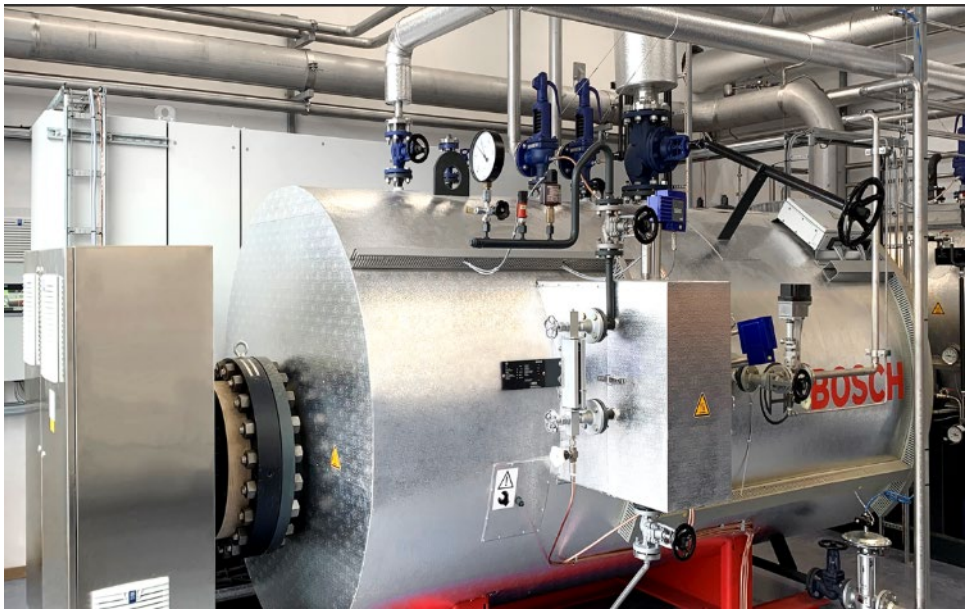
10.8 The Electricity Safety, Quality and Continuity Regulations 2002

These Regulations replaced the Electricity Supply Regulations 1988 (S.I. 1988/1057) and all subsequent amendments. They impose requirements regarding the installation and use of electrical networks and equipment owned or operated by generators, distributors and meter operators, and the participation of suppliers in providing electricity to consumers (all such persons are collectively referred to as “duty holders” in this note).

Agents, contractors and sub-contractors of duty holders also have duties under these Regulations.

Amongst many detailed requirements for DNOs and Electricity Suppliers they also contain provisions relating to:

- electrical protection and earthing;
- substations, specifically requirements for enclosures, safety and other signs, and fire precautions;
- provisions relating to distributors' and meter operators' equipment on consumers' premises, including electrical protection, security and connections to consumers' earthing terminals;
- requirements for persons connecting new installations or new networks to a distributor’s network.



Bosch electric steam boiler installation

11 LEGAL RESPONSIBILITIES

11.1 Risk assessments – for new and existing sites

Regulation 3 of MHSWR requires that 'suitable and sufficient' risk assessments be carried out before the work activity commences. The purpose is to determine whether any risks are present and, if they are not adequately managed, what further control measures are required. The significant findings of the risk assessments must be recorded where there are 5 or more employees.

The control measures must have the primary aim of eliminating the risks. Where elimination is not possible, the control measures must aim to reduce the risks to a level as low as is reasonably practical (ALARP). Regulation 4 and Schedule 1 of MHSWR sets out the principles of prevention.

The responsibility for the risk assessments lies with the employer although he may do this using input or assistance from various sources such as boiler manufacturers and control system experts, or have the entire risk assessments carried out on his behalf by someone competent to do so.

For a boiler, the risk assessments should consider issues such as:

- The likelihood and severity of injuries from:
  - Burns from steam;
  - Electric shock;
  - Fire;
  - Falls from height;
- The location of the boiler with respect to:
  - Numbers of persons likely to be affected;
  - Proximity to industrial premises/workers;
  - Proximity to the public especially vulnerable populations - such as in nurseries, schools, hospitals, care homes etc.;
  - The potential impact on neighbouring sites due to an incident;
- Capability of safety-related systems;
- Level of supervision;
- The positioning of alarms and the associated response times;
- The presence of other dangerous materials;
- The adequacy of boiler house ventilation;
- Environmental effects, e.g. noise, pollution ;
- Effect of chemicals on workers, the environment and others, e.g. water treatment chemicals;
- Operational risks:
  - Mechanical or water damage to plant or equipment;
  - Water-side explosion due to catastrophic failure of the pressure envelope;
  - Explosion caused by evolved gases;
  - Failure of the water treatment equipment to deliver properly treated water to the boiler;
  - Speed of response to loss of steam to process.

This is not an exhaustive list and specific site risks will differ, so the owner/user needs to consider all aspects of their own site.

Since risk assessments must assess the existing control measures, they should also consider information regarding:

- Manning and supervision;
- Type and reliability of controls and the integrity of safety-related systems;
- Additional controls for remote or unsupervised boiler operation.
- Boiler Water Treatment Risk Assessments and Written Control Schemes as referenced in BG04.

Risk assessments must be reviewed periodically, after any accident or incident, and when there is a significant change e.g. a system variation, change in operating parameters or manning levels etc. The outcome of any reviews must be recorded.

As an example, an owner moving to a lower level of supervision of the boiler shall, as a first step, review the boiler design and the current risk assessments to take account of the planned change in manning levels. The results of the risk assessments will be used to determine any measures necessary to ensure that the boiler remains safe to use and to operate. Such measures may include:

- The proper formulation and correct application of all modifications and installations to ensure they have sufficient safety integrity to adequately mitigate the risk of a dangerous occurrence;
- Amendment of procedures where appropriate to ensure the plant continues to be operated safely;
- Ensuring all personnel on-site & off-site and in surrounding property remain safe.

11.2 Written scheme of examination (WSE)

The requirement for a WSE is set out in Regulation 8 of PSSR. The user/owner is ultimately responsible for ensuring that the scope of the WSE covers all relevant parts of the boiler system, and they should select an organisation with sufficient knowledge and expertise on the systems in question to carry out the CP duties on that system.

The CP role and responsibilities are covered in the PSSR ACoP. A brief summary is provided below.

The WSE must include the name of the CP who certified the scheme as suitable, the date of the certification, and the following information:

- All parts which require examination by the CP;
- Justification for excluding items from examination;
- All protective devices;
- The nature and frequency of the examinations required;
- Details of any preparatory work required by the user/owner in order for the examinations to be completed;
- Details of any requirements for the initial examination;
- Details of any repairs and modifications where the CP needs to be involved.

Where there is more than one WSE for a single pressure system, (e.g. one for the boiler house and another covering the site) or there are hired boilers brought to site, the respective responsibilities for each part of the pressure system must be clearly identified. The boundaries of each WSE must be adjacent to each other with no physical gaps.

11.3 Examinations in accordance with the WSE (Thorough Examinations)

Regulation 9 of PSSR requires that all pressure systems be periodically examined by a Competent Person (CP) in accordance with a WSE, itself being drawn up by a CP.

The user/owner is responsible for ensuring their boilers meet this requirement. Where the WSE specifies any preparatory work, they are also responsible for ensuring that this is completed before the examination.

As soon as possible following examination, the CP will prepare a report of examination for the user/owner. The report will also include, amongst other information, the following:

- Whether any repairs are required and the date by which they must be completed;
- The latest date by which the next examination must be carried out;
- Whether any modifications are required to the WSE.

Note that the CP may also specify the manner and procedures which these modifications should take. The CP may also specify the nature of the required modifications to the scheme.

If any of these issues are raised in the report of examination, the user/owner must:

- Ensure that the boiler is not used or supplied if the date set for any repairs or examinations passes without these being completed;
- Make the required modifications to the WSE and have it re-certified by a CP;
- Ensure the boiler is not used or supplied if the date set for the modifications to the WSE passes without these being implemented and certified by a CP.

11.4 Summary of responsibilities

The user/owner of a boiler system is ultimately responsible for ensuring the system complies with all the relevant Health & Safety legislation (not just those responsibilities mentioned above).

While third parties, e.g. maintenance contractors, can be used to assist in achieving compliance with these legal obligations, the overall and legal responsibility remains with the user/owner and cannot be contracted out although there is scope for certain duties to be transferred (as set out in a written agreement) between the owner and user.

Useful help and advice on ensuring boiler systems remain safe to operate can be obtained from a number of sources, such as the CP carrying out the periodic examination of the boiler, or from the equipment manufacturer.

APPENDIX 1 - REFERENCES

The following is a list of applicable documents current at the time of preparation of this publication. The following should be noted:

- This is an indicative, not comprehensive list. Users should ensure they are working with the latest information available.
- Free copies of all legislation are available from gov.uk.
- Legislation marked with an asterisk is supported by Approved Codes of Practice and Guidance (ACoP) published by the HSE.
- Legislation marked with a double asterisk is supported by more than a single ACoP.
- The Electricity at Work Regulations (EAW) 1989 are supported by a Memorandum of guidance published by the HSE.

1. Health and Safety at Work etc Act 1974.
2. Management of Health and Safety at Work Regulations (MHSWR) 1998 SI 1999/3242.
3. Provision and Use of Work Equipment Regulations (PUWER) 1998* SI 1998/2306.
4. Electricity At Work Regulations 1989 - SI 1989/635
5. The Electricity Safety, Quality and Continuity Regulations 2002 No. 2665
6. Confined Spaces Regulations 1997* - SI 1997/1713.
7. Control of Substances Hazardous to Health Regulations (COSHH) 2002* SI 2002/2667.
8. Control of Noise at Work Regulations 2005 - SI 2005/1643.
9. Construction Design and Management Regulations (CDM) 2015* - SI 2015/51.
10. Supply of Machinery (Safety) Regulations (SMSR) 2008 - SI 2008/1597.
11. Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 - SI 2016/1107.
12. Pressure Equipment (Safety) Regulations (PE(S)R) SI 2016/1105.
13. Pressure System Safety Regulations (PSSR) 2000* - SI 2000/128.
14. Work at Height Regulations 2005 SI 2005/735.
15. The Regulatory Reform (Fire Safety) Order 2005 – SI 2005/1541.
16. L5 The Control of Substances Hazardous to Health Regulations 2002. Approved Code of Practice and guidance.
17. L22 Safe use of work equipment Provision and Use of Work Equipment Regulations 1998. Approved Code of Practice and guidance.
18. L101 Safe work in confined spaces. Confined Spaces Regulations 1997. Approved Code of Practice, Regulations and guidance.

19. L108 Controlling noise at work The Control of Noise at Work Regulations 2005 Guidance on Regulations.

20. L122 Safety of pressure systems. Pressure Systems Safety Regulations 2000. Approved Code of Practice.

21. L153 Managing health and safety in construction. Construction (Design and Management) Regulations 2015. Guidance on Regulations.

22. HSG253: The safe isolation of plant and equipment.

23. Permit-to-work systems HSE INDG98 ISBN 0 7176 1331 3

24. HSE Pressure Systems website http://www.hse.gov.uk/pressure-systems/index.htm

25. BEIS Pressure Equipment (Safety) Regulations 2016: Guidance

26. BG01 Guidance on Safe Operation of Steam Boilers (CEA)

27. BG03 Guidance on Steam Boiler Blowdown Systems. (CEA)

28. BG04 Guidance on Boiler Water Treatment. (CEA)

29. BG06 De-aerators and Hotwells – guidance for industrial installations (CEA)

30. BG08 Guidance on Temporary Steam and Hot water Boiler Plant (CEA)

31. BG10 Guidance on Safe Isolation of Plant and Equipment (CEA)

32. BS 5925:1991 Code of practice for Ventilation principles and designing for natural ventilation.

33. BS 6626 - Code of practice for maintenance of electrical switchgear and control gear for voltages above 1 kV and up to and including 36 kV.

34. BS 7430 - Code of practice for earthing.

35. BS 7671 Requirements for electrical installations. IET Wiring Regulations.

36. BS EN 12953 Shell Boilers.

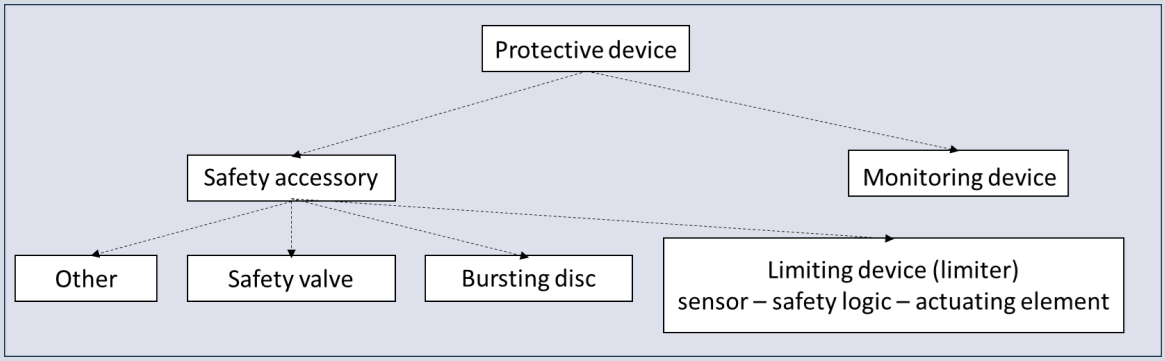
37. EN 45510 Guide for procurement of power station equipment Part 3-2 Shell Boilers.

38. IEC 61508 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems.

39. BS EN 61000-6-3, 4 - Electromagnetic compatibility. Generic emission standard.

APPENDIX 2 – DEFINITIONS

Boiler system	Boilers, ancillaries and all related items including pipework. Additionally may include: water treatment, feed tank, ventilation, blow down equipment, vents, monitoring, limiters and control equipment etc.
Boiler operator	Someone who has attended a training course with assessment, is familiar with the boiler system on-site and has suitable & sufficient competency, (Education Training and Experience) to operate the boiler system safely. Competent people operating or managing boiler plant will require different levels of training and assessment in order to be deemed competent for different activities.
Cold boiler or steam system	At atmospheric pressure and a temperature low enough to prevent harm to persons working on the equipment.
Competent Person (CP)	Competent Person as defined in The Pressure Systems Safety Regulations 2000 (PSSR). The individual or organisation that certifies the written scheme of examination and/or carries out the required examinations in accordance with the WSE.
Control	Devices used for maintaining the variable to be controlled (e.g. pressure, temperature, water level) at a specific value (set point).
Controlled blow down	Manually lowering the water level within the boiler in order to perform tests of level controls, having due regard to any discharge constraints. Discharge temperature to drain should not exceed the permissible limit of 43ºC.
Cut-out	A monitoring device, which on reaching a fixed value (e.g. pressure, temperature, flow, water level) is used to interrupt the energy supply and does not require manual reset when conditions return to normal.
Fail-safe	A limiter or control device is fail-safe if it possesses the capability of defaulting to remain in a safe condition or transferring immediately to another safe condition in the event of certain faults occurring, e.g. loss of power supply.
High-integrity	Refers to a control, limiter or cut-out system where a fault condition does not lead to loss of safety function (fail-safe). Components are high-integrity when they are of fail-safe design so that a single fault in any related part does not lead to loss of safety function. This may be achieved by fault avoidance techniques, self-monitoring, redundancy, diversity or a combination of these methods.

Limiter	A device that, on reaching a fixed value, e.g. pressure, temperature, flow, water level, is used to interrupt and lock-out the energy supply. Note: A limiting device comprises: • A measuring or detection function; and • An activation function for correction, or shutdown, or shutdown and lock-out, and which is used to carry out safety related functions as defined in the PED, on its own or as part of a safety (protective) system (e.g. sensors, limiters). If this is achieved by multi-channel systems, then all items or limiters for safety purposes are included within the safety (protective) system. • Protective devices and safety accessories according to PE(S)R and (from PSSR) devices designed to protect the pressure system against system failure and devices designed to give warning that system failure might occur, including bursting discs.
	
Lock-out	A safety shut-down condition of the limiter, such that a restart can only be accomplished by a manual reset of the limiter or by a manual reset of the safety logic and by no other means. This will be achieved by a competent operator taking account of the physical situation.
Maintenance personnel	Suitably competent persons who are responsible for undertaking maintenance on the plant. Refer to section 5 - There are a number of different areas that people are required to be competent in; these include but are not limited to; • Competent under PSSR • Competent in Boiler Water Treatment related to BG04 • Competent in Electrical systems • Competent in Mechanical operations The scope of competency required is down to the Owner/User to define.
Manned	Reference section 5
Off-site monitoring	An off-site location with direct links to the boiler controls and alarms, where monitoring takes place. A competent boiler operator attends site to carry out checks and is available to attend site at all other times.
On-site	Physical presence on-site, not necessarily in the boiler house.
Owner	'Owner' in relation to a pressure system, means the employer or self-employed person that owns the pressure system or if he does not have a place of business in Great Britain, his agent or if there is no such agent; the user (Reg 2, PSSR).

Redundancy	The provision of more than one device or system which, in the event of a fault, will still maintain the process.
Self-monitoring	Regular and automatic determination that all chosen components of a safety system are capable of functioning as required.
Shell boiler	Shell boilers may be defined as those boilers in which the heat transfer surfaces are all contained within a steel shell. In the case of electric steam boilers the electrical elements or electrodes are wholly contained in the shell.
Electrically powered Boiler	In the case of an electrically heated boiler the heat is transferred by an element or an electrode or jet electrode.
User	The user of a pressure system - the employer or self-employed person who has control of the operation of the pressure system
Water-hammer	Dynamic shock loading resulting from the accumulation of condensate in steam pipework moving quickly through the pipes.
WSE	Written Scheme of Examination.
Risk Assessments	You need to determine if the risks from your boiler are acceptable levels or if any additional measures are required to achieve this. This will require a systematic assessment of any risks that may be present and the control measures in place to address them. Ref HSE INDG 436
TBRA	Technical Boilerhouse Risk Assessment is one type of assessment looking at all aspects of a boilerhouse, and includes mechanical, electrical, safety, operational and control activities.
SBWTRA	Steam Boiler Water Treatment Risk Assessment. Site and system specific document, identifying and assessing the risk from the water treatment in relation to the steam boiler plant and total steam system, determining any necessary precautionary measures. Ref BG04
Boiler Water Treatment Written Control Scheme	This is a water treatment scheme arising from the findings of the Steam Boiler Water Treatment Risk Assessment that records the various control measures to be employed and how to use and carry out those measures. Ref BG04

Bosch ELSB 3000 electric boiler

APPENDIX 3 – TYPICAL LOG SHEET EXAMPLES

The boiler logs perform two functions:

- They should be formulated as the logical outcome of a risk assessment and as such the checks contained within constitute a risk assessment checklist.

- They are also a record of the activities that occur within a boiler house and as such all visits, work, actions and interventions which may affect the operation of the boiler should be recorded in as much detail as necessary for safe and efficient operation.

The examples that follow are suggestions for the types of records that need to be kept for typical boiler houses – **every boiler house is different and will need its own log sheet.**

Recommended checks and tests schedule for electric boilers

Log book front sheet

Boilerhouse log book for the boilers at _____

Date started: _____

Date closed: _____

Site name and address: _____

_____

Important notes

- All tests and records shall be completed and recorded by a competent boiler operator.
- Every visit to the boiler house and the name of every visitor shall be recorded.
- Visits by third parties who work on the boilers or associated plant shall be recorded in this log book and include a brief note of the work undertaken and the reference numbers of their job sheets.
- Keep all water treatment checks and records for a minimum of 2 years.
- On re-starting a boiler following maintenance or a breakdown, a full set of tests must be carried out and recorded prior to putting the boiler back on line.
- This log book contains sets of daily check sheets followed by sets of weekly check sheets.
- This log book shall be kept in a safe, secure location and shall be retained for a minimum of 2 years (INDG436).
- All annual inspection reports stay with the boiler for life.

DAY 1 (2, 3, 4 ….) EXAMPLE to be adjusted to suit installation

Print Name:		Date:		Time:	
Boiler		ONE	TWO	THREE	
Status		Online / Offline / Off	Online / Offline / Off	Online / Offline / Off	
Is water showing in LH glass?		Yes / No	Yes / No	Yes / No	
Is water showing in RH glass?		Yes / No	Yes / No	Yes / No	
If either glass indicates no level; shut down, isolate and report					
LH Sight glass blow-down		Pass / Fail	Pass / Fail	Pass / Fail	
RH Sight glass blow-down		Pass / Fail	Pass / Fail	Pass / Fail	
Do both glasses blow down in the same way? (Comment if required)		Yes / No	Yes / No	Yes / No	
Do the glasses show the same level? (Comment if required)		Yes / No	Yes / No	Yes / No	
If neither glass blows down correctly; shut down, isolate and report.					
1st low water electronic function test		Pass / Fail	Pass / Fail	Pass / Fail	
2nd low water electronic function test		Pass / Fail	Pass / Fail	Pass / Fail	
If either of these tests fail, the boiler must be shut down, isolated and the incident reported.					
Boiler pressure reading (gauge)					bar g
Steam main pressure					bar g
Electrical input					%
Ambient temperature					°C
Feed pH	*				pH
Boiler water pH level	*				pH
Boiler alkalinity	*				ppm
Boiler water sulphites	*				ppm
TDS PPM test result	*				ppm
TDS PPM readout	*				ppm
TDS recalibrated?		Yes / No	Yes / No	Yes / No	
Duty pump		One - Two	One - Two	One - Two	

*consult boiler water treatment specialist for correct tests and parameters for your system

Boiler	ONE	TWO	THREE	
Electricity meter reading				kW
Water meter reading				m^3
Steam meter reading				kg/h

Feed tank	One	Two	
Temperature			°C
Tank level			litre
Salt bin water level	Adequate / Inadequate		
Is salt visible in salt bin?	Yes / No		
Number of bags of salt on site			
Duty softener operating	One	Two	

Water test after the softener	2 max		ppm
Water meter reading at softener			m^3
Water daily consumption (softener)			m^3

Comments / faults / incidents

Signature:

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Guidance on Safe Operation of Electrically Powered Steam Boilers

This document will be formally reviewed periodically, although amendments and revisions may be made more frequently as required.

Users of this document should ensure they are working to the latest edition of this document and the related legislation and guidance.

Price - £95

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