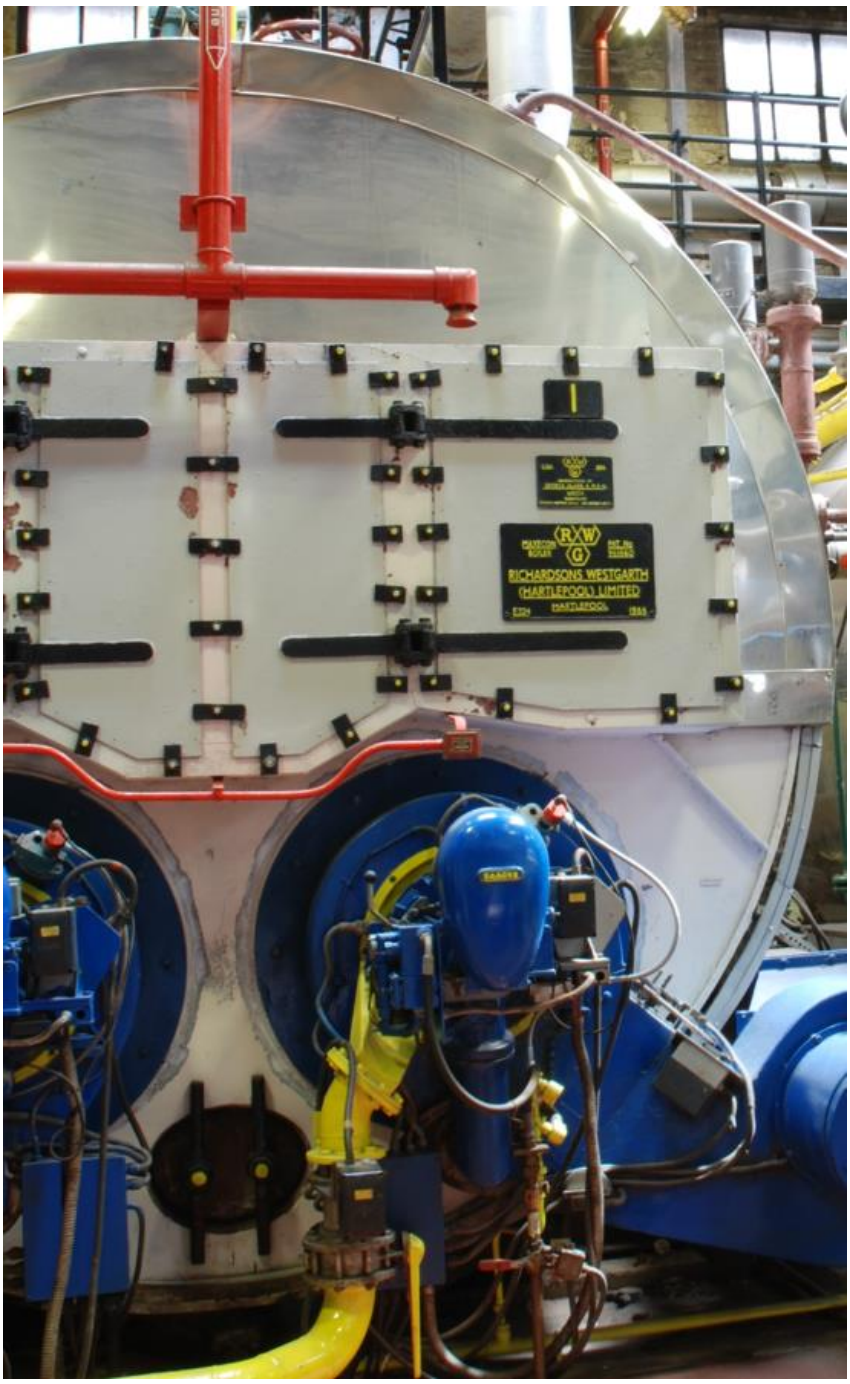
Guidance on Safe Operation of Steam Boilers

Ref: BG01



CEA
Combustion Engineering Association

Guidance on the Safe Operation of Steam Boilers (Ref: BG01)

Edition 2.5 – April 2024

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Foreword

This document, Guidance on the Safe Operation of Steam Boilers (BG01) 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 revision (Edition 2.5) incorporates up-to-date information and best practices relating to the operation of steam boiler plant; hot water boilers are now covered in a separate document, BG02.

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.

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 combustion related plant and equipment.

In this document the following words convey specific meaning:

Should: Compliance with this clause is not essential where supported by risk assessment 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.

Unless otherwise stated, all pressures refer to gauge pressure.

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1 INTRODUCTION

Guidance on the Safe Operation of Steam Boilers (Ref: BG01) is a guidance 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:

- 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 explosion or other dangers from events such as:
    - Loss of feed water or low water level;
    - Over-pressure;
    - Overheating e.g. due to excessive scale;
- Using efficient boiler operation to avoid excessive pressure or thermal cycles and load swings which can accelerate boiler fatigue or failure;
- Having the proper treatment and monitoring of the feed water and condensate to:
    - minimise corrosion and scale; 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 CP in accordance with a Written Scheme of Examination (WSE).

2 SCOPE

This document applies to all industrial & commercial steam boiler plant (normally shell boilers) operating at a working pressure up to 32 bar gauge, including vertical boilers, mobile steam boilers and waste heat boilers.

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

- Hot water boilers;
- Water tube boilers;
- Steam boilers with a capacity exceeding either:
    - 37 MW nett rated thermal input, or
    - 32 bar gauge working pressure;
- Domestic and commercial boilers with a capacity less than 70 kW;
- Electric immersion boilers, electrode boilers and steam coil heated boilers;
- Steam coil boilers (steam generators);
- Boilers used for transport.

However, just because these boilers are outside the scope of BG01, this does not mean that the regulations and general principles in this document should not be applied where suitable and applicable.

Note that BG01 excludes hot water boilers which are the subject of guidance note BG02 – Guidance on the Safe Operation of Hot Water Boilers.

3 LEGISLATION

Boiler systems are required to comply with different legislation, including 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); and
- The Dangerous Substances and Explosive Atmospheres Regulations (DSEAR).

With the exception of MHSWR and PER, all 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.

There are numerous sets of environmental legislation applicable to steam boilers, including the Clean Air Act, the Industrial Emissions Directive, and the Environmental Permitting Regulations (including the Medium Combustion Plant Directive). Relevant legislation is addressed in the following text.

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.

3.1 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.

Risk assessments for boiler systems are covered in more detail in the next section.

3.2 The Pressure Equipment (Safety) Regulations (PER)

PER applies to the design, manufacture and conformity assessment of pressure equipment and assemblies of pressure equipment with a maximum allowable pressure >0.5 bar.

All items of new and substantially modified pressure equipment (including steam raising plant) comes within the scope of PER 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 Regulations apply to pressure equipment and assemblies with a maximum allowable pressure PS greater than 0.5 bar, although there are a number of exclusions which are set out in regulation 4 and Schedule 1 to the Regulations. "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.

The Department for Business, Energy and Industrial Strategy has produced a guide to the Pressure Equipment (Safety) Regulations 2016 and this can be downloaded from gov.uk.

3.3 Pressure Systems Safety Regulations (PSSR)

PSSR set out the main legislative requirements to ensure the continued safety of the pressure systems in use (which includes 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. 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 (paras 151 & 152) instructions covering:

- pre-firing and start-up instructions;
- feed 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, bursting of tubes or other event requiring the boiler to be shut down.

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 supply to the site during the replacement of an existing boiler, but such an installation should not be treated as a mobile system. So 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.

3.4 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 this regulation. 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 trained 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.

3.5 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.

3.6 The Dangerous Substances & Explosive Atmospheres Regulations (DSEAR).

A risk assessment under DSEAR must be undertaken. DSEAR applies to all boilers (not just gas fired) as incorrect combustion can lead to an explosive atmosphere in the boiler itself or indeed in a separate combustor or CHP engine exhaust.

The owner of the system may assist the manufacturer by providing information from an assessment of the probability of the presence and the likely persistence of a potentially explosive atmosphere in the proposed working environment.

Equipment supplied for use in a potentially explosive atmosphere must also satisfy the relevant requirements of the *Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations*.

3.7 The Environmental Permitting Regulations

All combustion plants rated between 1 MW and 50 MW nett rated thermal input will be required to comply with the Medium Combustion Plant (MCP) Directive which has been transposed into UK legislation through changes to *The Environmental Permitting (England and Wales)(Amendment) Regulations, The Pollution Prevention and Control (Scotland) Amendment Regulations*, and *The Pollution Prevention and Control (Industrial Emissions) (Amendment) Regulations (Northern Ireland)*.

This legislation requires the registration of all new combustion plants put into first use after 19 December 2018 and the registration of existing combustion plant before 01/01/2024 for plants individually 5 MW and above, and 01/01/2029 for plants rated from 1 MW to <5 MW. Where more than one new plant is on a site the new plants will be aggregated to a single MCP.

From the date of first use (in the case of new plants after 20/12/2018) and from 01/01/2025 (for existing 5-50 MW plants) and 01/01/2030 (for existing 1-5 MW plants) the emissions from those combustion plants must not exceed specified emission limit values (ELV) for NOx, SOx and dust (total particulates), and these will be measured at specified intervals along with CO (no limits currently set for CO). Plants rated 20 MW and above will be measured annually, and plants below 20 MW will be measured every 3 years.

The Environment Agency (EA) in England and their equivalents in the devolved UK administrations will administer the new legislation and will consult with Local Authorities where there may be a combustion plant in or close to a Local Air Quality Management zone.

This may mean tighter ELVs will be applied. Sites that currently have environmental permits for other activities will have any MCPs added to their permits at the due date.

The EA have produced detailed guidance on how these regulations will be applied.

4 LEGAL RESPONSIBILITIES

4.1 Risk assessments – for new and existing sites

Regulation 3 of MHSWR requires that a 'suitable and sufficient' risk assessment be carried out before the work activity commences. Its 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 assessment 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 assessment 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 assessment carried out on his behalf by someone competent to do so.

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

- The likelihood and severity of injuries from:
  - Burns from hot water, steam, burners and flues;
  - Electric shock;
  - Fuel escape;
  - Fire;
  - Asphyxiation, and toxic effects from combustion products;
  - Falls from height;
  - Impact by a moving vehicle (particularly sites using solid or liquid fuels)
- 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 and flue integrity;
- 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;
  - Combustion explosion caused by unspent fuel;
  - Failure of the water treatment equipment to deliver properly treated water to the boiler;
  - Speed of response to loss
  - of steam to process.

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

- Manning and supervision (see section 5.9 below);
- Type and reliability of controls and the integrity of safety-related systems;
- Additional controls for remote or unsupervised boiler operation.

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 assessment to take account of the planned change in manning levels. The results of the risk assessment 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.

4.2 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 in section 5.3 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.

4.3 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.

4.4 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.

5 PERSONNEL AND RESPONSIBILITIES

5.1 User/owner

These legal terms have earlier been defined in section 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 3 and 4 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 him 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 trained and competent persons to be responsible for the safe management and operation of boiler systems. These supervisors or managers must be adequately trained 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 assessment 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 trained persons to be responsible for the daily safe operation of the boiler system. These boiler operators must be adequately trained 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 systems;
- Tests on ancillary equipment;
- Checking the burner and associated 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 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 trained 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 lock out.

5.7 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, burners, fittings or control equipment.

5.8 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.

5.9 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, 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 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 locally.

Arrangement drawings in Appendix 3 are **not associated with any particular level of supervision** - they are provided to guide designers and users/owners of steam boiler plant in the direction of possible boiler control and measurement arrangements, and do not represent final solutions for any particular circumstance. A detailed risk assessment is the only way to establish the manning requirements for your plant.

For all levels of manning, shell boilers shall not be warmed through from cold, put on the range, 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 Trained 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 in the immediate 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. It is also commonly used when firing solid fuels or unusual liquid fuels, or if there is an unacceptably high risk with the location of the boilers.

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; they shall be able to attend the boiler house within 5 minutes.

The operator shall be able to hear or see if the boiler is in alarm at all times. 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 warming through, starting and stopping the boiler, and shall have specific boiler operational duties such as testing alarms and water quality tests. The boilers shall be their first priority.

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 attend 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. Auto TDS and bottom blowdown shall be installed on any boiler left unattended for 24hrs.

However, a trained 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 trained person may need do no more than respond to an alarm (which can be as simple as "If this red light comes on press this red 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 at least on a daily basis or once in every 24 hours; they might not be based on site. Also, a suitably trained 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 must have advanced controls and monitoring, such as high integrity water level probes, flame detection units and 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. Auto TDS and bottom blowdown shall be installed on any boiler left unattended for 24hrs.

All the main boiler operational data and alarms shall be visible or audible at the remote monitor at all times. This could be a manned control room, either on site or off site, or a contracted monitoring centre where the suitably trained 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.

This 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 of response to alarms might be a critical part of the risk assessment.

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 at least every 72 hours - they might not be based on site. Speed 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, flame detection units and pressure control and limiters. The boiler water, feed water and condensate return chemistry must be checked automatically at a periodicity identified through risk assessment but at least every 24 hours. Continuous monitoring of the water treatment plant, TDS levels and hot well shall be provided, along with any other checks and alarm systems identified in the risk assessment. Auto TDS and bottom blowdown shall be installed on any boiler left unattended for 24hrs. 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 monitored 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 trained 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 assessment identifying unforeseen risks and also the 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.

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.

These qualifications form part of the Boiler Operation Accreditation Scheme (BOAS) which covers various types of boiler plant including shell boilers.

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 & burner controls and failure modes, taking account of fuels used;
- Feed water/boiler water analysis;
- Condensate drainage and water-hammer;
- 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), industrial gas operations (I-GAS), manufacturer specific training for burners and combustion systems, and bespoke training for the operation and daily maintenance of any other plant items provided in their boiler house.

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 DESIGN AND INSTALLATION

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

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).

7.1 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.

The design shall be based on the results of a risk assessment and relevant information from the appropriate design standards which provide further detail on the construction of shell boilers and their equipment. Boiler system designs shall address the following safety issues as a minimum:

- Boiler house ventilation - ensure adequate air supply for combustion. Designs shall comply with IGEM UP/10, IGEM UP/16 and BS 6644 as appropriate;
- The source of the boiler feed water, its effective treatment, and means for efficient monitoring of the water treatment plant, all in accordance with BG04, BS 2486:1997, BS EN 12953-10 or the manufacturer's instructions;
- Electrical installation - designs to comply with BS 7671 IET Wiring Regulations. Note: Consideration should be given to the operating environment, ensuring that cable type, size, routing and connections will prevent erroneous operation & maintain the required integrity of the control system;
- Boilers shall fail-safe, i.e. ensure boilers enter 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 and firing control 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 BG03);
- Emergency procedures;
- Access for operation and maintenance;
- Relevant aspects of the Construction Design and Management Regulations (CDM).

For guidance, three typical arrangements of steam boiler controls are outlined in the appendices. They are intended to be used in conjunction with the findings of the risk assessment, and represent suggested typical arrangements of certain steam boiler installations – they should not be used as design solutions or procurement specifications for new plant.

7.2 Control systems

Safe and efficient operation depends on the boiler remaining within its safe parameters during operation. A wide range of additional equipment that can be fitted to the boilers is available to help ensure this.

This equipment can have a monitoring role or a safety function where it acts in a predetermined manner to prevent a dangerous situation. For example, on an older installation, the “first low” water level alarm may prevent burner operation when the water level is low, but allows an automatic restart and resumption of operation once the water level has risen to a safe level. On the other hand, should the water level continue to fall, the “second low” water level alarm shuts the burner down completely and does not allow an automatic re-start. The burner may only be re-started manually once the cause of the low level event is established, the second low water level alarm is cleared, and the water level restored.

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).

7.2.1 Level sensing devices

These can be mounted through the boiler shell or in external chambers providing that the system has proven reliability and is inherently fail-safe. Detailed information can be found in BS EN 12953 Part 9, which specifies the following:

- External chambers must have, as a minimum, 20 mm diameter boiler shell connections at the steam and water level;
- Protection tubes (where fitted) must be designed:
    - With adequate venting to water and steam space;
    - To prevent steam bubbles causing undue disturbance to the water level;
    - To prevent sludge build-up;
    - With a minimum clearance of 14 mm from the probe;
- The two low water level limiters shall be mechanically and electrically independent so as to avoid “common cause” failures. Note that while the limiters should be independent of each other they do not have to be independent of other controls. i.e. a controlling probe can also act as a limiter provided it meets all of the other requirements of EN 12953-9.

Many existing boilers which were not designed and constructed to BS EN12953 will have a first low level cut-out and alarm (auto reset) and a low level limiter (lock-out). Risk assessment may demonstrate that this is not satisfactory for unmanned (remotely operated) boiler systems.

7.2.2 Combustion control devices

The system shall incorporate the following (as applicable):

- Ignition flame and main flame detection and safety systems;
- Forced draught and induced draught fan proving systems;
- Air and flue damper position proving systems;
- Flame detectors. High-integrity devices are required on all systems where the combustion system does not progress through a restart at least once per day;
- Systems to monitor the correct ratios of fuel and air;
- Interlocks where simultaneous fuel combustion is not permitted.

7.2.3 Pressure and temperature devices

Heat input must be controlled automatically (refer to BS EN 12953 Part 6) as follows:

- Steam boilers to be controlled by pressure controls;
- Limiting devices must be fitted to prevent excessive pressure or temperature. For new boilers they must be in accordance with BS EN 12953 Part 9.

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

7.2.4 Water treatment plant

The system shall incorporate the following (as applicable for the manning level):

- Means for treating incoming water, such as base exchange or reverse osmosis;
- Measurement and control devices to confirm that water flow is maintained, softened water is provided within the correct parameters, brine tanks are kept full of salt, and backwash is routinely and correctly carried out;
- Devices to record hotwell temperatures and levels, and alarm on deviation;
- Devices for monitoring condensate quality and potential contamination;
- Means for safely collecting boiler water samples from appropriate locations (such as from inside the boiler, from the hotwell, in the condensate return line, and from the softener outlet);
- 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.

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.

7.2.5 Blowdown

Blowdown Systems, Guidance for Industrial Steam Boilers (Ref: BG03) is a guidance document intended to provide advice to designers, specifiers, manufacturers, installers and those responsible for the management and operation of steam plant as well as Competent Persons (CP). It is applicable to both new and existing installations of 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.

Advice was previously provided by *Health and Safety Executive Guidance Note PM60 Steam boiler blowdown systems 2nd edition 1998* which has been withdrawn. This new, comprehensive guide deals with all aspects of steam boiler blowdown for industrial steam boilers and why it is necessary to carry out the function of “blowing down” the boiler.

It is aimed at the User/Owner, Engineer, Manager and Operator of the boiler plant to help them understand all aspects that affect the boilers and why blowing down is necessary, both from a practical operational performance view and for the legal requirements.

It covers who is responsible for the safe and efficient operation of steam boiler plant, and who is responsible for managing the safe operation of this type of equipment. Ultimately the responsibility lies with the user/owner as defined by the PSSR.

Where a high TDS alarm is fitted to the boiler system this shall be through a shell mounted probe and not a probe in the blowdown line.

7.2.6 Chimneys and flues

The safe handling of the products of combustion from steam boilers must be carefully considered. Poor combustion, and poorly constructed chimneys and flues, can give rise to life threatening accumulations of CO and other pollutants, and the emissions to atmosphere from combustion processes must be managed in accordance with environmental legislation such as the Clean Air Act and the Medium Combustion Plant Directive.

All new steam boiler installations will be notifiable under local planning requirements and larger installations (>1 MWth) will be subject to environmental permitting regulations and require a permit to operate. Chimneys will need to be designed to cope with the expected products of combustion under normal and abnormal operating conditions, and in certain conditions may need to be fitted with explosion relief in the chimney or associated ducting if the design risk assessment identifies this as a potential hazard.

Structural requirements may require the advice of specialists in supporting the loads, providing safe access to work on the chimneys, and providing access platforms for emissions monitoring activities.

Where multiple fuels can be burned in a single furnace or multiple flues enter a single chimney there may be a need for interlocked dampers and interlocked fuel supplies to provide for safe operation under all possible combinations of firing. These should be rigorously tested at appropriate intervals.

Chimney Inspections

Inspection of a chimney and its linings is a highly specialised task and should only be entrusted to a steeplejack who is an accredited member of a National body. Detailed specifications for the scope of the inspection should be agreed in advance, and it is recommended that the entire inspection process is photographically recorded. The presence and condition of lightning conductors and the integrity of holding down arrangements are key items to be included in the inspection.

Formal inspections of chimneys will normally take place every two to three years unless there is some obvious issue such as excessive corrosion, cracking, evidence of subsidence in the foundations, or items falling off the chimney. Other potential issues caused by blockages which prevent products of combustion from exiting the flue may be less easy to observe but could result in significant damage and danger.

Chimneys that are in highly polluted areas or coastal locations will require more frequent inspections, and burning fuels with a high sulphur content will similarly require additional observations to be made, especially if the boilers and flues are often allowed to cool down, increasing the likelihood of acid attack.

Site operators can carry out routine visual inspections of the general structure and its supports at more frequent intervals to help ascertain if a more detailed inspection is necessary. Unscheduled chimney inspections and repairs arising from failures or damage can cause lengthy plant shutdowns and other disruption to services, so planned inspections are essential.

In the UK, chimney manufacturers generally put an information plate at the foot of the chimney providing the recommended inspection intervals and other information - refer to BS 4076 (1989). Older chimneys or those without comprehensive records should be surveyed as part of an inspection and relevant measurements and construction details recorded.

Inspections may include the requirement for the chimney to be cleaned, and the handling of any waste arising must be entrusted to approved contractors.

7.3 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 this decision. 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. Some typical alarms are indicated in the three arrangements in Appendix 3.

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.

Where the risk assessment shows that the existing alarms are inadequate for the proposed operation, new alarms will be required in order that boiler operators can take appropriate action. 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 remote shut-down and lockout facility shall be provided;
- Alarms shall be clearly audible and visible at a permanently manned location where persons who are trained to take the appropriate action can 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-fault 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 remote location; e.g. it is unlikely to be appropriate to provide full boiler telemetry in a gate-house or reception area while more detailed information could be of use to those in, say, an engineer's 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 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.

7.4 Gas detection, fire detection and automatic fuel shut-off systems

Automatic fire detection and fuel shut-off is mandatory for all oil-fired plant. Burners shall include automatic shut-off valves on all fuel trains, and the control system shall close these valves when a fuel is not in use, and in the event of a fault condition. Dual or multi fuel systems shall include interlocks to prevent simultaneous use if the burner or boiler is not designed for this.

The need for gas detection and automatic fuel shut-off systems will be determined during the risk assessment; generally speaking, modern boiler houses are regularly attended and well-ventilated spaces, making it unlikely that an accidental release of natural gas of sufficient volume to create a flammable atmosphere will develop. Further information is available from IGEM/UP/16 and IGEM/SR/25.

Gas detection systems will be necessary where forced inlet and/or extract ventilation systems are employed, and where the gas is not sufficiently odorised (e.g. producer gas, or bio-gas) as leaks are likely to go unnoticed by boiler attendants. Similarly it may be necessary to consider CO and H_2S detection in certain circumstances (e.g. where CHP engine exhaust ducting passes through a boiler house).

The positioning of gas detection systems is of vital importance to ensuring their correct operation; the use of certain gases such as LPG will require careful consideration. Always consult the equipment manufacturer on the correct placement of sensors.

It is recommended that emergency push buttons isolate all fuels and power to the burners using the fuel train safety shut-off valves rather that the fitting of an extra automatic isolating valve. In most control systems it is possible to achieve this remotely so causing the system to go to lockout.

7.5 Typical control arrangements

The notes and diagrams in Appendix 3 describe three different typical steam boiler arrangements that might apply to different installations. **They are not definitive drawings of actual installations and must not be interpreted as being compliant with any particular circumstance – a boiler house technical risk assessment will always be required for every boiler house. They should also not be used as procurement instructions for particular boiler installations**.

The levels of attendance and manual testing will depend on the boiler and equipment layouts. They must be considered in conjunction with the findings of the risk assessment and information on the type and level of manning that is intended to be employed. It is more important that the target levels of monitoring and supervision are met rather than having a boiler that matches the example in the diagram. Different operating scenarios may well dictate different levels of supervision for the same level of automation.

The relationship between automation levels and supervision levels is discussed in more detail in Section 5.

8 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 site-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 risks remain as low as reasonably practicable. Additionally, all shell boilers must be examined and tested by the CP before first use (PSSR Reg 8 (3) c).

8.1 Boiler instructions

Boiler instructions shall as a minimum include the following:

- Instructions for the safe operation of steam boiler systems to comply with Regulation 11 of the Pressure Systems Safety Regulations, BS EN 12953-13, and the Pressure Equipment (Safety) Regulations;
- The recommended daily checks required including water treatment plant performance and water quality test results;
- How to warm through boiler systems starting from cold in a controlled manner, and add boilers to the range. Steam boilers shall be manned throughout the warming period and the water levels corrected to allow for expansion. 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.

8.2 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 trained and 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 dangers:

- Low water level which can expose the furnace or fire tubes and lead to metal overheating & catastrophic boiler failure;
- 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 water treatment regimes. These can cause boiler overheating or water carry-over which can ultimately cause boiler or system failure;
- Faulty combustion controls which can allow the uncontrolled presence of fuel, air and an ignition source, which can result in fires or explosions.

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. Examples of daily and weekly boiler log sheet contents are given in Appendix 4.

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

- Risk assessment;
- Boiler log book;
- Water treatment test records;
- Combustion analysis records;
- Manufacturer's records and instructions;
- Standard Operating Procedures;
- Emergency Procedures;
- Written Scheme of Examination (WSE);
- Examination reports;
- Record of periodic tests (e.g. 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.

8.3 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 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 on steam boilers are always left open to the boiler during normal operation and the connections to the gauge glasses must be fitted with auto shut off devices for safety of boiler operatives.

8.4 Burners and combustion tests

Combustion equipment must comply with the relevant standards (see Appendix 1, References). Maintenance and testing by a qualified person in accordance with manufacturer's instructions is essential to ensure safe and efficient operation.

Manufacturer's instructions for the operation of burners shall contain such information as is required for a boiler operator to use and test the equipment supplied.

Access to burner controls and safety related devices which are to be tested by operators shall not be obstructed by fixed panels or otherwise obscured.

Combustion tests shall also be carried out as appropriate to the type of system in operation. Certain tests, such as visual flame examination or furnace inspection may not be possible or practicable on some designs of boiler, so use of an alternative test such as a CO, CO_2 or O_2 may be appropriate.

Relevant systems must comply with the requirements of the Medium Combustion Plant Directive which places limits on emissions of NO_X, SO_X and particulates for all plant with a net thermal input of 1 MW to 50 MW. Some plant may need additional abatement systems in order to meet the Emission Limit Values (ELVs) in which case the abatement system shall be maintained in accordance with the manufacturer's instructions.

All tests shall be recorded on the log sheet and allowable limit data must be readily available. Suitably qualified persons shall investigate any problems and take corrective action.

All manufacturers' tests shall be carried out at recommended frequencies with special attention to:

- Testing flame surveillance equipment operation & recording the results. Prove lock-out and manually reset (but see note below). In a process where the burner is firing continuously, a self-checking photocell shall be used;
- Testing correct operation of forced ventilation and its interlocks and/or ensure natural ventilation is to design standards and is unobstructed;
- On dual fuel installations, it is recommended that the changeover to the stand-by fuel should be tested monthly or as recommended by the burner manufacturer;
- Fuel leak and shut-off checks:
    - Gas - if a significant gas leak is suspected, the gas supply must be shut down immediately and be reported to the Responsible Person. Follow site procedures for any necessary evacuation of personnel and/or activation of audible hazard alarms;
    - Oil - visually inspect pipework, tanks, bunds and supply lines for leakage. Record and immediately report any leaks to maintenance personnel; bund alarms are recommended, particularly where sites are unattended for 72 hours.

Note: Some types of high integrity self-checking photocell need professional adjustment and setting, and the manufacturer's recommendations and timescales must be followed.

Should the Emission Limit Values of any environmental permit be exceeded, the user/owner must notify the relevant authorities as soon as possible. If the plant cannot be brought back within limits in a reasonable time, the plant must be taken offline.

Where shell boilers are fitted with new burners to cope with new or additional fuel types, the design, installation and commissioning of the new equipment must be carried out in accordance with all required legislation and guidance. As one example, if changing a heavy oil fired installation to gas firing, a full check of the ventilation requirements will be required and may involve modifications to the boiler house.

8.5 Solid fuel (coal and biomass) and alternative sources of heat

Whilst this BG01 guidance is primarily written for oil & gas, much of its contents are relevant for other sources of heat such as biomass and Combined Heat and Power (CHP). In this case, references to burners and fuel systems can be taken to mean the heat source and any associated fuel handling equipment.

Where a heat source cannot be completely removed quickly, for example in the case of a solid fuel fired boiler where fuel is already on the grate or in the case of a CHP where it is unsafe to regularly and repeatedly trip the engine, particular consideration shall be given to:

- The residual heat left in a boiler after a shut-down condition. The plant shall be designed so as to be able to accept this heat;

- The margin between normal working pressure and the safety valve pressure;
- The sinking-time of the boiler, i.e. the time during which the water level will sink from the lowest permissible water level to the highest point of the heated surfaces. This may involve consideration of an automatically closing valve on the steam outlet so as to prevent steam export;
- In some installations, there may be exceptional environmental or operational implications to testing of boiler controls. Testing regimes should be established to ensure that the controls and trips can be proven without tripping the plant except under controlled conditions as justified by a risk assessment.

8.6 Feed water and boiler water checks

A water treatment specialist shall undertake regular checks on the water treatment plant and test the feed water, boiler water and condensate quality. If scale is found in boilers, the water treatment system should be checked for correct operation and appropriate corrective action taken immediately.

In addition, a suitably trained and 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 a frequency of up to 72 hours might 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 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 BG04, BS 2486:1997, BS EN 12953-10 or the manufacturer's instructions.

Unless risk assessment demonstrates otherwise the minimum frequency of checks on the feed and boiler water shall be the same as the minimum attendance requirement on the boiler when operating.

Special consideration shall be given to the water treatment requirements for reserve boilers and boilers that are to be left unused for any period.

9 MAINTENANCE, REPAIR AND MODIFICATION

9.1 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.

9.2 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 and hot water 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 to the burner control and alarm systems. 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.

Modifications to shell boiler installations may not directly affect the pressure envelope but could be just as significant. For example, MCP users/owners may find that the emissions limits in the MCPD are quite onerous for certain fuels and a change of fuel is proposed.

Designers and installers of new fuel systems and other modifications for shell boilers should ensure that all the necessary measures are taken to meet the legislative and standards requirements for the new equipment, and that comprehensive testing and commissioning of the installation by competent staff is undertaken and recorded.

9.3 Responsibility

The importance of adequate maintenance on boiler control and alarm systems cannot be over-emphasised. Responsibility can be divided between those who own and operate the boiler system and those who maintain it. As this can be different in each case it is imperative that the limits of responsibility of each organisation 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 trained 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.

10 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 controller;
- Safety relief valve; followed by
    - Pressure limit switch;
- Water level controls/limiters;
- Flame detection device.

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:

- Fuel interruption lockout;
- Fuel proving systems;
- Control system power failure;
- Mains power failure;
- Critical alarms (including temperature alarms where fitted);
- TDS alarm.

SAFed Guidance *PSG06: Examination of Pressure Systems in Accordance with Written Scheme of Examination*, and *PSG 07: Guidelines – on the PSSR SI 2000 No. 128 – Working examination requirements in WSE's* provide further information.

11 ENERGY AND ENVIRONMENT

11.1 Energy management

Energy management of boilers is sensible to minimise operating costs & emissions, 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;
- Combustion analysis and burner adjustment to reduce energy wastage & emissions;
- Energy improvement devices such as economisers, variable speed drives, flue gas dampers, auto TDS control, combustion control etc.;
- Plant scheduling and boiler optimisation to maximise plant efficiency.

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

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.

11.2 Environmental issues

All combustion plant has an impact on the environment through a combination of emissions to air, land and water.

Larger installations will already be covered by a permit issued by the Environment Agency, NRW, SEPA or NIHES. Individual combustion plants with a nett rated thermal input of between 1MW and 50MW will eventually all be covered by a permit issued under the Medium Combustion Plant Directive. This permit will detail the boiler's effect on the environment and list the permit conditions applied to the operator. It is illegal to operate the plant without a permit and outside these conditions, and all new medium combustion plants first fired after 19/12/2018 require a permit.

Smaller plants <1MWth will be regulated by local authorities under the Clean Air Act 1993 with the environmental agencies responsible for emissions to water courses. Local Authorities are principally concerned with the issues of nuisance, such as smoke and dust emissions, which will be regulated. However, operators still have a requirement to ensure that all products of combustion are adequately dispersed.

All solid and liquid waste products produced by a combustion plant must be removed by a licensed waste carrier.

Water discharged to drains must comply with water utility restrictions, and a discharge temperature of greater than 43^{o}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.

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. Confined Spaces Regulations 1997* - SI 1997/1713.
6. Control of Substances Hazardous to Health Regulations (COSHH) 2002* SI 2002/2667.
7. Dangerous Substances and Explosive Atmosphere Regulations (DSEAR)** SI 2002/2776.
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 (PER) 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. The Gas Safety (Installation and Use) (Amendment) Regulations (GSIUR) 2018 * SI 1998/2451.
17. The Environmental Permitting (England and Wales)(Amendment) Regulations 2018 SI2018/110 (MCPD).

18. L5 The Control of Substances Hazardous to Health Regulations 2002. Approved Code of Practice and guidance.

19. L22 Safe use of work equipment Provision and Use of Work Equipment Regulations 1998. Approved Code of Practice and guidance.

20. L101 Safe work in confined spaces. Confined Spaces Regulations 1997. Approved Code of Practice, Regulations and guidance.

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

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

23. L138 Dangerous Substances and Explosive Atmospheres Regulations 2002. Approved Code of Practice and guidance.

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

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

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

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

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

29. BG02 Guidance on Safe Operation of Hot Water Boilers. (CEA)

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

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

32. BG07 Guidance on Thermal Fluid Systems (CEA)

33. BG08 Guidance on Temporary Steam and Hot Water Boiler Plant (CEA)

34. BS 799: Part 4:1991 Specifications for atomising burners (other than monobloc type) together with associated equipment for single burner & multiburner installations.

35. BS 5410-2:2013 Code of practice for oil firing - Part 2: Installations over 45 kW output capacity for space heating, hot water and steam supply services.

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

37. BS 6644:2008 Specification for Installation of gas-fired hot water boilers of rated inputs between 70 kW (net) and 1.8 MW (net) (2nd and 3rd family gases).

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

39. BS EN 298:1994 Automatic Gas burners Control systems for gas burners and gas burning appliances with or without fans.

40. BS EN 676:1997 Automatic Forced Draught Burners for Gaseous Fuels.

41. BS EN 746:1997 Part 2 safety requirements for Combustion and Fuel Handling Systems.

42. BS EN 12953 Shell Boilers.

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

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

45. Institution of Gas Engineers and Managers Utilisation Procedure IGE/UP/1A - Strength/tightness testing and direct purging (Small I&C) and IGEM/UP/1C - Strength/tightness testing and direct purging (Meters).

46. Institution of Gas Engineers and Managers Utilisation Procedure IGEM/UP/2 - Installation pipework.

47. Institution of Gas Engineers and Managers Utilisation Procedure IGEM/UP/10 Installation of gas appliances in industrial and commercial premises.

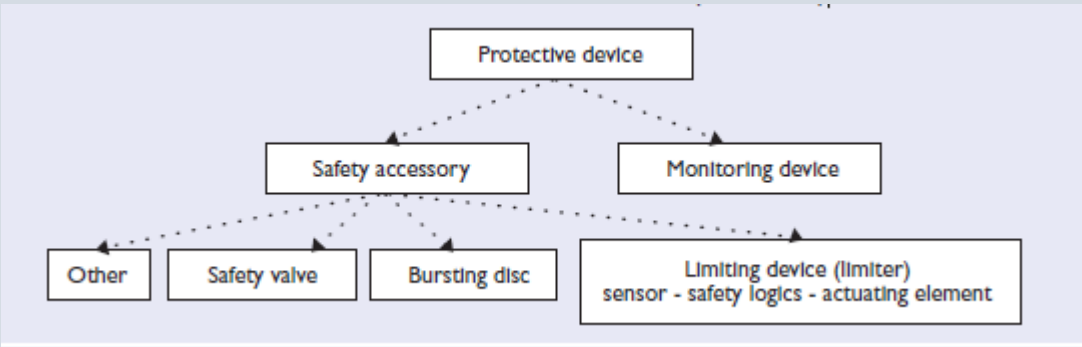
48. Institution of Gas Engineers and Managers IGEM/UP/12 Application of burners and controls to gas fired process plant.

49. Institution of Gas Engineers and Managers IGEM/UP/16 Design for Natural Gas installations on industrial and commercial premises with respect to hazardous area classification and preparation of risk assessments.

50. Institution of Gas Engineers and Managers IGEM/SR/25 - Hazardous area classification of Natural Gas installations.

APPENDIX 2 - DEFINITIONS

Boiler system	Boilers, ancillaries and all related items including pipework. Additionally may include: fuel supply, water treatment, feedtank, flue, 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 sufficient knowledge & experience to operate the boiler system safely.
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 43°C.
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.
Diversity	The provision of more than one different means of performing the required function, e.g. other physical principles, or other ways of solving the same problem.
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 Directive 97/23/EC (PED/PER) 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 trained persons who are responsible for undertaking maintenance on the plant.
Manned	A boiler operator is on-site during hours of boiler operation.
MAP	Maximum allowable pressure
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 I n Great Britain, his agent or: if there is no such agent; the user (Regulation 2, PSSR).
Redundancy	The provision of more than one device or system which, in the event of a fault, will still provide the necessary facilities.
Self-monitoring	Regular and automatic determination that all chosen components of a safety system are capable of functioning as required.
Shell boiler	In a shell boiler, hot gases pass through the furnace and tube banks, the heat from the hot gases transfer via convection through the tubes and conduction into the water within the boiler shell. Also known as fire tube boiler, shell and tube boiler, package steam boiler, smoke tube boiler.
SOL	Safe operating limit.
Steam generator	Steam is made in a coiled tube surrounded by products of combustion. No perceptible water level in the tube.
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.
WSE	Written Scheme of Examination.

APPENDIX 3 – DIAGRAMS OF TYPICAL BOILER ARRANGEMENTS

Arrangement drawings in this Appendix are not associated with any particular level of supervision - they are provided to guide designers and users/owners of steam boiler plant in the direction of possible boiler control and measurement arrangements, and do not represent final solutions for any particular circumstance. **A detailed risk assessment is the only way to establish the manning requirements for your plant.**

Note the definitions used in this Appendix and elsewhere:

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

Suitably Trained 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.

Typical Arrangement 1

This shows the minimum equipment required for the lowest levels of automation. This level does not meet the requirements of boiler standard BS EN 12953.

With typical Arrangement 1 the following factors need to be considered:

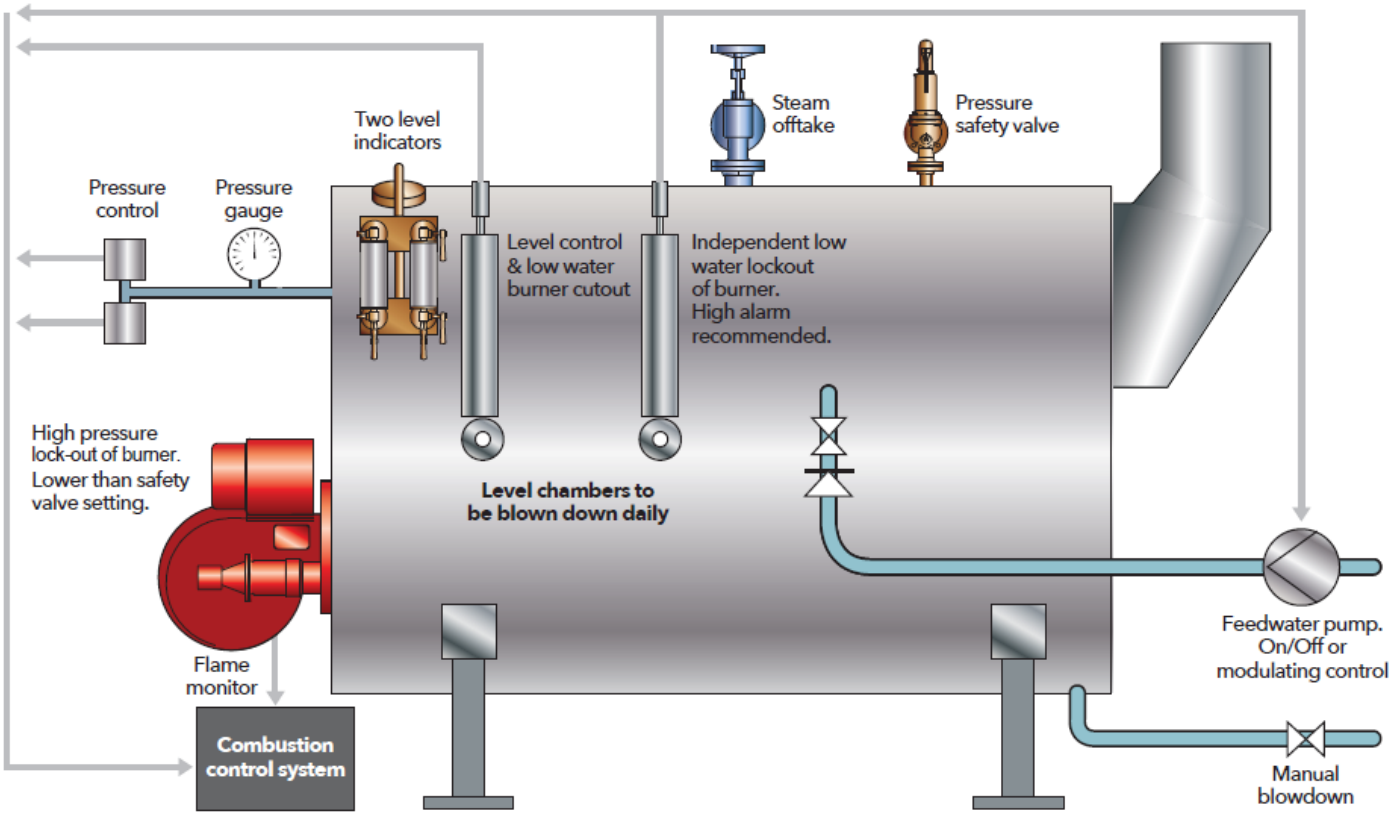
- **Attendance:** A competent boiler operator shall be on-site at all times that the boiler is operating and be able to respond immediately to an audible and/or visual alarm condition.
- **Equipment Integrity:** All control equipment shall be fail-safe.
- **Boiler house fire protection:** Fire detection should be provided. For oil fired installations, automatic fuel shut-off must be provided.
- **Minimum frequency of routine testing:**
    - Low water level devices **in external chambers**:
        - Daily checks: External chambers shall be manually blown down at least once per shift (or daily for continuous operation) and the low water cut-out and lock-out tested;
        - Weekly Checks: In addition, the low water level cut-out and lock-out shall be tested by lowering the boiler water level by evaporation and controlled blow down. Discharge temperature to drain must not exceed permissible limits.
    - Low water level devices **in internal protection tubes** in the boiler:
        - Daily Checks: The low water cut-out and lock-out shall be tested at least once per shift (or daily for continuous operation) by lowering the boiler water level or by an integrated test device, or at the beginning of each shift if a shift pattern is used;
        - Weekly Checks: In addition, the low water level cut-out and lock-out shall be tested by lowering the boiler water level by evaporation and controlled blow down. Discharge temperature to drain must not exceed permissible limits.

- **Level Indicators (gauge glasses):** Manually blown down at least once per shift (or once per day for continuous operation).
- **Boiler and feed water:** Monitoring of the water treatment plant parameters, hotwell temperature and water sample test results.

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

The levels of attendance and manual testing will depend on the boiler equipment layout. They should be considered in conjunction with the findings of the risk assessment and information on the type and level of manning that is intended to be employed. It is more important that the target levels of monitoring and supervision are met rather than having a boiler that matches the example in the diagram.

Typical equipment for the boiler:



Typical Arrangement 2

This shows the minimum equipment required for a boiler with critical alarms monitored on-site by a remote panel located in a manned area such as a gatehouse. New installations shall be manufactured to BS EN 12953, which requires additional limiters to be fitted.

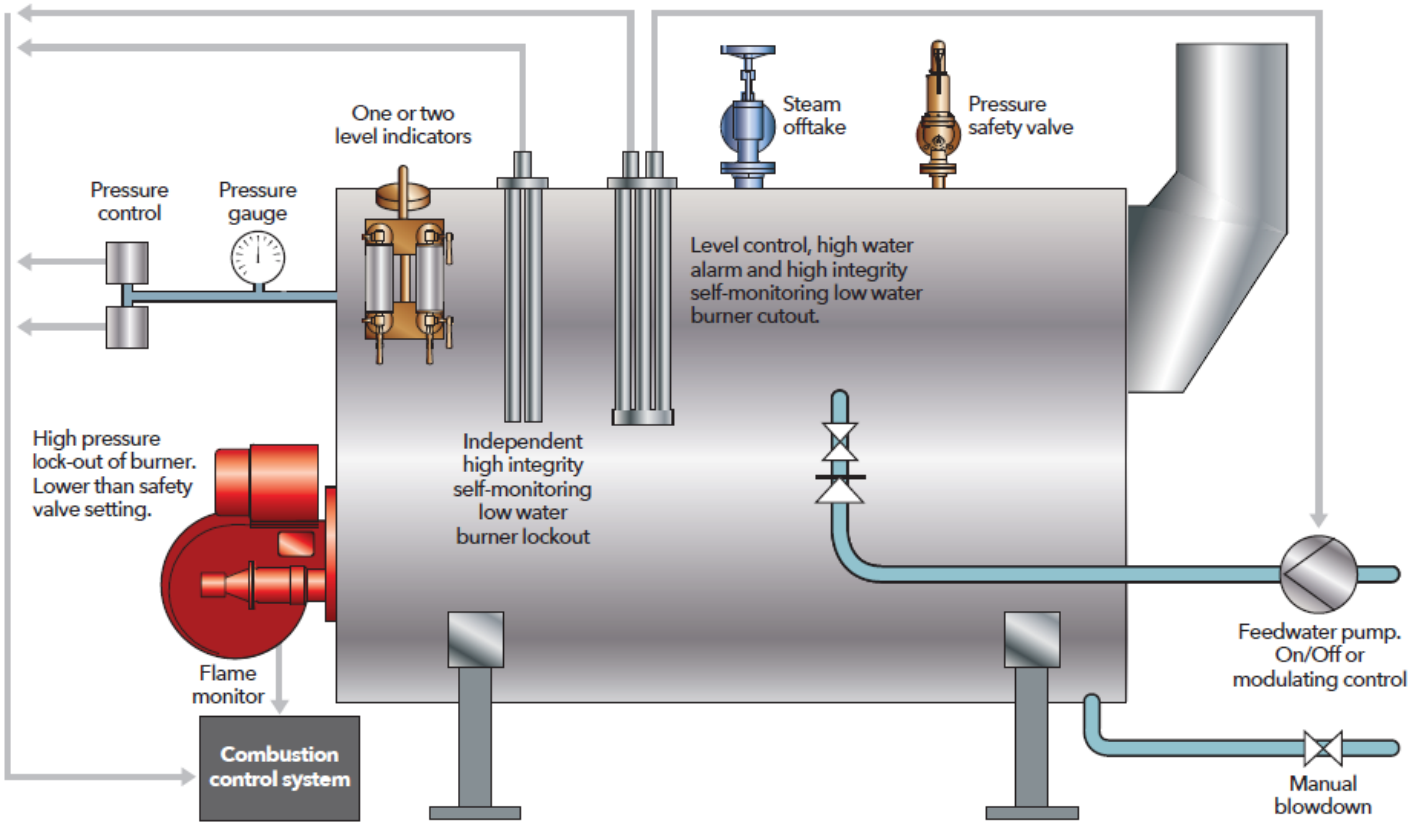
With typical Arrangement 2 the following factors need to be considered:

- **Attendance:** A suitably trained and instructed person must be on-site at all times that the boiler is operating and must be capable of responding to an alarm condition. As a minimum, that person must ensure that the boiler has shut down and notify the boiler operator of the alarm condition.
- The competent boiler operator must check the boiler at least once every day.
- **Equipment Integrity:** Low water level devices and an excess pressure device of the high integrity type must be fitted. All control equipment must be fail-safe. Some types of high integrity self-checking photocell need professional adjustment and setting, and the manufacturer's recommendations and timescales must be followed.
- **Boiler house fire protection:** Fire detection shall be provided. For oil fired installations, automatic fuel shut-off must be provided. For gas firing, gas detection and alarm shall also be considered.
- **Minimum frequency of routine testing:**
    - Low water level devices fitted directly to the boiler:
        - Weekly: The low water level cut-out and lock-out shall be tested by lowering the boiler water level by evaporation and controlled blow down. Discharge temperature to drain must not exceed permissible limits.
    - Low water level devices in external chambers fitted with automatic blow down facilities:
        - Daily: External chambers shall be automatically blown down at intervals typically of at least every six hours.
        - Weekly: In addition to the daily test, the low water level cut-out and lock-out shall be tested by lowering the boiler water level by evaporation and controlled blow down. Discharge temperature to drain must not exceed permissible limits.
- **Level Indicators (gauge glasses):** Manually blown down at least once per day.
- **Boiler and feed water:** Monitoring of the water treatment plant parameters, hotwell temperature and water sample test results.

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

The levels of attendance and manual testing will depend on the boiler equipment layout. They should be considered in conjunction with the findings of the risk assessment and information on the type and level of manning that is intended to be employed. It is more important that the target levels of monitoring and supervision are met rather than having a boiler that matches the example in the diagram.

Typical equipment for the boiler:



Typical Arrangement 3

This shows the minimum equipment requirements for the lowest degree of supervision, where no boiler operators could be on-site for up to 72 hours and with status monitoring and boiler safety shutdown by a remote location/telemetry system.

New installations shall be manufactured to BS EN 12953, which requires additional limiters to be fitted.

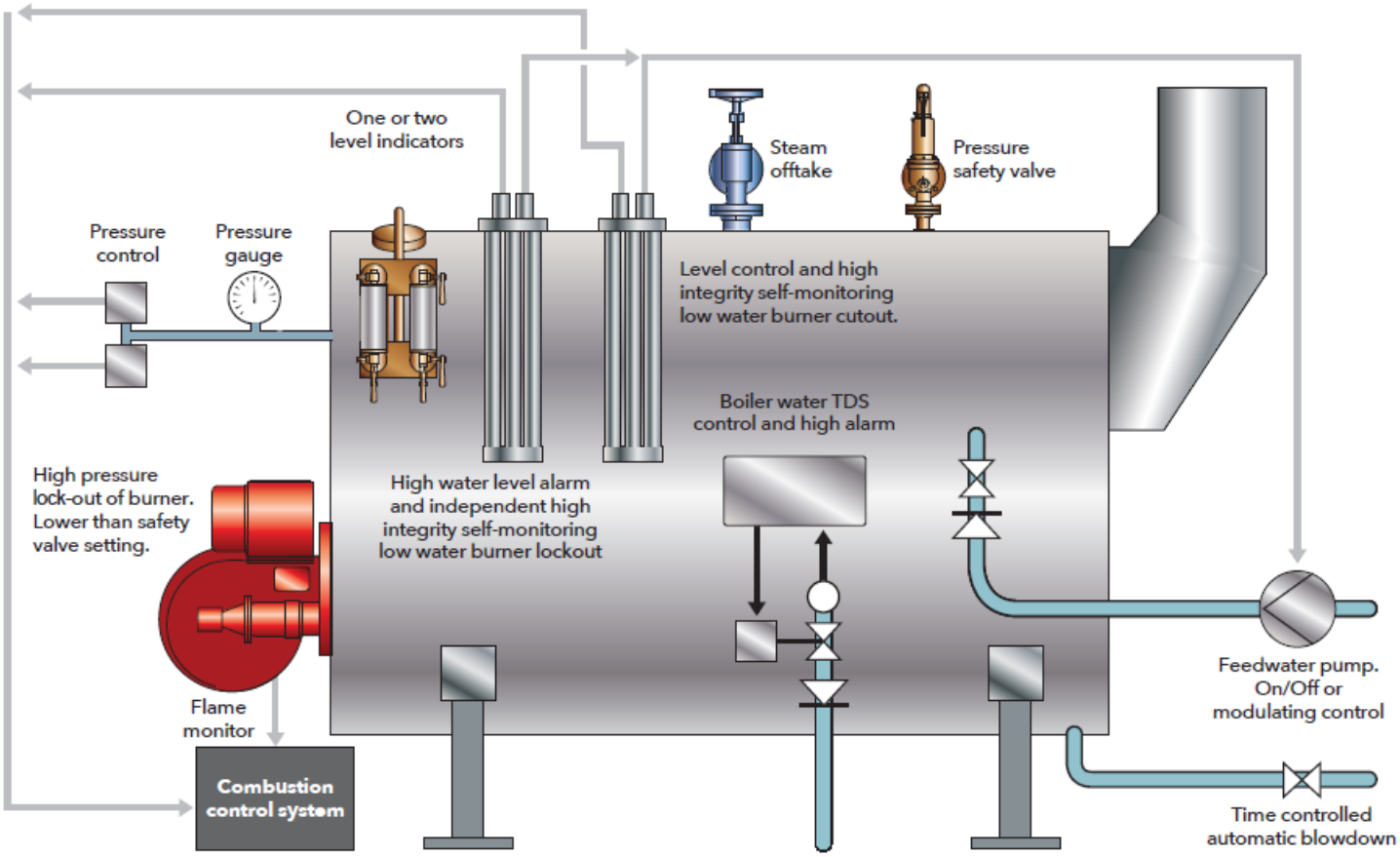
With typical Arrangement 3 the following factors need to be considered:

- **Attendance:** The site must be visited and checked by a boiler operator at least every day. Visits may be extended to 72 hours where additional monitoring is included such as that shown on the diagrams below. In any case, risk assessment may determine a more frequent visit is needed for reasons other than the level of automation. Boiler status is monitored from either an on-site or off-site location.
- **Equipment integrity:** This arrangement is the highest level of automation requiring the greatest degree of confidence in the boiler controls and equipment. Low water level devices and an excess pressure device must be high-integrity. Combustion control system shall be high-integrity. Auto TDS and bottom blowdown shall be installed on any boiler left unattended for 24hrs. All control equipment must be fail-safe. Some types of high integrity self-checking photocell need professional adjustment and setting, and the manufacturer's recommendations and timescales must be followed.
- **Boiler house fire protection:** Fire detection, fire alarm and automatic shut-off of fuel oil systems must be provided. For gas firing, gas detection and alarm shall also be considered.
- **Minimum frequency of routine testing:**
    - Low water level devices fitted directly to the boiler:
        - Weekly: The low water level cut-out and lock-out shall be tested by lowering the boiler water level by evaporation and controlled blow down. Discharge temperature to drain must not exceed permissible limits.
    - Low water level devices in external chambers fitted with automatic blow down facilities:
        - Daily: External chambers shall be automatically blown down at intervals typically at least every six hours. Discharge temperature to drain must not exceed permissible limits.
        - Weekly: In addition, the low water level cut-out and lock-out shall be tested by lowering the boiler water level by evaporation and controlled blow down. Discharge temperature to drain must not exceed permissible limits.
- **Level indicators (gauge glasses):** At least once every three days, manually blown down.
- **Water treatment:**
    - At least every three days, testing and recording of the feed water plant parameters, hotwell temperature and water sample results including pH, turbidity or other measurements of boiler water;
    - Water treatment plant and chemical dosing plant shall have flow monitoring for feedwater and chemical dosing integrity, and level monitoring for salt and chemical stocks;
    - Condensate monitoring and feedwater/dosing plant shall alarm if parameters are not met.

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

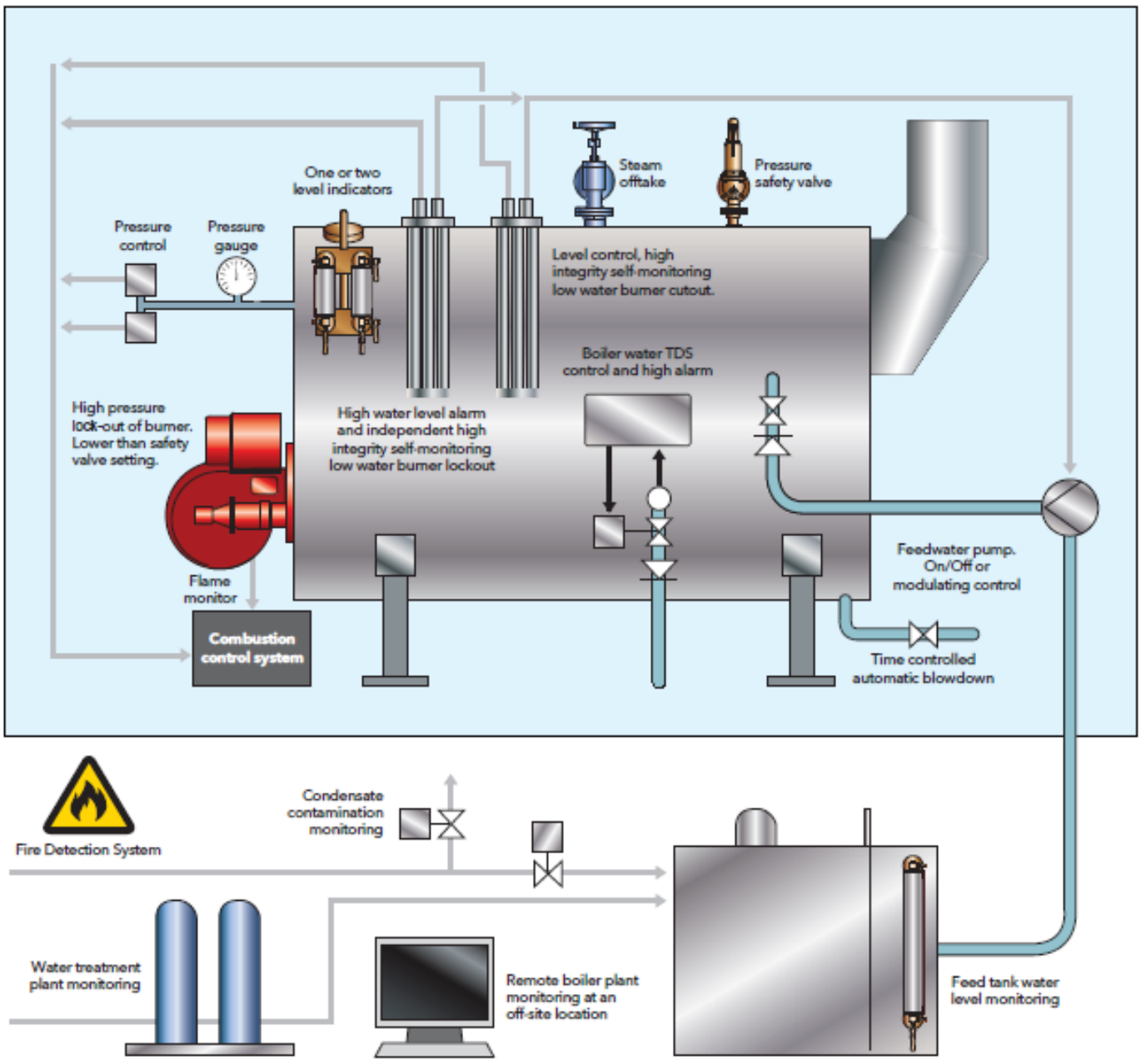
The levels of attendance and manual testing will depend on the boiler equipment layout. They should be considered in conjunction with the findings of the risk assessment and information on the type and level of manning that is intended to be employed. It is more important that the target levels of monitoring and supervision are met rather than having a boiler that matches the example in the diagrams.

Typical equipment for the boiler:



Note – for a TDS alarm to be effective, the probe must be directly mounted on the boiler shell, and not located in the blowdown line.

Typical additional equipment in the boiler house - 72 hours unattended is only possible with the following additional controls:



Where this additional equipment is not provided this decision must be supported by a risk assessment and other control measures may be required.

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APPENDIX 4 – TYPICAL LOG SHEET EXAMPLES

The boiler logs possess 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.**

For arrangements 1 and 2, the example log book has a front cover sheet with general information, a daily log (2 sheets) and a weekly log (2 sheets).

For arrangement 3, the suggested list of items to be logged comes from BS EN 12953 part 6.

Recommended checks and tests schedule for shell boilers to Arrangements 1 or 2.

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 31 sets of daily check sheets followed by 5 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 ….)

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
Burner firing rate					%
Exhaust temperature A					°C
Ambient temperature B					°C
A – B = C					°C
If there is a significant change at C from previous tests, shut down, isolate and report					
Flame inspection (describe if abnormal)		Normal / Abnormal	Normal / Abnormal	Normal / Abnormal	
If a part of the furnace is glowing orange / yellow, shut down, isolate and report					
Feed pH	8.5-9.5				pH
Boiler water pH level	10.5-12.0				pH
Boiler alkalinity	320 -1,200				ppm
Boiler water sulphites	30-70				ppm
TDS PPM test result	< 3,500				ppm
TDS PPM readout	< 3,500				ppm
TDS recalibrated?		Yes / No	Yes / No	Yes / No	
Duty pump		One - Two	One - Two	One - Two	

Boiler	ONE	TWO	THREE	
Gas meter reading				m^3
Water meter reading				m^3
Steam meter reading				kg/h
Hotwell		One	Two	
Temperature				^oC
Hotwell 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:

WEEK 1 (2, 3, 4 ….)

Date			Time			
Print Name						
Result of evaporation test	Circle as required					
	Boiler One		Boiler Two		Boiler Three	
Gauge glasses blown down	Yes	**No**	Yes	**No**	Yes	**No**
1st low audible alarm	Sounded	**Failed**	Sounded	**Failed**	Sounded	**Failed**
1st low visual alarm	Observed	**Failed**	Observed	**Failed**	Observed	**Failed**
Burner shutdown at 1st low	Yes	**Failed**	Yes	**Failed**	Yes	**Failed**
2nd low audible alarm	Sounded	**Failed**	Sounded	**Failed**	Sounded	**Failed**
2nd low visual alarm	Observed	**Failed**	Observed	**Failed**	Observed	**Failed**
Boiler lock out at 2nd low	Yes	**Failed**	Yes	**Failed**	Yes	**Failed**
Remote alarm (audible) Security Lodge	Sounded	**Failed**	Sounded	**Failed**	Sounded	**Failed**
Remote alarm (visual) Security Lodge	Observed	**Failed**	Observed	**Failed**	Observed	**Failed**
Is water visible in gauge glasses at lockout?	Yes	**Failed**	Yes	**Failed**	Yes	**Failed**
Pump on after 1st low recovered	Yes	**Failed**	Yes	**Failed**	Yes	**Failed**
Burner restart check	Normal	**Failed**	Normal	**Failed**	Normal	**Failed**
Flame Inspection at Low Fire Hold	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal
Pump stop and start	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal
Flame failure device test	Passed	**Failed**	Passed	**Failed**	Passed	**Failed**
Manual blow down performed	Performed	Not performed	Performed	Not performed	Performed	Not performed
Blow down OK	Confirmed	Not confirmed	Confirmed	Not confirmed	Confirmed	Not confirmed
IN THE EVENT OF ANY FAILURE OF EITHER THE EVAPORATION TEST OR THE FLAME FAILURE DEVICE, THE BOILER IS TO BE SHUT DOWN AND ISOLATED. THE FAILURE MUST BE REPORTED AND RECORDED IMMEDIATELY.						

Chemicals	Stock	Usage	
Chemical Level –			litre
Chemical Level –			litre
Chemical Level –			litre
Boilerhouse general condition	Adequate	Inadequate	

Boiler run on oil	ONE	TWO	THREE
Start litres			
Finish litres			
Usage (start litres - finish litres)			
Propane ignition cylinders	Bottle 1	Bottle 2	
	Online / standby / empty	Online / standby / empty	
Oil tank level	Tank 1	Tank 2	
	litres	litres	

Comments / faults / incidents

Signature:

Recommended checks and tests schedule for shell boilers to Arrangement 3.

(C) Observation of abnormal noises, smells or other noticeable factors.

(T) Checking and/or testing the functional behaviour of equipment parts, including observation.

Checks and testing	3 days	1 month	3 months	6 months	12 months	Remarks
Safeguards against excessive pressure (safety valves)	C				T	See NOTES 1 and 2 below
Water level indication	T					Compared with limiters and controls
Drain and blow-down devices	T					
Valves	C			T		As per manufacturer's instruction manual
Feed water control	C			T		
Low water protection	C	T				Functional check by lowering the water level to the switching points
Steam pressure and temperature indication	C					Compared with limiters and controls
Pressure limitation	C	T				Functional check by increasing the pressure to the switching points
Temperature limitation	C	T				
Devices for water quality protection	C	T (1)		T (2)		(1) Comparison of the measured values with the reliable samples (2) Performed by a suitably qualified and competent person
Protective systems	C			T (3)		(3) Electrical and mechanical testing performed by a suitably qualified and competent person
Pressure parts (pipes, inspection openings, flanges, gaskets, joints…)		C				
Pressure controller and temperature controller	C			T		
Feed water supply	C		T			
Water quality	T					See BG04
Heat supply	C				T (5)	(5) Performed by a suitably qualified and competent person as per manufacturer's instruction manual but not less than once a year

NOTE 1 Additional function tests and observation can be required either by National Rules, third parties or the manufacturer.

NOTE 2 Deviations of periods or tests are possible with agreement of third parties if safety level will not be reduced.

NOTE 3 Consideration should be given to functional testing of additional devices outside the boiler.
From BS EN 12953 – 6 2011

Recommended checks and tests schedule for shell boilers NOT to Arrangement 3.

(C) Observation of abnormal noises, smells or other noticeable factors.

(T) Checking and/or testing the functional behaviour of equipment parts, including observation.

Checks and testing	daily	weekly	1 months	6 months	12 months	Remarks
Safeguards against excessive pressure (safety valves)	C				T	See NOTES 1 and 2 below
Water level indication	T					Compared with limiters and controls
Drain and blow-down devices	T					
Valves	C			T		As per manufacturer's instruction manual
Feed water control	C			T		
Low water protection	C	T				Functional check by lowering the water level to the switching points
Steam pressure and temperature indication	C					Compared with limiters and controls
Pressure limitation	C	T				Functional check by increasing the pressure to the switching points
Temperature limitation	C	T				
Devices for water quality protection	C	T (1)		T (2)		(1) Comparison of the measured values with the reliable samples (2) Performed by a suitably qualified and competent person
Protective systems	C			T (3)		(3) Electrical and mechanical testing performed by a suitably qualified and competent person
Pressure parts (pipes, inspection openings, flanges, gaskets, joints…)		C				
Pressure controller and temperature controller	C			T		
Feed water supply	C		T			
Water quality	T					See BG04
Heat supply	C			T (5)		(5) Performed by a suitably qualified and competent person as per manufacturer's instruction manual but not less than once every 6 months.

NOTE 1 Additional function tests and observation can be required either by National Rules, third parties or the manufacturer.

NOTE 2 Deviations of periods or tests are possible with agreement of third parties if safety level will not be reduced.

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KEY CHANGES FROM EDITION 2 TO EDITION 2.5

Minor changes to foreword and acknowledgements

Removal of non CEA logos

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Guidance on the Safe Operation of 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.

Ref: BG01 Edition 2.5 - Published April 2024 -