

Safe management of industrial steam and hot water boilers

A guide for owners, managers and supervisors of boilers, boiler houses and boiler plant



Background

Accidents involving exploding boilers have killed people, damaged plant and affected production. These accidents resulted from problems such as inadequately designed boilers, wrongly sited or wrongly installed boilers as well as boilers that were not correctly operated or maintained.

As the manager of a workplace, you have a duty to manage the risks associated with that workplace. If there is a boiler installation on your premises, you must ensure it remains safe.

An efficient, reliable boiler is an essential requirement for many businesses, and the downtime caused by a failed boiler can have a major effect on production, plant and people.

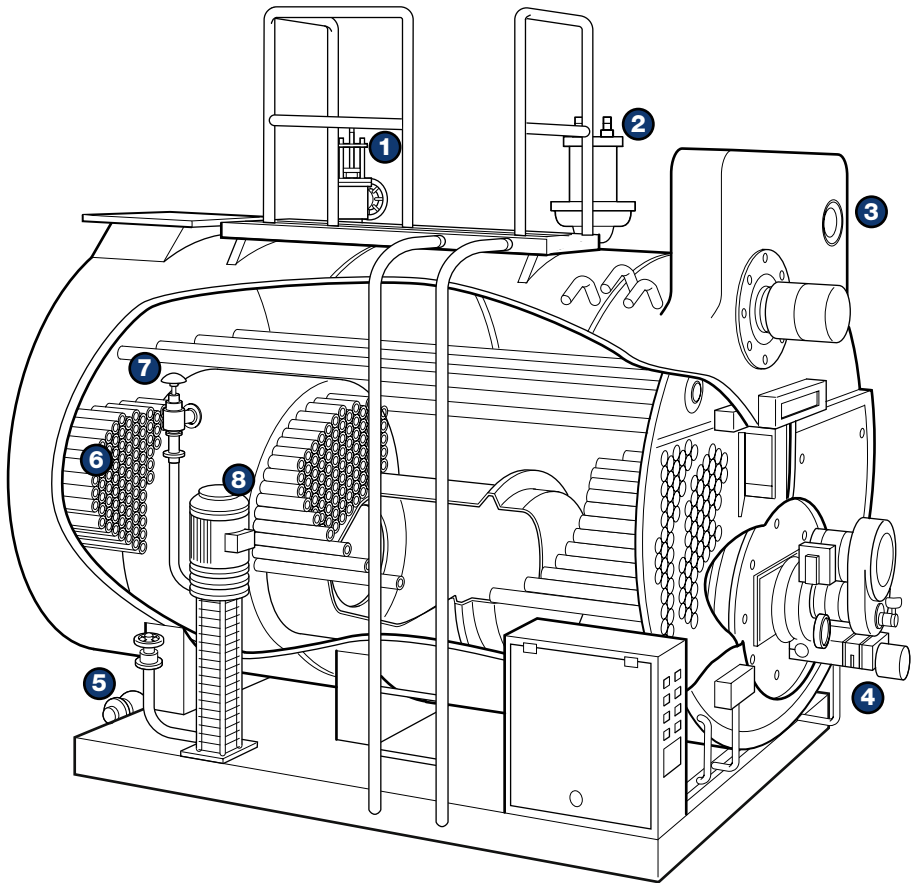
The word 'boiler', in everyday use, covers a wide range of equipment, from simple domestic hot water boilers to boilers housed within a power generation plant to convert fossil fuel to electricity. Generally, domestic hot water boilers do not produce steam and should operate at low pressure. While some combination boilers now operate at the pressure of the incoming cold water mains, this is still far below the normal operating pressure of steam-raising boilers.

This leaflet applies to steam and high temperature hot water boiler plant (operating above 0.5 bar pressure and a temperature of 110 °C). It describes a process which you, as a manager, can apply to assess if your boiler installation can continue to be operated safely.

Steam-raising plant and boilers

Figure 1 shows a sectional view of a typical steam-raising boiler. This is known as a shell and tube boiler and is the most common type. The hot gases from the burner go through the furnace tube and then back through the smoke tubes and out of the flue. The water is heated by the tubes and is contained by the main pressure-containing part, the shell.

Figure 2 shows a typical vertical boiler found in a number of factories for either generating very hot water or steam.



- 1 Main stop valve
- 2 Safety valve
- 3 Pressure gauge
- 4 Oil/gas burner
- 5 Blowdown valve
- 6 Smoke tubes
- 7 Feed check valve
- 8 Feed water pump

Figure 1 Sectional view of a typical steam-raising boiler

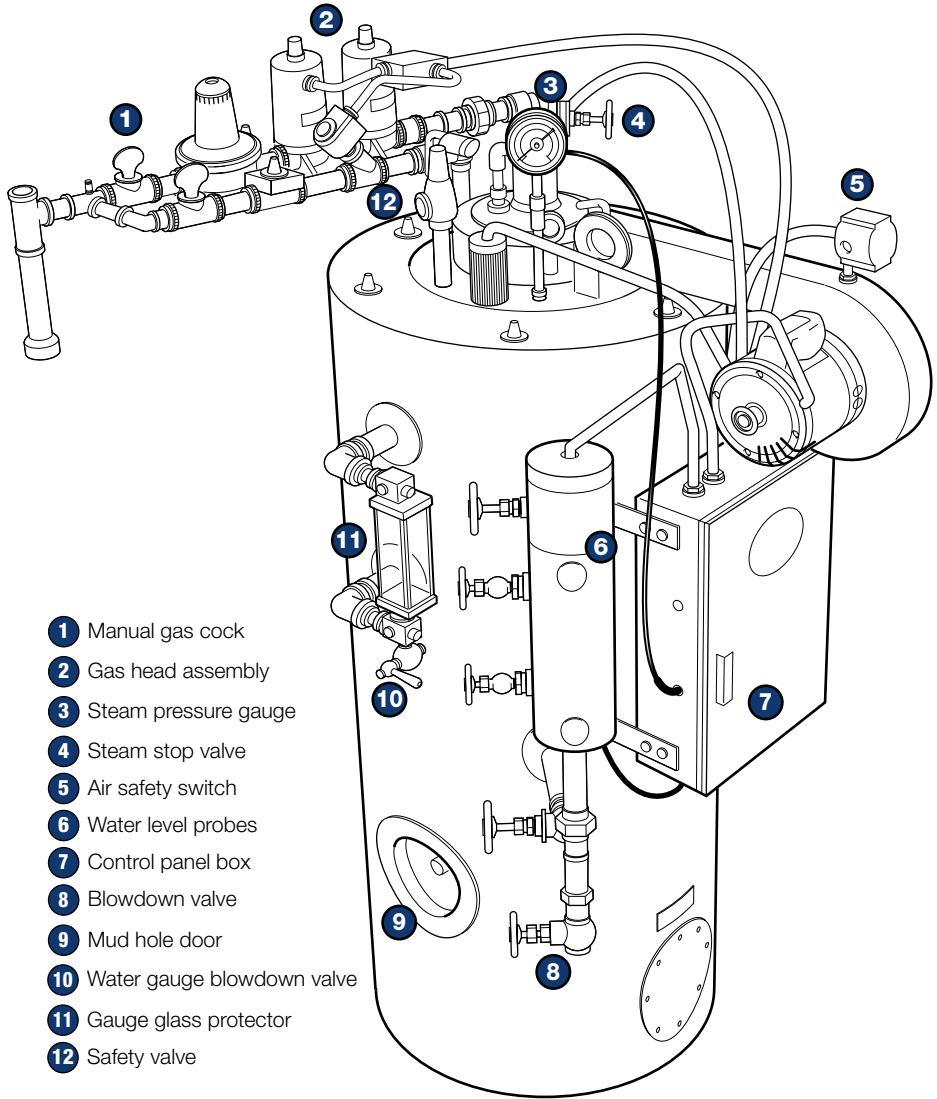


Figure 2 Typical vertical boiler

What affects the safe operation of boilers?



Figure 3 What can affect safe boiler operation?

All of the above factors need to be in place and adequately addressed to ensure the safe operation of a boiler. If one of more of these stops working, or is inadequate, or absent, this could result in the boiler breaking down or failing catastrophically, causing injuries and damage to property.

What do I need to do?

You need to determine if the risks from your boiler are at acceptable levels or if any additional measures are required to achieve this. This will require a systematic assessment of any risks that may be present and the control measures in place to address them.

A risk assessment does not need to include excessive detail; however, the findings and any actions taken should be recorded. In some cases, you may need to contact the manufacturer, installer or other experts for the required information to complete the assessment.

The exact considerations will depend on the site (site-specific) but may include the following:

- The boiler specification, condition and its associated plant.
- The manner in which the boiler is operated and maintained.
- Any safe systems of work, including management and supervision.
- How competent your workers are and how they have been trained.
- How reliable your electronic control system is.
- How regularly your boiler is examined and tested.
- The boiler house in general.

Information on a number of these considerations is often found in the existing documentation relating to the

boiler, eg manufacturer's instructions for operation and maintenance or drawings.

Boiler specification, operation and maintenance

Since installing your boiler and associated plant, there may have been a number of changes in the process or system, resulting in a change in the amount of steam you require. This will in turn affect the way in which the boiler is operated, which could end up being very different from what was envisaged when it was installed.

If a boiler is not operated within its design limits, it increases the risks of fatigue, stress and corrosion, which could eventually lead to leaks, ruptures and, in extreme cases, explosions. Similarly with feed water, incorrect water treatment can lead to scaling, which will again damage the boiler and could lead to premature or catastrophic failure.

In dealing with this issue, you may find it helpful to consider the following:

- Is there any existing documentation relating to your boiler plant?
- Does this documentation state how the boiler should be operated (including operating limits) and maintained?
- Can you establish (from the documentation or the manufacturer) that the boiler is suitable for the

way it is intended to be operated or maintained? Look at things like process demands or cyclic operation.

- Is the boiler being operated and maintained in accordance with the documentation?
- Can you demonstrate that the people operating and maintaining your boiler are suitably trained and competent?

Equipment

There is a wide range of safety and monitoring equipment that can be fitted to boilers, designed to help protect the boiler from operating outside the set parameters and shut it down to prevent a dangerous situation. This may include equipment such as alarms, water-level controls, burner controls and pressure-relief valves.

For example, with the water-level controls, the first low-water-level alarm prevents the boiler operating when the water level is low, but allows the boiler to restart and resume operation once the water has risen to an appropriate level. The second low-water-level alarm is triggered at a lower level than the first and this shuts the boiler down completely and requires a manual restart.

The level of control and monitoring required depends on a number of factors, but generally boilers with

automatic control and remote monitoring systems will require more monitoring and control equipment than manually controlled boilers. Figures 1 and 2 show the type of equipment that can typically be found on a boiler system. You may need expert help to determine whether the equipment you have on your boiler is sufficient to operate the system safely in the way you intend.

Water treatment

As with all systems where water is heated there will be a potential for scaling. This can lead to a loss of efficiency or, in extreme cases, premature failure of the boiler due to either scale build-up on the internal surfaces or debris from corrosion collecting in the bottom of the boiler. Water quality within the boiler must be maintained to reduce the risk of overheating, corrosion, water carryover causing destructive water hammer and build-up of solids. Water-treatment methods include:

- water-treatment plant, such as base exchange, demineralisation and reverse osmosis;
- hotwells or de-aerators; and
- adding chemicals.

Consult a water-treatment expert to find out what is best for your system.

Boiler house safety

The boiler is only one piece of equipment within the boiler house and there will be several other issues that require compliance with other legislation, for example ventilation, fire and gas. A number of different technical personnel may therefore need to be involved in aspects of boiler house safety, eg operation and maintenance staff. It is essential that you as the owner/manager of the site ensure there is adequate communication between these people, even though they may not be directly employed by you.²

All equipment, instrumentation and controls must be installed and maintained by suitably qualified and experienced personnel in accordance with the manufacturer's instructions.

Training

- The training boiler operators receive must be appropriate for the equipment they will operate.
- The level of competence and training required must be reviewed when a system is modified or changed, eg increased automation or remote supervision.

When selecting training providers, employers must be satisfied that:

- the training is delivered by people who have the appropriate knowledge and assessment skills on their specific equipment;² and
- trainers have enough industrial experience to put the information in the right context and knowledge of the working environment in which the trainee is expected to work.

Routine testing of steam boilers

Routine testing of boiler controls, limiting devices and feed water quality is essential to ensure the boiler continues to be safe, reliable and efficient. The routine tests recommended by the manufacturer should be carried out **as a minimum**. However, in certain circumstances, more frequent testing may be needed. For example, where the water quality is poor and there is a high dependence on water treatment, more frequent testing of the water and blowdown of the boiler may be required. These tests and the results should be recorded or logged (either electronically or manually) and must include:

- the results of the test and comparison against required values;
- identification of the operator;
- the date of the test; and
- any corrective action taken, if necessary.

Clear written instructions of how and when to carry out routine tests should be kept on site.³

Written scheme of examination

A written scheme of examination for all relevant pressure systems (including boilers) is a legal requirement under regulation 8 of the Pressure Systems Safety Regulations (PSSR) 2000.⁴

It should set out the nature and frequency of examination for a pressure system and should adequately describe the system, including all the pipework, vessels, safety devices and any other parts that could give rise to danger.

It must also specify any special measures necessary to prepare the system for such examinations. It should always reflect the operating conditions of the system and may need amending if these conditions change.

The scheme must be certified by a competent person and be available on site at all times. The owner of the system is responsible for ensuring that a scheme has been drawn up for all relevant pressure plant and that the competent person who certifies it has sufficient relevant knowledge and experience to carry out this task.

Who or what is a ‘competent person’?

The use of the term ‘competent person’ will have different meanings depending on the context in which it is used. The basic definition is a person who has sufficient knowledge and experience to make recommendations or decisions that will ensure the equipment or process is operated and used safely.

It is essential that any individual or organisation acting as a competent person should have sufficient practical and theoretical knowledge as well as experience of the actual systems involved. They should also be able to access any required specialist services, expertise and effective support, either from within their own organisation or through arrangements with external bodies.

The role of the competent person includes:

- advising the owner/user on the content of the written scheme of examination;
- compiling the written scheme of examination or certifying an already compiled scheme;
- modifying the scheme where necessary;
- helping the owner/user to establish the safe operating limit of a pressure system;

- determining the frequency of examination and stating the examination requirements;
- undertaking the periodic examinations as identified by the written scheme of examination. For a steam boiler this should include an out-of-service examination (cold, off-line, open for inspection) followed by an in-service examination at normal operating pressure to check that all protective and control devices are working properly;
- issuing notifications of imminent danger; and
- issuing a report of examination and notifications of dangerous defects.

The competent person carrying out the periodic examinations must have sufficient knowledge and experience of the type of system to be examined to be able to identify any defects or weaknesses that may affect the safety of the equipment. This person does not need to be the same one who compiled the written scheme of examination, so the current or a controlled copy of the scheme should always be available on site.

The owner of the system is responsible for arranging for the competent person to carry out the examinations in accordance with the written scheme of examination.

Records

You need to retain the following documentation and records:

- the report of the last examination under the written scheme of examination;
- any details of repairs or modifications to the system (including changes to the operating parameters);
- any previous reports containing information relating to the safe operation of the system;
- routine testing records for the previous two years; and
- technical documentation supplied by the manufacturer and installer of the boiler and associated equipment.

You also need to make these documents available to the boiler operator, the competent person and any new user or owner of the pressure equipment.

Changes and modifications

A change includes anything that has the potential to significantly change any risks from the boiler, for example:

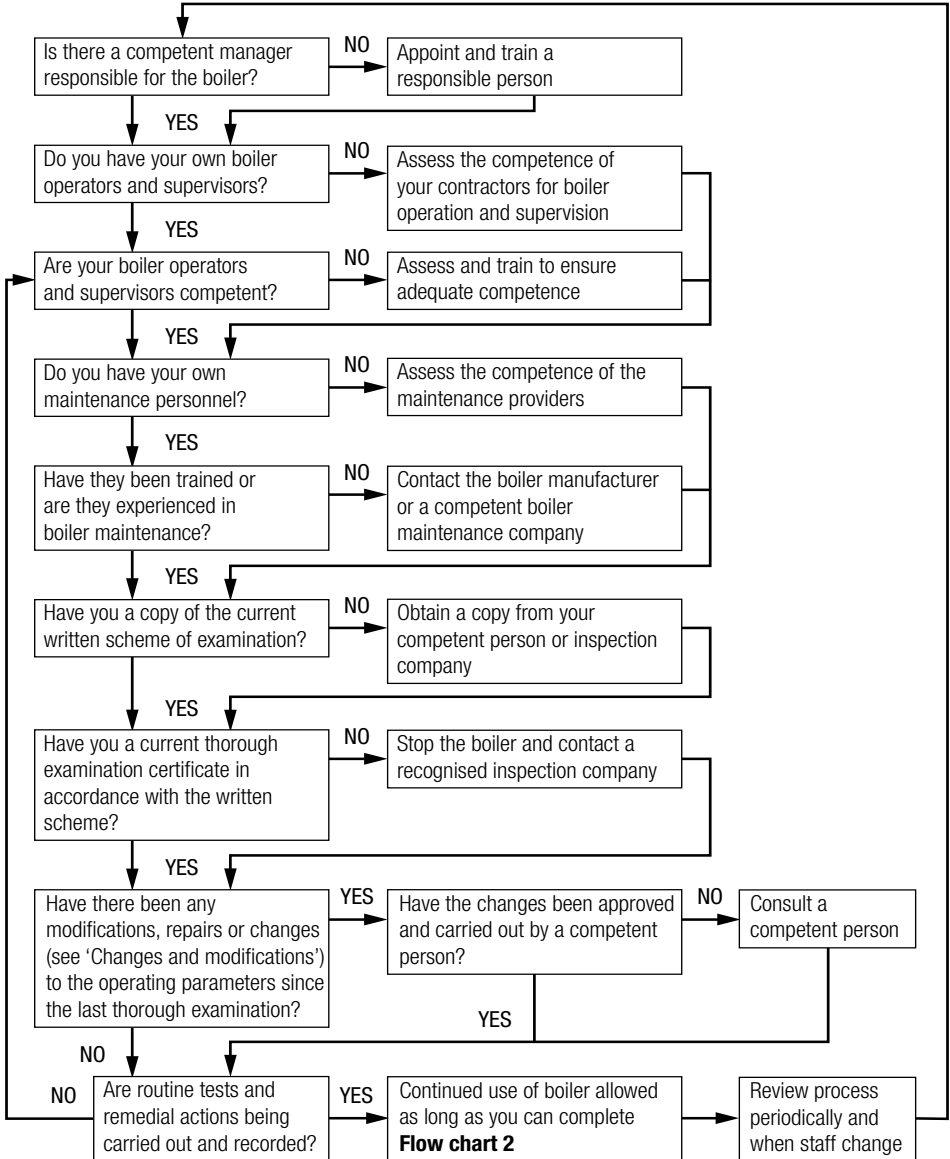
- any physical change to the boiler, or one of its components (such as water supply);
- a change in competence of the operator or maintenance staff;
- a change in the supervision or monitoring arrangements; or
- a change in the environment in which the boiler is operating.

You must notify a competent person of any such changes so that they can determine whether the written scheme of examination is suitable or needs to be modified.

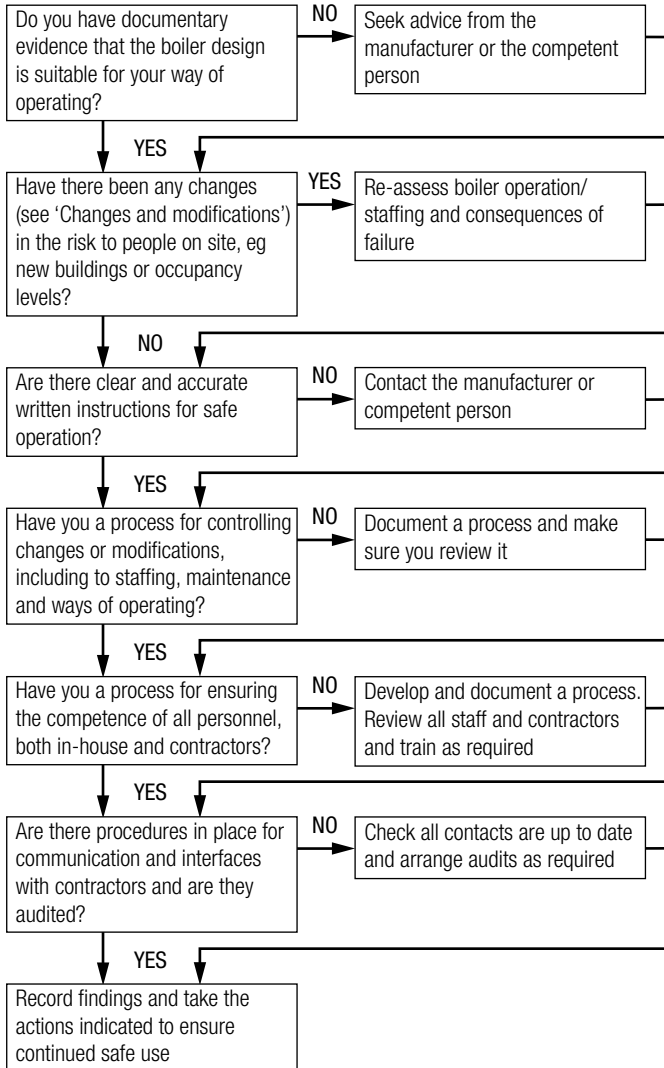
What do I do next?

Now work your way through the flow charts and take the action indicated to demonstrate that your boiler installation can continue to be operated safely. You may need help from a competent person.

Flow chart 1 Have you got the right people in place?



Flow chart 2 What evidence do you have that you are operating your boiler safely?



References

1 *Five steps to risk assessment* Leaflet INDG163(rev2) HSE Books 2006 (single copy free or priced packs of 10 ISBN 978 0 7176 6189 3) www.hse.gov.uk/pubns/indg163.pdf

2 *Simple guide to the Provision and Use of Work Equipment Regulations 1998* Leaflet INDG291 HSE Books 1999 (single copy free or priced packs of 15 ISBN 978 0 7176 2429 4) www.hse.gov.uk/pubns/indg291.pdf

3 *Safety of pressure systems. Pressure Systems Safety Regulations 2000. Approved Code of Practice L122* HSE Books 2000 ISBN 978 0 7176 1767 8

4 *Written schemes of examination: Pressure Systems Safety Regulations 2000* Leaflet INDG178(rev1) HSE Books 2002 (single copy free or priced packs of 15 ISBN 978 0 7176 2269 6) www.hse.gov.uk/pubns/indg178.pdf

Further reading

Pressure systems: Safety and you Leaflet INDG261(rev1) HSE Books 2001 (single copy free or priced packs of 15 ISBN 978 0 7176 1562 9) www.hse.gov.uk/pubns/indg261.pdf

Fire and explosion: How safe is your workplace? A short guide to the Dangerous Substances and Explosive Atmospheres Regulations Leaflet INDG370 HSE Books 2002 (single copy free or priced packs of 5 ISBN 978 0 7176 2589 5) www.hse.gov.uk/pubns/indg370.pdf

Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 (ATEX) www.hse.gov.uk/fireandexplosion/atex.htm

Safe work in confined spaces Leaflet INDG258 HSE Books 1997 (single copy free or priced packs of 20 ISBN 978 0 7176 1442 4) www.hse.gov.uk/pubns/indg258.pdf

Guidelines on safe operation of boilers BG01 www.cea.org.uk and www.safed.co.uk

Combustion Engineering Association Boiler Operation training schemes www.cea.org.uk/training.asp

For information about health and safety, or to report inconsistencies or inaccuracies in this guidance, visit www.hse.gov.uk. You can view HSE guidance online and order priced publications from the website. HSE priced publications are also available from bookshops.

This leaflet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

This leaflet is available in priced packs of 10 from HSE Books, ISBN 978 0 7176 6388 0. A web version can be found at: www.hse.gov.uk/pubns/indg436.pdf.

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