



SAFETY ASSESSMENT
FEDERATION

Guidelines

Pressure Systems

Guidelines for the examination of electrically
heated café boilers (Espresso Machines)

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FOREWORD

These guidelines are based on the collective experience of the Safety Assessment Federation (SAFed) member companies from examination of Café Boilers (Espresso Machines) over many years.

1. INTRODUCTION

These guidelines are intended to assist competent persons when considering the scope of examination, content of written scheme of examination (WSE) and other elements associated with the operation of café boilers, in order to meet the requirements of the Pressure Systems Safety Regulations 2000 (PSSR).

Some café boilers only deliver hot water at temperatures around 90°C - 95°C i.e. below 100°C and are not therefore, covered by the PSSR or this document.

Café boilers (Espresso Machines) have been manufactured for many years and can be found in many different facilities around the UK and whilst they may also be gas fired or steam heated, this document is only concerned with the issues and risks associated with electrically heated units containing a pressure vessel.

This guidance is published in the UK and therefore refers to its regulatory framework. However, much of the description of good practice it contains may be relevant elsewhere. UK Pressure Systems Safety Regulations require pressure systems to be periodically examined in accordance with a documented scheme of examination. The scheme specifies the nature and the frequency of the examination which are appropriate to the risks associated with the type of equipment under examination. Whilst formal schemes of examination are not common practice in some other countries, any references made to the nature and frequency of the examination in this document can be considered good practice.

2. DESIGN AND CONSTRUCTION

Items of pressure equipment generating steam at pressures greater than 0.5 bar, with a volume greater than 2 litres, are required to be designed and manufactured in accordance with the requirements of the Pressure Equipment (Safety) Regulations 2016 (and therefore should be CE marked). Pressure equipment falling below these criteria should be designed and manufactured in accordance with Sound Engineering Practice. It should also be noted that small, low pressure equipment coming under PED risk category 1 and also built in accordance with other directives are excluded from the PED. Cafeteria boilers commonly fall into this exception as they are built in accordance with the Low Voltage directive. There should nevertheless be markings or documentation which confirm SOL's.¹

A Declaration of Conformity should be sighted to confirm that compliance with the Pressure Equipment Directive or Low Voltage Directive has been achieved. This document may also provide other manufacturing data such as design pressure and temperature and instructions for safe operation.

1 Note: If the vessel does not fall within the scope of the PE(S)R then the PSSR regulations 4 and 5 apply in full.

3. PROVISION OF INFORMATION AND MARKING

The manufacturer's data plate may be attached to the casing of the machine rather than the boiler itself. This may lead to problems with boiler identification especially when the boilers are swapped around from machine to machine as they are overhauled, and it may be advisable to tag the boilers with a unique number to assist in clear identification.

4. INSTALLATION

Cafe boilers shall be installed in accordance with the manufacturer's guidance and should allow room for maintenance and examination.

Café boilers are often installed in areas such as restaurants and canteens which are likely to have several people in the vicinity, which increases the potential consequence should the boiler fail, consideration and advice should therefore be given to the user with respect to siting the boiler in a less populated area.

5. SAFE OPERATING LIMIT

Some boilers are designed and constructed for a safe operating limit considerably greater than the actual operating pressures. To reduce the consequence of failure, it could be considered best practice to size and set the safety valves as near to the actual operating pressures.

6. WRITTEN SCHEME OF EXAMINATION ETC

The competent person will need to take into account manufacturer's guidance in respect of the necessity and ability to carry out a thorough examination of the unit however, in the absence of any such guidance then the Competent Person shall determine, through risk assessment, the scope and content of the WSE.

Café boilers are regarded as Minor Pressure Systems since they are small, present few engineering problems and have a safe operating limit of less than 20 bar.

6.1. Failure modes

Experience to date suggests that the typical failure scenario is one of leaking around the brazed or bolted connections. However there remains a risk of catastrophic failure of the boiler unit due to over pressure, as happened in a retail outlet in 2010, causing injury to several customers. It is essential therefore that, in addition to a visual examination of all parts of the café boiler, all relevant protective devices are subjected to an examination and test to demonstrate their satisfactory operation.

Low water conditions are likely to result in failure of the heating elements rather than any overheating of the pressure retaining components.

Potential Failure Mechanisms

Thermal Fatigue is the result of cyclic stresses caused by variations in temperature. Damage is in the form of cracking that may occur anywhere in a component where relative movement or differential expansion is constrained, particularly under thermal cycling. Thermal fatigue may also occur and is sometimes referred to as thermal shock. In this situation, a hot surface contacted by a colder medium (cold water in heat exchanger elements) will experience tensile stresses as it attempts to contract but is restrained by the hotter bulk component. This can result in cracking of the surface contacted by the colder fluid.

Mechanical Fatigue is dependent on the number of cycles experienced over the operational life of a particular component and is more commonly associated with components subject to the normal operational cycling associated with boiler systems. Cracks are likely to initiate at locations such as nozzle weld toes, peaking and misalignment of seams and other geometrical changes.

Corrosion

Pitting Corrosion is the localised corrosion of a metal surface confined to a point or small area that takes the form of cavities.

Stress corrosion cracking (SCC) causes failure of normally ductile metals under tensile stress in a corrosive environment. This phenomenon is exacerbated with elevated temperature and is dependent upon particular chemicals reacting adversely with certain metals. For example, ammonia containing cleaning products may affect copper.

Erosion is the action of material wastage/thinning in a structure (shell, nozzle or piping) by fluid velocity and/or turbulence.

6.2. Scope of Written Scheme of Examination

These units are self-contained “packaged” systems and therefore the following items should be included in the written scheme:

- pressure vessel
- protective devices – typically comprising of safety valve, pressure indicator, water level control and high temperature cut-out
- integral pipework

Generally, it is not expected that any part of the system would be excluded from requiring any form of examination.

6.3. Preparation

Although there are many different makes, types and sizes of café boiler, the preparation required prior to examination will depend on whether the interiors of the boilers are accessible or inaccessible for examination.

6.3.1. Preparation of accessible café boilers

- The boiler shall be disconnected and isolated from any electrical source, vented of any residual pressure and drained of all contents.
- Electrical heating element shall be withdrawn from the boiler unit (where possible)
- All internal and external surfaces shall be thoroughly cleaned, with lagging or other insulation removed as required, to the satisfaction of the competent person
- All fittings and protective devices shall be dismantled as required by the competent person
- Personnel with operating knowledge and experience shall be available to carry out any functional testing necessary to ensure correct operation of the unit.

6.3.2. Preparation of internally inaccessible café boilers

- The boiler shall be disconnected and isolated from any electrical source, vented of any residual pressure and drained of all contents.
- All external surfaces shall be thoroughly cleaned, with lagging or other insulation removed as required, to the satisfaction of the competent person
- All fittings and protective devices shall be dismantled as required by the competent person
- Personnel with operating knowledge and experience shall be available to carry out any functional testing necessary to ensure correct operation of the unit.

6.4. Nature of out of service examination

6.4.1. Out of service examination of internally accessible café boilers

The out of service examination shall be made up of two parts:

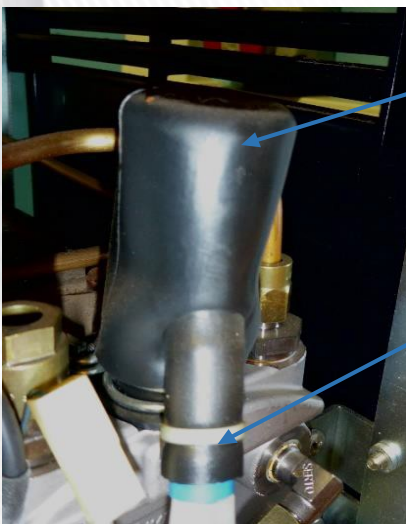
1. Out of Service examination shall be carried out with the system disconnected and comprise of a thorough internal and external visual examination of boiler, protective devices, integral pipework and support structures etc. for evidence of corrosion, erosion, deformation, cracking and other weld or material defects. This should include checks for blockages in pipework. Work carried out on other

small steam generators has shown blocked pipework as a highly probable failure mechanism, in particular where the protective devices are not directly mounted to the vessel.

Note: The competent person, may request a hydraulic test as part of the out of service examination.

In Service examination shall be carried out with the system operating and comprise of a thorough external examination of boiler together with integral pipework and fittings and witness functional tests of all identified protective devices as detailed below:

- A. **Safety valves** — All component parts and adjusting mechanisms shall be examined by the competent person. If the safety valve cannot be practicably tested under working conditions, the competent person may accept documentary evidence that the safety valve has been recently tested and certified by persons or bodies competent so to do. Where a new valve is fitted it should be pop tested prior to fitting. Some units are fitted with a cover and discharge pipework (often made from flexible silicon tube). The discharge should be to a safe place and any flexible tube prevented from whipping in the event of a valve operation.



Rubber Cover – Over safety valve.

Flexible Discharge Pipe

Cover fitted over safety valve.

- B. **Pressure gauges** (if fitted and included in the Written Scheme) — Pressure gauges should have in date calibration documentation, which should be sighted by the competent person. If such documentation is not available, then the competent person shall check the gauge against a calibrated gauge and report accordingly.

6.4.2. Out of Service examination of internally inaccessible café boilers

The out of service examination shall be made up of two parts:

1. Out of Service examination shall be carried out with the system disconnected and comprise of a thorough external visual examination of boiler, protective devices, integral pipework and support structures etc for evidence of corrosion, erosion, deformation, cracking and other weld or material defects.

Note 1: The cold examination may be supplemented with a hydraulic test.

Note 2: Consideration shall be given to manufacturer's instructions to replace the boiler unit at a prescribed frequency (maximum interval 5 years).

2. In Service Examination shall be carried out with the system operating and comprise of a thorough external examination of boiler together with pipework (where included in the Written Scheme) and fittings and witness functional tests of all identified protective devices as detailed in section 6.4.1

6.4.3. First Examination

After a new installation, the Competent Person should be informed before the unit is put into service, so that the item can be added to a Written Scheme of Examination. The initial examination would normally be an out of service examination except where there is sufficient documentation to establish the integrity of the unit and establish the date of the next examination.

6.5. Periodicity

The frequency of examination determined by the Competent Person should take into account that these units are used in areas of high population and exposed to usage greater than would be expected for any other similar item of plant. An examination frequency of 14 months is generally considered to be appropriate, unless a detailed risk assessment has demonstrated that a greater period is acceptable.

7. OPERATORS OF CAFÉ BOILERS

Operators must be given adequate training or provided with clear operational instructions, which should be updated as required to ensure that they are fully conversant with the operation of all protective devices. Manufacturer's instructions and/or other suitable operating procedures should be readily available to operators. All training should be documented and designed to ensure that operators understand the procedures and dangers that may arise from incorrect operation.

Operators and their managers should be fully aware of the dangers of bypassing or interfering with safety devices or of other malpractice.

Operators should switch the units off at the mains connection and not rely on the switch on the unit when the boiler is not operating for longer periods (over a weekend for example).

8. MAINTENANCE

The level of maintenance can vary from routine replacement of boiler or water filter units to regular strip down and overhaul.

Due to the electronic control systems it is imperative these units are subjected to routine maintenance and that a service engineer is present at the examination to allow the control system to be overridden to enable the safety valve(s) to be lifted and the functionality of other protective devices to be demonstrated.

Maintenance should only be carried out by someone who is competent to do so and should follow written procedures that take account of the manufacturer's instructions, any special factors relating to the particular use of the pressure equipment and frequency of operation.

A record of such maintenance and any remedial actions should be kept by the user/owner.

9. MODIFICATION AND REPAIRS

In the majority of cases mechanical repairs are likely to be limited to unit replacement. Where modifications and repairs are to be carried out that may affect the integrity and/or safety of the vessel, integral pipework and protective devices then the Competent Person should be informed, before any work commences.

The modification of electrical circuit components must not affect the performance of any of the safety devices or pressure control systems.

10. KEEPING OF RECORDS ETC

The following records should be kept on site or at a designated central location and be available for scrutiny by the competent person, responsible person or other interested parties:

- Declaration of conformity (as applicable)
- Examination reports
- Records of tests on protective devices
- Written scheme of examination
- Records of servicing, repairs or modifications
- Records of maintenance
- Training records of operators
- Audit reports for operators
- Test log

11. OTHER CONSIDERATIONS

11.1. Water quality

The wide variety in water quality is a leading issue to the ongoing viability of the steam boilers and is dependent on the location of the unit within the UK.

‘Hard’ water will lead to excessive scale deposition leading to premature failure of the electrical elements or dramatic loss of efficiency. High iron content whilst not contributing to scale problems can also lead to rapid failure of the element.

Local water suppliers will provide details of water quality.

Manufacturers may also provide recommendations as to the use of ancillary equipment such as water filters.

11.2. Potential for scalding

The PSSR recognises the hazards associated with the scalding effects of steam however these units are designed to allow the operators to 'sparge' steam directly into milk etc.

11.3. Electrical Hazard

Although not a concern of the PSSR, the competent person and the user need to be aware of the additional electrical hazards that they may be exposed to during operation and examination of these units.

11.4. Malfunctioning safety valves

Instances have been experienced where the vacuum from the boiler cooling down has drawn milk back into the boiler leading to the formation of sludge and other fatty deposits. This may prevent the correct operation of the electronic protective devices or prevent the safety valve operating at the correct pressure. The boilers can often be found coated with caramelised coffee grounds and sugar. This may also lead to sticking and a possible malfunctioning of the safety valves.

12. REFERENCES

The following documents are applicable at the time of preparation of these Guidelines:

- The Pressure Systems Safety Regulations 2000 (SI 2000 No.128)
- Pressure Systems Safety Regulations (Northern Ireland) 2004 (SR 2004 No.222)
- Pressure Equipment Directive 2014/68/EU
- Pressure Equipment (Safety) Regulations 2016
- The Provision and Use of Work Equipment Regulations 1998
- Management of Health and Safety at Work Regulations 1999
- Health and Safety at Work etc. Act 1974
- SAFed Guidelines on Periodicity of Examination (PSG1)