

EEMUA Publication 177 - Guide to the UK Pressure Systems Safety Regulations (2000)

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Edition 3

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Guide to the UK Pressure Systems Safety Regulations (2000)

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Engineering Equipment and Materials Users Association

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Contents

1 Introduction.....	1
1.1 Purpose	1
1.2 Scope	1
1.3 About this Edition.....	2
2 Regulation 2 – Interpretation	3
2.1 Mobile System	3
2.2 Pressure System.....	3
2.3 Protective Devices.....	4
2.3.1 Examples of Protective Devices.....	4
2.3.2 Maintenance checks on Protective Devices.....	5
2.4 Relevant Fluid	5
2.5 Pressure Systems excepted from certain regulations.....	5
3 Regulation 7 – Safe Operating Limits	6
4 Regulation 8 – Written Scheme of Examination	7
4.1 General	7
4.2 Application	8
4.3 First Examination.....	8
4.4 Types of Examination	8
4.5 Frequency of Examination.....	9
4.6 Protective Devices.....	10
4.7 Pipework.....	11
4.8 Pipelines.....	11
5 Regulation 9 – Examination in Accordance with the Written Scheme.....	13
5.1 Incomplete Examination	13
5.2 Reporting and Timescales	13
5.3 Postponement	14

6 Regulation 10 – Action in Case of Imminent Danger.....	15
6.1 General	15
6.2 Duties under other legislation.....	15
6.3 Consistency of taking Regulation 10 action	16
6.4 Liaison with HSE	16
6.5 Guidance Charts.....	16
7 Modification and Repair	17
8 Schedule 2 – Leased or Hired Pressure Systems	18
Annex 1 Examination of Distillation Columns	19
Annex 2 EEMUA Interpretation of the PSSR for Registration of Pipework.....	23
Annex 3 Guidance for Reporting Imminent Danger	24
Bibliography and Related Documents	36
EEMUA Publications: Feedback Form.....	39
EEMUA Publications Catalogue	42

1 Introduction

The UK Pressure Systems Safety Regulations 2000¹ cover the safe design and use of 'Pressure Systems'. Its aim is to prevent serious injury from the hazard of stored energy (pressure) and steam as a result of the failure of a Pressure System or one of its component parts. Included in the Regulations is the requirement for periodic 'Examination' of Pressure Systems, in or out-of-service as appropriate, in accordance with written Schemes of Examination.

1.1 Purpose

This Publication is intended to give practical guidance on the use of the Regulations.

The Pressure Systems Safety Regulations 2000 (otherwise referred to in this guidance as the Regulations), together with the Health & Safety Executive (HSE) Approved Code of Practice, Safety of Pressure Systems, ACOP L122 (referred to as the ACOP in this guidance), comprise a package of documents, which in this publication are collectively referred to as the PSSR.

The PSSR contains a complex series of requirements, for which EEMUA considered that guidance would be of value to its members as a reference document, since the PSSR allows for a significant element of experienced, professional judgement by the 'User' and/or 'Competent Person', together with a demand for careful interpretation.

The first edition of this guide was published in 1993 as a Selective Guide to The Pressure Systems and Transportable Gas Containers Regulations (PSTGC). Edition 2 was issued in 2009 after the PSSR replaced the PSTGC Regulations and the ACOP was issued. Though the Regulations were not changed the ACOP was reissued in 2014. It contains some minor changes which are generally not relevant to industrial Users. This guide is now updated in the light of experience gained in its application since the issue of the second edition.

It is recommended to also refer to EEMUA 231 which exemplifies a large number of the elements of the PSSR.

1.2 Scope

This Publication gives guidance on the interpretation of the PSSR relating to the periodic Examination of Pressure Systems and certain associated aspects, and considers in particular regulations 2, 7, 8, 9, 10 and 13, plus Schedule 2; it does not refer in detail to the other regulations already clearly expounded in the ACOP. This Guide, therefore, should not be read in isolation, but should be used to augment the existing ACOP.

¹For the purposes of this Publication the Pressure Systems Safety Regulations 2000 is construed to refer also to the Pressure Systems Safety Regulations (Northern Ireland) 2004. The latter Regulations contain the same technical content and vary only in reference to Northern Ireland legislation and some minor editorial changes.

Throughout this Guide, the terms contained within single quotation marks when first used are meant to be interpreted as defined in regulation 2 of the PSSR (thereafter in general shown with initial letters capitalized except where reproduced in paragraphs from the PSSR).

'Transportable Pressure Receptacles' (transportable gas containers) are not within the scope of this Publication.

Whilst this Publication refers throughout to UK regulations and practice, much of the general advice is relevant to practice outside the UK. However readers outside UK jurisdiction should abide by local regulations and codes of practice.

1.3 About this Edition

The authors of this Publication are members of EEMUA's User Inspectorates Committee (UIC).

The principal changes from the previous edition include: additional guidance on postponement of Examinations (within regulation 9); a revision to the guidance on regulation 10 Action in case of imminent 'Danger'; additional guidance on regulation 13 Modification and repair; together with other points of interest based upon actual use of the PSSR.

2 Regulation 2 – Interpretation

2.1 Mobile System

‘Mobile Systems’ can be confused with Transportable Pressure Receptacles or tank containers moved by road or rail in the UK, however the latter come under the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (see ACOP Exception 9). A Transportable Pressure Receptacle on its own is not a Pressure System. If pressure receptacles are transported offsite (whilst still under pressure) to be refilled, then the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations apply.

Pressure Systems that can be readily moved between and used in different locations are Mobile Systems under the PSSR (note also paragraph 39 of the ACOP Guidance). Mobile Systems are likely to be subject to lease/hire agreements where the ‘Owner’ has duties under the Regulations.

2.2 Pressure System

The Regulations are founded on the concept of Pressure Systems, not solely pressure vessels. A Pressure System is defined in regulation 2 as:

- a) a system comprising one or more pressure vessels of rigid construction, any associated pipework and protective devices;*
- b) the pipework with its protective devices to which a transportable pressure receptacle is, or is intended to be connected; or*
- c) a pipeline and its protective devices,*

which contains or is liable to contain a relevant fluid, but does not include a transportable pressure receptacle.

It is thus apparent that the equipment necessary to comprise a Pressure System under the Regulations is bounded by lower limits but there are no maxima. A Pressure System may therefore encompass the whole of a process plant or small portions thereof, providing the latter include the minimum elements noted in (a), (b) or (c) above. Precisely how a complex industrial plant is segregated into Pressure Systems in terms of regulation 2 is a matter of individual preference and convenience, but it is recommended that the number of such systems be optimised for the effective application of Schemes of Examination (regulation 8).

2.3 Protective Devices

The Regulations define 'Protective Devices' as those designed to protect the Pressure System against 'System Failure' and devices designed to give warning that System Failure might occur. Bursting discs are included.

Guidance Paragraph 18 in the ACOP explains clearly that the definition of Protective Device does not include every device that has a control or measuring function. Rather it includes any protective control or measuring equipment which is essential to prevent a dangerous situation from arising. Instrument and control equipment should be considered as a Protective Device subject to the Regulations where it has to function correctly in order to prevent the 'Safe Operating Limits' being exceeded where no other Protective Device is provided.

2.3.1 Examples of Protective Devices

Table 1 offers typical examples of Protective Devices which may be considered as essential to prevent System Failure and which therefore should be included in a 'Scheme of Examination'. It should be stressed that the examples given in Table 1 are for the purpose of illustration and should not be regarded as definitive. Some industry sectors have found it useful to have definitive listings of safety critical devices and safety instrumented systems to assist with Scheme of Examination considerations and maintenance priorities.

There are other devices that are used to prevent physical damage to equipment. These are not necessary to prevent a sudden discharge of pressure energy that may cause Danger to persons, because either there is a backup device to prevent overpressure or the subject components are non-pressure containing - such devices therefore do not come within the scope of the Regulations.

The decision to apply the Regulations to a device is dependent upon whether or not the correct operation of that device is essential for the mechanical integrity of the Pressure System. In general, devices that monitor normal operating parameters, such as pressure gauges and temperature indicators, would not be included in a Scheme of Examination.

Table 1 Examples of Protective Devices to be considered for inclusion in a Scheme of Examination

Description of function	Typical examples	Possible consequence of device failing to operate
Devices to prevent under-pressure	Vacuum breakers	Failure due to collapse
Devices to relieve excess internal pressure	Safety valves Relief valves Bursting discs	Failure to over-pressurisation
Devices to prevent a predetermined temperature level from being exceeded	a) High temperature trips and fusible plugs b) Low temperature trips	a) Failure due to loss of strength as a result of exposure to high temperature b) Reduction of fracture toughness at low temperature

Warning devices	Pressure alarm or recording systems which identify a pressure excursion beyond a predetermined limit (typically within a margin of the Safe Operating Limit)	The Competent Person should be informed of such incidents to ensure that a suitable operation review is conducted
Rapid isolation of excessive pressure source	Slam shut valves, High Integrity Pressure Protection Systems (HIPPS)	Failure due to over-pressurisation
Restriction device to limit the flow rate from a high pressure source	Restriction orifice plate Control valve	Failure due to over-pressurisation
Device to protect against low level of water in boiler	Level gauge Low level alarm/shutdown device	Failure due to overheating of boiler

2.3.2 Maintenance checks on Protective Devices

In addition to Examination and testing of Protective Devices, the ACOP Guidance draws attention to checks that are carried out as part of maintenance programmes: *Checks should be carried out to ensure that safety-related features are operating correctly. A fault affecting production is normally apparent within a short time whereas a fault in a safety critical part, such as a protective device, could remain undetected unless appropriate safety checks are included as part of the maintenance programme.*

See also Annex A3.11 of this guidance regarding testing and setting of Protective Devices.

2.4 Relevant Fluid

Pressure systems contain, or are liable to contain a 'Relevant Fluid' (regulation 2). It should be noted that steam at any pressure is a Relevant Fluid; there is no minimum limit on steam pressure. The interpretation of Relevant Fluid is reproduced in the chart in Annex 2 of this document.

2.5 Pressure Systems excepted from certain regulations

Schedule 1 in the ACOP lists exceptions. Various of the regulations do not apply to a Pressure System containing a Relevant Fluid (other than steam) if the product of the pressure in bar and internal volume in litres of its pressure vessels is in each case less than 250 bar litres. The excepted regulations are: 5(4) (pressure vessel markings); 8 (Written Scheme of Examination); 9 (Examination in accordance with the Written Scheme); 10 (Action in case of imminent Danger); and 14 (Keeping of records etc).

3 Regulation 7 – Safe Operating Limits

The Safe Operating Limits are defined in the PSSR as the operating limits (incorporating a suitable margin of safety) beyond which System Failure is liable to occur. In addition to pressure and temperature, the following should be considered: flow rates, volumes, heat input, coolant flow, operating hours, operating cycles, process changes and the like. The aim of regulation 7 is to require the User to know and define the safe limits of operation of the Pressure System and to ensure it is operated within these limits and properly maintained. (See ACOP and Guidance paragraphs 89 to 93).

The Safe Operating Limits should be reviewed and revised if necessary after each Examination (or should relevant knowledge arise between Examinations), or when significant repairs or modifications are carried out, or if there are significant changes to operating conditions, including Relevant Fluids. In all these cases, it should be confirmed that the Protective Devices and settings are sufficient. Note also that changes to operating limits may be required in the event of imminent Danger, if determined by the Competent Person (see Section 6).

Many Pressure Systems are either:

- designed to contain the maximum pressure that can be generated; or
- protected by appropriate devices, to safely limit the pressure that can be generated.

In the latter case, the Safe Operating Limits are defined by the design rating of the Pressure System and/or the settings of the Protective Devices.

For Pressure Systems where the operating parameters can be adjusted such that it is reasonably foreseeable that System Failure could occur if certain limits are exceeded, then these have to be specified as Safe Operating Limits.

Examples are:

- For an oil lubricated air compressor system, air/oil explosions can occur if the machine operates with the incorrect oil temperature combination; the Safe Operating Limits may include the maximum operating temperature and oil specification.
- For a fired boiler, the Safe Operating Limits may include the minimum water level or the minimum feed water flow rate to avoid overheating.
- For limited life equipment (e.g. due to fatigue or creep) the Safe Operating Limits may include the number of pressure cycles, or the hours of operation at specified temperatures.
- For some Pressure systems a temperature limit may need to be imposed to prevent excessive thermal stresses, or unacceptable reduction in material strength.
- For some Pressure Systems a maximum heating or cooling rate may need to be imposed to prevent excessive thermal stresses.

4 Regulation 8 – Written Scheme of Examination

4.1 General

Regulation 8 requires that for certain parts of a Pressure System the User shall have a Written Scheme of Examination, produced and/or certified by a Competent Person. The User shall not operate the system unless they have such a Scheme of Examination. A written Scheme can be in the form of an electronic or series of electronic documents. Examinations must be reported and the Scheme reviewed to take account of any significant changes in the process or equipment, as required under regulation 9.

The WSE is one of the most important documents associated with managing integrity under the Regulations. It is used to define what Examinations and testing shall be carried out, when, by whom and how the results should be reported. It also specifies what preparatory work needs to be undertaken to allow the Examination to proceed.

It is, therefore, important that it is worded carefully and is prepared by one or more individuals with an extensive and detailed knowledge of the Pressure System and the processes contained within it.

The WSE is an instruction to an inspector about what to look for during an Examination. This will always be the minimum acceptable and although the inspector can always request more, the inspector should not do less than is specified, unless it is in accordance with approved amendments to the scheme.

Examination reports are included in the records of the Pressure System as described under regulation 14. It should be noted that regulation 12 requires the User to ensure that the Pressure System is properly maintained – maintenance and Examination are separate matters although problems identified during an Examination may require maintenance to correct (see ACOP paragraphs 161-165.)

The contents of the Scheme are elaborated in the ACOP, which indicates that all Protective Devices, most pressure vessels and some 'Pipework' should be included; whilst the Guidance on the PSSR offers further comment on the foregoing.

A study of the above indicates that there are three elements of the PSSR that need to be addressed in relation to a Scheme of Examination:

- the application of the Regulations to the Pressure System;
- the nature of the Examination to be undertaken;
- the frequency of the Examination.

In view of the special nature of Protective Devices, these items are considered separately in Section 4.6 (see also Table 1 on page 4).

4.2 Application

Within a given Pressure System, the equipment items to which regulations 8, 9, 10 and 13 are to be applied must be identified, listed and covered by appropriate documentation. Guidance on this is given in ACOP paragraphs 94 and 95. The User is responsible for this; they may seek advice from an experienced advisor or a Competent Person.

Leased or hired equipment should be treated with care (see Section 8).

4.3 First Examination

The following applies to both new systems and where additions or modifications are made to existing systems.

A Scheme of Examination is required before the User can operate a system. Where appropriate, the requirement for an Examination before the system is first taken into use (which may include commissioning activities) should be specified in the Scheme of Examination. This Examination can indicate whether the equipment has been designed, manufactured and installed in accordance with all the relevant drawings and specifications though should not duplicate information already covered by approved certification schemes.

As the Scheme of Examination has to be drawn up or certified by a Competent Person, consideration should also be given to the stages of the design, manufacture and construction when the Competent Person could be involved for the purpose of considering documentation, certification, and other information (including operation and maintenance instructions, etc.) relevant to the drawing up of the Scheme of Examination and its content. This would equally be relevant when Pressure Systems were repaired or modified.

An Examination before equipment is put into service can also be used for material baseline thickness measurements to be taken before any deterioration has taken place. Actual thicknesses can be different to those specified because of material manufacturing tolerances and such measurements can help establish more reliable material loss figures later in life and for Fitness For Service Assessments should they become necessary.

4.4 Types of Examination

The broad categories of Examination are out-of-service/off-stream, in-service/on-stream internal/external and full/partial; these may involve destructive or non-destructive testing.

Out-of-service/off-stream Examinations comprise monitoring of critical areas for credible damage mechanisms such as corrosion, hydrogen attack, creep, etc.

In-service/on-stream partial Examination involves those areas of the Pressure System most susceptible to deterioration that require more frequent Examination than the remainder.

To illustrate, some commonly used options for types of Examinations are:

- a) **Thorough Internal Examination:** A detailed Examination from both the interior and exterior of the equipment. It is usually considered onerous because of the need to take the equipment

out of service, clean and make safe and therefore the frequency of inspection can be an issue. Most commonly used on vessels, and may not be an option for smaller equipment such as Pipework.

- b) **Intermediate External Examination:** A detailed Examination but undertaken from the exterior only and therefore can sometimes be carried out when the equipment is still in service, or at least without the requirements for internal cleaning and confined space entry. It is usually accepted that this provides less information than an internal Examination, but it is considered less onerous and for that reason it can be carried out at greater frequency. It is often used to supplement the less frequent thorough internal and external Examination, hence the term 'Intermediate'.
- c) **Operator routines:** These usually only consist of brief checks on equipment condition at a very basic level. They can provide value as they are not considered onerous and therefore can be carried out on a regular basis in comparison to more detailed Examinations. They are particularly useful for equipment in remote locations, where damage may otherwise go undetected for some time. Checklists are often used for operator routines.

This list is not exhaustive, but provided only to illustrate that one cycle of an inspection regime may be made up of a combination of one thorough Examination, one or more intermediate Examinations and many operator routines.

Partial Examinations are a legitimate option available to the Competent Person when compiling a Scheme of Examination. They may also be initiated during a Thorough Examination as a pre-condition of setting the subsequent interval to the next Thorough Examination and may be undertaken either out-of-service/off-stream or in-service/on stream, as appropriate.

For low risk situations where all equipment involved could be shown to be of similar design and condition, and exposed to identical threats, companies may develop in-house documentation defining a standard procedure of Examination to which reference can be made, thus avoiding repetition in writing Schemes of Examinations. However, overall, it is not considered good practice to develop generic written schemes for similar items of equipment though a template procedure may be used as a starting point, each piece of equipment should be assessed against its own susceptibilities and operating conditions and its individual periodic Examination requirements defined.

Templates typically would cover the following types of equipment: Protective Devices, towers, drums, reactors, pressure storage equipment, heat exchangers, furnaces, fired heaters and boilers, and Pipework.

The documentation should also cover preparation requirements for equipment prior to Examination or (non-destructive testing, NDT), together with information to be recorded and reported after inspection.

An example of a typical procedure and pro forma are given in Annex 1.

4.5 Frequency of Examination

The intervals between Examinations for Pressure Systems are determined by the Competent Person. Recommended maximum intervals for different Pressure Systems and constituent items of equipment, based on long-term experience in the petroleum industry, are described