



Safe operation of pressure systems for the model engineer

Introduction

This information sheet is aimed at model engineers operating, as a hobby activity, models and equipment that include pressure systems. It is provided as guidance as to how the *Pressure Systems Safety Regulations 2000* (PSSR) may be used as a basis for the design, construction, installation, examination, testing, maintenance and safe operation of boilers and ancillary safety devices used in miniature locomotives, miniature traction engines, miniature road vehicles, miniature stationary engines and boats. It also includes information on other pressure vessels to which the regulations equally apply, eg. compressed air systems.

PSSR, strictly speaking, only applies to pressure systems used at work, but there may be some implications when using miniature locomotives, etc. where the public may be present and so in order to demonstrate a commitment to safety it is prudent to follow the principles in PSSR. The HSE considers it good practice for those using such equipment to provide the same level of health and safety protection as they would if they were duty holders under the Regulations. It is suggested that you should obtain a copy for reference.

Anyone operating pressure vessels as part of a work activity or in the course of business will have to fully comply with all relevant statutory legal obligations.

The guidance in this information sheet has been prepared after consultation with:

- Ground Level 5" Gauge Mainline Association
- Health and Safety Executive
- Midlands Federation of Model Engineering Societies
- Model Steam Road Vehicle Society
- Northern Association of Model Engineers
- 7¼" Gauge Society
- Society of Model and Experimental Engineers
- Southern Federation of Model Engineering Societies
- Representatives from the trade, manufactures, model engineering press and insurers

Application of PSSR to model engineering activities

It is worthwhile considering the purpose of the Regulations and how its principles may be adopted by the model engineer.

The aim of PSSR is to prevent serious injury from the hazard of stored energy as a result of the failure of a pressure system or one of its component parts. The Regulations are concerned with steam at any pressure, gases which exert a pressure in excess of 0.5 bar above atmospheric pressure and fluids (which may be mixtures of liquids, gases and vapours) where the gas or vapour phase may exert a pressure in excess of 0.5 bar above atmospheric pressure.

PSSR is concerned with the risks created by the release of stored energy through a system failure. The amount of stored energy in a vessel is directly related to the volume of the vessel and the pressure of the contents, so as pressure and volume increase so does the danger therefrom in the event of a failure. The application of heat to a pressure vessel increases the stored energy and introduces added risks, eg. scalding in the event of a release of steam or hot water.

Obviously, the foregoing equally applies to the safe operation of boilers in miniature locomotives, traction engines, boats, etc. and therefore the principles laid down in PSSR can be used to advantage.

As with all safety matters, the steps that need to be taken to reduce the risk should be commensurate with the level of risk, and the following outlines how the Regulations may be applied by the model engineer. Appropriate extracts from the Regulations appear in italics

Design and Construction

(Reg 4.2) The pressure system shall be properly designed and properly constructed from suitable material so as to prevent danger.

This regulation places duties on the designer and manufacturer to ensure it is fit for purpose, so as to prevent danger. The material used for construction must be suitable for the intended use, and of appropriate thickness. Material certificates may be required in certain circumstances, eg. welded steel boilers, TIG welded copper boilers, stainless steel boilers, etc.

A boiler must be designed for intended use, eg. a traction engine boiler is subjected to additional stresses imposed by the reciprocating motion and road shocks and may have to be of a sturdier construction than a similar sized locomotive boiler.

Those undertaking joining procedures, eg. silver soldering, welding or rivetting should do so only if they are sufficiently competent. In this instance, 'competent' may be described as having a level of practical and

theoretical knowledge that will enable them to produce joints of satisfactory quality and strength. Individuals should know their own limitations and should not undertake joining operations outside their level of qualification, experience or knowledge.

Any boiler manufactured in the course of business and placed on the market after 29th May 2002 needs to comply with the *Pressure Equipment Regulations 1999* (PER) and should be provided with sufficient documentation to show that it complies - see the Appendix and Further Reading sections of this information sheet. A boiler made in the course of business should thereby satisfy the design and construction requirements of PSSR.

Boilers constructed by model engineers, not in the course of business, and put into service for their own use, are not subject to the requirements of PER; although it would be prudent to consider the design and manufacturing criteria within the essential safety requirements of PER, as they contain much useful information as to what is deemed to be good practice. Nevertheless, the design and construction requirements of PSSR should be considered, even though the full application of PSSR to model engineering activities may not necessarily be appropriate.

(Reg 4.3) The pressure system shall be so designed and constructed so that all necessary examinations for preventing danger can be carried out.

Wherever practicable, and particularly for larger boilers, provision should be made to enable internal inspection.

(Reg 4.5) The pressure system shall be provided with such protective devices as may be necessary for preventing danger: and any such device designed to release contents shall do so safely, so far as is practicable.

Provision shall be made for the fitting of protective devices, eg safety valve(s), water gauge(s), pressure gauge(s), etc. Safety valve(s) should be designed and set so that no matter how hard a boiler is worked the pressure will not exceed more than 10% above the working pressure of the boiler.

Information and marking

(Reg 5.4) Any person who manufactures a pressure vessel shall ensure specified information is marked on the vessel in a visible, legible and indelible form.

At the very least a boiler should be marked with a serial number that can identify the boiler against records appertaining to it. The date of manufacture and the working pressure of the boiler should also be included. If space permits, a plate should be permanently affixed to the boiler for this purpose, to enable the stamping of such information without affecting the integrity of the boiler, and that it should be in an easily viewed location, eg. on the backhead above the firebox door. Boilers manufactured in the course of business (after 29.5.02) should additionally identify the

manufacture and those over two litres capacity will need to be marked with the CE mark. (See Appendix)

Installation

(Reg 6) shall ensure that nothing about the way it is installed gives rise to danger or impairs the operation of any protective device

Ensure that safety valves are clear of obstruction, operate correctly without hindrance or blockage and that the discharge is routed to a safe place. Where possible provide suitable protection against mechanical damage for items such as safety valves, water gauge glasses and pressure gauges. Ensure that water gauges indicate the true water level and are not blocked (tri-cock water gauges should be fitted where practicable. This enables the water gauge to be isolated in the event of a gauge glass failure and also enables the gauge glass to be 'blown-down').

Safe operating limits

(Reg 7.2b) ensure that the system is legibly and durably marked with safe operating limits and that the mark is clearly visible.

In addition to any information marked on the boiler itself, pressure gauges fitted to a model should be marked with a red line indicating the working pressure. Pressure gauges should have a capacity of at least 30% beyond working pressure.

Written scheme of examination

(Reg 8.1) The user shall not operate the system unless he has a written scheme for the periodic examination, by a competent person, of all protective devices every pressure vessel in which a defect may give rise to danger

(Reg 8.3) the scheme of examination shall be suitable and specify the nature and frequency of examination provide for an examination to be carried out before the pressure system is used for the first time.

A Written Scheme of Examination needs to be formally documented and should include:

- the name of the person or organisation drawing-up the scheme;
- the date the scheme was written;
- identification of the types of model covered by the scheme;
- the parts of the system to be examined;
- the nature of the examination, including inspection and testing of protective devices (e.g. safety valves);
- any preparatory work necessary;
- specify what examination is necessary before the system is first used;

- the maximum interval between examinations;
- any parts of the system which if repaired or modified should be examined before it may be used again;
- a description of how the results of the examination are to be recorded and communicated;

Most, if not all, of the foregoing is already documented in one or other of the boiler test codes prepared by the national organisations that administer the affairs of the various branches of the hobby. Individual modellers not belonging to a club, etc are to be encouraged to acquaint themselves with such test codes or other written schemes of examination - see Further Information section of this information sheet.

Examination in accordance with the written scheme

(Reg 9.1a) the user shall ensure the pressure system is examined by a competent person within the intervals specified by the scheme and before it is used for the first time;

A competent person shall examine, test and report on all parts of the system as covered by the forgoing written scheme of examination. This person should be someone other than the designer, builder, owner or seller of the boiler. An independent witness may verify the outcome of the proceedings

In the context of the regulation, a 'competent person' means someone who has sufficient sound practical and theoretical knowledge and experience of the plant he is to examine, as will enable him to detect defects or weakness which it is the purpose of the examination to discover; and to assess their importance in relation to the strength and function of the particular plant. The individual should know his own limitations and should not act outside his level of qualification, experience or knowledge.

Initially, the person who carries out the examination needs to satisfy himself that a boiler has been constructed to the relevant design drawings and that materials of adequate strength have been used in its construction. Particular emphasis shall be paid to the penetration of silver solder used in the jointing procedures, alternatively the adequacy of any welding should be assessed. Once satisfied with a visual inspection of the boiler, a hydraulic test should be carried out, to the pressure as indicated in the written scheme of examination.

Subsequent retests should be made at the specified intervals.

The hydraulic test pressure, for both copper and steel boilers, is twice (2 x) the working pressure for the initial test. The pressure for subsequent tests are at one and a half times (1.5 x) the working pressure.

At the first steaming and at each subsequent test a steam test shall be undertaken to ensure that the safety valve(s) are correctly set and limit the pressure rise to

not exceeding 110% of the working pressure, no matter how hard the boiler is worked, and that the water gauge functions correctly. The operation of injectors and feed pumps should be checked and it should be established that there is an adequate method of refilling the boiler, when in steam, by at least two independent means.

The pressure gauge should be permanently marked with a red line indicating the working pressure of the boiler. This mark should be made to indicate the true pressure when compared against a calibrated master gauge.

Preparatory work may need to be undertaken prior to the examination, eg it may be a requirement of the scheme that after every so many periodical examinations are undertaken a more thorough examination needs to be made of the external surfaces of a boiler, that requires the external cladding be removed.

The minimum requirements for the examination/testing of miniature steam boilers as drawn up by the national model engineering organisations also include information on the equipment and methods to be adopted for boiler testing.

Operation and maintenance

(Reg 11.1) any persons operating the system should have adequate and suitable instructions for the safe operation of the system; and the action to be taken in an emergency.

The user of any boiler should be fully acquainted with its operation. It is recommended that novices in the operation of this type equipment should seek guidance from those experienced in its operation. Consideration should be made to:

- what checks and precautions are necessary before the system is used;
- start-up and shut-down procedures;
- precautions for standby operation;
- the effect of controls and protective devices;
- likely fluctuations expected in normal operation;
- methods of establishing the proper water level in the boiler and maintaining adequate water supplies;
- the requirements to ensure that the system is adequately protected against overpressure at all times;
- safe blowdown of the boiler;
- precautions to be taken when emptying a boiler, eg. allow a reduction in pressure to enable emptying to be safely carried out;
- procedures in the event of an emergency, eg. low water level, shortage of water, bursting of water gauge glass.

(Reg 12) The user shall ensure that the system is properly maintained in good repair, so as to prevent danger.

In addition to the periodical examination, a pressure system should be checked prior to each time it is used and any problems identified should be rectified. This may entail nothing more than checking and rectifying faults as outlined below; but may involve more detailed checks and maintenance to systems that have been out of service for a significant period of time, eg. winter lay-up. Problems identified during use of any system should be noted and rectified at the earliest opportunity, the system being taken out of service if there is the likelihood of danger, eg. sticking safety valve. A simple maintenance programme (inspection, replacement of parts, etc) should be decided for all those parts which, through failure or malfunction, would affect the safe operation of the system.

The need for maintenance should not be confused with the requirements undertaken under the written scheme of examination.

Whilst not comprehensive, the following is a list that should be considered before everyday operation:

- does the safety valve(s) operate at its specified release pressure?
- are the waterways clear in the water gauge(s) enabling it to show the true water level?
- do mechanical pumps/injectors work effectively enabling the water level to be maintained in the boiler?
- do the clack valves seat properly?
- does the regulator operate smoothly enabling it to be completely closed and opened?
- is there provision to be able to remove or shut-down the heat source in the event of an emergency, eg. the grate can be removed enabling the fire to be dumped?

Modification and Repair

(Reg 13)shall ensure that nothing about the way in which it is modified or repaired gives rise to danger or otherwise impairs the operation of any protective device

The design of any modification or repair should be in accordance with appropriate standards, taking into account the expected future use of the system as well as the original design specification.

Modifications or repairs must be carried out so that the integrity of the system is not adversely affected and that the operation of any safety device is not affected. The design and carrying out of any modification or repair must be undertaken by a person who is competent to do so.

Consideration should be made to the continued suitability of the existing written scheme of examination and alterations made if necessary.

A modified or repaired boiler will require a competent person to examine, test and report on all parts of the system as covered by the (revised) written scheme of examination before it is placed into service. Details of any modification or repair will need to be appended to the documents relating to the system.

Documentation

(Reg 14.1) The user shall keep the last report relating to the system made by a competent person and any such previous reports which will assist in assessing whether the system is safe to operate

(Reg 14.3) Where the owner of the pressure system changes, the previous owner shall give to the new owner anything (documentation) kept by him under this regulation.

It is essential to be able to prove that a particular boiler has satisfactorily passed examination by a competent person. A certificate (Boiler Certificate) is issued to this effect which is normally acceptable by anyone seeking proof that the boiler is safe to operate. The certificates should include the following information:

- a means of identifying that the certificate relates to a particular piece of equipment, eg. serial number of boiler;
- type of boiler;
- material used in construction;
- date of construction;
- date of hydraulic test;
- validity period;
- expiry date;
- maximum working pressure of boiler;
- test pressure;
- date of steam test;
- safety valve working pressure;
- names and signatures of examiner (and witness, if applicable).
- Registration number if a miniature road vehicle that is registered for use on the road.

A boiler certificate is not valid for safe operation until both the hydraulic and steam tests have been undertaken. One copy of the test certificate should be handed to the owner/operator, a second copy should be retained by the examiner.

No boiler/pressure equipment may be used unless the owner/operator is in possession of a valid boiler certificate.

Any modification or repair to a boiler will void a current boiler certificate and it may not be used again until a new boiler certificate is issued.

Any boiler built in the course of business after 29th May 2002 will need to have documentation to show that it has been built in accordance with the Pressure Equipment Regulations 1999.

All documents and certificates should be retained by the owner, along with details of any repairs or modifications to the boiler, thus enabling a historical record of the boiler to be kept. This record should be passed on to the new owner should the model change hands.

Other Equipment

PSSR applies to any form of pressure system, and the foregoing principles can also be applied to any system that might have impact on the public and/or club members and their families. For example:

- air compressors used in workshops and signalling/points systems;
- pneumatic systems associated with steaming bays;

PSSR does not apply to any pressure system that forms part of any braking, control or suspension system of any wheeled, tracked or rail mounted vehicle. (Note that guidance on the required performance of braking systems for miniature railways is given in *HSG 216* paras 80-84)

Further information relating to these topics can be found in the relevant publications suggested in the Further Reading section of this information sheet.

Refillable Gas Tanks.

Now known under the generic term 'Transportable Pressure Equipment', gas tanks and valves are subject to their own regulations under *The Transportable Pressure Vessels Regulations 2001 (TPVR)* and *The Carriage of Dangerous Goods (Classification Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996 (CDGCPL2)* (see the relevant references in Further Reading). The current regulations are due to be replaced in 2004 and further information concerning the application of the new regulations to model engineers will be issued in a separate publication.

Further Reading

Pressure Systems Safety Regulations 2000. L122 HSE Books 2000 ISBN 0 7176 1767 X

The Pressure Equipment Regulations 1999. SI 1999/2001 The Stationery Office Ltd.

Pressure Equipment – Guidance Notes on the UK Regulations.

Department of Trade & Industry (November 1999, URN99/1147)

<http://www.dti.gov.uk/strd/strdpubs.html#pressure>

Compressed Air Safety
HSG39 HSE Books ISBN 0 7176 1531 6

Guide to the selection and installation of compressed air services
British Compressed Air Society ISBN 0 905608 13 5

The Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Receptacles Regulations 1996.
SI 1996/2092 (as amended) The Stationery Office Ltd.

The Transportable Pressure Vessels Regulations 2001
SI 2001/1426 The Stationery Office Ltd.

Passenger-carrying miniature railways - Guidance on safe practice.
HSG216 HSE Books ISBN 0 7176 2035 2

Safe operation of miniature railways, traction engines and road vehicles.
Entertainment Sheet No12. Free leaflet HSE Books

Harris, K N - *Model Boilers & Boilermaking*
TEE Publishing 2000 ISBN 1 85761 114 4

Evans, Martin - *Model Locomotive Boilers*
Argus Books Ltd 1976 ISBN 0 05242 483 3

Farmer, Alec - *Model Locomotive Boilermaking*
Alec Farmer 1988 and reprints ISBN 1 85260 007 1

Further information

Boiler testing procedures are available from the secretaries of the following organisations;

- Midlands Federation of Model Engineering Societies
- Model Steam Road Vehicle Society
- Northern Association of Model Engineers
- 7/8" Gauge Society
- Southern Federation of Model Engineering Societies

While every effort has been made to ensure the accuracy of the references listed in this publication, their future availability cannot be guaranteed.

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

Appendix

For the purposes of this document, it is considered the term 'working pressure' to have the same meaning as maximum allowable pressure in PSSR and PER.

The following tables outline the requirements of PER that a manufacturer making pressure equipment in the course of business would need to meet for the documentation, design and manufacture of boilers likely to be used by the model engineer. Steam boilers are classified according to pressure, volume, or a combination of both.

TABLE 1

LESS THAN 0.5BAR OPERATING PRESSURE.

(No upper volume limit)

Below 0.5bar (approx 7.5psi) PER is not applicable. However, the boiler and any ancillary equipment (if supplied) must comply with the requirements of PSSR in matters relating to design and construction.

The pressure system or article shall be properly designed and properly constructed from suitable material so as to prevent danger. – PSSR Regulation 4.(2)

The pressure system shall be provided with such protective devices as may be necessary for preventing danger. – PSSR Regulation 4.(5)

Pressure Vessel only.

The boiler should be permanently marked to show the manufacturers identity and its serial number.

Documentation should include:

- the manufacturers name and address.
- the date of manufacture.
- the maximum allowable pressure (ie, 0.5bar).
- the minimum allowable pressure, if other than atmospheric. (A vessel of such a low operating pressure could be part of a condensing system and therefore subjected to vacuum).
- design temperature.
- valid pressure test certificate.
- operating instructions.
- the standard to which the vessel was built.

Additionally:

- provision should be made to allow the fitting of protective devices (eg a safety valve, a pressure gauge and, if a heated vessel, provision for fitting a device to assess water level).
- provision should be made to allow the boiler to be drained.

Kit.

In addition to the above, the fittings should be supplied and, if a heated vessel, a means of being able to remove or shut down the heat source in an emergency should also be provided.

Completed model.

In addition to the above, the fittings should be installed with the safety valve pressure set and tested. The boiler test certificate should be suitably amended to record this fact.

The manufacturer should be able to provide sufficient written information regarding design and construction as may reasonably, foreseeably be needed to enable the provision of the Regulations to be complied with. The manufacturer doesn't necessarily have to supply such information to the purchaser, but it must be retained for inspection should the need arise.

TABLE 2

BOILERS UP TO AND INCLUDING 2 LITRES VOLUME.

(No upper pressure limit)

Boilers in this category need to have been designed and manufactured in accordance with 'sound engineering practice' (SEP) in a Member State in order to ensure safe use.

Pressure Vessel only.

The boiler should be marked to show the manufacturers identity and its serial number. CE marking shall not be affixed to SEP equipment.

Documentation should include:

- the manufacturers name and address.
- the date of manufacture.
- the maximum allowable pressure.
- the volume of the boiler.
- valid pressure test certificate.
- intended use.
- instructions for use.
- weight (empty).

Additionally:

- provision should be made to allow the fitting of protective devices (eg a safety valve, a pressure gauge and, if a heated vessel, provision for fitting a device to assess water level).
- provision should be made to allow the boiler to be drained.

Kit.

In addition to the above, the fittings should be supplied and, if a heated vessel, a means of removing or shutting down the heat source in an emergency should also be provided.

Completed model.

In addition to the above, the fittings should be installed with the safety valve pressure set and tested. The boiler test certificate should be suitably amended to record this fact.

The manufacturer needs to be able to show the boiler has been designed and manufactured in accordance with 'sound engineering practice'. Copies of all drawings, calculations, etc relating to its design should be retained to enable subsequent inspection by the relevant authorities should the need arise. The manufacturer doesn't necessarily have to supply such information to the purchaser.

1 bar = 14.5038 psi

1 litre = 1.760 pints

1 pint = 0.568 litres

10 psi = 0.689 bar

TABLE 3

CATEGORY I

(Boilers above 2 litres volume, up to and including 50 bar-litres, maximum pressure 32 bar.)

Boilers in this category need to have been designed and manufactured in accordance Module A of the Conformity Assessment Procedures. (Internal Production Control)

What to expect:

Pressure Vessel only.

The boiler should be marked to show the manufacturers identity, its serial number and the CE mark.

Documentation should include:

- the manufacturers name and address.
- the date of manufacture.
- the maximum allowable pressure.
- the volume of the boiler.
- valid pressure test certificate.
- intended use.
- instructions for use.
- weight (empty).
- a Declaration of Conformity, that the equipment satisfies the requirements of the Pressure Equipment Directive.
- boilers should have the appropriate material certificates,

Additionally:

- provision should be made to allow the fitting of protective devices (eg a safety valve, a pressure gauge and, if a heated vessel, provision for fitting a device to assess water level).
- provision should be made to allow the boiler to be drained.

Kits and Completed models.

As Table 2.

The manufacturer will have drawn-up technical documentation for the equipment that includes manufacturing drawings, design calculations, examinations carried out, test reports etc. along with a Declaration of Conformity. Records of materials used in manufacture shall be kept. The manufacturer must keep documentation, for inspection by the relevant national authorities, for a period of ten years from the date of manufacture. A method of internal production control must be established that ensures the manufacturing process enables the manufactured pressure equipment to comply with the technical documentation and meet the requirements of the Directive. All the relevant Essential Safety Requirements must be met.

TABLE 4

CATEGORY II & III

**(Category II. Boilers above 50 bar-litres, up to and including 200 bar-litres, maximum pressure 32 bar)
(Category III. Boilers above 200 bar-litres, up to and including 3000 bar-litres, maximum pressure 32 bar, maximum volume 1000 litres)**

Boilers in these categories need to have been designed and manufactured in accordance with one or more of a number of conformity assessment modules, which increase in severity according to the increase of stored energy in the boiler. Design and manufacture will be monitored by a Notified Body.

What to expect:

Pressure Vessel only.

The boiler should be marked to show the manufacturers identity, its serial number, and the CE mark together with the identification number of the Notified Body involved at the production control stage.

Documentation and provisions:

As outlined for Category 1 (See Table 3) but

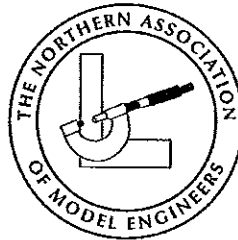
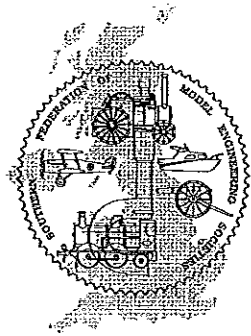
- all boilers should have the appropriate material certificates (eg. certificates of specific product control), prepared by the material manufacturer, affirming compliance with specification. Barrel tube and plates be marked with the correct numbers, to relate materials to certificates.

Kits and Completed models.

As Table 2.

The manufacturer will have drawn-up technical documentation for the equipment that includes manufacturing drawings, design calculations, examinations carried out, test reports etc. along with a Declaration of Conformity. The manufacturer will work in conjunction with a Notified Body, whose job it is to monitor and verify that the pressure equipment has been manufactured according to the relevant assessment module. Typically the Notified Body will examine the technical documentation and quality control methods, conduct checks on samples, assess materials and check conformity to harmonised standards, approve procedures for joining and verify that personnel undertaking such joining are suitably qualified. All the relevant Essential Safety Requirements must be met. All documentation regarding design, manufacture, quality assessment, examinations and reports from the Notified Body and other similar records must be kept, for inspection by the relevant national authorities, for a period of ten years.

The national organisations that administer the affairs of various branches of the hobby have somewhat more stringent requirements in that whenever steel is used in the construction of a boiler, irrespective of volume or working pressure, full traceability of materials are required and the boiler should be marked with the relevant material codes. Any joining of a steel boiler will have been carried out by a competent welder.



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