A Code of Practice for the Fabrication and Operation of Pressure Equipment in the University of Cambridge - DRAFT

Scope

This code of practice describes the management of all systems operating above atmospheric pressure in the University. It complements the code of practice giving advice on the use of compressed gases and cryogens.

This code of practice is the extended version of the code for operation of pressure equipment, and it includes advice on the fabrication of pressure equipment in-house.

Contents

1 Introduction to Pressure Vessels and Pressure Systems

1.1 Technical Terms

The following are defined in The Pressure Systems Safety Regulations 2000, SI 128 (which will be abbreviated to PSSR):

Protective devices – devices that are intended to protect the pressure system against system failure, including bursting discs and devices intended to give warning that system failure may occur. This includes items to prevent the safe operating limits of equipment being exceeded.

Safe operating limits are the operating limits, incorporating a suitable margin of error, beyond which system failure is liable to occur.

Written Scheme of examination – means a written scheme as defined by Regulation 8 of the PSSR (note: the written scheme can be electronic). This scheme will be drawn up by a competent person from the Insurance Company, it will define the checks that must be done, and the frequency of those checks. The examinations themselves will be carried out by a competent person from the Insurance Company.

Transportable pressure vessel is a cylinder, tube or cryogenic receptacle that is used for the storage or transport of a gas. Examples are gas cylinders and the Dewars used in many laboratories. The owner and the user are frequently different employers.

1.2 Definition of Pressure Systems

Pressure systems are defined as belonging to one of the following three arrangements:

A pressure vessel of rigid construction + associated pipework + protective devices, *or*

Pipework + protective devices + a transportable pressure vessel, *or*

Pipelines

(Note: since pipelines are specifically for the transport of fluids across the boundaries of the premises they are not discussed in detail in this document).

Transportable pressure vessels are not of themselves pressure systems, but become so when they are hooked up to other apparatus. They do, however, have to meet safety standards and they are subject to a scheme of examination.

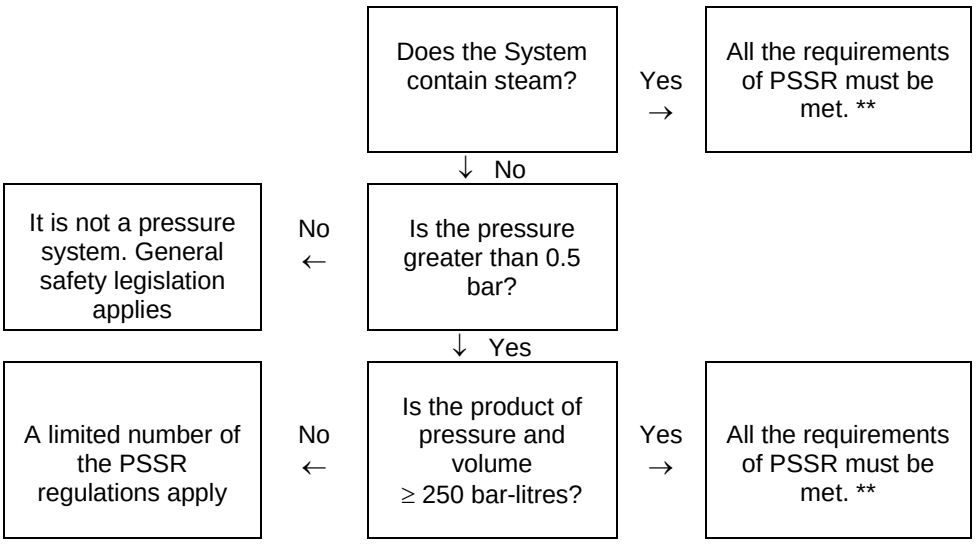
To qualify as a ***pressure system*** the equipment must contain either

- steam at any pressure, or
- a gas or mixture of gases at > 0.5 bar, or
- a liquid with a vapour pressure > 0.5 bar either at its actual temperature or at 17.5 ^{o}C, or
- a gas dissolved under pressure in a solvent contained on a porous substance which could be released without application of heat.

This means that the current document applies to systems containing gases, liquefied gases and steam, but does not apply to water or hydraulic fluids.

(Throughout this document pressures are quoted as gauge pressure that is, pressure above the atmosphere, so that 0.5 bar means 1.5 bar in absolute terms. The justification is that most pressure measuring equipment for increased pressures works on the basis that the atmosphere is the datum point.)

The flow chart below summarises in simplified form the thresholds that bring about regulatory requirements.



** these items should all be on the register with the Insurance Company, if they are the property of the University.

Thus, pressure systems are likely to fall into one of the following broad categories

- Above the 250 bar litre threshold, or containing steam, entered on the Insurance register and subject to Written Scheme of Examination.
- Below the 250 bar litre threshold, so not to be named individually on the register, not subject to a written scheme of examination.
- Not belonging to the University, and therefore the responsibility of another employer.

Regardless of which category a system fits into, it is still our responsibility to conduct a risk assessment so as to define how to install it safely, use it safely and maintain t in safe condition.

2 Essential Legal Requirements

2.1 Management of the Pressure Systems that are Named on the Insurance Policy

Each department must nominate a **single individual** (or designate a post-holder) who will be responsible for:

- notifying (the Insurance Section or the Insurers direct?) of changes to their holdings of pressure vessels,
- keeping the written schemes of examination safe,
- reviewing the Insurers reports, taking remedial action where required, or ensuring that action is taken by an appropriate person.

The identity of the designated person must be notified to (RSA, Insurance Section, H&S Division, EMBS?). The designated person is not required to be a source of engineering advice for pressure systems; their primary task is to ensure that the legal requirements as regards the periodic examinations for the significant pressure systems are being met, and that important records are not lost.

The designated person may choose to give written schemes of examination to certain users for their safe-keeping, but it is essential that these documents are always readily found.

The legal responsibility for the equipment owned by the University rests with the University. When we hire a mobile piece of pressure equipment the legal responsibility for the equipment as regards its basic safety and integrity remain with the owner. For example, with few exceptions, transportable cylinders remain the property of the gas company. The integrity of a pressure vessel itself, including the execution of the requirements of the written scheme of examination remain the legal responsibility of the owner.

Where Departments do own transportable cylinders and mobile equipment falling above the threshold they must ensure that they, too, are on the Insurance register and that they are examined according to a written scheme.

EMBS – we need to define how departments will know whether they have anything that will continue to be managed by EMBS in its entirety (i.e. if there are any items for which EMBS will retain the WSE).

Users of pressurised equipment, whether it is equipment on the insurers list or is a more minor system, must undertake risk assessment for the use for the equipment and devise safe operating procedures. They must take into account all the aspects described in section 2.2. Further advice on the use of pressure equipment is in section 4. The responsibility for the safe use of pressure equipment on a day-to-day basis rests with the line management of the user – e.g. research equipment would be the responsibility of the research supervisor.

2.2 Essential Requirements of PSSR

The following is a summary of the key requirements. Subsequent sections give advice and guidance designed to meet these requirements.

- All parts of a pressure system must be properly designed and constructed
- The system must have protective devices to prevent danger
- The equipment must have sufficient written information to enable the user to meet the requirements of the regulations
- Any person who repairs or modifies a pressure system shall provide sufficient written information about the work to enable the regulations to be complied with.
- The pressure system shall be installed in a way that does not give rise to danger, and so that the operation of any protective device or inspection facility is not impaired.
- Systems shall not be used unless the safe operating limits have been established.
- Systems that contain steam at any pressure and other systems where the pressure-volume product is 250 bar litres or more, shall not be operated unless there is a written scheme of examination.
- The pressure system shall be examined in accordance with the written scheme of examination, at the intervals specified by it, by a competent person.
- Any person operating the system must be given adequate and suitable instructions for the safe operation of the system and the actions to take in an

emergency. The system must be operated in accordance with the instructions provided.

- The system must be maintained so as to prevent danger. Any modifications or repairs must not give rise to danger or otherwise impair the operation of any protective device or inspection facility.

- Certain records must be kept.

2.3 Fabrication of Vessels and Systems

Legislation relating to manufacturing standards is not, in general, retrospective, so that equipment that complied with earlier legislation (in particular the repealed Pressure Systems and Transportable Gas Containers Regulations 1989, SI 2169) would not need to be re-tested or re-assessed. Clearly its inspection and maintenance programme would need to continue.

The Transportable Pressure Vessels Regulations 2002, SI 1426, determine the requirements for the manufacture and use of transportable pressure vessels. In general, these are not of concern to the University, since almost all transportable vessels belong to the gas companies.

The Pressure Equipment Regulations 1999, SI 2001, (PER), lay down requirements for the manufacture of vessels, piping, safety accessories, pressure accessories, and elements attached to pressurised parts such as flanges, nozzles, couplings, supports, lifting lugs and similar. As in section 1.2, the definition of pressure equipment begins at 0.5 bar, and the stringency of the requirements is on a sliding scale which is determined by the energy stored, the properties of the fluid and, in the case of the pipework, the dimensions.

There are some notable exemptions from these pieces of legislation. There is an exemption from the PSSR for the assembly of pressure equipment on the site and under the responsibility of the user. Also exempt from these regulations are tyres, containers for carbonated drinks, some vapour compression refrigeration systems and the radiators and pipes in a hot water heating system. The full list of exemptions is in Schedule 1 to the Regulations.

There are also exemptions from the PER (the full list is in Schedule 1 to those regulations) that include tyres, fire extinguishers, and some vapour compression refrigeration systems.

One important partial exemption is for a:

'pressure system or part thereof which - (a) is the subject of a research experiment; or (b) comprises temporary apparatus in a research experiment'.

This exemption only applies to apparatus that is itself the subject of a research experiment and we are cautioned by the accompanying guide to the law that anyone relying on this exception should be able to justify their reasons for non-compliance and any failure to take the basic precautions required under the Regulations to prevent risk of injury from system failure. This would not be a decision to be made lightly.

3 Procedure on Acquisition of Equipment

3.1 Procedures That Apply to all Equipment

To meet the requirements of section 2.2, the system must be assessed to decide whether it must go on the Insurers list – the simple flowchart in section 1.2 will help in this decision making process. Departments will need to ensure that those individuals in the department who are likely to acquire pressure systems know that they have a

duty to make contact with the person who maintains the database to ensure that all systems that need to be on the insurance list are notified.

The recipient should check that relevant test certificates and instructions relating to the equipment are received. These need to be stored in a safe place. It is suggested that the users retain the instructions, but that the test certificates are stored by the person in the department who has been nominated to manage the insurance records for pressure systems.

3.2 New Equipment Sourced Within the EU

Pressure equipment sourced within the EU is subject to the Pressure Equipment Directive and must be manufactured to meet the essential safety requirements. These are listed in Appendix B.

The equipment should comply with one of the major pieces of legislation, such as the PER, or the equivalent legislation in the country of origin.

Since the stringency of the requirements for manufacture is subject to a sliding scale, different pieces of equipment will come with different markings and paperwork. Low risk equipment must be fabricated according to the principles of sound engineering practice, and must not be CE marked. Larger pieces of equipment must be CE marked and must then be supplied with a Declaration of Conformity, or, if they constitute only part of a pressurised assembly, such as a pressure release valve, must be supplied with a Declaration of Incorporation. The declaration will detail the standards to which they have been manufactured, and the way in which conformity has been assessed. These documents should be preserved.

3.3 New Equipment Sourced from Outside the EU

Equipment that has come from outside the EU must be assessed as to whether it meets the requirements of EU legislation before it can be put into use in the Department, and CE marked if relevant. It is advised that the contract for supply is drawn up in such a way that the supplier or importer is required to do this. Failure to specify this is likely to lead to the University having to assess the equipment, which could be both time-consuming and expensive. Advice should be sought from the Engineering Department.

3.4 Acquisition of second-hand equipment

The Regulations do not apply retrospectively to second-hand equipment. Thus, second hand equipment does not need to be CE marked. However, it must still be safe. Equipment that is transferred from one department to another must be accompanied by its documentation, and the insurance register must be adjusted accordingly.

3.5 Installation of Equipment into a User Department by EMBS

Describe here the process by which equipment is installed, and the details and any necessary paperwork are handed over to the Department so that it can be put on the register.

4 Using Pressure Systems

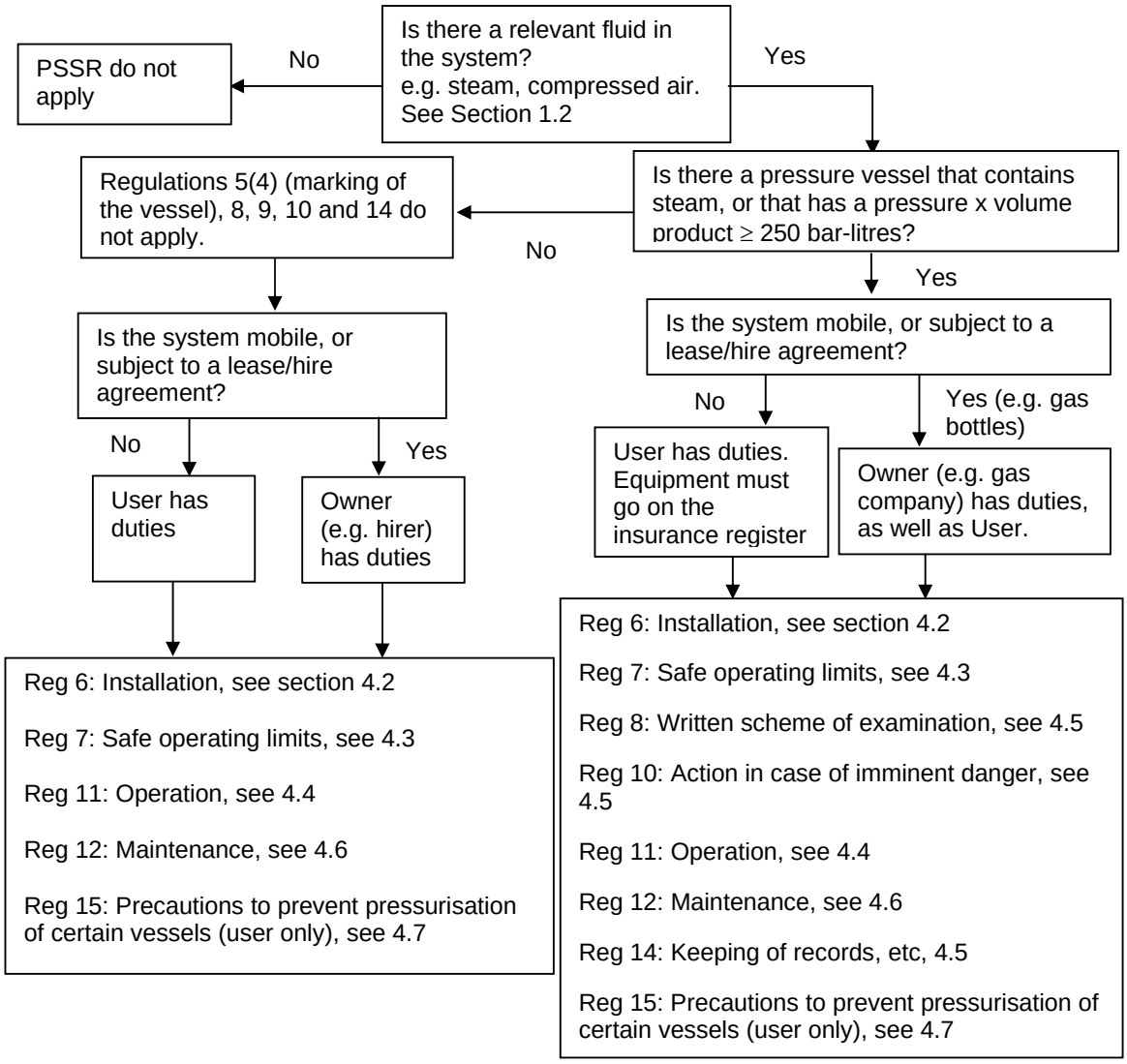
4.1 Risk Assessment

Risk assessments will be required at several points in the life of a pressure system. This will include:

- Installation and commissioning

- Normal use
- Maintenance and repair, and eventually
- Decommissioning and scrapping (particularly relevant if the system has contained toxic substances).

Whether the University is responsible for every element depends on the status of the equipment. The decision chart below (adapted from the HSE guidance) shows the main distribution of responsibility and the requirements for the two major categories of pressure equipment. The Regulation numbers themselves refer to PSSR.



4.2 Installation

4.2.1 Vessels plus associated pipework and protective devices

It is important to install a pressure system in such a way that it does not give rise to danger. A risk assessment should be done, that should consider not only the risk inherent in physically transporting it onto the premises, but also the risks in its future use that may be reduced at this early stage. Important points would include:

- Preparation of a suitable area for the equipment, taking into account the loads

- How to handle and lift the equipment so as to avoid damaging its protective devices and pipework
- Checking for damage that may have arisen in transit
- Ensuring that the protective devices are clear of obstruction, that they operate properly, and that they discharge to a safe place.
- Ensuring that access doors/hatches are clear of obstruction and operate correctly
- Ensuring that labels and markings are clearly visible
- That there is adequate access for maintenance and examination.
- That the system is adequately protected against accidental damage (e.g. protection of pipes against damage from being climbed on).
- That there is adequate space around and beneath valves
- That the work is checked by a suitably qualified person.

In addition, compressed air systems should be arranged so that they are in a well ventilated, cool environment, that any air-cooled surfaces are located so that the air flow is unobstructed, and that inlet air is drawn from an area that is free from potentially flammable, corrosive contaminants, and excessive dust or moisture.

The system, if falling within the total scope of PSSR should be registered with the designated person in the Department (see the chart in section 1.2).

4.2.2 Pipework plus protective devices plus transportable pressure vessel

In this instance the integrity of the pressure vessel is treated separately, because it is either the property of a third party, or is on our insurance register in its own right. However, it is important to design the apparatus that is to be connected to the cylinder in such a way that parts of it cannot become over-pressurised and themselves become dangerous. This may mean that pressure relief devices should be placed at strategic points in the apparatus, to limit the maximum pressure that can accumulate there.

Pressure regulators for gas cylinders should be inspected fully on a five-year cycle. The cost-effective way of doing this is often to enter into an exchange-reconditioning arrangement.

In apparatus where there is a possible source of ignition and the cylinder contains a fuel gas (e.g. hydrogen, LPG, acetylene, methane) some arrangement is required to prevent flame flashing back into the cylinder. A common solution to this problem is to fit flashback arrestors on the outlet of the regulator. These should also be replaced at an interval recommended by the manufacturer, or if this is not defined, on a five year cycle.

4.3 Safe Operating Limits

You must establish the safe operating limits of every pressure system. There is a legal responsibility for the supplier of a mobile system to provide written information specifying the safe operating limits and to ensure that these limits are durably marked on the system.

Second hand systems need to be thoroughly assessed to ensure that the safe operating limits have been established correctly.

The safe operating limits should be reviewed when undertaking the examinations under the written scheme (where applicable) and when significant repairs or modifications are carried out.

The information regarding the safe operating limits must be recorded and kept readily available to the users. This information should be made available to the person responsible for the examinations in accordance with the written scheme, and it is also recommended that the documentation if made available to the person operating the system.

A system MUST NOT be operated outside its safe operating limits. If it is desired to extend the limits of a system, it MUST be re-assessed and re-tested so that its safe operating limits can be re-established.

4.4 Operation

The person operating the system must be provided with adequate and suitable instructions for the safe operation of the system and for the action to be taken in the event of any emergency.

The content might therefore include:

- Start-up and shut-down procedures.
- Precautions for standby operation
- Function and effect of controls and protective devices
- Likely fluctuations expected in normal operation
- The requirement to ensure that the system is adequately protected against over-pressure at all times.
- Emergency actions.

4.5 Written Schemes of Examination

Those items that contain steam or are at or above the 250 bar litre threshold must have written schemes of examination. This is to specify the periodic examination by a competent person of the following parts of the system:

- All protective devices
- Every pressure vessel and every pipeline in which a defect may give rise to danger
- Those parts of the pipework in which a defect may give rise to danger.

It is the responsibility of the user to ensure that such a scheme is drawn up. In simple cases it may be possible for the Department to draw up a scheme, which must then be approved by the insurers. In more complex cases it is likely that the Department will request the Insurers to draw up the scheme. The competent person who will carry out the examinations will generally be an engineer sent by RSA.

The scheme will include the following:

- Those parts of the system that are to be examined
- Identification of the item of plant or equipment
- The nature of the examination required, including the inspection and testing to be carried out on any protective devices
- The preparatory work necessary to enable the item to be examined safely,
- What examination is necessary before the system is first used, where appropriate
- The maximum interval between examinations
- The critical parts of the system, which if modified or repaired should be examined by a competent person before it is used again.
- The name of the competent person certifying the scheme
- The date of the certification.

It is the responsibility of the user to ensure that examinations are carried out according to the scheme – individuals should liaise with the person designated in their Department.

If the competent person carrying out the examination is of the opinion that the pressure system will give rise to imminent danger unless certain repairs or modifications are carried out they are obliged by law to immediately make a written report to both the user (or owner if a mobile system) and the HSE. The system must be taken out of service forthwith until the specified remedial work has been carried out.

The reports of the competent person in accordance with the written scheme of examination must be retained in any event until replaced by a subsequent report. If the report contains information which will materially assist in assessing whether the system is safe to operate it any repairs to the system can be carried out safely it should be retained.

4.6 Maintenance, Modification and Repair

All systems shall be properly maintained in good repair, so as to prevent danger. The maintenance programme should take account of:

- The age of the system
- The operating/process conditions
- The working environment
- The manufacturer's or supplier's instructions
- Any previous maintenance history
- Reports of examinations carried out under the written scheme of examination (for equipment to which this applies)
- Results of other relevant inspections
- Repairs and modifications to the system and
- The risks to health and safety from failure or deterioration.

When carrying out repairs or modifications, it is essential to ensure that nothing about the way in which this work is done gives rise to danger or otherwise impairs the operation of any protective device or inspection facility.

4.7 Precautions to Prevent Pressurisation of Certain Vessels

Some vessels have a permanent outlet to the atmosphere e.g. a steam vent or vent from a chemical reaction vessel. If blockage of this vent could cause the vessel to become a pressure vessel, the user must ensure that the vent is kept open and free from obstruction at all times when the vessel is in use.

5 Fabrication of Pressure Equipment In-House

5.1 PER

Any equipment fabricated in accordance with the PER, with accompanying documentation, will be considered to meet the requirements in Sections 4.2 and 4.3, which are taken from the PSSR.

Risk assessment is a key process in the planning, design and fabrication of the pressure system. A preliminary assessment will show the key features of the system, such as a suitable location, design, material, etc. There is a body of advice on the design and fabrication of pressure vessels, and it is prudent to use this.

While the University does not normally manufacture pressure systems to place them on the market it would be prudent to apply the same principles of manufacture as outlined in the PER, which classify equipment on sliding scales related to the hazards of the working fluid, the stored energy and the dimensions.

The classification charts are in Appendix A. Note that below 0.5 bar the system is not classified as a pressure system, and there is a zone in which the legend 'Sound Engineering Practice' appears. It is anticipated that most pressure equipment fabricated in the University will lie in this region.

5.2 Design and Construction

5.2.1 General requirements

The pressure system must be:

- Properly designed and properly constructed from suitable material so as to prevent danger,
- Designed and constructed so that all necessary examinations can be carried out to prevent danger,
- Provided with such protective devices as may be necessary for preventing danger; and if such devices are designed to release the contents, that they do so safely, so far as is practicable.

This will require the designer to take into consideration:

- The working life of the system,
- The properties of the fluid contained within it,
- The extreme conditions such as start-up, shut down, fault and emergency conditions,
- Any foreseeable changes to the design conditions,
- Conditions for standby operation,
- Protection against system failure, using suitable measuring, control and protective devices as appropriate,
- Suitable materials for each component part,
- The external forces that might act on the system,
- Safe access for operation, maintenance and examination, including the fitting of access safety devices or suitable guards, as appropriate.

Before embarking on the design of a pressure vessel, advice should be sought – see Appendix D.

5.2.2 Equipment in the 'Sound Engineering Practice' category

'Sound Engineering Practice' means that the equipment is to be designed taking into account all relevant factors influencing its safety. The equipment must be manufactured, verified and instructions for its use written to ensure its safety during its intended life, when used in foreseeable and reasonably foreseeable conditions. Such equipment must not be CE marked.

5.2.3 Equipment in Category I or above

Items falling within the category marked 'I' or above on the classification charts must be designed and built in accordance with the Essential Safety Requirements, which are summarised in Appendix B.

Items falling within category 'I' can be designed, fabricated and tested within the University. They must be CE marked, and this can be by self-certification.

Items falling into the higher categories cannot be self-certified within the University but must be referred to a Notified Body.

Advice should therefore be sought before embarking on the fabrication of pressure equipment – see Appendix D.

4.3 Provision of Information and Marking

For all vessels that are greater than or equal to 250 bar litres, there must be a label, either on the vessel itself, or on a plate, detailing:

- The manufacturer's name
- A serial number to identify the vessel
- The date of manufacture of the vessel
- The standard to which the vessel was built
- The maximum allowable pressure of the vessel

- The minimum allowable pressure of the vessel where it is otherwise than atmospheric
- The design temperature (including upper and lower limits).

In addition, for all vessels, sufficient information must be supplied with them that may reasonably foreseeably be needed to comply with the regulations. In addition to the information on the label/plate, this **may** include:

- Fatigue life
- Creep life
- Intended contents
- Flow rates and discharge capacities
- Corrosion allowance
- Wall thickness
- Volume capacity
- Materials of construction.

When the equipment has been fabricated in-house, the generation and storage of this information is just as important as for purchased items, due to the rapid turnover of students and Post-Docs and the transient nature of funding in some project areas.

5.4 Testing

In general, pressure vessels must be tested to a pressure in excess of the maximum working pressure.

Pressure tests are specialised, and are generally hydraulic, to avoid the catastrophic effects of the release of compressed gas in the event of failure. Even a hydraulic test is not without danger; pieces of equipment can still be projected several metres in the event of failure.

There is a test laboratory within the Engineering Department. There are also commercial facilities available in the vicinity of Cambridge. See Appendix D.

- The critical parts of the system, which if modified or repaired should be examined by a competent person before it is used again.
- The name of the competent person certifying the scheme
- The date of the certification.

It is the responsibility of the user to ensure that examinations are carried out according to the scheme – individuals should liaise with the person designated in their Department.

If the competent person carrying out the examination is of the opinion that the pressure system will give rise to imminent danger unless certain repairs or modifications are carried out they are obliged by law to immediately make a written report to both the user (or owner if a mobile system) and the HSE. The system must be taken out of service forthwith until the specified remedial work has been carried out.

The reports of the competent person in accordance with the written scheme of examination must be retained in any event until replaced by a subsequent report. If the report contains information which will materially assist in assessing whether the system is safe to operate it any repairs to the system can be carried out safely it should be retained.

6 References

Appendix A

Classification of vessels and pipework according to the statutory requirements for assurance of safety (PER). The Categories are 'Sound Engineering Practice' and categories I to IV. The category into which a pressure vessel falls determines the steps that must be taken to certify it. Charts have been organised to group the vessel together with the piping for each type of fluid in turn.

A Group 1 gas or liquid is one of the following:

- Explosive
- Extremely flammable
- Highly flammable
- Flammable (where the maximum allowable temperature is greater than the flashpoint)
- Very toxic
- Toxic

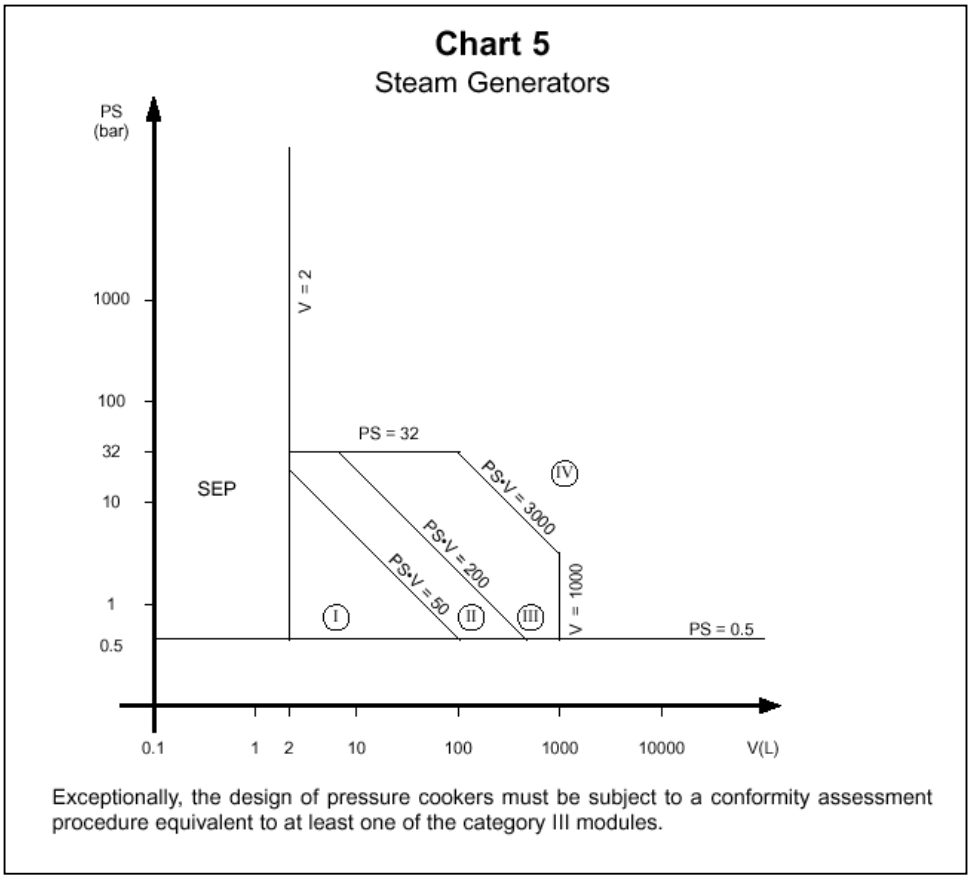
A Group 2 gas or liquid is anything that is not in Group 1, including steam.

PS Maximum allowable pressure, maximum pressure for which the equipment is designed.

PS*V The product of PS (in bar) and volume in litres

DN Numerical designation of size common to all components in a piping system other than components indicated by outside diameters or by thread size.

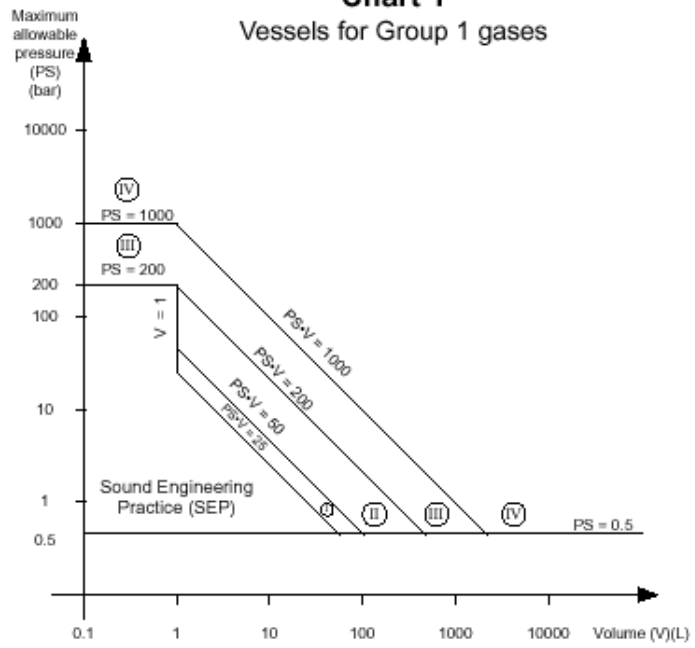
PS*DN The product of PS (in bar) and DN



Appendix A, *continued*

Chart 1

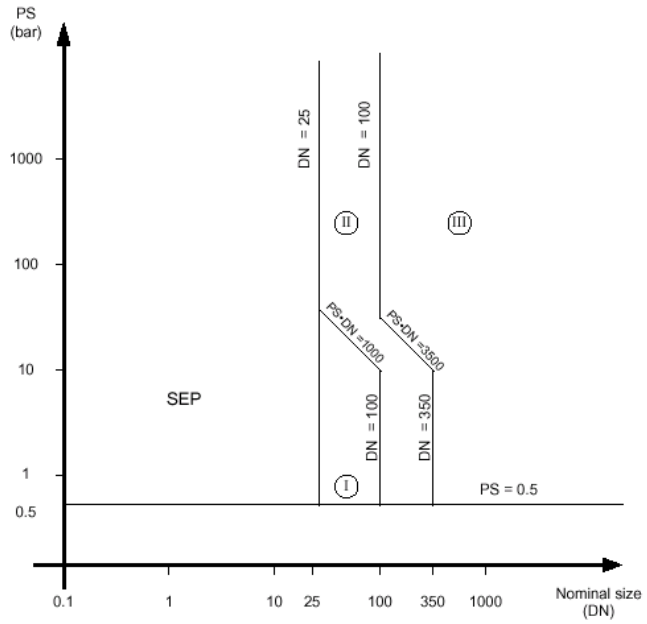
Vessels for Group 1 gases



Exceptionally, vessels intended to contain an unstable gas and falling within categories I or II on the basis of Chart 1 must be classified in category III

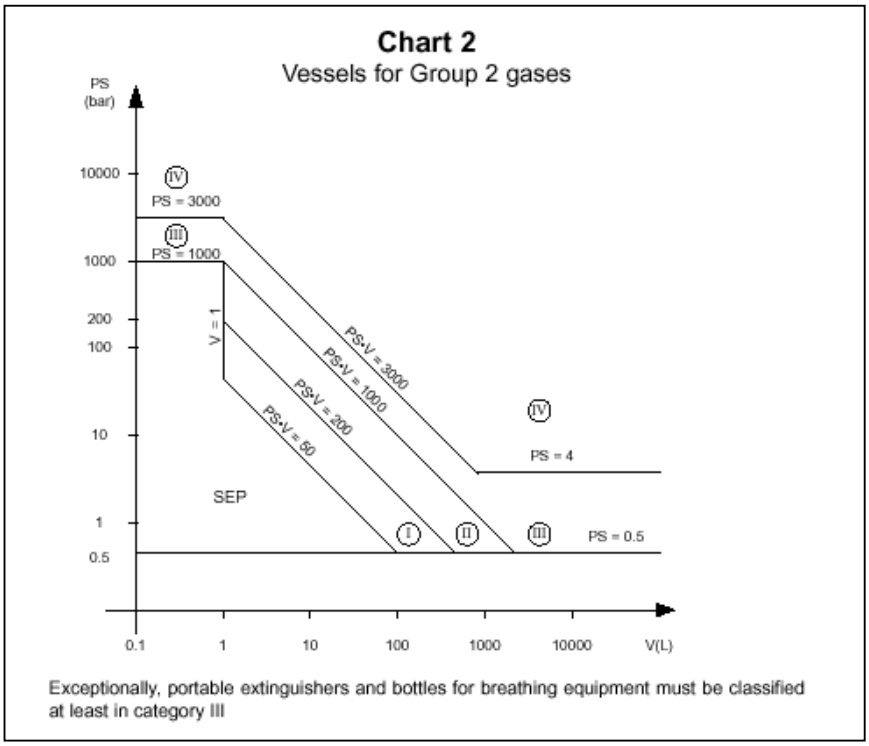
Chart 6

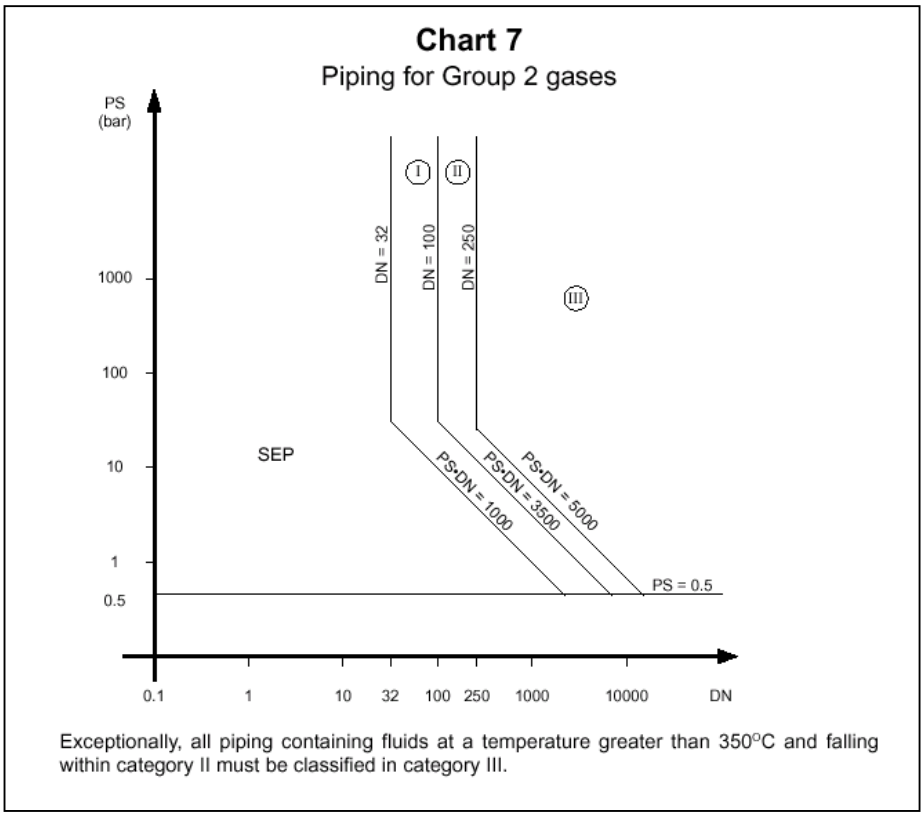
Piping for Group 1 gases



Exceptionally, piping intended for unstable gases and falling within categories I or II must be classified in category III.

Appendix A, *continued*





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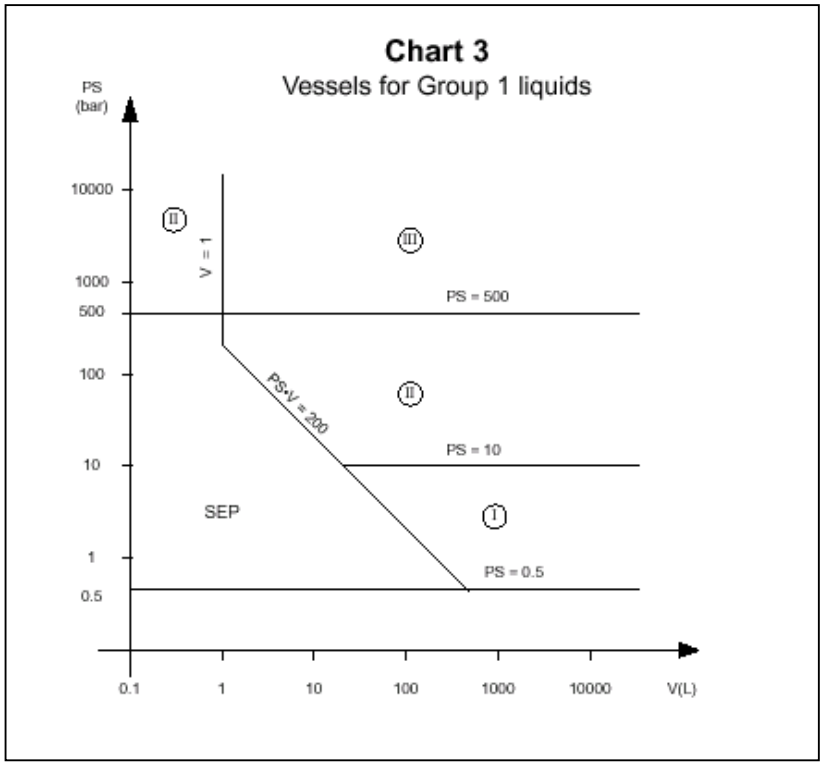
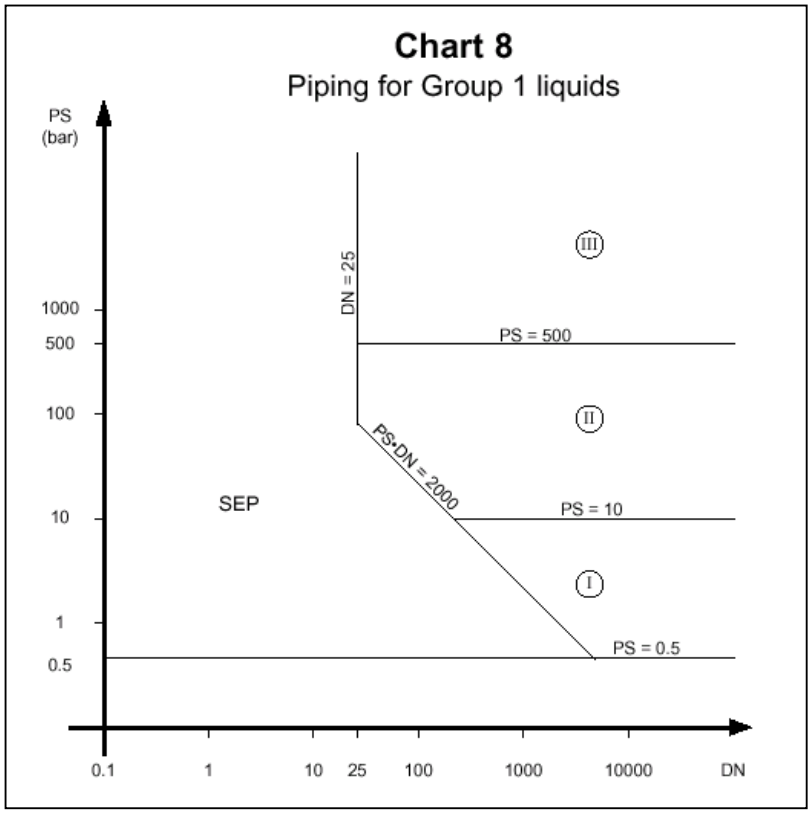
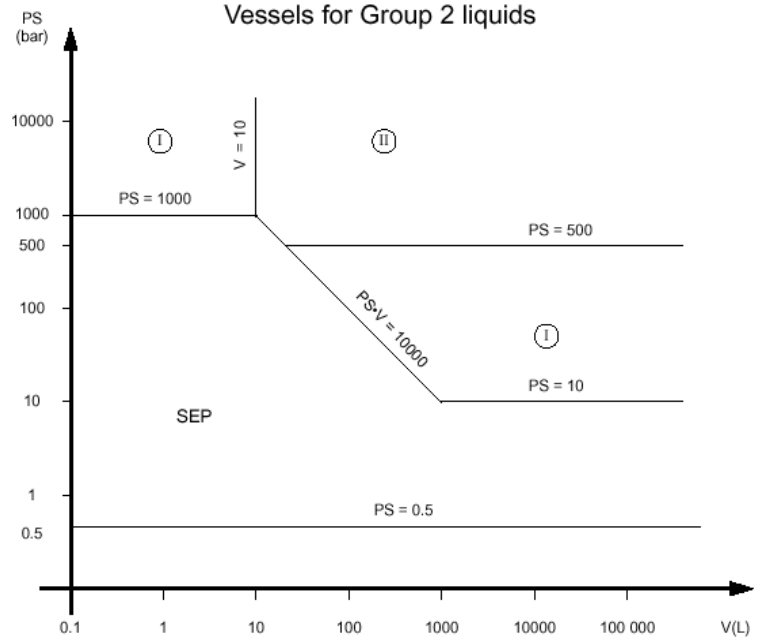




Appendix A, *continued*

Chart 4

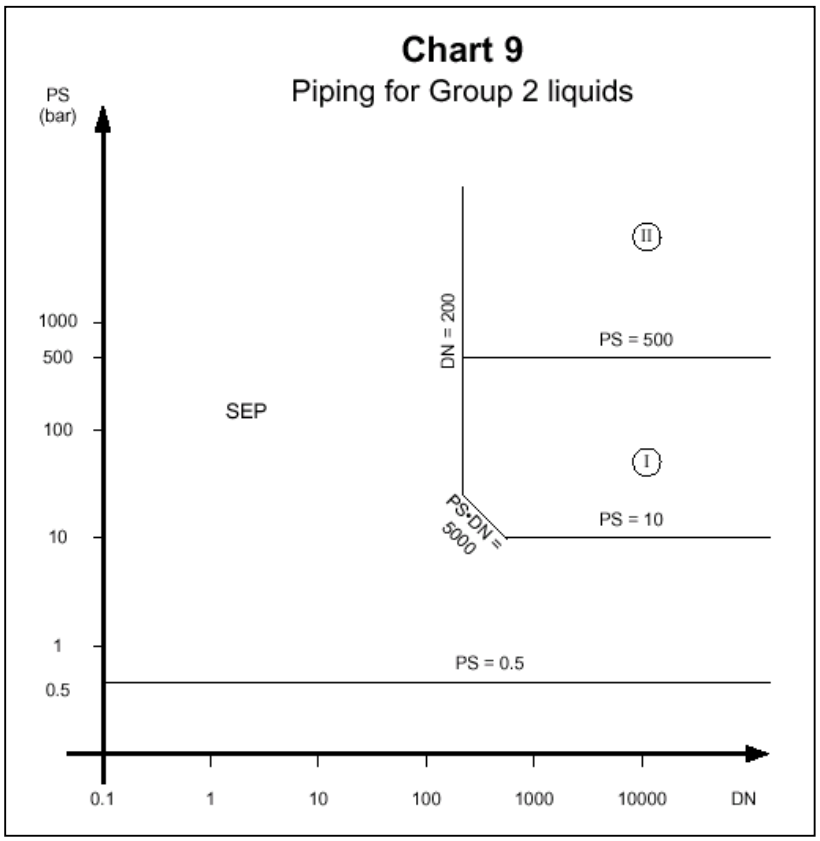
Vessels for Group 2 liquids



Exceptionally, assemblies intended for generating warm water at temperatures not greater than 110°C which are manually fed with solid fuels and have a product of pressure and volume greater than 50 bar litres, must be subject either to an EC design examination (Module B1) with respect to their conformity with Sections 2.10, 2.11, 3.4, 5(a) and 5(d) of the essential safety requirements, or to full quality assurance (Module H).

Chart 9

Piping for Group 2 liquids



Appendix B

Essential Safety Requirements for Pressure Vessels

The requirements are set out in full as Schedule 2 to the PER,
http://www.hmso.gov.uk/si/si1999/19992001.htm

The categories are shown in Appendix A.

Equipment must be designed, manufactured and checked to ensure its safety when put into service in accordance with the manufacturer's instructions, or in reasonably foreseeable conditions. The principle that hazards should be eliminated or reduced as a priority over protection and information about residual hazards must have been applied. Where the potential for misuse is known or can be clearly foreseen, the equipment must be designed to prevent danger from such misuse or, if this is not possible, adequate warning is to be given that the equipment must not be used that way.

Design
The equipment must be properly designed, taking all relevant factors into account, to ensure it is safe throughout its intended life. The design must incorporate appropriate safety coefficients using methods that are known to incorporate adequate safety margins against all relevant failure modes in a consistent manner.

Materials
The materials for construction must have appropriate properties including strength, toughness, corrosion resistance and resistance to ageing. For pressure equipment in categories II, III and IV documentary evidence will be required to establish that the material meets specification.

Strength
The equipment must be designed for loadings appropriate to its intended use, to include taking into account, where relevant

- Internal/external pressures
- Ambient and operating temperatures
- Static pressure and mass of contents
- Traffic, wind, earthquake loading
- Forces arising from the supports and attachments
- Corrosion, erosion, fatigue, etc
- Decomposition of unstable fluids.

Provisions to ensure safe handling and operation
The method of operation specified must preclude any reasonably foreseeable risk in operation, in particular to

- Closures and openings
- Dangerous discharge of pressure relief blow-off
- Devices to prevent physical access while pressure or vacuum exists
- Surface temperature
- Decomposition of unstable fluids.

Means of examination
Equipment must be designed so that all necessary examinations to ensure safety can be carried out. If it is necessary to inspect the inside of the equipment to ensure its continued safety access shall be available or other means provided.

Draining and venting
Adequate means must be provided where necessary.

Corrosion
Where necessary, adequate allowance or protection against corrosion or other chemical attack must be provided.

Wear
Where severe conditions of erosion or abrasion may arise, adequate measures must be taken to

- Minimise the effect by design
- Permit the replacement of parts that are most affected
- Draw attention to the users the measures necessary for continued safe use.

Assemblies
These must be designed so that the components are suitable and reliable, and that they are properly integrated and assembled in an appropriate manner.

Provisions for filling and discharge
Where appropriate, the design must be provided with safe means for filling and discharge, in particular to avoid:

- On filling: the overfilling or over-pressurisation, or instability
- On discharge: the uncontrolled release of pressurised fluid
- On either: the unsafe connection and disconnection.

Protection against exceeding the allowable limits
Where the allowable limits could be exceeded under reasonably foreseeable conditions provision must be made for suitable protective devices, unless the equipment is intended to be protected by other protective devices within an assembly.

Safety Accessories
They must be designed and constructed so as to be

- Reliable and suited to their intended duty, taking into account the testing and maintenance requirements of the devices.
- Be independent of other functions, unless their safety function cannot be affected by such other functions.
- Comply with appropriate design principles, in particular, fail-safe modes, redundancy, diversity and self-diagnosis.
- Pressure limiting devices must be so designed so that the pressure will not permanently exceed the maximum allowable pressure.
- Temperature monitoring devices must have an adequate response time with regard to safety requirements.

External fire
Where necessary, equipment must be so designed and where appropriate fitted with suitable accessories so as to meet damage limitation requirements in the event of an external fire.

Manufacture
The preparation of the component parts must not introduce defects or changes in the material that are likely to be detrimental to the safety of the equipment

Joints must be free from surface or internal defect detrimental to safety. The properties of joints must meet the minima specified for the parent material unless other values are specifically taken into account in the design calculations.

Permanent joins (welds) must be carried out by suitably qualified personnel, using suitable operating procedures. For equipment in categories II, III and IV this will include approval, both of the welding procedure and the welder by a competent third party (this is often referred to as a ‘coded welder’).

Where there is a risk that the manufacturing process will change the material properties to an extent that would impair the safety of the equipment, suitable heat treatment must be applied at the appropriate stage in manufacture.

Suitable procedures must be established for identifying that the material that makes up the component parts of the equipment actually meets the specifications.

Non-destructive tests
Non-destructive tests must be carried out by suitably qualified personnel. For equipment in categories III and IV the personnel must be approved by a third-party organisation.

Final tests
There must be a final inspection to assess visually and by examination of the relevant documents that there has been compliance with the directive. Tests done during manufacture may be taken into account. So far as is necessary on safety grounds the final inspection must be carried out internally and externally on every part of the equipment. Where appropriate this may be done during the course of manufacture.

The final assessment must include a test for pressure containment.

For assemblies, the final inspection must include a check of the safety devices intended to protect against exceeding the allowable limits.

Marking
In addition to CE marking (where applicable) the following information must be provided:

- Name and address or other means of identifying the manufacturer
- The year of manufacture
- The identification of the equipment
- Essential maximum/minimum allowable limits.

Depending on the type of equipment, further information such as

- Volume, V
- Nominal size of piping
- Test pressure applied, and date
- Safety device set pressure
- Output in kW
- Supply voltage
- Filling ratio
- Maximum filling mass
- Tare mass
- The product group,

and, where necessary, warnings drawing attention to misuse that experience has shown might occur.

The CE marking and this information will normally be on a data plate firmly attached to the equipment.

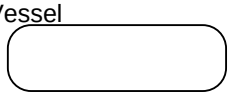
Instructions
The equipment must be accompanied by instructions for the user, containing all the necessary safety information relating to

- Mounting, including assembling
- Putting into service
- Use
- Maintenance.

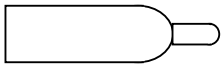
Appendix C

Symbols

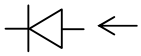
Vessel



Gas cylinder



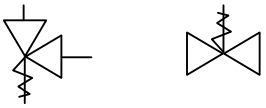
Check valve/non-return valve



Flow direction

Bursting disc

Pressure relief valve



Valve

screw-down

Powered

Flame arrestor

Vacuum venturi

Appendix D