

A PROCESS ENGINEER'S GUIDE TO THE PRESSURE EQUIPMENT DIRECTIVE

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Preface

Thank you for reading this guide. I hope that it will give you a clear introduction to the Pressure Equipment Directive and be of help to you in your work.

I would appreciate any feedback you have – good or bad. Let me know what you find useful, what could be improved and what else you would find helpful in future.

Email: info@blackmonk.co.uk

Best regards,

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Introduction

The Pressure Equipment Directive (PED) is a European Union Directive applicable to the design, manufacture and conformity assessment of pressure equipment and assemblies of pressure equipment with a maximum allowable pressure greater than 0.5 barg.

The basic purpose of the PED is to ensure that pressure equipment used in the European Economic Area¹ (EEA) is safe. Additionally, because the requirements of the Directive are common to all states within the EEA, all equipment complying with the PED may be sold and used anywhere within the EEA. This promotes the free movement of goods within the EEA.

Within the UK, the Pressure Equipment Regulations 1999 (PER) and subsequent amendments implement the European Union Pressure Equipment Directive. Failure to comply with the Pressure Equipment Regulations is illegal and can result in prosecution and penalties on conviction of a fine, imprisonment or both.

Process Engineers & the PED

Design of pressure equipment and pressure systems in the process industries inevitably involves process engineers. Given that all relevant equipment, plant and systems in the EEA must comply with the PED, it is essential that process engineers have at least a basic understanding of the requirements of the Directive.

Essentially, the PED requires the level of hazard of pressure equipment to be assessed and classified into 1 of 5 categories. The 5 categories are:

- SEP (Sound engineering practice)
- Category I
- Category II
- Category III
- Category IV



Increasing level of
hazard

The higher the level of hazard, the more extensive the level of quality assurance required during the design, manufacture and testing of the equipment.

It is generally the process engineer's responsibility to determine the hazard category of each particular equipment item and system.

¹ The European Economic Area consists of the member states of the European Union plus Iceland, Norway and Liechtenstein.



Determining the Hazard Category

In order to classify pressure equipment correctly, the process engineer must follow the methodology stated in the PED. This methodology is summarised in the flowchart at the end of this guide.

Once it is determined that the equipment is covered by the PED, the classification has 6 steps:

1. Determine the type of pressure equipment being considered
2. Determine the state of the fluid in the equipment
3. Determine the hazard group of the fluid in the equipment
4. Select the appropriate hazard category chart
5. Determine the maximum allowable pressure and the defining dimension of the equipment
6. Determine the PED hazard category

Equipment Excluded From the PED

Some equipment is excluded from the Pressure Equipment Directive (and therefore also the Pressure Equipment Regulations).

Excluded equipment includes:

- Pressure equipment and assemblies placed on the market before 29 November 1999
- Pressure equipment or assemblies placed on the market on or before 29 May 2002 if they comply with the safety provisions in force in the UK on 29 November 1999 and do not bear a CE marking (unless required by another Community Directive or any indication of compliance with the PED)
- Pressure equipment and assemblies as listed below:
 1. Pipelines
 2. Water supply, distribution and discharge networks
 3. Simple pressure vessels (as per Directive 87/404/EEC)
 4. Aerosol dispensers
 5. Equipment intended for vehicles



6. Equipment classified no higher than PED Category I for the following:
 - a. Machinery (Directive 98/37/EC)
 - b. Lifts (Directive 95/16/EC)
 - c. Electrical equipment for certain voltages (Directive 73/23/EEC)
 - d. Medical devices (Directive 93/42/EEC)
 - e. Burning gaseous fuels (Directive 90/396/EEC)
 - f. Equipment and protective systems intended for use in potentially explosive atmospheres (Directive 94/9/EC)
7. Military equipment
8. Nuclear equipment, failure of which may cause an emission of radioactivity
9. Well control equipment including wellhead (Christmas tree), blowout preventers (BOP), piping manifolds and upstream equipment
10. Casings and machinery where pressure is not a significant design factor which may include:
 - a. Engines (including turbines and internal combustion engines)
 - b. Steam engines, gas/steam turbines, turbogenerators, compressors, pumps and actuating devices
11. Blast furnaces and associated equipment
12. Enclosures for high voltage electrical equipment
13. Pressurized pipes for the containment of transmission systems such as electrical power and telecommunications cables
14. Ships, rockets, aircraft and mobile off-shore units
15. Pressure equipment consisting of a flexible casing e.g. tyres, balls, air cushions, inflatable craft
16. Exhaust and inlet silencers
17. Bottles or cans for carbonated drinks
18. Vessels designed for transport and distribution of drinks with a maximum allowable pressure x volume of not more than 500 barg.litres and a maximum allowable pressure of not more than 7 barg.
19. Equipment covered by the following:
 - a. ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road)
 - b. RID (Regulations concerning the International Carriage of Dangerous Goods by Rail)
 - c. IMDG (International Maritime Dangerous Goods Code)
 - d. ICAO (International Civil Aviation Organization)
20. Radiators and pipes in warm water heating systems



21. Vessels designed to contain liquids with a gas pressure above the liquid of not more than 0.5 barg

The detailed list of excluded equipment can be found in Article 1 Section 3 of the Pressure Equipment Directive:

http://ec.europa.eu/enterprise/pressure_equipment/ped/directive/directive_article1_en.html

Types of Pressure Equipment

The PED defines 6 types of pressure equipment:

1. Vessel
2. Steam generator
3. Piping
4. Safety accessories
5. Pressure accessories
6. Assemblies

The **first step** in determining the PED category of a particular piece of equipment is to select the appropriate equipment type from the list.

Definitions of each equipment type are given below.

Vessel

A housing designed and built to contain fluids under pressure. A vessel includes its direct attachments up to the coupling point connecting it to other equipment. A vessel may be composed of more than one chamber.

Steam Generator

A steam generator is a particular type of vessel and means fired or otherwise heated pressure equipment with the risk of overheating intended for generation of steam or super-heated water at temperatures higher than 110C.

Piping

Piping components intended for the transport of fluids when connected together for integration into a pressure system. Piping includes a pipe or system of pipes, tubing, fittings, expansion joints, hoses, or other pressure-bearing components as appropriate. Heat exchangers consisting of pipes for the purpose of cooling or heating air shall be considered as piping.



Safety Accessories

Safety accessories are devices designed to protect pressure equipment against the allowable limits being exceeded. Such devices include devices for direct pressure limitation, such as safety valves and bursting discs, etc, and limiting devices which either activate the means for correction or provide for shutdown or shutdown and lock-out, such as pressure switches or temperature switches, etc.

Pressure Accessories

Pressure accessories are devices with an operational function and having pressure-bearing housings. Examples of pressure assemblies include valves, pressure regulators, pressure gauges and filters.

Assemblies

Assemblies are defined as several pieces of pressure equipment assembled by one manufacturer to constitute an integrated and functional whole. Examples of assemblies include skid mounted systems, distillation units, evaporation units and filtering units.

Fluid State

The **second step** in determining the PED category is to establish whether the fluid contained within the equipment is gas or liquid.

If the fluid has a vapour pressure at the maximum allowable temperature of the equipment of greater than 0.5 bar above normal atmospheric pressure (1013 mbara), it is treated as a **gas**, otherwise it is treated as a **liquid**.

Gas

Gases include gases, liquefied gases, gases dissolved under pressure, vapours and also those liquids whose vapour pressure at the maximum allowable temperature is greater than 0.5 bar above normal atmospheric pressure (1013 mbara).

Liquid

Liquids include liquids having a vapour pressure at the maximum allowable temperature of not more than 0.5 bar above normal atmospheric pressure (1013 mbara).



Fluid Group

The **third step** in determining the PED category is to decide whether the fluid contained within the equipment is classified as a Group 1 fluid or a Group 2 fluid.

Basically, if the fluid is hazardous it is a Group 1 fluid, otherwise it is a Group 2 fluid.

Group 1

Group 1 comprises those fluids classified, according to the EC Directive on the classification of dangerous substances as:

- explosive
- extremely flammable
- highly flammable
- flammable (where the maximum allowable temperature is above flashpoint)
- very toxic
- toxic
- oxidizing

For more information see <http://www.hse.gov.uk/pubns/indg350.pdf>

Group 2

Group 2 comprises all other fluids including steam.



Classification Charts

Once the equipment type, fluid state and fluid group have been determined, the appropriate classification chart can be selected. This represents the **fourth step** in determining the PED category.

There are 9 separate classification charts (also called tables in the PED), one for each of the possible combinations of equipment type, fluid state and fluid group.

Equipment Type	Fluid State	Fluid Group	Chart
Vessel	Gas	1	1
Vessel	Gas	2	2
Vessel	Liquid	1	3
Vessel	Liquid	2	4
Steam Generator	N/A	N/A	5
Piping	Gas	1	6
Piping	Gas	2	7
Piping	Liquid	1	8
Piping	Liquid	2	9

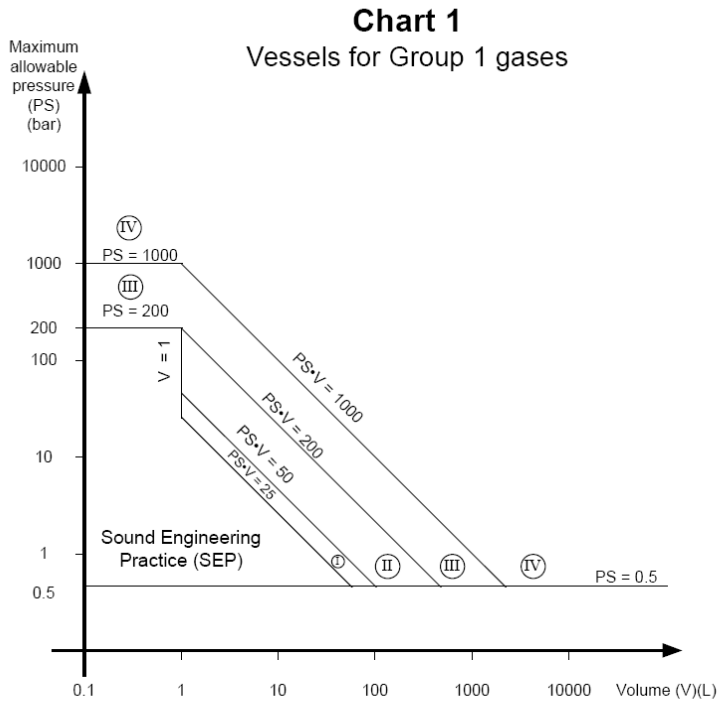
The demarcation lines in the classification charts indicate the upper limit for each PED hazard category.

The charts assign each piece of equipment to a definite category.

Note: over classification of equipment, e.g. declaring it to be category IV when it is category II, is expressly prohibited.

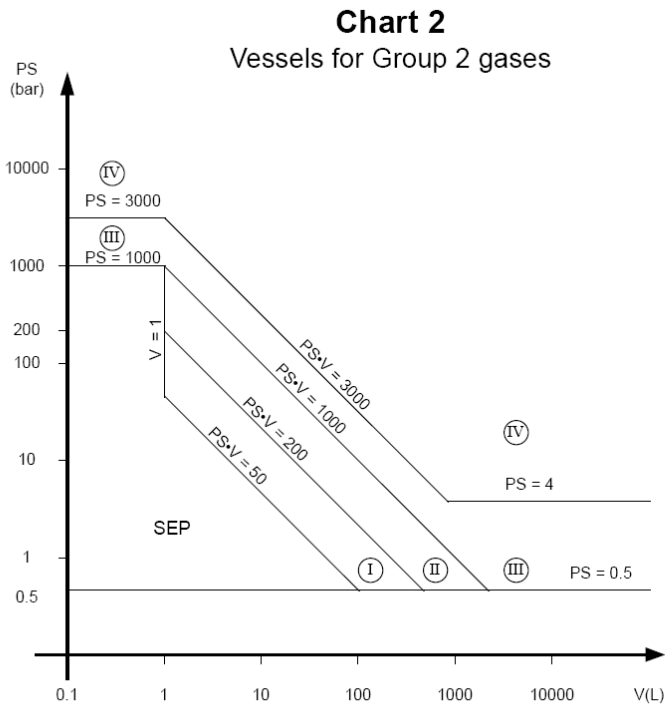


Chart 1



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 2



Exceptionally, portable extinguishers and bottles for breathing equipment must be classified at least in category III



Chart 3

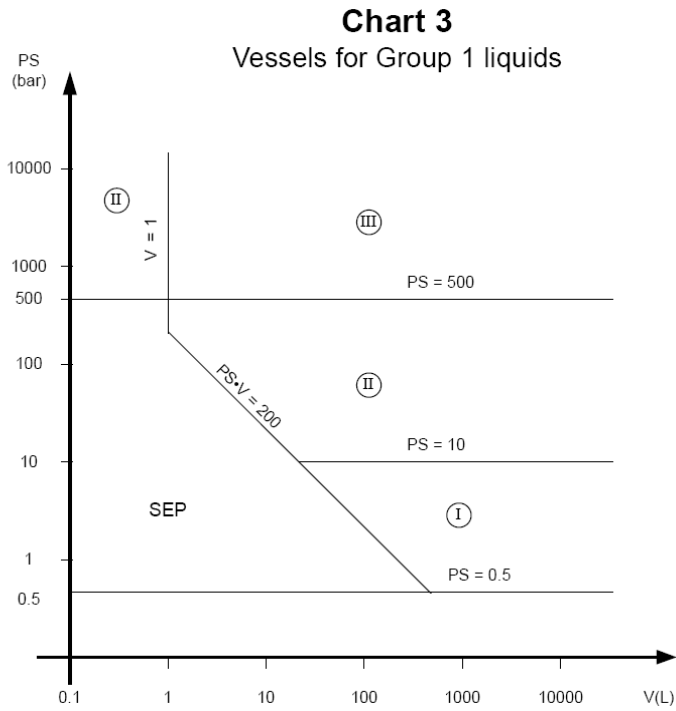
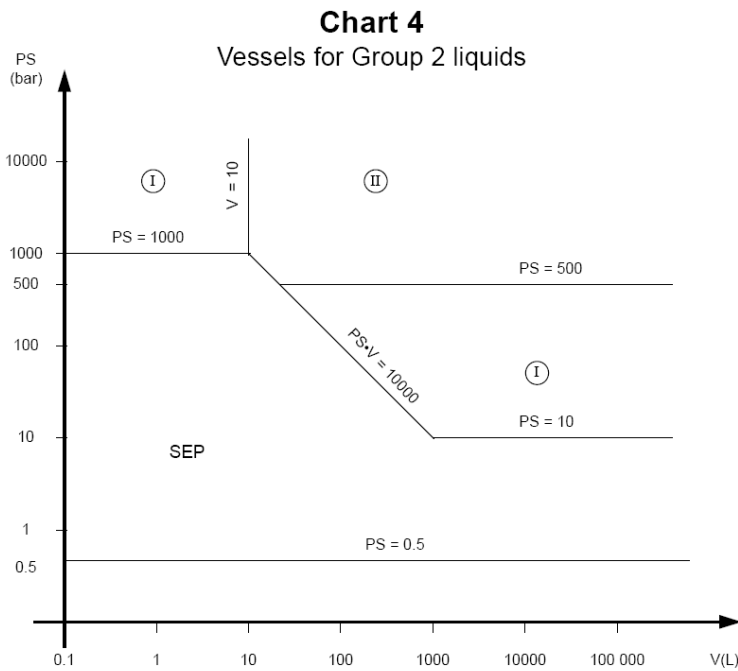


Chart 4

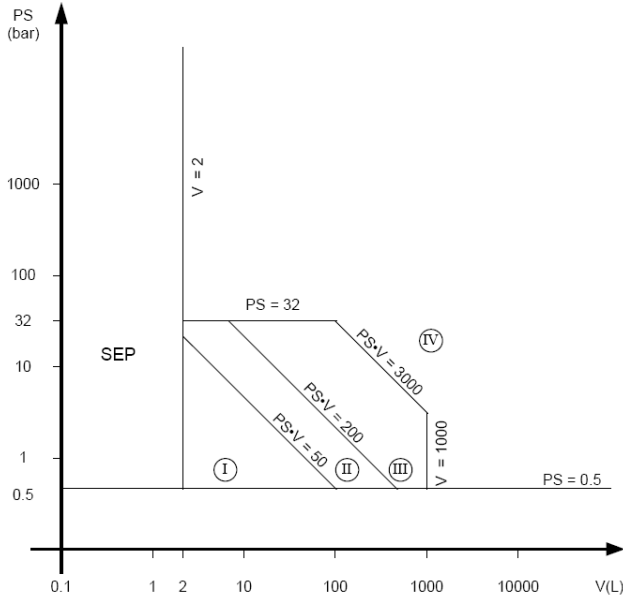


Exceptionally, assemblies intended for generating warm water at temperatures not greater than 110°C which are manually fed with solid fuels and have a product of pressure and volume greater than 50 bar litres, must be subject either to an EC design examination (Module B1) with respect to their conformity 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 5

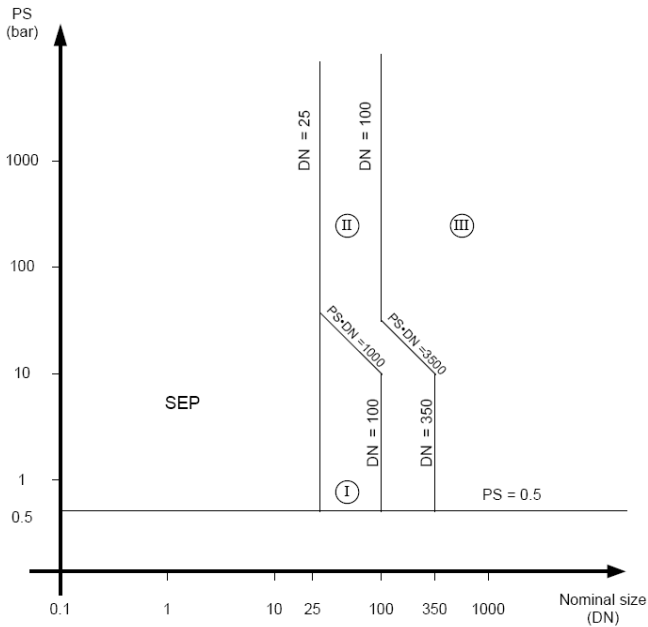
Chart 5
Steam Generators



Exceptionally, the design of pressure cookers must be subject to a conformity assessment procedure equivalent to at least one of the category III modules.

Chart 6

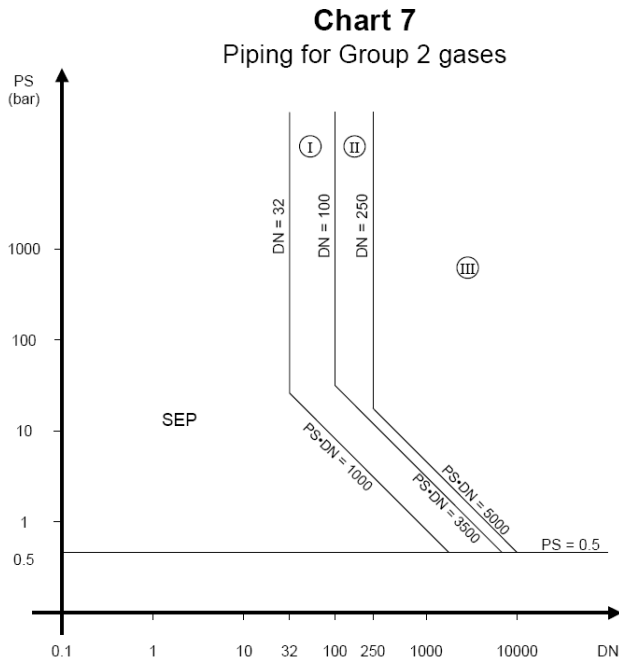
Chart 6
Piping for Group 1 gases



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



Chart 7



Exceptionally, all piping containing fluids at a temperature greater than 350°C and falling within category II must be classified in category III.

Chart 8

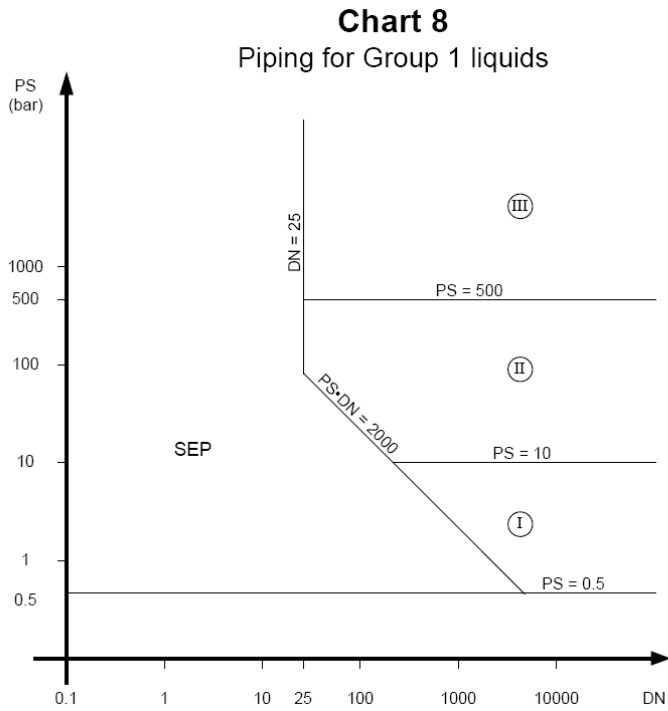
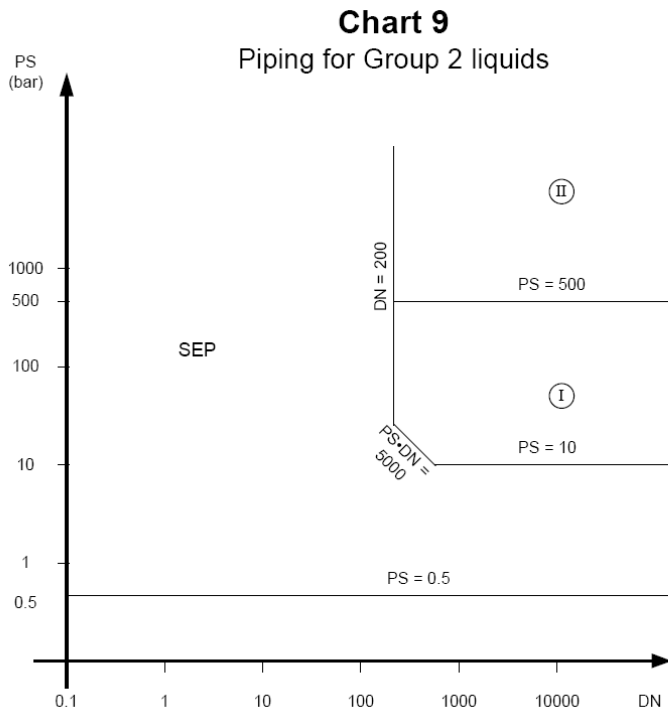




Chart 9





Determine the Maximum Allowable Pressure & Defining Dimension

The **fifth step** in determining the PED category is to determine the maximum allowable pressure and defining dimension of the equipment.

The maximum allowable pressure is the maximum pressure for which the equipment has been designed as specified by the manufacturer.

The defining dimension of the equipment is dependent on the equipment type.

For vessels and steam generators, the defining dimension is the equipment volume expressed in litres.

For piping, the defining dimension is the nominal size of the components comprising the piping system expressed in millimetres. Typically this is the nominal pipe diameter.

Determine the PED Hazard Category

The **sixth and final step** is to read off the PED hazard category from the appropriate chart using the relevant values of maximum allowable pressure and defining dimension.

PED Calculator

As an alternative to manually referencing the charts, a calculator is available at <http://www.blackmonk.co.uk/calculators/pressure-equipment-directive-calculator> which will automatically determine the PED hazard category given the equipment type, fluid state and fluid group.

Conformity Assessment

When the PED category has been established for equipment, the conformity assessment requirements can be defined. In effect, the conformity assessment is the quality assurance required to validate the design, manufacture, testing and inspection of the equipment. The higher the equipment PED category, the higher the level of hazard and therefore the more extensive the quality assurance requirements are.

The PED category defines the required conformity assessment module. Where multiple module choices apply, the equipment manufacturer may select the module(s) best suited to their particular requirement.



PED Category	Module
SEP	Sound engineering practice
I	A
II	A1, D1, E1
III	B1+D, B1+F, B+E, B+C1, H
IV	B+D, B+F, G, H1

Module Definitions

Module	Design Stage Assessment	Production Stage Assessment
Sound Engineering Practice	No specific requirements	No specific requirements
A	Technical documentation	Internal production control
A1	Technical documentation	Internal production control with monitoring of the final assessment
B	Type examination	No specific requirements
B1	Design examination	No specific requirements
C1	No specific requirements	Monitoring of final assessment
D	No specific requirements	Quality assurance for production, final inspection and test
D1	Technical documentation	Quality assurance for production, final inspection and test
E	No specific requirements	Quality assurance for final inspection and test
E1	Technical documentation	Quality assurance for final inspection and test
F	No specific requirements	Product verification
G	Unit verification	Unit verification
H	Quality assurance for design	Quality assurance for manufacture, final inspection and test
H1	Quality assurance for design with design examination	Quality assurance for manufacture, final inspection, test and monitoring of final assessment

The management of the conformity assessment is generally a quality assurance or project management responsibility but it is useful for process engineers to have an overview of the procedure.



Examples

Three examples of determining the PED category for various equipment types are given below to help with understanding the PED methodology.

Example 1

Determine the PED category of a 50m³ horizontal storage vessel containing propane with a maximum allowable pressure of 100 barg and a maximum allowable temperature of 75C.

Solution:

Because the maximum allowable pressure of the equipment is above 0.5 barg and the equipment is not on the excluded list, the PED will apply. To classify the equipment remember the 6 steps of the PED classification methodology:

1. Determine the type of pressure equipment being considered
2. Determine the state of the fluid in the equipment
3. Determine the hazard group of the fluid in the equipment
4. Select the appropriate hazard category chart
5. Determine the maximum allowable pressure and the defining dimension of the equipment
6. Determine the PED hazard category

Step 1

The equipment type is a vessel.

Step 2

Propane at the maximum allowable temperature of 75C has a vapour pressure of 28.5 bara².

This is greater than 0.5 bar above normal atmospheric pressure of 1013 mbara so the state of the fluid in the equipment is classed as gas.

Step 3

Propane is classified as “extremely flammable”³ and is therefore a Group 1 fluid.

² Reference for propane vapour pressure: NIST Webbook
(<http://webbook.nist.gov/chemistry/fluid/>)

³ Reference for classification: European Commission, European Regulation on the Classification, Labelling and Packaging of Substances and Mixtures website
(http://ecb.jrc.ec.europa.eu/documents/Classification-Labelling/Table_3-2.doc)



Step 4

The appropriate hazard category chart is Chart 1. This is the chart for a vessel containing a Group 1 gas.

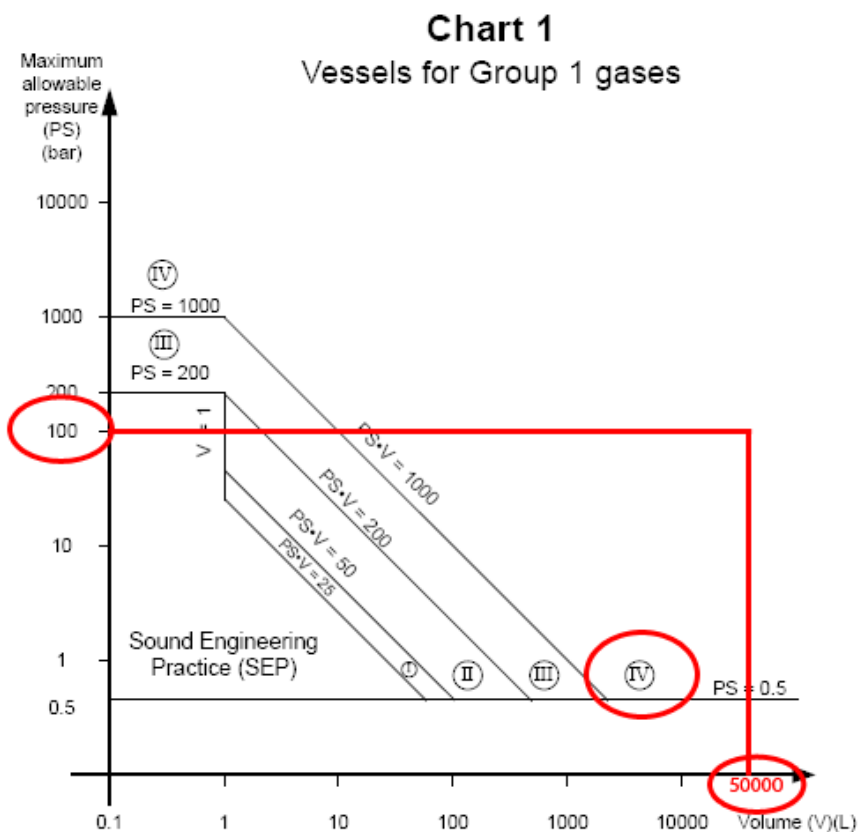
Step 5

The maximum allowable pressure of the vessel is 100 barg.

The defining dimension of a vessel is volume. The volume of the vessel is 50m^3 which is equivalent to 50000 litres.

Step 6

The point corresponding to 100 barg and 50000 litres on Chart 1 is in the category IV area.



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

The required PED category for the equipment is category IV.



Example 2

Determine the PED category of 100m of 4" nominal diameter piping transporting water with a maximum allowable pressure of 20 barg and a maximum allowable temperature of 50C.

Solution:

Because the maximum allowable pressure of the equipment is above 0.5 barg and the equipment is not on the excluded list, the PED will apply. To classify the equipment remember the 6 steps of the PED classification methodology:

1. Determine the type of pressure equipment being considered
2. Determine the state of the fluid in the equipment
3. Determine the hazard group of the fluid in the equipment
4. Select the appropriate hazard category chart
5. Determine the maximum allowable pressure and the defining dimension of the equipment
6. Determine the PED hazard category

Step 1

The equipment type is piping.

Step 2

Water at the maximum allowable temperature of 50C has a vapour pressure of 0.123 bara⁴.

This is less than 0.5 bar above normal atmospheric pressure of 1013 mbara so the state of the fluid in the equipment is classed as liquid.

Step 3

Water is not classified as a dangerous substance and is therefore a Group 2 fluid.

Step 4

The appropriate hazard category chart is Chart 9. This is the chart for piping containing a Group 2 liquid.

⁴ Reference for water vapour pressure: steam tables.



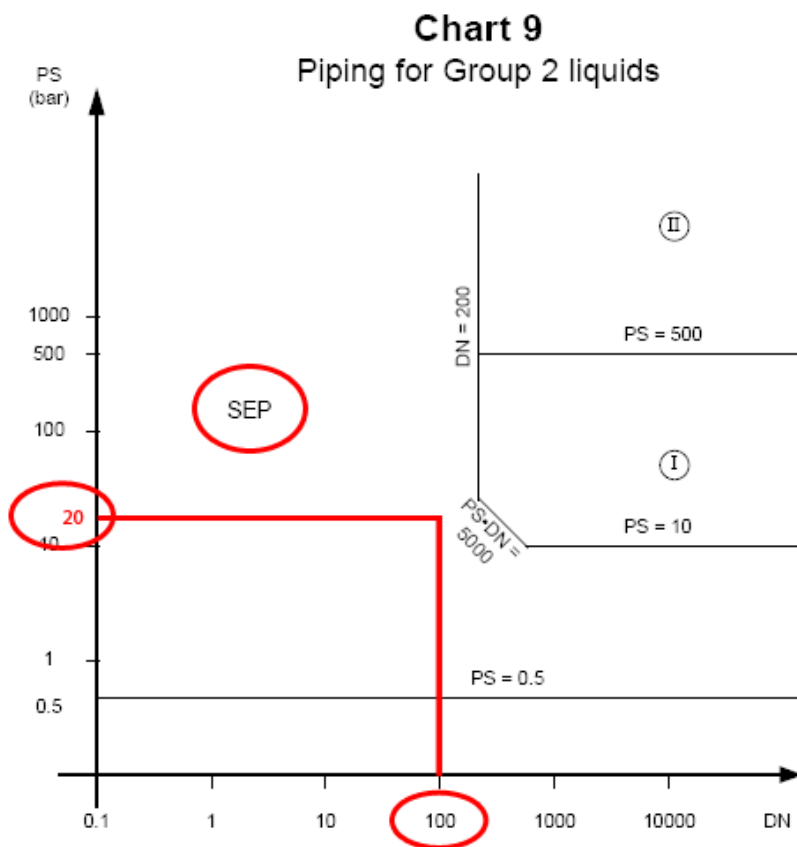
Step 5

The maximum allowable pressure of the piping is 20 barg.

The defining dimension of piping is the nominal size. The nominal size of 4" diameter piping is 100mm.

Step 6

The point corresponding to 20 barg and 100mm on Chart 9 is in the category SEP area.



The required PED category for the equipment is category SEP.



Example 3

Determine the PED category of a 0.1m³ steam flash drum designed to raise saturated steam at 10 barg with a maximum allowable pressure of 15 barg and a maximum allowable temperature of 200C.

Solution:

Because the maximum allowable pressure of the equipment is above 0.5 barg and the equipment is not on the excluded list, the PED will apply. To classify the equipment remember the 6 steps of the PED classification methodology:

1. Determine the type of pressure equipment being considered
2. Determine the state of the fluid in the equipment
3. Determine the hazard group of the fluid in the equipment
4. Select the appropriate hazard category chart
5. Determine the maximum allowable pressure and the defining dimension of the equipment
6. Determine the PED hazard category

Step 1

The equipment is designed to raise saturated steam at 10 barg which is equivalent to a steam temperature of about 184C. The equipment type is therefore classed as a steam generator as the vessel is designed to raise steam at temperatures above 110C.

Step 2

The state of the fluid is not applicable to a steam generator.

Step 3

Classification of the fluid group is not required for a steam generator. However for completeness, steam is not classified as a dangerous substance and is therefore a Group 2 fluid.

Step 4

The appropriate hazard category chart is Chart 5. This is the chart for a steam generator.



Step 5

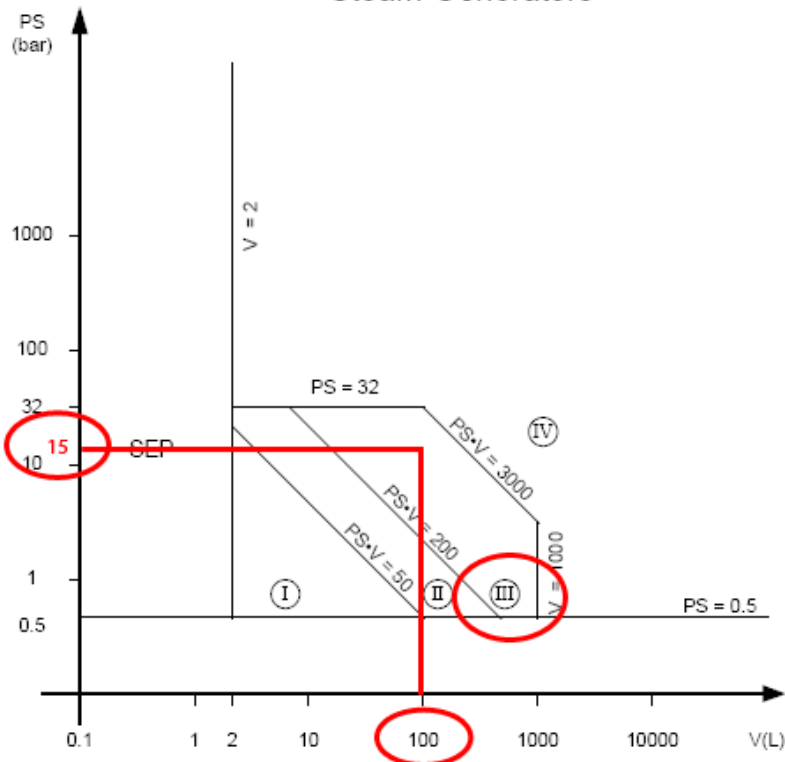
The maximum allowable pressure of the steam generator is 15 barg.

The defining dimension of a steam generator is volume. The volume of the steam flash drum is 0.1m³ which is equivalent to 100 litres.

Step 6

The point corresponding to 15 barg and 100 litres on Chart 5 is in the category III area.

Chart 5
Steam Generators



Exceptionally, the design of pressure cookers must be subject to a conformity assessment procedure equivalent to at least one of the category III modules.

The required PED category for the equipment is category III.



References

1. The Pressure Equipment Directive (97/23/EC)
(http://ec.europa.eu/enterprise/pressure_equipment/ped/index_en.html)
2. The Pressure Equipment Regulations 1999
(<http://www.opsi.gov.uk/si/si1999/19992001.htm>)
3. UK DTI Product Standards Pressure Equipment: Guidance Notes on the UK Regulations, April 2005
(<http://www.berr.gov.uk/files/file11284.pdf>)

PED Classification Flowchart

