USE OF PRESSURE RELIEF DEVICES FOR GAS CYLINDERS

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Prepared by WG-2 Cylinders and Valves

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Amendments from 91/10

Section	Change
	Rewrite to align to EIGA style manual
8	Reference section added and references updated

1 Introduction

This publication is based on the common practice of the use of pressure relief devices for gas cylinders containing gases and gas mixtures in service in Europe.

Pressure relief devices are used to prevent the failure of gas cylinders, due to over pressurisation caused by accidental overfilling and, or exposure to an unexpected high temperature.

Since pressure relief devices also involve side effects such as the risk of undesirable release of the product to the ambient atmosphere, their use should not be generalised. The regulatory requirements for the fitting of relief devices in Europe to gas cylinders are covered by the European Agreement on the Carriage of Dangerous Goods, ADR [1] [1].

2 Scope

This document specifies the use, when needed, of pressure relief devices according to the nature of the gas contained in the gas cylinder to protect the cylinder against over pressurisation. Material, design and testing of pressure relief devices are not part of this document.

Pressure relief devices for cryogenic vessels are excluded from the scope of this publication.

3 Definitions

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Bursting disc assembly

Complete assembly of components which are installed in the bursting disc holder to perform the desired function.

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.2.2 Bursting disc safety device

Non-reclosing pressure relief device actuated by differential pressure and designed to function by the bursting of the bursting disc(s), and which is the complete assembly of installed components including, where appropriate, the bursting disc holder.

3.2.3 Bursting disc

Pressure-containing and pressure-sensitive component of a bursting disc safety device.

3.2.4 Bursting pressure

Value of the differential pressure between the upstream side and the downstream side of the bursting disc when it bursts.

3.2.5 Compressed gas

A gas which when packaged under pressure for carriage is entirely gaseous at – 50 °C; this category includes all gases with a critical temperature less than or equal to – 50 °C.

3.2.6 Dissolved acetylene

Acetylene gas which is dissolved under pressure in a liquid phase solvent. The solvent is distributed through the porous material.

3.2.7 Filling ratio

Ratio of the mass of gas (kg) introduced in a cylinder to the water capacity (l) of the cylinder at 15 °C.

3.2.8 Fusible plug

A fusible plug is a pressure relief device which consists of material, usually metallic, and functions by melting in a narrow predetermined range of temperatures, when it is exposed to heat.

3.2.9 Liquefied gas

A gas which when packaged under pressure for carriage is partially liquid at temperature above –50 °C. A distinction is made between

a) High pressure liquefied gas

A gas which has a critical temperature between –50 °C and equal to or below +65 °C and

b) Low pressure liquefied gas

A gas which has a critical temperature above +65 °C.

3.2.10 Minimum burst pressure

Minimum bursting pressure quoted with a coincident temperature when defining the bursting disc requirements.

3.2.11 Maximum bursting pressure

Maximum bursting pressure quoted with a coincident temperature when defining the bursting disc requirements.

3.2.12 Maximum permissible operating pressure

Highest pressure permitted to be developed during service, which shall not exceed the test pressure of the cylinder.

3.2.13 Performance tolerance of the bursting disc

The range of pressure between the specified maximum bursting pressure and the specified minimum bursting pressure, or the range of pressure in positive and negative percentages or quantities, which is related to the specified rated bursting pressure.

3.2.14 Safety valve

A valve which automatically, without the assistance of any energy other than that of the fluid concerned, discharges a quantity of the fluid so as to prevent a predetermined safe pressure being exceeded, and which is designed to re-close and prevent further flow of fluid after normal pressure conditions of service have been restored.

NOTE The valve can be characterised either by pop action (rapid opening) or by opening in proportion (not necessarily linear) to the increase in pressure over the set pressure.

NOTE For additional information see EN ISO 4126-1 *Safety devices for protection against excessive pressure. Safety valves* [2]

3.2.15 Set pressure of a safety valve

The predetermined pressure at which a safety valve under operating conditions commences to open.

NOTE It is the gauge pressure measured at the valve inlet at which the pressure forces tending to open the valve for specified service conditions are in equilibrium with the forces retaining the valve disc on its seat.

NOTE For additional information see EN ISO 4126-1 *Safety devices for protection against excessive pressure. Safety valves* [2]

3.2.16 Test pressure

Required pressure applied during a pressure test for qualification or requalification.

3.2.17 Working pressure

Settled pressure of a compressed gas at a uniform reference temperature of 15 °C in a full gas cylinder.

4 Recommendations for the application of pressure relief devices for gas cylinders

4.1 General

Gas cylinders are usually filled by monitoring pressure (corrected for temperature) or weight. Gas cylinders are equipped with valves to open and close the cylinder for filling and use of the gas contained. Gas cylinders are designed with a safety factor to test pressure, which is greater or equal to the maximum operating pressure. Therefore it is normally not necessary to install a pressure relief device, because under normal operating conditions the test pressure is not reached.

4.2 Compressed gases

Compressed gases are filled by monitoring the pressure (corrected for temperature) or weight. For most gases the maximum operating pressure is far below the test pressure, which is 50% higher than the working pressure. The increase of pressure under influence of temperature is relatively slow, consequently pressure relief devices are normally not recommended, and not allowed for very toxic gases (LC_{50} below 200ppm).

4.3 Liquefied gases

Liquefied gases are normally filled by weight. The maximum allowed filling ratio of each liquefied gas depends on its physical properties and is covered by standards. In Europe the filling ratio are defined in Table P200 of ADR [1]. The developed pressure in the cylinder is dependent on the actual temperature of the gas. If the reference temperature of 65 °C or the maximum allowed filling ratio is exceeded the developed pressure may be higher than the test pressure of the cylinder. Hence the use of pressure relief devices shall be considered only for liquefied gases. For UN cylinders the ADR/RID/ADN and UN model regulation require this for carbon dioxide and nitrous oxide.

4.4 Dissolved acetylene

Acetylene is a flammable gas, normally dissolved in a solvent. Therefore leakage from the containment package must be avoided. Experience from countries using pressure relief devices is not encouraging in that they have been shown to be responsible for providing a potential leak path.

4.5 Groups and list of relevant gases for use with pressure relief devices

Table 1 Gases and fitting of pressure relief devices

	Compressed Gases	**Liquefied Gases Low pressure**	**Liquefied Gases High Pressure**	**Dissolved Acetylene**
Non-toxic Non-flammable	Not recommended	Not recommended[3]	Recommended[1]	....
Flammable, toxic, corrosive, pyrophoric	Not recommended	Not recommended[2]	Not recommended	Not recommended
Very toxic	Not allowed[4]	Not allowed[4]	Not allowed[4]	....

1) For certain applications it may not be advisable to use a pressure relief device, e.g. medical applications
2) Optional use for liquefied petroleum gas, (LPG), depending on National Regulations or company standards
3) Certain applications may require pressure relief devices
4) Not allowed by regulation

Recommended use of pressure relief devices:

- For carbon dioxide and nitrous oxide
- For other high pressure liquefied gases, not dangerous to the environment or the public

Where the use of pressure relief devices is not recommended:

- see Table 1.

Where the use of a pressure relief devices is not allowed

- see Table 1.

NOTE The use of pressure relief devices is not recommended or not allowed when due to the very low risk of over pressurisation compared to the greater danger associated with a product release, this latter risk is considered prevailing.

5 Basic requirements for pressure relief devices for gases

5.1 Material

The materials used in the construction shall be suitable for the relevant conditions, including pressure, temperature, gas / material compatibility and atmospheric corrosion. Where necessary it should be

coated. The coating should be flexible and non porous, see EN ISO 11114 -1 *Gas cylinders -- Compatibility of cylinder and valve materials with gas contents -- Part 1: Metallic materials* and EN ISO 11114 *Gas cylinders -- Compatibility of cylinder and valve materials with gas contents -- Part 2: Non-metallic materials* [3,4].

5.2 Other characteristics

Pressure relief devices shall be restricted for pressure limiting purposes only and their relevant components shall be failsafe. They shall maintain their properties at least during the retest period of the cylinder.

Pressure relief devices shall be effective over the range of operating temperatures (normally between –20 to +65 °C) at a pressure not exceeding, including all tolerances, 1.15 times the test pressure of the gas cylinder, e.g. for a cylinder with a test pressure of 250 bar this value is 288 bar. The lower limit shall be as high as possible to prevent undue product release during normal service.

5.3 Seat

The seat of the bursting disc should be designed and mounted so that it is concentric with the opening. It should not be damaged in the area where it is only arched under pressure.

5.4 Gas tightness

In the range of the working temperature and pressure, the pressure relief device shall not leak.

5.5 Bursting

After bursting adequate gas flow shall be ensured in order to avoid further pressure increase of the gas cylinder.

5.6 Security of assembly

The pressure relief device should be secured against accidental loosening for example by application of an appropriate torque.

5.7 Assembly

Assembly should be carried out by trained personnel using correct equipment and procedures.

5.8 Vent openings

Vent openings should be designed so that the reaction forces are minimised to prevent the cylinder from falling over when the relief device operates

5.9 Cylinder caps

Cylinder caps without venting holes shall not be used to protect valves with pressure relief devices.

5.10 Bundles

Only one pressure relief device needs to be used if correctly connected to each cylinder.

5.11 Marking

It shall be possible to identify the appropriate pressure relief device for the cylinder to be used, for example test pressure, year of manufacture and part number.

5.12 Flow rate

5.12.1 Capacity of bursting discs after rupture.

The discharge capacity of pressure relief devices should be in accordance with the applicable standards or national regulations. Where these are not available the following formulae may be used:

5.12.1.1 For compressed gases:

$$QG = 0{,}0096 \times V \ m^3/min.$$

Where:

QG = Flow capacity at 690 kPa(abs.) in cubic metres per minute of free air
V = Water capacity of the cylinder in litres (dm^3)

5.12.1.2 For liquefied gases:

$$QL = 2 \times 0{,}0096 \times V \ m^3/min.$$

Where:

QL = Flow capacity at 690 kPa(abs.) in cubic metres per minute of free air
V = Water capacity of the cylinder in litres (dm^3)

NOTE Where the same design of valve is used in cylinders of different water capacities the size used should be that for the largest cylinder.

NOTE In Europe PRDs are normally used to avoid overfilling liquefied gases, for example carbon dioxide. In this case the expected pressure increase rate will be low and consequently there is no need to follow the above flow rate requirements.

6 Present use of pressure relief devices in Europe

RID/ADR/ADN indicates when PRDs shall be used.

In summary

- PRD shall not be used for toxic gases. (LC_{50} less than 200 ppmV).
- There is no specific requirement concerning the use or set pressure of PRDs for other gases in ADR [1].

For UN cylinders PRDs shall be used for carbon dioxide and nitrous oxide.

Member companies often use bursting discs for carbon dioxide and nitrous oxide in non UN cylinders to prevent cylinder rupture due to over pressurisation, usually as a result of overfilling. These bursting discs shall not be backed by a fusible element.

It is always important to ensure that no overfilling is possible. However, where PRDs are not used on cylinders for such liquefied gases, it is even more important that there shall be procedures in place to ensure no overfilling, for example by check weighing or control of filling temperature.

7 References

[1] European Agreement Concerning the International Carriage of Dangerous Goods by Road, ADR www.unece.org

[2] EN ISO 4126-*1 Safety devices for protection against excessive pressure. Safety valves* www.cen.eu

[3] EN ISO 11114 -1 *Gas cylinders -- Compatibility of cylinder and valve materials with gas contents -- Part 1: Metallic materials* www.cen.eu

[4] EN ISO 11114 *Gas cylinders -- Compatibility of cylinder and valve materials with gas contents -- Part 2: Non-metallic materials* www.cen.eu