

# Transportable gas cylinders — Gas cylinders conforming to the TPED to be used for PED applications — Applicability and justifications

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## National foreword

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**Transportable gas cylinders - Gas cylinders conforming to the  
TPED to be used for PED applications - Applicability and  
justifications**

Bouteilles à gaz transportables - Bouteilles à gaz  
conformes à la Directive sur les équipements sous  
pression transportables, à utiliser pour des applications  
relevant de la Directive sur les équipements sous pression  
- Applicabilité et justifications

Ortsbewegliche Gasflaschen - Gasflaschen entsprechend  
der TPED für PED Anwendungen - Anwendbarkeit und  
Begründung

This Technical Report was approved by CEN on 13 May 2006. It has been drawn up by the Technical Committee CEN/TC 23.

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## Foreword

This document (CEN/TR 15444:2006) has been prepared by Technical Committee CEN/TC 23 "Transportable gas cylinders", the secretariat of which is held by BSI.

## **Introduction**

This CEN technical report has been prepared to address the essential requirements of the Pressure Equipment Directive (PED) 97/23/EC with regard to European Standards prepared originally for transportable gas cylinders, which address the essential safety requirements of the Transportable Pressure Equipment Directive (TPED) 99/36/EC.

## 1 Scope

This Technical Report provides a rationale and technical justification for certain European Standards for transportable gas cylinders, produced in accordance with the requirements of the Transportable Pressure Equipment Directive (TPED), to be used for applications currently listed in the Pressure Equipment Directive (PED). Its purpose is to prove equivalence of approach in the two directives and demonstrate equivalence to the overall level of safety in the Essential Safety Requirements (ESRs) of the PED, thereby allowing European Standards and EEC directives listed in this Technical Report to be used to fulfil the requirements of the PED, provided that their filling conditions fulfil the requirements of ADR/RID (P200, 4.1.4.1), in respect of portable fire extinguishers and breathing apparatus.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1964-1, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres — Part 1: Cylinders made from seamless steel with an  $R_m$  value of less than 1 100 MPa*

EN 1964-2, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres — Part 2: Cylinders made from seamless steel with an  $R_m$  value of 1 100 MPa and above*

EN 1964-3, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres — Part 3: Cylinders made of seamless stainless steel with an  $R_m$  value of less than 1 100 MPa*

EN 1975, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless aluminium and aluminium alloy gas cylinders of capacity from 0,5 litre up to 150 litre*

EN 12245, *Transportable gas cylinders — Fully wrapped composite cylinders*

EN 12257, *Transportable gas cylinders — Seamless, hoop wrapped composite cylinders*

EN 13322-1, *Transportable gas cylinders — Refillable welded steel gas cylinders — Design and construction — Part 1: Carbon steel*

prEN ISO 10286:2006, *Gas cylinders — Terminology (ISO/FDIS 10286: 2006)*

EN ISO 13769 Gas Cylinders, Stampmarking

## 3 Terms and definitions

For the purposes of this document the terms and definitions in prEN ISO 10286 apply.

## 4 Technical justification

### 4.1 General

The following standards, together with those referred to in the Bibliography, have been produced to support the essential requirements of the TPED.

- EN 1964-1, -2 and -3 for seamless steel cylinders;
- EN 1975 for seamless aluminium alloy cylinders;
- EN 12245 for fully wrapped, composite cylinders;
- EN 12257 for hoop wrapped, composite cylinders;
- EN 13322-1 for welded steel cylinders.

They have been adjudged by the experts to conform to the requirements of the TPED, the Regulations concerning the International Carriage of Dangerous Goods (RID) and the European Agreement on the International Carriage of Dangerous Goods by Road (ADR). Gas cylinders are manufactured using stock materials which are transformed to their final shape, then carefully heat treated and finally tested to well defined criteria. Hence the manufacture of gas cylinders follows a different approach from that of conventional pressure vessels. In the case of gas cylinders, the mechanical properties of the final product are significantly altered during the manufacturing process from those of the stock materials. Consequently the mechanical properties of the stock materials, guaranteed by material standards, are of little relevance.

### 4.2 Application

#### 4.2.1 General

It is proposed by this Technical Report that cylinders manufactured in accordance with the design and manufacturing standards quoted in 4.1 are suitable for the design and construction of seamless or welded portable fire extinguishers and breathing apparatus (see clause 1.1 (a) of Article 3, PED). The dimensions of these cylinders should reflect the limits in the various standards.

#### 4.2.2 Materials

##### a) Steels

Materials used in the steel cylinder design standards and EEC Directive 84/525 need to meet stringent mechanical properties. Hence their composition is defined according to a narrow specification, as is the manufacturing process e.g. non-ageing, non-rimming quality steel is stipulated. Additionally full materials' compatibility with the gas contained is an essential, normative requirement in gas cylinder manufacturing standards (EN ISO 11114-1 refers).

##### b) Aluminium alloys

Materials used in the aluminium alloy cylinder design standards and EEC Directive 84/526 are referred back to recognised and registered compositions within the International Aluminium Federation (IAF), for most commonly used materials. These materials and other permitted alloys shall meet stringent mechanical properties. Hence their composition is defined according to a narrow specification. Additionally full materials' compatibility with the gas contained is an essential, normative requirement in gas cylinder manufacturing standards (EN ISO 11114-1 refers).



## c) Composites

## — Liner materials

When steel or aluminium alloy is used, conditions in 4.2.2 a) and 4.2.2 b) above apply. In the case of non-metallic liners, the latter are non-load sharing but shall be both chemically compatible (EN ISO 11114-2 and EN ISO 11114-3, where applicable, refer) with the gas contained and be leak-tight. Additionally full materials' compatibility of the liner, with the gas contained is an essential, normative requirement in gas cylinder manufacturing standards (EN ISO 11114-1 refers).

## — Overwrap materials

These are closely specified by the manufacturer and subsequently verified, as required in the manufacturing/design standard, by various stringent tests on the starting materials and completed cylinders.

**4.2.3 Safety considerations****4.2.3.1 General**

The PED requires a proof test at the final assessment which will normally take the form of a hydrostatic pressure test at a pressure ( $PT$ ) at least equal, where appropriate, to the maximum allowable pressure ( $PS$ ) x 1,43. For gas cylinders this factor may be lower and depends on the gas used and the maximum expected allowable temperature,  $TS$ . However, in no case shall the maximum allowable pressure  $PS$  ever exceed  $PT$ . Furthermore in order to compensate for this possible lower ratio, gas cylinders produced and tested according to the standards listed in 4.1 are subjected to stringent experimental tests at various stages of their design and production.

One way of illustrating the pressure considerations of the two Directives (PED/TPED) is shown in Figure 1. Here it can be seen that the wall stress at maximum allowable pressure at maximum temperature for gas cylinders designed under TPED, does not exceed the maximum allowable stress as per the PED.

Figure 1 shows an example of the pressures relating to cylinders used for breathing apparatus applied in accordance with the PED and the TPED for a case where  $PT = 1,43 \times PS$ .

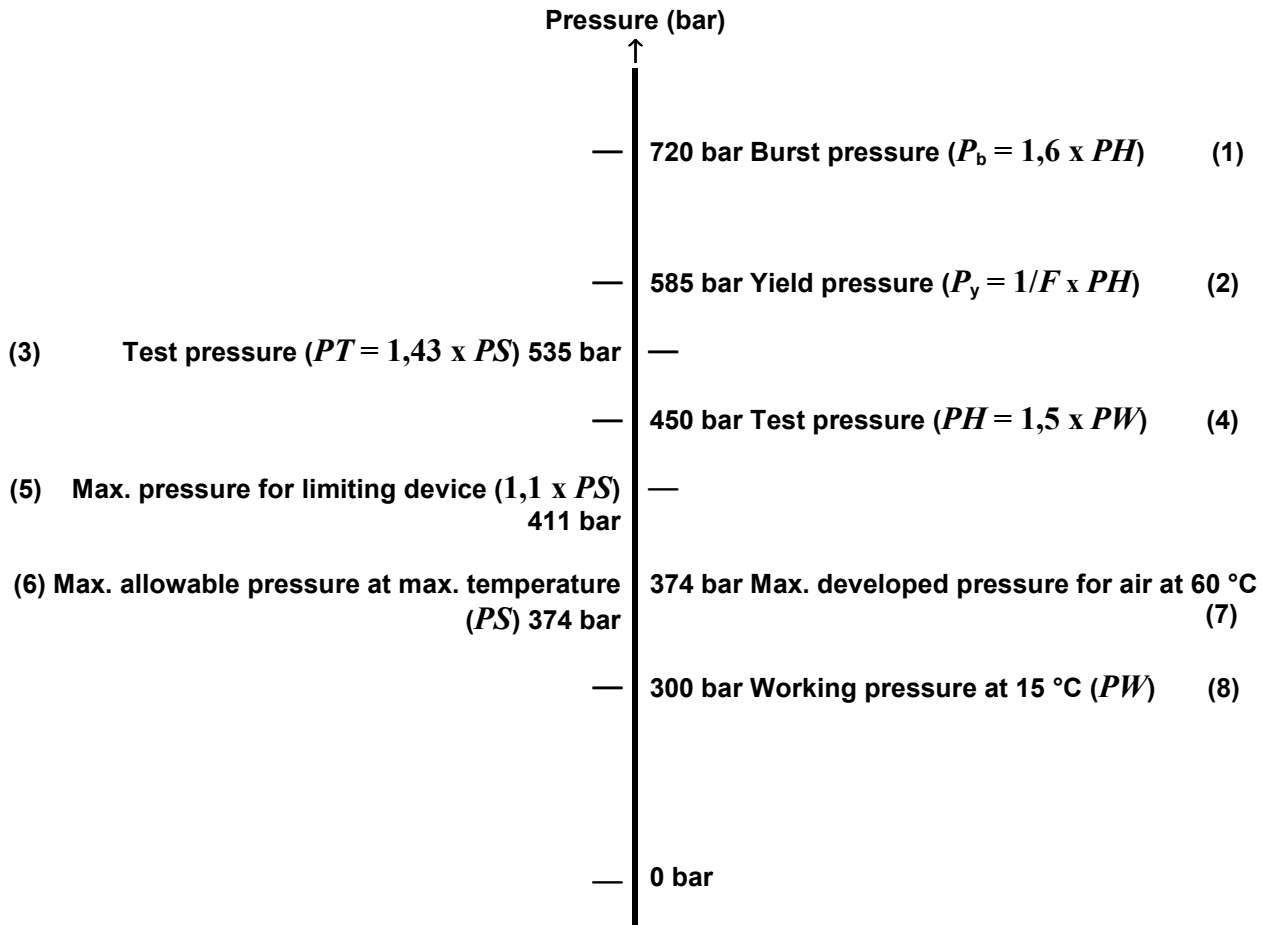
The only pressure they have in common is the maximum allowable pressure ( $PS$ ) at the maximum allowable temperature for the PED on the left and the maximum developed pressure at elevated temperature for the TPED on the right.

The PED requires a proof test at the final assessment which will normally take the form of a hydrostatic pressure test at a pressure ( $PT$ ) at least equal, where appropriate, to the maximum allowable pressure ( $PS$ ) multiplied by 1.43 i.e.  $PT \geq 1,43 \times PS$ .

TPED cylinders have a test pressure ( $PH$ ) based on the working pressure ( $PW$ ) at 15 °C, i.e.  $PH \geq 1,5 \times PW$ . Additionally TPED cylinders are required to pass the minimum yield pressure ( $Py$ ) and minimum burst pressure ( $P_b$ ) requirements.

If all these requirements are plotted together, as in Figure 1, it is evident that the maximum wall stress at test pressure for a TPED cylinder is 77% of yield stress which would result in a maximum wall stress at test pressure for an equivalently designed PED cylinder of less than 95% of yield stress.

This example thus proves that the safety factors for TPED cylinders are comparable with those of PED.



**Key**

- 1 Minimum burst pressure
- 2 Minimum yield pressure
- 3 Test pressure according to the PED (at which pressure the wall stress does not exceed 95% of yield stress)
- 4 Test pressure according to the TPED (this pressure is used for wall thickness calculation whereby the maximum wall stress does not exceed 77% of yield stress)
- 5 Opening pressure of pressure limiting device according to the PED
- 6 Maximum allowable pressure according to the PED (in the case of the example at 60 °C)
- 7 Maximum developed pressure at elevated temperature (in the case of the example at 60 °C)
- 8 Maximum working pressure at 15°C according to the TPED (ADR)

**Figure 1 — Schematic representation of an example of pressures for breathing apparatus cylinders**

**4.2.3.2 Experimental testing of a new design (at design stage)**

In addition to the conventional tests that PED vessels undergo, gas cylinders are subjected to type approval regimes including two main types of tests. These are Pressure cycling and Burst testing. Cylinders are required to withstand a considerable amount of pressure cycles, e.g. 12 000 cycles at test pressure for monolithic gas cylinders without any deformation, leakage or burst, for each design. Additionally, for each new design, cylinders are required to undergo burst tests and meet a value at least 60% higher than the test pressure (up to 100% in the case of some types of composite cylinder).

#### **4.2.3.3 Experimental testing of a batch**

To verify conformity to the design, for most cylinder geometries, cylinders from batches of 200 off or fewer are tested to ensure mechanical property conformity and burst characteristics. The mechanical properties are checked by tensile tests, bend tests and toughness tests. Burst test results have to meet the requirements in 4.2.3.2. For composites at least one cylinder per 1 000 is also cycle tested to confirm conformity to design.

#### **4.2.3.4 Experimental testing on individual cylinders**

Tests on every cylinder include a hydrostatic pressure test, visual and dimensional checks, and neck thread checks, as in the PED, but additionally each seamless cylinder is hardness tested to confirm conformance to heat-treatment and homogeneity requirements. Non-destructive examinations, e.g. ultrasonics, are performed on seamless steel cylinders and steel liners where necessary.

#### **4.2.3.5 Additional experimental testing**

For more advanced cylinder designs, the standards specify mandatory additional tests: e.g. flawed fatigue and flawed burst tests for high strength steel and aluminium alloy cylinders, sustained load cracking tests for all aluminium alloy cylinders, extreme temperature cycling/creep tests for composites etc.

#### **4.2.4 Design by experimental methods**

Some categories of cylinders are initially designed using finite element analysis models backed up by experimental trials. The detailed requirements from the various tests are accurately detailed within the standards listed in 4.1 and the Bibliography.

#### **4.2.5 Corrosion allowance**

No corrosion allowance is included in any of the standards supporting the TPED. It is expected that a management system exists within the various cylinder users to ensure that only dry cylinders are filled with dry gas. Checks are required at time of filling to ensure dryness, (EN 1919 and EN 1920 refer).

#### **4.3 Stamp marking**

Stamp marking of cylinders made in conformance with this TR, shall be in accordance with EN ISO 13769. In addition, a CE mark shall be applied to signify conformance to the PED.

## Bibliography

[1] Transportable pressure equipment:

99/36/EC, Council Directive 1999/36/EC of 29 April 1999 on transportable pressure equipment

84/525/EEC Council Directive of 17 September 1984 on the approximation of the laws of the Member States relating to seamless, steel gas cylinders

84/526/EEC Council Directive of 17 September 1984 on the approximation of the laws of the Member States relating to seamless, unalloyed aluminium and aluminium alloy gas cylinders

84/527/EEC Council Directive of 17 September 1984 on the approximation of the laws of Member States relating to welded, steel gas cylinders.

ADR European agreement on the International Carriage of Dangerous Goods by Road

RID Regulations concerning the International Carriage of Dangerous Goods by Rail

EN 1919 *Transportable gas cylinders — Cylinders for liquefied gases (excluding acetylene and LPG) — Inspection at time of filling*

EN 1920 *Transportable gas cylinders — Cylinders for compressed gases (excluding acetylene) — Inspection of cylinders at time of filling*

EN ISO 11114-1, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials*

EN ISO 11114-2, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 2: Non-metallic materials*

EN ISO 11114-3, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 3: Autogenous ignition test in oxygen atmosphere*

[2] Pressure equipment:

Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment.



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