

Transportable gas cylinders — Seamless, hoop-wrapped composite cylinders

The European Standard EN 12257:2002 has the status of a
British Standard

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National foreword

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The UK participation in its preparation was entrusted by Technical Committee PVE/3, Gas containers, to Subcommittee PVE/3/3, Transportable gas cylinders — Cylinder design, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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frettées composites

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Flaschen aus Verbundwerkstoffen

This European Standard was approved by CEN on 9 November 2001.

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Foreword

This document EN 12257:2002 has been prepared by Technical Committee CEN/TC 23 "Transportable gas cylinders", the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2002, and conflicting national standards shall be withdrawn at the latest by August 2002.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports the objectives of the framework Directives on Transport of Dangerous Goods.

This European Standard has been submitted for reference into the RID and/or the technical annexes of the ADR. Therefore in this context the standards listed in the normative references and covering basic requirements of the RID/ADR not addressed within the present standard are normative only when the standards themselves are referred to in the RID and/or the technical annexes of the ADR.

Annex A is normative and annex B is informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

The purpose of this standard is to provide a specification for the design, manufacture, inspection and testing of refillable transportable seamless, hoop wrapped composite cylinders.

The specifications given are based on knowledge of, and experience with, materials, design requirements, manufacturing processes and control during manufacture of cylinders in common use in the countries of the CEN members.

1 Scope

This European Standard specifies minimum requirements for the materials, design, construction, prototype testing and routine manufacturing inspections of composite gas cylinders with a water capacity up to and including 450 litres for compressed, liquefied and dissolved gases.

NOTE For the purposes of this standard, the word "cylinder" includes tubes up to 450 litres water capacity.

This standard is applicable to cylinders that comprise a seamless metal liner reinforced over a substantial part of the parallel length by wound composite fibres of glass, carbon, aramid, or wire.

This standard is not applicable to gas cylinders which are almost totally covered with fibres and commonly called "fully-wrapped" cylinders. For fully-wrapped composite cylinders see EN 12245.

NOTE The specification does not address the design, fitting and performance of removable protective sleeves. Where these are fitted they should be considered separately.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate place in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1089-1, *Transportable gas cylinders— Gas cylinder identification (excluding LPG) – Part 1: Stampmarking.*

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 of seamless steel with an R_m value of less than 1 100 MPa.*

prEN 1964-2, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders from 0,5 litres up to and including 150 litres — Part 2: Tensile strength (R_m max) $\geq$ 1 100 MPa.*

EN 1964-3, *Transportable gas cylinders — Specification for the design and construction of refillable transportable seamless steel gas cylinders of capacity from 0,5 litres up to 150 litres — Part 3: Stainless steel cylinders.*

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 l up to 150 l.*

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test (at ambient temperature)*

EN ISO 11114-1, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic Materials (ISO 11114-1:1997).*

EN ISO 11120, *Gas Cylinders — Refillable seamless steel tubes of water capacity between 150 l and 3000 l — Design, construction and testing (ISO 11120:1999).*

EN ISO 13341, *Transportable gas cylinders — Fitting of valves to gas cylinders (ISO 13341:1997).*

ASTM D 2290-92, *Test method for apparent tensile strength of ring or tubular plastics and reinforced plastics by split disk method.*

ASTM D 2291-83, *Fabrication of ring test specimens for glass-resin composites.*

ASTM D 2343-95, *Test method for tensile properties of glass fibre strands, yarns and rovings used in reinforced plastics.*

ASTM D 4018-93, *Test methods for tensile properties of continuous filament carbon and graphite fiber tows.*

3 Terms, definitions and symbols

For the purposes of this European Standard, the following terms, definitions and symbols apply.

3.1 Terms and definitions

3.1.1

ambient temperature

temperature of surroundings varying between 10 °C and 35 °C (for test purposes only)

3.1.2

autofrettage

pressure application procedure which strains the metal liner past its yield point sufficiently to cause permanent plastic deformation, and results in the liner having compressive stresses and the fibres having tensile stresses internally when at zero internal gauge pressure

3.1.3

batch, (of fibres, wires or components of the resin system)

homogeneous quantity of material, identified and certified as such by the supplier

3.1.4

batch, (of metallic liners)

quantity of liners of the same nominal diameter, thickness, length and design, made successively from the same material cast and subjected to the same heat treatment for the same length of time

3.1.5

batch, (of finished cylinders with liners)

quantity of up to 200 finished cylinders plus finished cylinders required for destructive testing, of the same nominal diameter, thickness, length and design. The batch may contain different batches of liners (providing the batches are nominally the same and have had the same treatments), fibres and matrix materials

3.1.6

burst pressure

highest pressure reached in a cylinder or liner during the relevant burst test

3.1.7

composite overwrap

fibres and matrix taken together as a combined unit, or wire reinforcement

3.1.8

exterior coating

layer of clear or pigmented material applied to the cylinder for protection or for cosmetic purposes

3.1.9**fibre or strand**

load-carrying part of the composite overwrap e.g. glass, aramid or carbon

3.1.10**hoop-wrapped cylinder**

cylinder with composite overwrap along the cylindrical portion of the liner which carries part of the circumferential stress

3.1.11**liner**

metallic cylinder that contains the gas and provides a substantial structural strength to the composite cylinder

3.1.12**matrix**

material which is used to bind and hold the fibres in place

3.1.13**rejected cylinder**

cylinder which in its present condition has not passed the test requirements

3.1.14**wire reinforcement**

load carrying overwrap, using a metallic wire (e.g. steel), that does not require a matrix

3.2 Symbols

- p_b actual burst pressure of composite cylinder, in bar¹⁾ above atmospheric pressure
- p_{bL} burst pressure of liner, in bar¹⁾ above atmospheric pressure
- p_{bmin} minimum burst pressure of composite cylinder obtained during design variant testing, in bar¹⁾ above atmospheric pressure
- p_h hydraulic test pressure of composite cylinder, in bar¹⁾ above atmospheric pressure

4 Design and manufacture**4.1 General**

4.1.1 A hoop-wrapped composite gas cylinder shall comprise the following parts:

- An internal metal liner, which carries the total longitudinal load and a substantial circumferential load; and either
 - a composite overwrap formed by layers of continuous fibres in a matrix; or
 - wire reinforcement.
- An optional exterior coating to provide external protection. When this is an integral part of the design it shall be permanent.

1) 1 bar = 10⁵ Pa = 0,1 MPa.

The cylinder can also include additional parts such as rings, bases, etc.

4.1.2 Cylinders shall be designed with one or two openings along the central axis only.

4.2 Liner

4.2.1 Liner materials

The liners shall be manufactured in accordance with the relevant sections of the following European standards:

- | | |
|-------------------------------------|--|
| a) seamless steel liners: | EN 1964-1 or prEN 1964-2 as appropriate; |
| b) seamless stainless steel liners: | EN 1964-3; |
| c) seamless aluminium alloy liners: | EN 1975; |
| d) steel tubes (i.e. >150 l): | EN ISO 11120. |

The relevant sections are: materials, thermal treatments, neck design, construction and workmanship, mechanical tests.

NOTE This excludes the design requirements, since these are specified by the manufacturer for the design of the composite cylinder. For liners with water capacity above 150 l manufactured of stainless steel or aluminium alloy the relevant sections of the appropriate standard also apply.

The liner material shall be compatible with the gases intended to be used as determined by EN ISO 11114-1.

4.2.2 Design drawing

A fully dimensioned drawing of the liner shall be supplied which includes the specification of the material and material properties. The following material properties shall be specified:

- minimum yield stress;
- minimum tensile strength;
- minimum elongation;
- minimum burst pressure;
- compatibility with the contained gas as determined by EN ISO 11114-1.

4.2.3 Design of ends (heads and bases)

The design of the ends shall be in accordance with the general requirements of the relevant cylinder standard (as identified in 4.2.1). In order to achieve satisfactory stress distribution, the liner wall thickness shall increase progressively in the transition zone between the cylindrical shell and the ends, particularly the base.

The external diameter and thickness of the formed neck end of the liner shall be designed to withstand the torque applied in fitting the valve to the cylinder, and the tests specified in Test No 12 (see 5.2.12) and Test No 13 (see 5.2.13).

4.2.4 Neck ring

When a neck ring is provided, it shall be of a material compatible with that of the cylinder, and shall be securely attached by a method appropriate to the liner material.

4.3 Composite overwrap

4.3.1 Materials

Material requirements for the fibre and the matrix, and for the wire where appropriate, shall be as specified by the cylinder manufacturer.

4.3.2 Winding

Appropriate procedures shall be defined for the winding and curing process to ensure good repeatability and traceability.

The following parameters shall be defined and monitored:

- percentages of the components of the matrix system and their batch numbers;
- the batch numbers of the fibres or wire used;
- the number of strands used;
- the winding tension per strand or wire, (if applicable);
- the winding speed(s);
- the winding angle and/or pitch for each layer;
- resin bath temperature range, (if applicable);
- the number of layers;
- the procedure used to obtain correct impregnation (e.g. wet winding or pre-impregnation);
- the polymerisation cycle;
- the polymerisation process (e.g., thermal cycle, ultrasonic, ultraviolet, or radiation).

For thermal polymerisation, the temperature and the length of the polymerisation cycle of the resin system shall be such that they do not affect the mechanical characteristics of the liner. In addition, tolerances for holding time and temperature at each stage shall be defined.

4.4 Finished cylinder

4.4.1 Design drawings

A fully dimensioned drawing of all parts that constitute the finished cylinder shall be supplied. The design drawing shall also include tolerances on all dimensions, including out-of-roundness, straightness, weight and water capacity.

The drawing shall include the specification of the material(s), the material properties and the reinforcement pattern. The specifications and the reinforcement patterns may be given in a technical specification enclosed with the drawing.

The test pressure, autofrettage pressure (if applicable) and minimum burst pressure for the design shall be specified. The minimum burst pressure shall be at least $1,67 \times$ test pressure (p_h).

Any special characteristics or special limitations (e.g. design life, underwater suitability and/or maximum fitting torque restrictions) shall also be stated.

4.4.2 Autofrettage

Internal pressurisation to autofrettage pressure of cylinders with metallic liners can be part of the manufacturing process; if so this operation shall be executed after polymerisation of the composite for thermosetting resins.

During the autofrettage operation, the following parameters shall be recorded:

- autofrettage pressure;
- length of application of this pressure.

If autofrettage is performed, a check shall be made that the procedure has been effectively performed on all cylinders (e.g. through measurement of autofrettage expansions or other equivalent methods).

4.4.3 Manufacturing requirements for the finished cylinder

The internal and external surfaces of the finished cylinder shall be free of defects which could adversely affect the safe working of the cylinder. In addition there shall be no visible foreign matter present inside the cylinder (e.g. resin, swarf or other debris).

5 Cylinder and material tests

5.1 General

This clause describes tests to be conducted on seamless, hoop-wrapped composite cylinders, cylinder liners and the materials used in manufacture of cylinders for prototype testing of new cylinder designs, design variant testing and batch acceptance tests. The tests listed may be required or optional, as identified in the schedule of testing and inspections in annex A.

No tests shall be performed with a removable protective sleeve fitted to the cylinder.

5.2 Test procedures and test requirements

5.2.1 Test No 1 - Composite material tests

Procedure:

Tests on the composite materials to establish their mechanical properties shall be carried out in accordance with the following procedures:

a) Tensile properties of fibres:

- | | |
|--------------------|------------------------------------|
| For glass, aramid: | - ASTM D 2290-92 and ASTM 2291-83; |
| | - ASTM D 2343-95; |
| For carbon: | - ASTM D 4018-93. |