BS EN 17339:2024

BSI Standards Publication

Transportable gas cylinders — Hoop wrapped and fully wrapped carbon composite cylinders and tubes for hydrogen

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National foreword

This British Standard is the UK implementation of EN 17339:2024. It supersedes BS EN 17339:2020, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PVE/3/3, Transportable Gas Containers - Cylinder Design, Construction and Testing at the Time of Manufacture.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Transportable gas cylinders - Hoop wrapped and fully wrapped carbon composite cylinders and tubes for hydrogen

Bouteilles à gaz transportables - Bouteilles et tubes frettés et entièrement bobinés en matériaux composites carbones pour l'hydrogène

Ortsbewegliche Gasflaschen - Vollumwickelte Flaschen und Großflaschen aus Kohlenstoff-Verbundwerkstoffen für Wasserstoff

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European foreword

This document (EN 17339:2024) 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of an identical text or by endorsement, at the latest by May 2025, and conflicting national standards shall be withdrawn at the latest by May 2025.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 17339:2020.

EN 17339:2024 includes the following significant technical changes with respect to EN 17339:2020: introduction of Type 2 cylinders (hoop wrapped cylinders).

This document has been submitted for reference in:

— the RID and

— the technical annexes of the ADR.

NOTE These regulations take precedence over any clause of this document. It is emphasized that RID/ADR are being revised regularly at intervals of two years which may lead to temporary non-compliances with the clauses of this document.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

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Introduction

The purpose of this document is to provide a specification for the design, manufacture, inspection and testing of refillable, transportable carbon fully wrapped composite cylinders and tubes filled with hydrogen and protected in a frame such as a bundle or a trailer.

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

For gas cylinders covered by RID/ADR, the maximum service pressure (maximum developed pressure at 65 °C) should not exceed the test pressure. Consequently, the safety factor applies to the test pressure since, whatever the gas, the maximum developed pressure (p_{max}) is, in any case, lower than or equal to the test pressure.

This document only covers compressed hydrogen (dedicated service), therefore, the safety factor is applied to the maximum developed pressure at 65 °C (p_{max}), which is the maximum accepted temperature by transport regulations.

Additionally, for assembly purposes, where the cylinders and tubes are transported with an inert gas at a limited pressure (e.g. no more than 30 bar) other than hydrogen, there may be special requirements, in the applicable regulation.

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1 Scope

This document specifies minimum requirements for the materials, design, construction, type testing and routine manufacturing inspections of composite gas cylinders and tubes for compressed hydrogen.

NOTE 1 Unless specified in the text, for the purposes of this document, the word “cylinder” includes tubes.

This document applies to:

— fully wrapped composite cylinders (Type 3 and Type 4);

— hoop wrapped cylinders (Type 2);

with carbon fibres, intended to be permanently mounted in a frame (e.g. bundle or trailer) with a test pressure of not less than 300 bar, with:

— non-metallic liners (Type 4) or seamless metallic liners (for Type 2 and Type 3);

— a maximum water capacity of 3 000 l;

— a maximum working pressure of 1 000 bar;

— the product of working pressure times water capacity (p × V) not exceeding 1 000 000 bar.l.

NOTE 2 A glass fibre protective layer is sometimes applied to the external surface of the cylinder.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 13807, *Transportable gas cylinders - Battery vehicles and multiple-element gas containers (MEGCs) - Design, manufacture, identification and testing*

EN ISO 75-1, *Plastics - Determination of temperature of deflection under load - Part 1: General test method (ISO 75-1)*

EN ISO 75-3, *Plastics - Determination of temperature of deflection under load - Part 3: High-strength thermosetting laminates (ISO 75-3)*

EN ISO 527-1, *Plastics - Determination of tensile properties - Part 1: General principles (ISO 527-1)*

EN ISO 527-2, *Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion plastics (ISO 527-2)*

EN ISO 1133-1, *Plastics - Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics - Part 1: Standard method (ISO 1133-1)*

EN ISO 1183 (all parts), *Plastics — Methods for determining the density of non-cellular plastics*

EN ISO 1628-3, *Plastics - Determination of the viscosity of polymers in dilute solution using capillary viscometers - Part 3: Polyethylenes and polypropylenes (ISO 1628-3)*

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EN ISO 2884-1, *Paints and varnishes - Determination of viscosity using rotational viscometers - Part 1: Absolute viscosity measurement with cone-plate measuring geometry at high shear rates (ISO 2884-1)*

EN ISO 3146, *Plastics - Determination of melting behaviour (melting temperature or melting range) of semi-crystalline polymers by capillary tube and polarizing-microscope methods (ISO 3146)*

EN ISO 7866, *Gas cylinders - Refillable seamless aluminium alloy gas cylinders - Design, construction and testing (ISO 7866)*

EN ISO 9809-1, *Gas cylinders - Design, construction and testing of refillable seamless steel gas cylinders and tubes - Part 1: Quenched and tempered steel cylinders and tubes with tensile strength less than 1 100 MPa (ISO 9809-1)*

EN ISO 9809-2, *Gas cylinders - Design, construction and testing of refillable seamless steel gas cylinders and tubes - Part 2: Quenched and tempered steel cylinders and tubes with tensile strength greater than or equal to 1 100 MPa (ISO 9809-2)*

EN ISO 9809-4, *Gas cylinders - Design, construction and testing of refillable seamless steel gas cylinders and tubes - Part 4: Stainless steel cylinders with an Rm value of less than 1 100 MPa (ISO 9809-4)*

EN ISO 10961, *Gas cylinders - Cylinder bundles - Design, manufacture, testing and inspection (ISO 10961)*

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

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

EN ISO 11114-4, *Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents - Part 4: Test methods for selecting steels resistant to hydrogen embrittlement (ISO 11114-4)*

EN ISO 11120, *Gas cylinders - Refillable seamless steel tubes of water capacity between 150 l and 3000 l - Design, construction and testing (ISO 11120)*

EN ISO 13341, *Gas cylinders - Fitting of valves to gas cylinders (ISO 13341)*

EN ISO 13769, *Gas cylinders - Stamp marking (ISO 13769)*

EN ISO 14130, *Fibre-reinforced plastic composites - Determination of apparent interlaminar shear strength by short-beam method (ISO 14130)*

ISO 6721-11, *Plastics — Determination of dynamic mechanical properties — Part 11: Glass transition temperature*

ISO 10618, *Carbon fibre — Determination of tensile properties of resin-impregnated yarn*

ASTM D 2196-10, *Test methods for rheological properties of non-newtonian materials by rotational (Brookfield) viscometer*

ASTM D 2344/D 2344M-13, *Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates*

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ASTM D 4018-11, *Test methods for properties of continuous filament carbon and graphite fibre tows*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp/

— IEC Electropedia: available at https://www.electropedia.org/

3.1
ambient temperature
temperature of surroundings varying between 0 °C and 35 °C (for test purposes only)

3.2
autofrettage
pressure application procedure which strains the metal liner past its yield strength sufficient to cause permanent plastic deformation, and results in the liner having compressive stresses and the fibres having tensile stresses when at zero internal gauge pressure

[SOURCE: EN ISO 10286:2021, 3.3.4]

3.3
batch
<of fibres, pre-impregnated fibres or components of the matrix system> homogeneous quantity of material, identified and certified as such by the supplier

3.4
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

3.5
batch
<of non-metallic liners> quantity of liners of the same nominal diameter, thickness, length and design, made successively from the same batch of materials and subjected to the same manufacturing process

3.6
batch
<of finished cylinders with liners> quantity of up to 200 finished cylinders, plus cylinders for destructive testing, of the same nominal diameter, thickness, length and design which may contain different batches of liners (providing the batches are nominally the same and have had the same treatments), fibres and matrix materials

3.7
burst pressure
highest pressure reached in a cylinder or liner during a burst test

[SOURCE: EN ISO 10286:2021, 3.5.26, modified — “or liner” has been added.]

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3.8
composite overwrap
combination of fibres and matrix

3.9
elastomer
material which at ambient temperature can be stretched repeatedly to at least twice its original length and will return with force to approximately its original length immediately upon release of the stress

3.10
external coating
layer of clear or pigmented material applied to the cylinder as protection or for cosmetic purposes

3.11
liner
inner portion of a composite cylinder, whose purpose is both to contain the gas and transmit the gas pressure to the composite overwrap

Note 1 to entry: It can be metallic or non-metallic, load sharing or non-load sharing

[SOURCE: EN ISO 10286:2021, 3.1.3.3 modified — "comprising a metallic or non-metallic vessel" has been removed and Note 1 to entry has been added.]

3.12
matrix
material that is used to bind and hold the fibres in place

[SOURCE: EN ISO 10286:2021, 3.1.3.2]

3.13
non-load sharing liner
liner that contributes less than 5 % of the load bearing of the overall cylinder design at nominal burst pressure of the finished composite cylinder

Note 1 to entry: In this document, a non-load sharing liner is assumed to be a non-metallic one.

3.14
non-metallic liner
liner made from thermoplastic, thermosetting or elastomer material

Note 1 to entry: In this document, a non-metallic liner is assumed to be a non-load sharing one.

3.15
thermoplastic
plastics capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature

3.16
thermoset
plastics which, when cured by the application of heat or chemical means, change into a substantially infusible and insoluble product

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3.17
test pressure
required pressure applied during a pressure test

[SOURCE: EN ISO 10286:2021, 3.5.24]

3.18
working pressure
settled pressure of a compressed gas at a uniform reference temperature of 15 °C in a full gas cylinder

[SOURCE: EN ISO 10286:2021, 3.5.30]

4 Symbols

p_b actual burst pressure of composite cylinder, in bar above atmospheric pressure (1 bar = 10^5 Pa = 0,1 MPa.)

p_{bL} burst pressure of liner, in bar above atmospheric pressure (1 bar = 10^5 Pa = 0,1 MPa.)

p_{bmin} minimum burst pressure of composite cylinder obtained during design variant approval testing, in bar above atmospheric pressure

p_h hydraulic test pressure of composite cylinder, in bar above atmospheric pressure, p_h is equal to 1,5 × p_w (1 bar = 10^5 Pa = 0,1 MPa.)

p_{max} maximum developed pressure at 65 °C, in bar above atmospheric pressure. It is assumed in this document to be equal to 1,18 × p_w (1 bar = 10^5 Pa = 0,1 MPa.)

p_w working pressure

5 Design and manufacture

5.1 General requirements

A hoop wrapped composite gas cylinder is manufactured with a metallic liner.

A fully wrapped composite gas cylinder may be manufactured with a metallic or non-metallic liner. An optional external coating or fibre layers may be used to provide external protection and when this is an integral part of the design, it shall be permanent.

The cylinder may also include additional parts (e.g. neck rings and foot rings).

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

The cylinders covered by this document shall be permanently mounted in a bundle according to EN ISO 10961 or a trailer/MEGCs according to EN 13807.

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5.2 Liner

5.2.1 Metallic liner

Metallic liners shall be manufactured in accordance with the relevant sections of:

	Type of metallic liner	Related Standard
a)	seamless steel liners:	EN ISO 9809-1, EN ISO 9809-2 or EN ISO 11120, as appropriate;
b)	seamless stainless steel liners:	EN ISO 9809-4;
c)	seamless aluminium alloy liners:	EN ISO 7866

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

The liner material shall be compatible with hydrogen as determined by EN ISO 11114-1 and EN ISO 11114-4.

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.

5.2.2 Non-metallic liners

A cylinder with a non-metallic liner shall be designed as if the liner will be non-load sharing. The liner material shall be compatible with hydrogen as determined by EN ISO 11114-2 or demonstrated by suitable testing.

Where a metal end boss is used in a non-metallic liner, it shall be considered part of the liner material and shall fulfil the material requirements specified in the relevant standard, as listed in 5.2.1. Other materials are acceptable if hydrogen compatibility is demonstrated by testing according to EN ISO 11114-4 or if it is accepted by design standards (e.g. EN ISO 7866).

The drawing of the liner shall include the specification of the material and material properties of the boss. The following material properties of the boss shall be specified in the design:

— minimum yield stress;

— minimum tensile strength;

— minimum elongation;

— compatibility with hydrogen as determined by EN ISO 11114-1.

The metal end boss bearing the cylinder thread shall be designed to withstand the torque applied in fitting the valve to the cylinder and the tests specified in Test 13 (for taper threads only, see 6.2.13) and Test 14 (see 6.2.14).

5.2.3 Design drawing

A fully dimensioned drawing of the liner shall be supplied which includes the specification of the material and material properties. Material and liner properties to be specified on the drawing are:

a) for metallic liners:

— minimum yield stress;

— minimum tensile strength;

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— minimum elongation;

— minimum burst pressure;

— compatibility with hydrogen as determined by EN ISO 11114-1.

b) for non-metallic liners:

— density;

— melting point, as determined by:

— EN ISO 3146 for thermoplastics; or

— EN ISO 75-1 and EN ISO 75-3 for thermoset materials;

— glass transition temperature as determined by differential scanning calorimetry;

— composition;

— compatibility with hydrogen as specified by EN ISO 11114-2 or demonstrated by suitable testing;

— end boss design in accordance with 5.2.2.

5.2.4 Design of ends

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 13 (for taper threads only, see 6.2.13) and Test 14 (see 6.2.14).

5.2.5 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 an appropriate method to the liner (or cylinder for cylinders without liner) or boss material.

5.3 Composite overwrap

5.3.1 Materials

Material requirements for the fibre and matrix or the pre-impregnated material shall be as specified by the cylinder manufacturer.

5.3.2 Winding

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

Parameters to be specified, monitored and/or recorded, as applicable, are:

a) composite overwrap component percentages;

b) batch numbers of the material used as defined in 3.3 to 3.6;

c) number of strands used;

d) winding tension per strand (if applicable);

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e) winding speed(s);

f) winding angle and/or pitch for each layer;

g) resin bath temperature range (if applicable);

h) temperature of the strand before consolidation (if applicable);

i) number and order of layers;

j) procedure used to obtain correct impregnation (e.g. wet winding or pre-impregnation);

k) polymerisation cycle (if applicable);

l) polymerisation process (e.g. thermal cycling, 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 adversely affect the mechanical characteristics of the liner. In addition, tolerances for holding time and temperature at each stage shall be defined.

5.4 Finished cylinder

5.4.1 Design drawings

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

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 details of a permanently applied external coating, if it is an integral part of the design, shall be specified.

The test pressure, autofrettage pressure (if applicable) and minimum burst pressure for the design shall be specified.

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

5.4.2 Autofrettage

Internal pressurization 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 or after the consolidation process for thermoplastics.

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

a) autofrettage pressure;

b) length of application of the autofrettage pressure;

c) expansion at autofrettage pressure;

d) permanent expansion after autofrettage.

If autofrettage is used, a check shall be made on all cylinders that the procedure has been effectively performed.

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5.4.3 Manufacturing requirements for the finished cylinder

The internal and external surfaces of the finished cylinder shall be free of defects which can 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).

NOTE EN ISO 9809-1, EN ISO 9809-2, EN ISO 9809-3 and EN ISO 7866 provide guidelines on possible defects in metallic liners. For composite cylinders, EN ISO 11623 contains information on possible defects.

6 Cylinder and material tests

6.1 General

This clause specifies tests to be conducted on cylinders, cylinder liners and the materials used in manufacture of cylinders for type testing of new cylinder designs, design variant testing and production testing. The tests listed can 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.

Precautions should be taken to avoid blistering and collapse, manufacturers's instructions should provide guidelines in order to do so.

6.2 Requirements and test methods

6.2.1 Test 1 – Composite material tests, including adhesives (where applicable)

6.2.1.1 Procedure

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

a) carbon fibre tensile properties: ISO 10618 or ASTM D 4018-11;

b) shear properties: EN ISO 14130 or ASTM D 2344/D 2344M-13;

c) matrix properties:

   1) glass transition temperature: ISO 6721-11;

   2) heat distortion temperature: EN ISO 75-3;

   3) viscosity: EN ISO 1628-3 for thermoplastics; EN ISO 2884-1 or ASTM D 2196-10 for thermosets.

The glass transition temperature (Tg) shall be at least 85 °C. Tg shall be verified during type test.

Equivalent tests in accordance with alternative standards or test specifications may be applied.

6.2.1.2 Criteria

The mechanical properties shall meet the minimum requirements for the design as specified by the cylinder manufacturer.

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