SLOVENSKI STANDARD
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Premične plinske jeklenke - Popolnoma obvite jeklenke in velike jeklenke za vodik iz kompozitnih materialov

Transportable gas cylinders – Fully wrapped carbon composite cylinders and tubes for hydrogen use

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

Bouteilles à gaz transportables - Bouteilles et tubes composites entièrement bobinés en fibre de carbone pour l'hydrogène

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (prEN 17339:2018) has been prepared by Technical Committee CEN/TC 23 “Transportable gas cylinders”, the secretariat of which is held by BSI.

This document is currently submitted to the CEN Enquiry.

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 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 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 the test pressure.

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

1 Scope

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

This document applies only to fully wrapped composite cylinders 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.

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

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 12862, *Transportable gas cylinders - Specification for the design and construction of refillable transportable welded aluminium alloy gas cylinders*

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

EN 13322-2, *Transportable gas cylinders - Reffilable welded steel gas cylinders - Design and construction - Part 2: Stainless steel*

EN 13807, *Transportable gas cylinders - Battery vehicles and multiple-element gas containers (MEGCs) - Design, manufacture, identification and testing*

EN 14638-1, *Transportable gas cylinders - Refillable welded receptacles of a capacity not exceeding 150 litres - Part 1: Welded austenitic stainless steel cylinders made to a design justified by experimental methods*

EN 14638-3, *Transportable gas cylinders - Refillable welded receptacles of a capacity not exceeding 150 litres - Part 3: Welded carbon steel cylinders made to a design justified by experimental methods*

EN ISO 75-1, *Plastics - Determination of temperature of deflection under load - Part 1: General test method (ISO 75-1:2013)*

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

EN ISO 175, *Plastics - Methods of test for the determination of the effects of immersion in liquid chemicals (ISO 175)*

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 of determining the density and relative 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)*

EN ISO 2884-1, *Paints and varnishes - Determination of viscosity using rotary viscometers - Part 1: Cone-and-plate viscometer operated at a high rate of shear (ISO 2884-1)*

EN ISO 3341, *Textile glass — Yarns — Determination of breaking force and breaking elongation*

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

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

EN ISO 9809-3, *Gas cylinders - Refillable seamless steel gas cylinders - Design, construction and testing - Part 3: Normalized steel cylinders (ISO 9809-3)*

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)*

EN ISO 15512, *Plastics - Determination of water content (ISO 15512)*

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*

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 terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
ambient temperature
temperature of surroundings varying between 10 °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 10286:2014, definition 557]

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 can contain different batches of liners

(providing the batches are nominally the same and have had the same treatments), fibres and matrix materials

3.7
batch (of finished cylinders with no liners)
production quantity of up to 200 finished cylinders, plus cylinders for destructive testing, of the same nominal diameter, thickness, length and design

3.8
burst pressure
highest pressure reached in a cylinder or liner during a burst test

3.9
composite overwrap
combination of fibres and matrix

3.10
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

3.11
exterior coating
layer of clear or pigmented material applied to the cylinder as protection or for cosmetic purposes

3.12
fully wrapped cylinder
cylinder reinforced by wrapping to take both circumferential and longitudinal stress

3.13
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 10286:2014, definition 246]

3.14
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

3.15
non-metallic liner
liner made from thermoplastic, thermosetting or elastomer material

3.16
cylinder without liner
cylinder having no liner and consisting wholly of the composite winding

3.17
matrix
material that is used to bind and hold the fibres in place

[SOURCE: EN ISO 10286:2014, definition 245]

3.18
thermoplastic
plastics capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature

3.19
thermoset
plastics which, when cured by the application of heat or chemical means, change into a substantially infusible and insoluble product

3.20
working pressure
settled pressure of a compressed gas at a uniform reference temperature of 15 °C in a full gas cylinder

[SOURCE: EN ISO 10286:2014, definition 736]

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 [1)] above atmospheric pressure
p_{bmin}	minimum burst pressure of composite cylinder obtained during design variant approval testing, in bar [1)] above atmospheric pressure
p_h	hydraulic test pressure of composite cylinder, in bar [1)] above atmospheric pressure
p_{max}	maximum developed pressure at 65 °C, in bar [1)] above atmospheric pressure. It is assumed in this document to be equal to 1,25 x working pressure

5 Design and manufacture

5.1 General requirements

A fully wrapped composite gas cylinder may be manufactured with a metallic or non-metallic liner or without a liner. An optional exterior coating or fibre layers may be used to provide external protection and when this is an integral part of the design shall be permanent.

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

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.

For the cylinders covered by this document, the product of working pressure times water capacity (p x V) should not exceed 1 000 000 bar l. For higher (p x V), up to a maximum of 3 000 000 bar l, a risk assessment, using a recognized method, involving manufacturers of the cylinders and the trailer or bundle as applicable, with suitable inputs from the user shall be performed.

5.2 Liner

5.2.1 Metallic liners

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

a)	seamless steel liners:	EN ISO 9809-1 or EN ISO 9809-2, as appropriate;
b)	seamless stainless steel liners:	EN ISO 9809-3;
c)	seamless aluminium alloy liners:	EN ISO 7866;
d)	welded steel liners:	EN 13322-1 or EN 14638-3, as appropriate;
e)	welded stainless steel liners:	EN 13322-2 or EN 14638-1, as appropriate;
f)	welded aluminium liners:	EN 12862;
g)	steel tubes (i.e. > 150 l):	EN ISO 11120.

The relevant sections are those covering materials, thermal treatments, neck design, construction and workmanship and 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, aluminium or welded steel, 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 and EN ISO 11114-4.

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 the gases intended to be used as determined by EN ISO 11114-2.

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.

The drawing of the liner shall include the specification of the material and material properties of the boss. Important material properties shall be specified in the design and are those such as:

a) minimum yield stress;

b) minimum tensile strength;

c) minimum elongation of the boss material;

d) compatibility with the contained gas 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 14 (see 6.2.14) and Test 15 (see 6.2.15).

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:

   1) minimum yield stress;

   2) minimum tensile strength;

   3) minimum elongation;

   4) minimum burst pressure;

   5) compatibility with the contained gas as determined by EN ISO 11114-1.

b) for non-metallic liners:

   1) density;

   2) melting point, as determined by:

      i) EN ISO 3146 for thermoplastics; or

      ii) EN ISO 75-1 and EN ISO 75-3 for thermoset materials;

   3) glass transition temperature as determined by differential scanning calorimetry;

   4) composition;

   5) compatibility with the contained gas as determined by EN ISO 11114-2;

   6) 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 14 (see 6.2.14) and Test 15 (see 6.2.15).

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 a method appropriate 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 manufacturer.