SLOVENSKI STANDARD
SIST EN 17533:2020

01-september-2020

Plinasti vodik - Jeklenke in velike jeklenke za stacionarno shranjevanje

Gaseous hydrogen - Cylinders and tubes for stationary storage

Gasförmiger Wasserstoff - Flaschen und Großflaschen zur ortsfesten Lagerung

Hydrogène gazeux - Bouteilles et tubes pour stockage stationnaire

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Ta slovenski standard je istoveten z: **EN 17533:2020**

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ICS:

23.020.35	Plinske jeklenke	Gas cylinders
71.100.20	Industrijski plini	Gases for industrial application

SIST EN 17533:2020 **en,fr,de**

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 17533

June 2020

ICS 23.020.30; 71.100.20

English Version

Gaseous hydrogen - Cylinders and tubes for stationary storage

Hydrogène gazeux - Bouteilles et tubes pour stockage stationnaire

Gasförmiger Wasserstoff - Flaschen und Großflaschen zur ortsfesten Lagerung

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European foreword

This document (EN 17533:2020) 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of an identical text or by endorsement, at the latest by December 2020, and conflicting national standards shall be withdrawn at the latest by December 2020.

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.

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Introduction

As the use of gaseous hydrogen evolves from the chemical industry into various emerging applications, such as fuel for fuel cells, internal combustion engines and other speciality hydrogen applications, new requirements are foreseen for seamless and composite pressure vessels, including higher number of pressure cycles.

Requirements covering pressure vessels for stationary storage of compressed gaseous hydrogen are listed in this document and are mainly intended to maintain or improve the level of safety for this application.

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1 Scope

This document specifies the requirements for the design, manufacture and testing of standalone or manifolded (for some specific tests such as bonfire) cylinders, tubes and other pressure vessels of steel, stainless steel, aluminium alloys or of non-metallic construction material. These are intended for the stationary storage of gaseous hydrogen of up to a maximum water capacity of 10 000 l and a maximum allowable working pressure not exceeding 110 MPa, of seamless metallic construction (Type 1) or of composite construction (Types 2, 3 and 4), hereafter referred to as pressure vessels.

This document is not applicable to Type 2 and 3 vessels with welded liners.

This document is not applicable to pressure vessels used for solid, liquid hydrogen or hybrid cryogenic-high pressure hydrogen storage applications.

This document is not applicable to external piping which can be designed according to recognized standards.

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 ISO 306, *Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST)*

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

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EN ISO 1519, *Paints and varnishes — Bend test (cylindrical mandrel)*

EN ISO 2808, *Paints and varnishes — Determination of film thickness*

EN ISO 2812-1, *Paints and varnishes — Determination of resistance to liquids — Part 1: Immersion in liquids other than water*

EN ISO 4624, *Paints and varnishes — Pull-off test for adhesion*

EN ISO 6272-2, *Paints and varnishes — Rapid-deformation (impact resistance) tests — Part 2: Falling-weight test, small-area indenter*

EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

EN ISO 7225, *Gas cylinders — Precautionary labels*

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

EN ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

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*

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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*

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

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

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

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

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 11119-1, *Gas cylinders — Refillable composite gas cylinders and tubes — Design, construction and testing — Part 1: Hoop wrapped fibre reinforced composite gas cylinders and tubes up to 450 l*

ISO 11119-2, *Gas cylinders — Refillable composite gas cylinders and tubes — Design, construction and testing — Part 2: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 l with load-sharing metal liners*

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ISO 11119-3, *Gas cylinders — Refillable composite gas cylinders and tubes — Design, construction and testing — Part 3: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450L with non-load-sharing metallic or non-metallic liners*

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

EN ISO 11357-2, *Plastics — Differential scanning calorimetry (DSC) — Part 2: Determination of glass transition temperature*

EN ISO 11439, *Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles*

ISO 12108, *Metallic materials — Fatigue testing — Fatigue crack growth method*

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

EN ISO 16474-1, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 1: General guidance*

EN ISO 16474-3, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*

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

ASTM D3170/D3170M - 14, *Standard Test Method for Chipping Resistance of Coatings*

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ASTM E647, *Standard Test Method for Measurement of Fatigue Crack Growth Rates*

3 Terms, definitions and symbols

3.1 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:

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

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

3.1.1
autofrettage
pressure application procedure which strains the metal *liner* (3.1.13) past its yield point sufficiently to cause permanent plastic deformation, resulting in the liner having compressive stresses and the fibres having tensile stresses when at zero internal gauge pressure

3.1.2
autofrettage pressure
pressure within the overwrapped composite pressure vessel at which the required distribution of stresses between the *liner* (3.1.13) and the *composite overwrap* (3.1.6) is established

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3.1.3
batch of pressure vessels
batch of pressure liners
set of manufactured *finished pressure vessels* (3.1.10) or *liners* (3.1.13) subject to a manufacturing quality pass/fail criterion based on the results of specified tests performed on a specified number of units from that set

3.1.4
boss
dome shaped metallic component mounted on one end or on the two ends of a non-metallic *liner* (3.1.13) with a neck providing an opening and/or an external element of mechanical support

3.1.5
burst pressure
highest pressure reached in a cylinder during a burst test

3.1.6
composite overwrap
combination of fibres (including steel wire) and *matrix* (3.1.15)

3.1.7
controlled tension winding
process used in manufacturing composite pressure vessels with metal *liners* (3.1.13) by which compressive stresses in the liner and tensile stresses in the *composite overwrap* (3.1.6) at zero internal pressure are obtained by winding the reinforcing fibres under controlled tension

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3.1.8
cycle amplitude
ratio of pressure increase to maximum pressure in a *pressure cycle* (3.1.21)

Note 1 to entry: Cycle amplitude is expressed in %.

3.1.9
design change
change in the selection of structural materials or dimensional change exceeding the tolerances as on the design drawings

3.1.10
finished pressure vessel
pressure vessel, which is ready for use, typical of normal production, complete with identification marks and external coating including integral insulation specified by the manufacturer, but free from non-integral insulation or protection

Note 1 to entry: In the framework of this document, a tube or a cylinder is a finished pressure vessel.

3.1.11
full cycle
cycle of pressure amplitude between the *maximum allowable working pressure (MAWP)* (3.1.17) and 10 % of the MAWP

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3.1.12
leakage
release of hydrogen through a crack, pore, or similar defect

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Note 1 to entry: Permeation through the wall of a Type 4 pressure vessel that is less than the rates described in A.13 is not considered a leakage.

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3.1.13
liner
inner portion of the composite cylinder, comprising a metallic or non-metallic vessel, whose purpose is both to contain the gas and transmit the gas pressure to the fibres

3.1.14
load-sharing liner
liner (3.1.13) that has a *burst pressure* (3.1.5) of at least 5 % of the minimum burst pressure of the finished composite cylinder

3.1.15
matrix
material that is used to bind and hold the fibres in place

3.1.16
maximum allowable temperature
maximum temperature of any part of the pressure vessel for which it is designed (or intended to be used if Annex B is followed)

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3.1.17
maximum allowable working pressure
MAWP
design pressure
maximum pressure to which the component is designed to be subjected to and which is the basis for determining the strength of the component under consideration

3.1.18
minimum allowable temperature
minimum temperature of any part of the pressure vessel for which it is designed (or intended to be used if Annex B is followed)

3.1.19
operator
entity legally responsible for the use and maintenance of the vessel

3.1.20
pressure-activated pressure relief device
pressure-activated PRD
device designed to release pressure in order to prevent a rise in pressure above a specified value due to emergency or abnormal conditions

Note 1 to entry: Pressure-activated PRDs may be either re-closing devices (such as valves) or non-re-closing devices (such as rupture disks).

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3.1.21
pressure cycle
pressure variation composed of one period of monotonic pressure increase up to a peak pressure followed by one period of monotonic pressure decrease

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Note 1 to entry: Pressure variations exclusively due to variations of ambient temperature are not counted as pressure cycles.

3.1.22
pressure cycle life
maximum number of *pressure cycles* (3.1.21) in hydrogen service that the pressure vessel is designed to withstand in service

3.1.23
pre-stress
process of applying *autofrettage* (3.1.1) or *controlled tension winding* (3.1.7)

3.1.24
service life
maximum period for which the pressure vessel is designed to be in service based on fatigue life and stress rupture characteristics of composite cylinders

Note 1 to entry: Service life is expressed in years.

Note 2 to entry: Service life usually depends on the *pressure cycle* (3.1.21) or other service conditions and requirements from applicable standards. For composite cylinders, life in years is a requirement to address reliability under stress rupture conditions, which is also an underlying basis for the required *stress ratios* (3.1.29).

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3.1.25
shallow pressure cycle
pressure cycle (3.1.21) from the *MAWP* (3.1.17) to not less than 70 % of the MAWP

3.1.26
shallow pressure cycle life
maximum number of *shallow pressure cycles* (3.1.25) that the pressure vessel is designed to withstand in hydrogen service

3.1.27
stationary storage
pressurized storage in a fixed location for a fixed purpose that is not transported while pressurized

3.1.28
stationary test pressure
TP
required pressure applied during a pressure test for the pressure vessel used in stationary service

Note 1 to entry: If Annex B is used, this is not to be confused with the *test pressure* (3.1.30) P_h used in e.g. the EN ISO 9809 series for design purposes as transportable gas cylinder.

3.1.29
stress ratio
stress in fibre at specified minimum *burst pressure* (3.1.5) divided by stress at the *MAWP* (3.1.17)

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3.1.30
test pressure
required pressure applied during a pressure test

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3.1.31
thermally activated pressure relief device
thermally activated PRD
device that activates by temperature to release pressure and prevent a pressure vessel from bursting due to fire effects and which will activate regardless of the vessel pressure

3.1.32
thermoplastic material
plastic capable of being repeatedly softened by an increase of temperature and hardened by a decrease of temperature

3.1.33
Type 1 pressure vessel
metal seamless cylindrical pressure vessel

Note 1 to entry: All metal multi-layered non-seamless vessels are not covered in this document. For reference, several types of multi-layered pressure vessels are addressed by ASME BPVC Section VII and Chinese standards GB 150 and GB/T 26466.

3.1.34
Type 2 pressure vessel
hoop wrapped cylindrical pressure vessel with a load-sharing metal *liner* (3.1.13) and composite reinforcement on the cylindrical part only

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3.1.35
Type 3 pressure vessel
fully wrapped cylindrical pressure vessel with a load-sharing metal *liner* (3.1.13) and composite reinforcement on both the cylindrical part and dome ends

3.1.36
Type 4 pressure vessel
fully wrapped cylindrical pressure vessel with a *non-load-sharing liner* (3.1.37) and composite reinforcement on both the cylindrical part and the dome ends

3.1.37
non-load-sharing liner
liner (3.1.13) that has a *burst pressure* (3.1.5) less than 5 % of the nominal burst pressure of the finished composite cylinder

3.1.38
working pressure
settled pressure of a fully filled cylinder at a uniform temperature of 15 °C

Note 1 to entry: This term is normally used for transportable cylinders, see Annex B.

[SOURCE: ISO 11439:2013, 3.23, modified — Note 1 to entry has been added.]

3.2 Symbols

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ΔP_i	variation of pressure during a given actual pressure cycle (in bar)
ΔP_{max}	variation of pressure during the pressure test specified in the reference standard (in bar)
F	design stress factor (ratio of equivalent wall stress at test pressure P_h to guarantee minimum yield strength)
F_a	hydrogen accelerating factor (see B.2.2.6), this factor is the multiplication factor to be applied on equivalent cycles n_{eq} calculation to take into account the ageing effect of H2 on cycling.
n_{eq}	number of cycles equivalent to full cycles (guaranteed in a given standard)
n_i	number of pressure cycle corresponding to ΔP_i
P_h	test pressure (in bar)
P_w	working pressure (in bar)
a	flaw size
N	number of pressure cycles
da/dN	crack growth rate, da/dN_{low} and da/dN_{high} are given in Table 5
C	constant, see Table 5
m	constant, see Table 5
C_H	constant when fatigue is performed in hydrogen
ΔK	range of the stress intensity factor during the fatigue cycle
ΔK_c	range of the stress intensity factor at which transition in the da/dN from low to high occurs