SLOVENSKI STANDARD
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Premiļne plinske jeklenke - Specifikacije za zasnovo in izdelavo ponovno polnljivih jeklenk iz celega iz jekla z vodno prostornino med 0,5 in vkljuļno 150 litri - 1. del: Jeklenke iz celega iz jekla z Rm manj kot 1100 Mpa

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 Rm value of less than 1100 MPa

Ortsbewegliche Gasflaschen - Gestaltung und Konstruktion von nahtlosen wiederbefüllbaren ortsbeweglichen Gasflaschen aus Stahl mit einem Fassungsraum von 0,5 Liter bis einschließlich 150 Liter - Teil 1: Nahtlose Flaschen aus Stahl mit einem Rm-Wert bis zu 1100 MPa

Bouteilles a gaz transportables - Spécifications pour la conception et la fabrication de bouteilles a gaz rechargeables et transportables, de capacité en eau comprise entre 0,5 litre et 150 litres inclus - Partie 1: Bouteilles en acier sans soudure ayant une valeur de Rm inférieure a 1100 MPa

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EUROPEAN STANDARD
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English version

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This European Standard was approved by CEN on 13 December 1998.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

Contents

Foreword

This European Standard 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of an identical text or by endorsement, at the latest by July 1999, and conflicting national standards shall be withdrawn at the latest by July 1999.

This European Standard has been submitted for reference into the RID and/or in 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 in the technical annexes of the ADR

This standard is one of a series of three standards concerning refillable seamless steel gas cylinders of water capacities from 0,5 l up to and including 150 l for compressed, liquefied and dissolved gases:

Part 1: Cylinders made of seamless steel with an R_m value of less than 1100 MPa
Part 2: Cylinders made of seamless steel with an R_m value of 1100 MPa and above
Part 3: Cylinders made of seamless stainless steel

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, 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 approval of refillable, transportable seamless steel gas 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

The standard specifies minimum requirements for the material, design, construction and workmanship, manufacturing processes and tests at manufacture of refillable transportable seamless steel gas cylinders of water capacities from 0,5 l up to and including 150 l for compressed, liquefied and dissolved gases. This standard is applicable to cylinders manufactured from steel with an R_m value of less than 1100 MPa.

NOTE: This standard is also suitable for the manufacture of cylinders of water capacity less than 0,5 l.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places 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.

EN 473	Qualification and certification of NDT personnel - General principles
EN 1089-1:1996	Transportable gas cylinders - Gas cylinder identification (excluding LPG) - Part 1: Stampmarking
EN 10002-1	Metallic materials - Tensile testing - Part 1: Method of test (at ambient temperature)
EN 10003-1	Metallic materials - Brinell hardness test - Part 1: Test method
EN 10028-1	Flat products made of steels for pressure purposes - Part 1: General requirements

EN 10045-1	Metallic materials - Charpy impact test - Part 1: Test method
EN 10052	Vocabulary of heat treatment terms for ferrous products
EN ISO 11114-1:1997	Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents -Part 1: Metallic materials (ISO 11114-1:1997)
EURONORM 6-55	Bend test for steel

3 Definitions and symbols

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

3.1 Definitions

3.1.1 yield stress: Value corresponding to the lower yield stress R_{eL} or, for steels that do not exhibit defined yield, the 0,2 % proof stress $R_{p0,2}$.

3.1.2 normalizing: Heat treatment in which a cylinder is heated to a uniform temperature above the upper critical point (Ac_3, as defined in EN 10052) of the steel and then cooled in still air.

3.1.3 quenching: Hardening heat treatment in which a cylinder, which has been heated to a uniform temperature above the upper critical point (Ac_3, as defined in EN 10052) of the steel, is cooled rapidly in a suitable medium.

3.1.4 tempering: Softening heat treatment which follows quenching (or in some cases normalizing), in which the cylinder is heated to a uniform temperature below the lower critical point (Ac_1, as defined in EN 10052) of the steel.

3.1.5 batch: A quantity of up to 200 cylinders, plus cylinders for destructive testing, of the same nominal diameter, thickness, length and design made from the same steel cast and subjected to the same heat treatment for the same duration of time.

3.1.6 burst pressure: Highest pressure reached in a cylinder during a burst test.

3.1.7 working pressure: Settled pressure at a uniform temperature of 15 °C and full gas content.

3.1.8 test pressure: Required pressure applied during a pressure test.

3.1.9 design stress factor (F) (variable): The ratio of equivalent wall stress at test pressure (p_h) to guaranteed minimum yield stress (R_e).

3.2 Symbols

a Calculated minimum thickness, in millimetres, of the cylindrical shell.

a' Guaranteed minimum thickness, in millimetres, of the cylindrical shell (see figure 1).

a_1 Required minimum thickness, in millimetres, of a concave base at the knuckle (see figure 2).

a_2 Required minimum thickness, in millimetres, at the centre of a concave base (see figure 2).

A Percentage elongation.

b Required minimum thickness, in millimetres, at the centre of a convex base (see figure 1).

d_1 Dimension, in millimetres, of acceptable burst profile for quenched and tempered cylinders (see figure 8).

d_2 Dimension, in millimetres, of acceptable burst profile for normalized and tempered cylinders (see figure 9).

D Outside diameter of the cylinder, in millimetres (see figure 1).

D_f Diameter of former, in millimetres (see figure 5).

F Design stress factor (variable) see 3.1.9.

h Outside height (concave base end), in millimetres (see figure 2).

H Outside height of domed part (convex head or base end), in millimetres (see figure 1).

L_o Original gauge length, in millimetres, according to EN 10002-1 (see figure 4).

n Ratio of diameter of bend test former to actual thickness of test piece (t).

p_b Measured burst pressure, in bar[1)], above atmospheric pressure.

p_h Hydraulic test pressure, in bar[1)], above atmospheric pressure.

p_{lc} Lower cyclic pressure, in bar[1)], above atmospheric pressure.

p_w Working pressure, in bar[1)], above atmospheric pressure.

p_y Observed yield pressure, in bar[1)], above atmospheric pressure.

[1)] 1 bar = 10^5 Pa = 0,1 MPa.

r Inside knuckle radius, in millimetres (see figure 1).

R_e Minimum guaranteed value of yield stress (see 3.1.1), in megapascals.

R_{ea} Value of the actual yield stress in megapascals determined by the tensile test (see 7.1.2.1).

R_g Minimum guaranteed value of tensile strength, in megapascals.

R_m Actual value of tensile strength, in megapascals determined by the tensile test (see 7.1.2.1).

S_o Original cross-sectional area of tensile test piece, in square millimetres, according to EN 10002-1.

t Actual thickness of the test specimen in millimetres.

u Ratio of distance between platens in flattening test to actual thickness of test piece.

V Water capacity of cylinder, in litres.

w Width, in millimetres, of tensile test piece (see figure 4).

4 Materials

4.1 General provisions

4.1.1 Steels for the manufacture of gas cylinders shall meet the requirements of this standard.

4.1.2 The steel used for the fabrication of gas cylinders shall have acceptable non-ageing properties and shall not be rimming quality.

In cases where examination of this non-ageing property is required, the criteria by which it is to be specified shall be agreed between the parties.

4.1.3 The cylinder manufacturer shall identify the cylinders with the cast of steel from which they are made.

4.1.4 Grades of steel used for cylinder manufacture shall be compatible with the intended gas service, e.g. corrosive gases, embrittling gases. (See EN ISO 11114-1 : 1997).

4.2 Controls on chemical composition

4.2.1 The chemical composition of all steels shall be specified and recorded, including:

- maximum sulphur and phosphorus content;
- carbon, manganese and silicon content;
- nickel, chromium, molybdenum and all other alloying elements intentionally added.

The content of carbon, manganese, silicon and where appropriate, nickel, chromium and molybdenum shall be given, with tolerances, such that the differences between the maximum and minimum values of the cast do not exceed the values shown in table 1.

Table 1: Chemical composition tolerances

Element	Nominal content in %	Maximum permissible range in %
Carbon	< 0,30 %	0,06 %
	≥ 0,30 %	0,07 %
Manganese	All values	0,30 %
Silicon	All values	0,30 %
Chromium	< 1,50 %	0,30 %
	≥ 1,50 %	0,50 %
Nickel	All values	0,40 %
Molybdenum	All values	0,15 %
NOTE: The maximum permissible range for each element is not required to be centred on its nominal content. As an example, for a steel with nominal carbon content of 0,10 %, the following three maximum permissible ranges are equally acceptable: +0,00 %, -0,06 % +0,06 %, -0,00 % +0,03 %, -0,03 %		

The combined content of the following elements: V, Nb, Ti, B, Zr, shall not exceed 0,15 %.

4.2.2 Sulphur and phosphorus in the cast analysis of material used for the manufacture of gas cylinders shall not exceed the values shown in table 2.

Table 2: Sulphur and phosphorus limits

	R_m in MPa	
	$R_m < 950$	$950 \leq R_m < 1100$
Sulphur	0,020 %	0,010 %
Phosphorus	0,020 %	0,020 %
Sulphur + phosphorus	0,030 %	0,025 %

4.2.3 The cylinder manufacturer shall obtain and provide certificates of cast analyses of the steels supplied for the manufacture of gas cylinders.

Should check analyses be required, they shall be carried out either on specimens taken during manufacture from material in the form as supplied by the steelmaker to the cylinder manufacturer, or from finished cylinders avoiding decarburised zones from the cylinder surface. In any check analysis, the maximum permissible deviation from the limits specified for cast analyses shall conform to the values specified in EN 10028-1.

NOTE : EN 10028-1 is a general standard which cross refers the actual tables of permissible deviations given in the other parts of EN 10028.

4.3 Heat treatment

4.3.1 The cylinder manufacturer shall provide a certificate stating the heat treatment process applied to the finished cylinders.

4.3.2 Quenching in media other than mineral oil is permissible provided that the method produces cylinders free of cracks.

If the rate of cooling in the medium is greater than 80 % of that in water at 20 °C without additives, every production cylinder shall be subjected to a non-destructive test to prove freedom from cracks.

4.3.3 The tempering process for quenched and tempered cylinders and for normalized and tempered cylinders shall achieve the required mechanical properties.

The actual temperature to which a type of steel is subjected for a given tensile strength shall not deviate by more than 30 °C from the temperature specified by the cylinder manufacturer.

5 Design

5.1 General provisions

5.1.1 The calculation of the wall thickness of the pressure-containing parts shall be related to the yield stress (R_e) of the material.

5.1.2 Cylinders may be designed with one or two openings along the central cylinder axis only.

5.1.3 For calculation purposes, the value of the yield stress (R_e) is limited to a maximum of 0,75 R_g for normalized and tempered cylinders, and 0,90 R_g for quenched and tempered cylinders.

5.1.4 The internal pressure upon which the calculation of wall thickness is based shall be the hydraulic test pressure (p_h).

5.2 Limiting design stress

5.2.1 Where there is no risk of hydrogen embrittlement the maximum tensile strength is limited by the ability of the steel to pass the requirements of A.1 and A.2.

5.2.2 Where there is a risk of hydrogen embrittlement, the maximum value of the tensile strength shall be limited in accordance with EN ISO 11114-1:1997.

5.2.3 Other gas/material compatibility risks, including stress corrosion, shall be assessed in accordance with EN ISO 11114-1:1997.

5.3 Calculation of cylindrical wall thickness

The guaranteed minimum wall thickness of the cylindrical shell (a') shall not be less than the thickness calculated using the equation:

$$a = \frac{D}{2}\left(1 - \sqrt{\frac{10 \cdot F \cdot R_e - \sqrt{3} \cdot p_h}{10 \cdot F \cdot R_e}}\right)$$

Where the value of F is the lesser of $\frac{0{,}65}{(R_e / R_g)}$ or 0,77

R_e/R_g shall be limited to 0,90 for quenched and tempered cylinders and 0,75 for normalized and tempered cylinders.

The calculated minimum wall thickness shall also satisfy the equation:

$$a \geq \frac{D}{250} + 1\,\text{mm}$$

with an absolute minimum of a = 1,5 mm.

When choosing the minimum guaranteed value of the thickness of the cylindrical shell (a'), the manufacturer shall take into account all requirements for prototype and production testing, particularly the burst and yield pressure test requirements of 7.2.2.2.

The guaranteed minimum wall thickness (a') shall be equal to or greater than the calculated wall thickness (a).

5.4 Calculation of convex ends (heads and base ends)

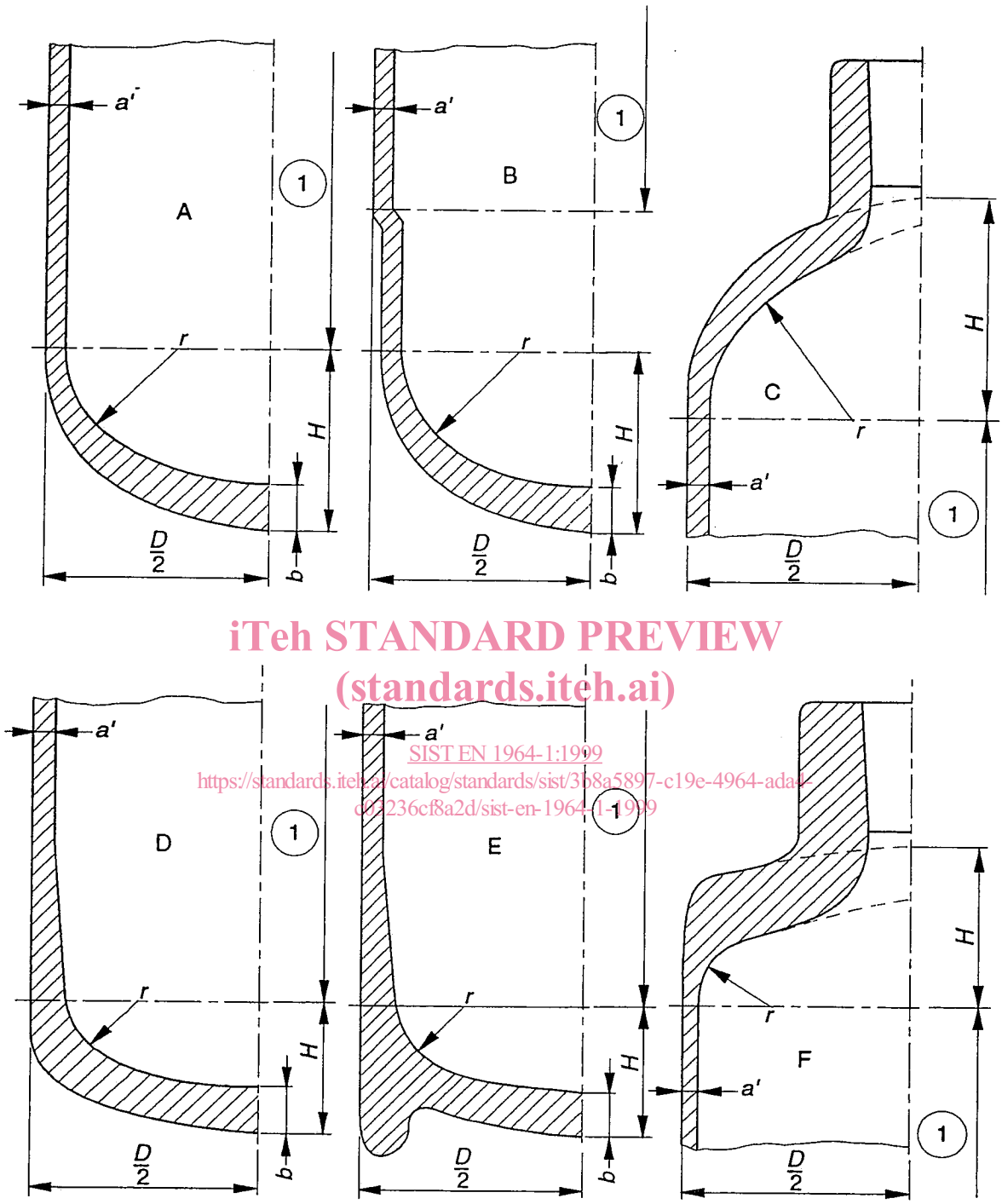
5.4.1 The shapes shown in figure 1 are typical for convex heads and base ends. Shapes A and B are base ends formed from tubing, shapes D and E are base ends formed during the piercing of a billet, and shapes C and F are heads.

5.4.2 The thickness (b) at the centre of the convex end shall be not less than that required by the following criteria:

Where the inside knuckle radius (r) is not less than 0,075 D, then

$b \geq 1{,}5a$ for $0{,}40 > H/D \geq 0{,}20$

$b \geq a$ for $H/D \geq 0{,}40$



Key
1 Cylindrical part

Figure 1: Typical convex ends

In order to obtain a satisfactory stress distribution in the region where the end joins the cylindrical part, any thickening of the end that may be required shall be gradual from the point of juncture. For the application of this rule, the point of juncture between the cylindrical part and the end is defined by the horizontal line indicating dimension *H* in figure 1.

Shape B shall not be excluded from this requirement.

The cylinder manufacturer shall prove by the pressure cycling prototype test as required in A.1 that the design is satisfactory.

5.5 Calculation of concave base ends

When concave base ends are used, the dimensions defined in figure 2 shall be not less than the following calculated values:

$$a_1 = 2a \; ; \; a_2 = 2a \; ; \; h = 0{,}12D \; ; \; r = 0{,}075D$$

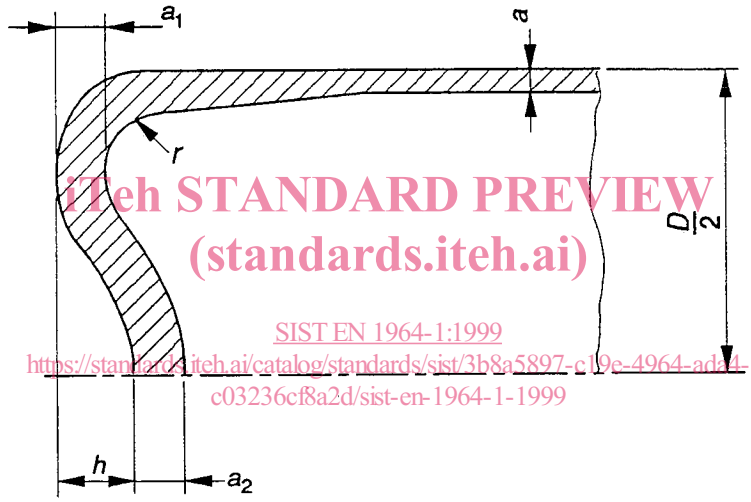


Figure 2: Concave base ends

In order to obtain a satisfactory stress distribution, the thickness of the cylinder shall increase progressively in the transition area region between the cylindrical part and the base, and the wall shall be free from defects.

The cylinder manufacturer shall prove by the pressure cycling prototype test as required in A.1 that the design is satisfactory.

5.6 Neck design

5.6.1 The external diameter and thickness of the formed neck end of the cylinder shall be adequate for the torque applied in fitting the valve to the cylinder. The torque may vary according to the diameter of thread, the form of thread, and the sealant used in the fitting of the valve.

NOTE: For recommended valving torques see EN ISO 13341.