SLOVENSKI STANDARD
SIST EN 12862:2001

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Premične plinske jeklenke - Specifikacije za zasnovo in izdelavo ponovno polnljivih varjenih jeklenk iz aluminijevih zlitin

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

Ortsbewegliche Gasflaschen - Gestaltung und Konstruktion von wiederbefüllbaren ortsbeweglichen geschweißten Gasflaschen aus Aluminiumlegierung

Bouteilles a gaz transportables - Spécification pour la conception et la construction des bouteilles a gaz rechargeables transportables soudées en alliage d'aluminium

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This European Standard was approved by CEN on 8 April 2000.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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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of an identical text or by endorsement, at the latest by November 2000, and conflicting national standards shall be withdrawn at the latest by November 2000.

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.

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.

This Standard is primarily for industrial gases other than LPG but may also be applied for LPG. However for dedicated LPG cylinders, see prEN 13110:1997 - *Transportable refillable welded aluminium cylinders for LPG - Design and construction* prepared by CEN/TC 286 - *Liquefied petroleum gas equipment and accessories.*

Introduction

The purpose of this standard is to provide a specification for the design, manufacture, inspection and approval of refillable transportable welded aluminium alloy 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

This standard specifies minimum requirements for the material, design, construction and workmanship, manufacturing processes and tests at manufacture of refillable transportable welded aluminium alloy gas cylinders of water capacities from 0,5 1 up to and including 150 l for compressed, liquefied and dissolved gases.

This standard includes requirements for spherical cylinders.

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 (including amendments).

EN 287-2	Approval testing of welders – Fusion welding – Part 2 Aluminium and aluminium alloys
EN 288-4:1992	Specification and approval of welding procedures for metallic materials - Part 4: Welding procedure tests for the arc welding of aluminium and its alloys
EN 910:1996	Destructive tests on welds in metallic materials - Bend tests
EN 962:1996	Transportable gas cylinders - Valve protection caps and valve guards for industrial and medical gas cylinders - Design, construction and tests
EN 970	Non-destructive examination of welds - Visual examinations
EN 1089-1:1996	Transportable gas cylinders - Gas cylinder identification (excluding LPG) - Part 1: Stampmarking
EN 1435	Non-destructive examination of welds – Radiographic examination of welded joints
EN 10002-1	Metallic materials - Tensile testing - Part 1: Method of test
EN 10003-1	Metallic materials - Brinell hardness test - Part 1: Test Method
EN 30042:1994	Arc-welded joints in aluminium and its weldable alloys - Guidance on quality levels for imperfections (ISO 10042:1992)

EN ISO 7539-6:1995	Corrosion of metals and alloys – Stress corrosion testing – Preparation and use of pre-cracked specimens (ISO 7539-6:1989)
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)
EN ISO 13341:1997	Transportable gas cylinders - Fitting of valves to gas cylinders (ISO 13341:1997)
EURONORM 6:1955	Bend test for steel
EURONORM 12:1955	Bend test for steel sheet and strip less than 3 mm thick

3 Definitions and symbols

For the purposes of this standard the following definitions and symbols apply.

3.1 Definitions

3.1.1 yield stress: Value corresponding to the 0,2 % proof stress (non proportional elongation), $R_{p0,2}$.

3.1.2 solution heat treatment: A thermal treatment which consists of heating the products to a suitable temperature, holding at that temperature long enough to allow constituents to enter into solid solution and cooling rapidly enough to hold the constituents in solution.

3.1.3 quenching: Controlled rapid cooling in a suitable medium to retain the solute phase in solid solution.

3.1.4 artificial ageing: A heat treatment process in which the solute phase is precipitated to give an increased yield stress and tensile strength.

3.1.5 batch: A quantity of up to 200 cylinders, plus cylinders for destructive testing, of the same nominal diameter, thickness and design, made successively from the same cast and subjected to the same heat treatment for the same duration of time. The lengths of the cylinders in the heat treatment batch may vary by up to 12 %.

3.1.6 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	Percentage elongation, determined by the tensile test 7.2.3
a	Calculated minimum thickness, in millimetres, of the cylindrical or spherical shell
a'	Guaranteed minimum thickness, in millimetres, of the cylindrical spherical shell
b	Guaranteed minimum thickness, in millimetres, at the centre of a convex base
D_o	Nominal outside diameter, in millimetres, of the cylinder, spherical cylinder or domed end (see figure 2)
D_i	Nominal inside diameter, in millimetres, of the cylinder, spherical cylinder or domed end (see figure 2)
d	Diameter of former, in millimetres (see figure 4)
F	Design stress factor (variable) (see 3.1.6)
h_i	Internal height, in millimetres, of semi-ellipsoidal or torispherical domed end (convex head or base end) (see figure 2)
h_e	Variable used in the determination of shape factor, K (see 5.3.1)
h_o	External height, in millimetres, of a semi-ellipsoidal or torispherical domed end (convex head or base end) (see figure 2 and note below)
K	Shape factor for a semi-ellipsoidal or torispherical domed end, obtained according to the values h_e/D_o and a/D_o, with interpolation where necessary, (see figure 1)
L_o	Original gauge length, in millimetres, according to EN 10002-1
n	The ratio of the diameter of the 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_y	Observed yield pressure which produces a permanent volumetric expansion of 0,2 %, in bar[1)] above atmospheric pressure

1) 1 bar = 10^5 Pa = 10^5 N/m^2

R_e	Minimum guaranteed value of yield stress (see 3.1.1), in megapascals, for the finished cylinder
R_{ea}	Actual value of yield stress, in megapascals, determined by the tensile test 7.2.3.
R_g	Minimum guaranteed value of tensile strength, in megapascals, for the finished cylinder
R_m	Actual value of tensile strength, in megapascals, determined by the tensile test 7.2.3
r_i	Internal knuckle radius, in millimetres, of torispherical end (see figure 2c))
r_i'	Internal radius, in millimetres, of dishing of torispherical end (see figure 2c))
r_o	External knuckle radius, in millimetres, of torispherical end (see figure 2c))
r_o'	External radius, in millimetres, of dishing of torispherical end (see figure 2c)
s_f	Straight flange length, in millimetres, for semi-ellipsoidal and torispherical domed ends (see figure 2b) and 2c))
S_o	Original cross-sectional area of tensile test piece, in square millimetres, according to EN 10002-1
t	Actual thickness of test specimen, in millimetres
t_e	Calculated minimum thickness, in millimetres, of a domed end
w	Width, in millimetres, of tensile test piece
V_{exp}	Volumetric expansion attained at burst, expressed as a percentage of the initial volume (see 7.3)
Z	Stress reduction factor (see 5.2.1)

4 Materials

4.1 General provisions

4.1.1 Aluminium alloys may be used to produce gas cylinders provided that they satisfy the requirements of the corrosion resistance tests defined in annex A, and meet all other requirements of this standard including annex B.

The alloys most commonly used for the fabrication of gas cylinders are those given in table 1.

4.1.2 After the completion of all welding (including that of the attachments) and before the hydraulic test each cylinder shall be heat treated as required to meet the design criteria.

4.2 Heat Treatment

4.2.1 *Heat treatable alloys*

The manufacturer shall specify on the prototype testing documentation the solution heat treatment and artificial ageing temperatures and the times for which the cylinders have been held at those temperatures. The medium used for quenching after solution heat treatment shall be identified.

4.2.2 *Non-heat treatable alloys*

The manufacturer shall specify on the prototype testing documentation the type of metal forming operation carried out (extrusion, drawing, ironing, head forming, etc.)

Unless the alloy is subjected to a temperature in excess of 400 °C during the forming process, a stabilizing treatment shall be carried out and the temperature and time at temperature shall be identified by the manufacturer.

4.2.3 *Control of specified heat treatment*

During the heat treatment, the manufacturer shall comply with the specified temperatures and durations, within the following ranges:

a) Temperatures

Solution temperature : maximum range 20 °C

Artificial ageing temperature : maximum range 20 °C

Stabilizing temperature : maximum range 20 °C

b) Durations

Time cylinders actually spend at temperature during treatments:

All treatments : maximum range 20 %

4.3 Gas/material compatibility

Gas/material compatibility shall be verified as specified in EN ISO 11114-1:1997.

Tableau 1 - Composition chimique des alliages d'aluminium

Type d'alliage AA[1] désignation enregistrée	Type[2]		Composition chimique - poids %											
			Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Pb	Autres		Aluminium
												Chacun	Total	
6082	A	min	0,7	-	-	0,40	0,60	-	-	-	-	-	-	Restant
		max	1,3	0,50	0,10	1,0	1,2	0,25	0,20	0,10	0,0030	0,05	0,15	
-	B	min	1,2	-	-	0,8	1,0	-	-	-	-	-	-	Restant
		max	1,6	0,5	0,1	1,0	1,4	0,1	0,2	0,2	0,0030	0,05	0,15	
6063	C	max	0,2	-	-	-	0,4	-	-	-	-	-	-	Restant
		min	0,7	0,5	0,1	0,3	0,9	0,1	0,2	0,2	0,0030	0,05	0,15	

[1] AA est l'Aluminum Association Inc., 900 19th Street N.W., Washington D.C., 20006-2168, USA.

[2] Il est admis d'utiliser les types A et B pour le corps et le type C pour la partie non soumise à la pression

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 to ensure elastic behaviour.

5.1.2 For calculation purposes the value of the yield stress (R_e) is limited to a maximum of 0,85 R_g for aluminium alloys.

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

5.1.4 For dissolved gases, the manufacturing process of the porous mass can modify the characteristics of the aluminium alloy used. This shall be considered when designing the shell.

5.2 Calculation of wall thickness

5.2.1 *Wall thickness of cylindrical shell*

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

$$a = \frac{D_o}{2}\left(1 - \sqrt{\frac{10\,FZ\,R_e - \sqrt{3}.p_h}{10\,FZ\,R_e}}\right)$$

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

the value of Z is dependent on the amount of non-destructive examination (NDE) and type of cylinder and shall be as specified in Table 2.

R_e/R_g shall be limited to 0,85.

The manufacturer may choose between 100 % NDE of welds or spot checks as defined as follows :

- for circumferential welds (including of bung or boss) 25 mm on each side of the weld overlap shall be examined;
- for longitudinal welds 100 mm beyond intersection of the circumferential/longitudinal weld and 25 mm on each side of the circumferential weld shall be examined.

Table 2 - Stress reduction factor *Z*

Cylinder Type		High Pressure (p_h > 60 bar)	Low Pressure ($p_h \leq$ 60 bar)
		Stress reduction factor *Z*	
Without longitudinal welds	100 % of welds NDE tested	0,95	1,00
	Welds spot checked	0,90	0,95
With longitudinal welds	100 % of welds NDE tested	0,90	0,95
	Welds spot checked	0,85	0,90

The calculated minimum thickness shall also satisfy the equation:

$$a \geq \frac{D_o}{200} \quad 1{,}5\ mm$$

When choosing the guaranteed value of the wall thickness of the cylindrical shell (a'), the manufacturer shall take into account all the test requirements for prototype and production testing, particularly the burst test requirements of 7.3.2.2.

The burst ratio (p_b/p_h) shall be determined by test and shall be as follows:

- for low pressure cylinders ($p_h \leq$ 60 bar), burst ratio > 2,0

- for high pressure cylinders (p_h > 60 bar), burst ratio ≥ 1,6

5.2.2 *Wall thickness of spherical cylinder*

The thickness of the wall shall not be less than the values given by the following equations:

1) $a = (p_h D_i)/(40FZR_e - 4{,}5p_h)$

2) $a = (p_h D_o)/(40FZR_e - 2{,}5p_h)$

3) $a = 2{,}48\sqrt{D_i/R_g}$

where the values of F and Z shall be as defined in 5.2.1.

5.3 Design of ends (heads and bases)

5.3.1 *Thickness of domed ends*

The minimum thickness of a hemispherical domed end shall be equal to the minimum thickness of the cylindrical shell a.

The minimum thickness of a semi-ellipsoidal or torispherical domed end shall be the greater of:

a) the thickness of the cylindrical wall; or

b) the value calculated from equation

$$t_e = aK$$

where K shall be as determined from figure 1.

For a semi-ellipsoidal end, $h_e = h_o$

For a torispherical end, h_e is the lesser of h_o, $\frac{D_o^2}{4r_o}$ or $\sqrt{\left(\frac{D_o r_o}{2}\right)}$

NOTE 1 The external height of a torispherical domed end (h_o), can be determined from:

$$h_o = r_o' - \sqrt{\left\{\left(r_o' - \frac{D_o}{2}\right) \times \left(r_o' \quad \frac{D_o}{2} - 2r_o\right)\right\}}$$

5.3.2 *Limitations of shape (see figure 2)*

The shape of the ends shall be subject to the following limitations.

a) For a torispherical end, r_I' shall not be greater than D_o.

b) For a torispherical end, r_i shall be not less than 0,1 D_i and not less than three times the actual thickness of the end as manufactured.

c) For a semi-ellipsoidal end the ratio h_o/D_o shall be not less than 0,192.

d) s_f shall be not less than 0,3 $\sqrt{(D_o t_e)}$.