SLOVENSKI STANDARD
SIST EN 1442:1999

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Transportable refillable welded steel cylinders for liquefied petroleum gas (LPG) - Design and construction

Transportable refillable welded steel cylinders for liquefied petroleum gas (LPG) - Design and construction

Ortsbewegliche, wiederbefüllbare, geschweißte Flaschen aus Stahl für Flüssiggas (LPG) - Gestaltung und Konstruktion

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Bouteilles en acier soudé transportables et rechargeables pour gaz de pétrole liquéfiés (GPL) - Conception et fabrication

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23.020.30	Tlaļne posode, plinske jeklenke	Pressure vessels, gas cylinders

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EUROPEAN STANDARD
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EN 1442

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Descriptors: gas cylinders, liquefied petroleum gases, commercial butane, commercial propane, steels, welded construction, materials, design, dimensions, manufacturing welding, qualification, heat treatment, tests, mechanical tests, pressure tests, radiographic analysis, acceptability, marking

English version

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 286 "Liquefied petroleum gas equipment and accessories", the secretariat of which is held by NSAI.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the Free Trade Association, and supports the objectives of the framework Directives on Transport of Dangerous Goods.

The standard has been submitted for reference into the RID and/or in the technical annexes of the ADR.

Therefore 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 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of an identical text or by endorsement, at the latest by August 1998, and conflicting national standards shall be withdrawn at the latest by August 1998.

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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.

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Introduction

This European Standard calls for the use of substances and procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.
It has been assumed in the drafting of this European Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

1 Scope

This European Standard specifies minimum requirements concerning material, design, construction and workmanship, procedure and test at manufacture of transportable refillable welded steel Liquefied Petroleum Gas (LPG) cylinders of water capacity from 0,5 l up to and including 150 l exposed to ambient temperatures.

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 test and the publications are listed thereafter. 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 287-1	Approval testing of welders - Fusion Welding - Part 1: Steels.
EN 288-3	Specification and approval of welding procedures for metallic materials - 3: Welding procedure tests for the arc welding of steels
EN 876	Destructive test on welds in metallic materials - Longitudinal tensile test on weld metal in fusion welded joints.
EN 895	Destructive tests on welds in metallic materials - Transverse tensile test
EN 910	Destructive tests on welds in metallic materials - Bend tests.
EN 1321	Destructive tests on welds in metallic materials - Macroscopic and microscopic examination of welds.
EN 10002-1	Metallic materials - Tensile testing - Part 1: Method of test.
EN 25817	Arc-welded joints in steel - Guidance on quality levels for imperfections (ISO 5817: 1992).
EN 970	Non-destructive examination of fusion welds- Visual examination.
EN 1435	Non-destructive examination of welds - Radiographic examination of welded joints.
EN 10120	Steel Sheet and strip for welded gas cylinders.
Euronorm 6-55	Essai de pliage pour l'acier. (Bend tests for steel).
Euronorm 12-55	Bend tests for steel sheet and strip less than 3mm thick.
Euronorm 103-71	Détermination micrographique de la grosseur du grain ferritique on austénitique des aciers. (Micrographic determination of the ferritic or austenitic grain size of steels).
ISO 2504: 1973	Radiography of welds and viewing conditions for films - Utilisation of the recommended patterns of image quality indications (I.Q.I.).

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3 Definitions and Symbols

3.1 Definitions

For the purposes of this standard the following definitions apply:

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3.1.1 yield stress :
The upper yield strength, R_{eh} or, for steels that do not exhibit a defined yield, the 0,2% proof stress (non-proportional elongation), R_p. (see EN 10002-1)
3.1.2 normalising:
Heat treatment in which a finished cylinder is heated to a uniform temperature above the upper critical point (AC_3) of the steel and then cooled in a controlled atmosphere.
3.1.3 stress relieving:
Heat treatment given to the finished cylinder, the object of which is to reduce the residual stresses without altering the metallurgical structure of the steel, by heating to a uniform temperature below the lower critical point (AC_1) of the steel and cooling in a still atmosphere.
3.1.4 competent body :
A person or corporate body defined by a national authority which by combination of appropriate qualifications, training, experience and resources is able to make objective judgements on the subject.

3.2 Symbols :

a	Calculated minimum thickness, in millimetres, of the cylindrical shell.
A	Percentage elongation after fracture.
b	Calculated minimum thickness, in millimetres, of the end of the cylinder.
C	Shape factor (see **table 1** and **figure 2**)
D	Outside diameter, in millimetres, of the cylinder as given in the design drawing (see **figure 1**)
D_p	Outside diameter in millimetres of a bend tests former (see **figure 10**)
h	Height, in millimetres, of the cylindrical part of the end (see **figure 1**)
H	Outside height, in millimetres, of the domed part of the end (see **figure 1**)
J	Stress reduction factor.
L	Length, in millimetres of the cylinder.
L_o	Original gauge length, of the test piece in millimetres, in accordance with EN 10002-1.
n	Ratio of diameter of bend test former to the thickness of the test piece. (see **table 2**).
P_c	Calculation pressure, in bar (1 bar = 10^5 Pa = 10^5 N/m^2), used to calculate the minimum required thickness of the cylindrical shell and ends.
P_b	Maximum pressure, in bar, attained during the burst test.
P_t	Actual test pressure, in bar, applied to the cylinder by the manufacturer.
P_{tmin}	Minimum permissible test pressure, in bar.
r	Inside knuckle radius, in millimetres, of the end.
R	Inside dishing radius, in millimetres, of the end.
R_g	Guaranteed tensile strength
R_o	Minimum value of yield stress in newtons per square millimetre, guaranteed by the cylinder manufacturer for the finished cylinder.
R_m	Actual value of tensile strength, in newtons per square millimetre, determined by the tensile test specified in **7.1.2.2**.

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4 Materials

4.1 Materials for shells and end pressings shall conform with EN 10120.

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Materials refer to materials in the state before any specific transformation with regard to the manufacturing process.

4.2 All parts welded to the cylinder shall be made of compatible material.

4.3 The welding consumables shall be such that they are capable of giving consistent welds with minimum tensile strength at least equal to that specified for the parent materials in the finished cylinder.

4.4 The cylinder manufacturer shall have certificates of the ladle analysis and mechanical properties of the steel supplied for the construction of the pressure retaining parts of the cylinder.

4.5 The manufacturer shall maintain a system of identification for the materials used in the fabrication in order that all materials for pressure parts in the completed cylinder can be traced to its origin.

5 Design

5.1 General Requirements

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5.1.1 The calculation of the wall thickness of the pressure parts to resist the internal pressure in the gas cylinders shall be related to the yield stress of the material.

5.1.2 For calculation purposes, the value of the yield stress R_0 is limited to a maximum of $0{,}85 \times R_g$.

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5.1.3 The internal pressure upon which the calculation of the wall thickness of gas cylinders is based shall be the calculation pressure P_C.

a) For cylinders for commercial butane service only

$P_C = P_{t\,min} = 15$ bar.

b) For all other LPG cylinders

$P_C = P_{t\,min} = 30$ bar.

5.1.4 A fully dimensional drawing including the specification of the material shall be produced.

5.2 Calculation of cylindrical shell thickness.

The wall thickness of the cylindrical shell shall be not less than that calculated using the formula.

$$a = \frac{P_c \times D}{\frac{20 \times R_0 \times J}{4/3} + P_c}$$

For cylinders with a longitudinal weld : $J = 0{,}9$
For cylinders without a longitudinal weld : $J = 1{,}0$
In no case shall the actual thickness be less than that specified in **5.5**

5.3 Design of ends concave to pressure

5.3.1 Except as permitted by **5.4** the shape of ends of gas cylinders shall be such that the following conditions are fulfilled:

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- for torispherical ends $R \leq D$; $r \geq 0{,}1\,D$; $h \geq 4b$ (see **figure 1a**).
- for semi-ellipsoidal ends $H \geq 0{,}192\,D$; $h \geq 4b$ (see **figure 1b**).

5.3.2 The wall thickness of the ends of gas cylinders shall be not less than that calculated using the formula

$$b = \frac{P_c \times D \times C}{\frac{20 \times R_a}{4/3} + P_c}$$

In this formula, C is a shape factor, the value of which depends on the ratio H/D.
The value of C shall be obtained from **table 1** and the graphs in **figure 2** and **figure 3**.
Graph in figure 2 details the value of C in relation to ratio of b/D

Table 1: - Relationship between H/D and Shape Factor C

H/D	C	H/D	C
0,25	1,000	0,38	0,612
0,26	0,931	0,39	0,604
0,27	0,885	0,40	0,596
0,28	0,845	0,41	0,588
0,29	0,809	0,42	0,581
0,30	0,775	0,43	0,576
0,31	0,743	0,44	0,572
0,32	0,713	0,45	0,570
0,33	0,687	0,46	0,568
0,34	0,667	0,47	0,566
0,35	0,649	0,48	0,565
0,36	0,633	0,49	0,564
0,37	0,621	0,50	0,564
NOTE : Intermediate values may be obtained by linear interpolation.			

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5.4 Ends of Other Shapes

Ends of shapes other than those covered by **5.3** may be used provided that the adequacy of their design is demonstrated by a fatigue test in accordance with **7.6** or by appropriate stress analysis acceptable to a competent body.

5.5 Minimum Wall Thickness

5.5.1 The minimum wall thickness of the cylindrical shell, a and of the end, b, shall not be less than the value derived from any of the following formulae:

for $D <$ 100 mm: . . . (1)

$a_{min} = b_{min} = 1{,}1$ mm

for $100 \leq D \leq 150$ mm: . . . (2)

$a_{min} = b_{min} = 1{,}1 + 0{,}008 \times (D\text{-}100)$ mm

for $D >$ 150 mm: . . . (3)

$$a_{min} = b_{min} = \frac{D}{250} + 0{,}7 \text{ mm}$$

(With an absolute minimum of 1,5 mm.)

These formulae apply to cylindrical shells and ends irrespective of whether they are designed by calculation as specified in **5.2** and **5.3** or by testing as specified in **5.4** Apart from the

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requirements of **5.3**, **5.4** and **5.5** any cylindrical part integral with an end shall, except as qualified by **5.5.2** also satisfy the requirements in **5.2** for the cylindrical shell.

5.5.2 The equation in **5.2** is not applicable where the length of the cylindrical portion of the cylinder, measured between the beginning of the domed parts of the two ends, is not more than $\sqrt{2bD}$. In this case the wall thickness shall be not less than that of the domed part (see **5.3.2**).

5.6 Design of Openings

5.6.1 The location of all openings shall be restricted to one end of the cylinder.
5.6.2 Each opening in the cylinder shall be reinforced, either by a valve boss or pad, of weldable and compatible steel, securely attached by welding and so designed as to be of adequate strength and to result in no harmful stress concentrations. This shall be confirmed by design calculations acceptable to a competent body or a fatigue test in accordance with **7.6**.
5.6.3 The welds of the openings shall be clear of circumferential joints.
5.6.4 If the leak-tightness between the valve and the cylinder is assured by a metallic seal (e.g. copper) a suitable internal valve boss can be fitted to the cylinder by a method which need not independently guarantee leak-tightness.

6 Construction and workmanship

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6.1 Welding qualification

6.1.1 The manufacturer shall have the technical capability, have at his disposal all appropriate means, and qualified personnel to carry out the manufacture of cylinders.
6.1.2 The manufacturer, with the agreement of a competent body, before proceeding with the production of a given design of cylinder, shall approve the welding procedures to EN 288-3 and welders to EN 287-1, for all welding associated with the pressure envelope including the non pressure containing parts. Records of such approvals shall be retained by the manufacturer.
6.1.3 Welding procedure approval tests shall be made in such a manner that the welds shall be representative of those made in production.
6.1.4 Welders shall have passed the approval tests for the specific type of work and procedure concerned.

6.2 Plates and pressed parts

Before assembly, the pressure parts of the cylinders shall be visually examined for uniform quality and freedom from defects which may ultimately affect the cylinder integrity.

6.3 Welded joints

6.3.1 The welding of the longitudinal and circumferential joints shall be by a fully mechanised or automatic process to provide consistent and reproducible quality of welds.
6.3.2 The longitudinal joint, of which there shall be no more than one, shall be the butt welded type.
6.3.3. Circumferential joints, of which there shall be no more than two, shall be butt welded, or butt welded with one member offset to form an integral backing strip i.e. joggled (see **figure 4**.)
6.3.4 Before the cylinders are closed, longitudinal welds shall be visually examined from both sides in accordance with EN 970. Permanent backing strips shall not be used with longitudinal welds.

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6.3.5 The fusion of the welded metal with the parent metal shall be smooth and free from overlapping, undercutting or abrupt irregularity. There shall be no cracks, notching or porous patches in the welded surface and the surface adjacent to the weld. The welded surface shall be regular and even without concavity.
6.3.6 Butt welds and joggled butt welds shall have full penetration.
The excess thickness shall not exceed one fourth of the width of the weld.

6.4 Tolerances
6.4.1 Out of roundness
The out-of-roundness of the cylindrical shell shall be limited so that the difference between the maximum and the minimum outside diameter in the same cross-section is not more than 1% of the mean of these diameters for two piece cylinders and 1,5% for three piece cylinders.
6.4.2 Straightness
Unless otherwise shown on the manufacturer's drawing, the maximum deviation of the cylindrical part of the shell from a straight line shall not exceed 0,3% of the cylindrical length.
6.4.3 Verticality
When the cylinder is standing on its base, the cylindrical shell and the axis of the top opening shall be vertical to within 1,5°.

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6.5 Non pressure containing attachments
6.5.1 Where non pressure containing attachments are to be attached to the cylinder by welding, such attachments shall be made of weldable and compatible steel (see **4.2**).
6.5.2 Attachments shall be designed to permit inspection of welds, which shall be clear of longitudinal and circumferential joints, and so designed as to avoid trapping water.
6.5.3 Where a footring is fitted, it shall be of adequate strength to provide stability and be attached so that it does not prevent inspection of any pressure containing welds. Any footring shall be suitably drained and the space enclosed by the footring suitably ventilated e.g. by means of openings.
6.6 Valve protection
6.6.1 Valves shall be effectively protected from damage in order to avoid release of contents.
6.6.2 When the requirements of **6.6.1** are not met then the cylinders shall be conveyed in crates or cradles or shall be provided during transportation with some other effective valve protection, unless it can be demonstrated that the valve can withstand damage without leakage of product.

NOTE: See prEN 13152 "Specification and testing for liquefied petroleum gas (LPG) - Cylinder valves-self closing" and prEN 13153 "Specification and testing for liquefied petroleum gas (LPG) - Cylinder valves-manually operated"