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

Bouteilles à gaz — Bouteilles en acier soudé transportables et rechargeables pour gaz de pétrole liquéfié (GPL) — Conception et fabrication

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22991 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

Introduction

This International 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 International Standard, that the execution of its provisions is entrusted to appropriately qualified and experienced people.

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

1 Scope

This International 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 up to and including 150 l, exposed to ambient temperatures.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 643, *Steels — Micrographic determination of the apparent grain size*

ISO 1106-1:1984, *Recommended practice for radiographic examination of fusion welded joints — Part 1: Fusion welded butt joints in steel plates up to 50 mm thick*

ISO 1106-3:1984, *Recommended practice for radiographic examination of fusion welded joints — Part 3: Fusion welded circumferential joints in steel pipes of up to 50 mm wall thickness*

ISO 2504:1973, *Radiography of welds and viewing conditions for films — Utilization of the recommended patterns of image quality indications (I.Q.I.)*

ISO 4136, *Destructive tests on welds in metallic materials — Transverse tensile test*

ISO 4978, *Flat rolled steel products for welded gas cylinders*

ISO 5178, *Destructive tests on welds in metallic materials — Longitudinal tensile test on weld metal in fusion welded joints*

ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*

ISO 7438, *Metallic materials — Bend test*

ISO 9606-1, *Approval testing of welders — Fusion Welding — Part 1: Steels*

ISO 9956-3, *Specification and approval of welding procedures for metallic materials — Part 3: Welding procedure tests for arc welding of steels*

ISO 10920, *Gas cylinders — 25E taper thread for connection of valves to gas cylinders — Specification*

ISO 11116-1, *Gas cylinders — 17E taper thread for connection of valves to gas cylinders — Part 1: Specifications*

ISO 13769, *Gas cylinders — Stamp marking*

ISO 14732, *Welding personnel — Approval testing of welding operators for fusion welding and of resistance weld setters for fully mechanized and automatic welding of metallic materials*

ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO 17639, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
yield stress
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

[ISO 6892]

3.2
normalizing
heat treatment in which the cylinder is heated to a uniform temperature above the upper critical point (AC_3) of the steel and then cooled in a controlled atmosphere or still air

3.3
stress relieving
heat treatment given to the 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 controlled atmosphere or still air

3.4
competent body
person or corporate body who, by combination of appropriate qualifications, training, experience and resources, is able to make objective judgements on the subject

4 Symbols

Table 1 — Symbols and their designations and units

Symbol	Designation	Unit
a	calculated minimum thickness of the cylindrical shell	mm
A	percentage elongation after fracture	%
b	calculated minimum thickness of the end of the cylinder	mm
C	shape factor (see Table 3 and Figure 2)	1
D	outside diameter of the cylinder as given in the design drawing (see Figure 1)	mm
D_p	outside diameter of a bend tests former (see Figure 10)	mm
h	height of the cylindrical part of the end (see Figure 1)	mm
H	outside height of the domed part of the end (see Figure 1)	mm
J	stress reduction factor	1
L	length of the cylinder	mm
L_o	original gauge length of the test piece in accordance with ISO 6892	mm
n	ratio of diameter of bend test former to the thickness of the test piece (see Table 4)	1
P_c	calculation pressure used to calculate the minimum required thickness of the cylindrical shell and ends (see 6.1.3)	bar
P_b	maximum pressure attained during the burst test	bar
P_t	actual test pressure, applied to the cylinder by the manufacturer	bar
P_{tmin}	minimum permissible test pressure	bar
r	inside knuckle radius of the end	mm
R	inside dishing radius of the end	mm
R_g	minimum guaranteed tensile strength	MPa
R_0	minimum value of yield stress guaranteed by the cylinder manufacturer for the finished cylinder	MPa
R_m	actual value of tensile strength determined by the tensile test specified in 8.1.2.2	MPa
NOTE	1 MPa = 1 N/mm^2 = 10 bar.	

5 Materials

5.1 Materials for shells and end pressings shall either conform to ISO 4978 or to another equivalent material specification meeting the requirements of Table 2.

NOTE "Materials" refers to materials in the state before any specific transformation with regard to the manufacturing process.

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

5.3 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.

5.4 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.

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

Table 2 — Material requirements

Element	Limits % max.
Materials, other than those given in ISO 4978, used for the fabrication of gas cylinders, shall be of weldable quality and the following limits shall not be exceeded in the cast analysis:	
Carbon	0,22
Silicon	0,45
Manganese	1,60
Phosphorus	0,025
Sulfur	0,020
Phosphorus plus sulfur	0,040
Use of micro-alloying elements such as niobium, titanium and vanadium shall be confined to the following contents:	
Niobium	0,08
Titanium	0,20
Vanadium	0,20
Niobium plus vanadium	0,20
Where other micro-alloying elements are used, their presence and amounts shall be reported, together with the above, in the steel manufacturer's certificate.	
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 steel maker to the cylinder manufacturer or from finished cylinders.	

6 Design

6.1 General requirements

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

6.1.2 For calculation purposes, the value of the yield stress R_0 is limited to a maximum of 0,85R_g.

6.1.3 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 $P_c = P_{tmin}$ = 15 bar;

b) For all other LPG cylinders $P_c = P_{tmin}$ = 30 bar.

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

6.2 Calculation of cylindrical shell thickness

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

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

— 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 6.5.

6.3 Design of ends concave to pressure

6.3.1 Except as permitted by 6.4, the shape of ends of gas cylinders shall be such that the following conditions are fulfilled:

— for torispherical ends: $R \leqslant D$; $r \geqslant 0{,}1\ D$; $h \geqslant 4b$ [see Figure 1a)];

— for semi-ellipsoidal ends: $H \geqslant 0{,}2\ D$; $h \geqslant 4b$ [see Figure 1b)].

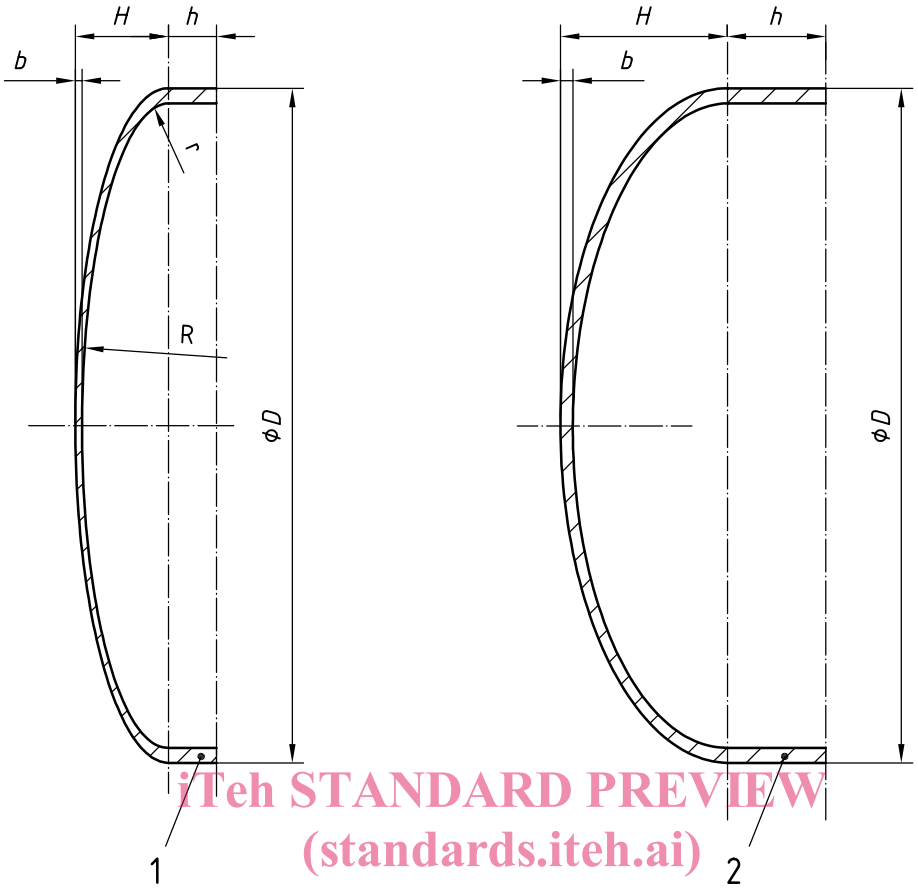
6.3.2 The wall thickness of the ends of gas cylinders shall be not less than that calculated using the formula:

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

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 3 and the graphs in Figure 2 and Figure 3.

The graph in Figure 2 details the value of C in relation to the ratio b/D.



Key

1 torispherical end
2 semi-ellipsoidal end

NOTE For torispherical ends:

$$H = (R+b) - \sqrt{[(R+b) - \tfrac{D}{2}] \times [(R+b) + \tfrac{D}{2} - 2(r+b)]}$$

Figure 1 — Illustration of cylinder ends concave to pressure

Table 3 — 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.			