INTERNATIONAL STANDARD

ISO 18172-1

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Gas cylinders — Refillable welded stainless steel cylinders —

Part 1: Test pressure 6 MPa and below

Bouteilles à gaz — Bouteilles soudées en acier inoxydable rechargeables —

Partie 1: Pression d'épreuve de 6 MPa et inférieure

Reference number
ISO 18172-1:2007(E)

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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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Contents

Page

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 18172-1 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

ISO 18172 consists of the following parts, under the general title *Gas cylinders — Refillable welded stainless steel cylinders*:

— *Part 1: Test pressure 6 MPa and below*

— *Part 2: Test pressure greater than 6 MPa*

Introduction

The purpose of this part of ISO 18172 is to provide a specification for the design, manufacture and testing of refillable transportable welded stainless steel gas cylinders with a test pressure up to 6 MPa (60 bar).

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.

ISO 18172 has been prepared to address the general requirements in Section 6.2.1 of the UN model regulations for the transportation of dangerous goods ST/SG/AC.10/1/Rev.13. It is intended to be used under a variety of regulatory regimes, but has been written so that it is suitable for use with the conformity assessment system in paragraph 6.2.2.5 of the above-mentioned model regulations.

Gas cylinders — Refillable welded stainless steel cylinders —

Part 1:
Test pressure 6 MPa and below

1 Scope

This part of ISO 18172 specifies minimum requirements concerning material, design, construction and workmanship, manufacturing processes and testing of refillable transportable welded stainless steel gas cylinders, of water capacities from 0,5 l up to and including 500 l, for compressed, liquefied and dissolved gases. This part of ISO 18172 is applicable only to cylinders manufactured from stainless steels with test pressures up to 6 MPa (60 bar).

If required, transportable large cylinders of water capacity above 150 l and up to 500 l may be manufactured and certified to this part of ISO 18172, providing that handling facilities are provided (see 6.5.5).

For acetylene service, additional requirements for the cylinder and the basic requirements for the porous mass are given in ISO 3807-1 and ISO 3807-2.

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

ISO 3651-2, *Determination of resistance to intergranular corrosion of stainless steels — Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels — Corrosion test in media containing sulfuric acid*

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

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

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

ISO 7438, *Metallic materials — Bend test*

ISO 9328-7:2004, *Steel flat products for pressure purposes — Technical delivery conditions — Part 7: Stainless steels*

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

ISO 9956-1, *Specification and approval of welding procedures for metallic materials — Part 1: General rules for fusion welding*

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

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

ISO 11117, *Gas cylinders — Valve protection caps and valve guards — Design, construction and tests*

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 17636, *Non-destructive testing of welds — Radiographic testing of fusion-welded joints*

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

ISO 20807, *Non-destructive testing — Qualification of personnel for limited application of non-destructive testing*

3 Terms, definitions and symbols

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

3.1 Terms and definitions

3.1.1
yield stress
value corresponding to 0,2 % proof stress ($R_{p0,2}$) or, for austenitic steels in the solution annealed condition, 1 % proof stress ($R_{p1,0}$)

3.1.2
solution annealing
softening heat treatment for austenitic steels in which a cylinder is heated to a uniform temperature above the solid solution temperature, followed by rapid cooling

3.1.3
cryoforming
process where the cylinder is subjected to a controlled low temperature deformation treatment that results in a permanent increase in strength

3.1.4
cold working
plastic deformation treatment given to sheet material at ambient temperature, with the aim of permanently increasing the material strength

3.1.5
cold forming
final deformation treatment at ambient temperature given to the prefabricated cylinder, known as the preform, which results in a permanent increase in the material strength

3.1.6
batch
quantity of cylinders made consecutively by the same manufacturer, using the same manufacturing techniques, to the same design, size and material, from the same cast on the same type of welding machines and welding procedures

3.1.7
design stress factor
F
ratio of equivalent wall stress at test pressure (p_h) to guaranteed minimum yield stress (R_e)

3.1.8
meta-stable austenitic steel
CrNi stainless steel, which is austenitic in the annealed state at room temperature, but is unstable regarding transformation when plastically deformed at low temperatures

3.2 Symbols

a calculated minimum thickness, in mm, of the cylindrical shell

a' guaranteed minimum thickness, in mm, of the cylindrical shell, including any corrosion allowance (see 7.1.1)

a_1 calculated value of a used in the calculation of b (see 5.3.2)

a_m mean wall thickness, in mm, of the cylindrical shell of the cylinder preform

A percentage elongation after fracture

b calculated minimum thickness, in mm, of the cylinder end

b' guaranteed minimum thickness, in mm, of the cylinder end (see 7.1.1)

C shape factor of dished ends

D outside diameter, in mm, of the cylinder (see Figure 1)

D_f diameter of former, in mm (see 8.4.3 and Figure 10)

D_m mean diameter of the cylindrical shell of a cylinder preform, in mm

F design stress factor (see 3.1.7)

f_c cryoforming factor established by the manufacturer for each batch of cylinders

h height, in mm, of the cylindrical part of the end (see Figure 1)

H outside height, in mm, of the domed part of the end (see Figure 1)

J stress reduction factor

L length, in mm, of the cylinder

n ratio of diameter of bend test former (D_f) to the thickness of the test piece (t)

p_b measured burst pressure, in MPa (bar)[1)], above atmospheric pressure, in the burst test

p_c cryoforming or cold forming pressure in MPa (bar), above atmospheric pressure

1) 0,1 MPa = 10^5 Pa = 1 bar

p_h hydraulic test pressure, in MPa (bar), above atmospheric pressure

p_y observed yield pressure, in MPa (bar), above atmospheric pressure

r inside radius of the knuckle end, in mm (see Figure 1)

R inside radius of the dished end, in mm (see Figure 1)

R_e yield stress, in MPa, as defined in 3.1.1 and used for design calculation

R_{ea} value of the actual yield stress, in MPa, determined by the tensile test

$R_{p0,2}$ minimum value of 0,2 % proof stress, in MPa, guaranteed by the cylinder manufacturer for the finished cylinder, in accordance with ISO 6892 (see Note)

$R_{p1,0}$ minimum value of 1,0 % proof stress, in MPa, guaranteed by the cylinder manufacturer for the finished cylinder, in accordance with ISO 6892 (see Note)

R_g minimum value of tensile strength, in MPa, guaranteed by the cylinder manufacturer for the finished cylinder

R_m actual value of tensile strength, in MPa, determined by a tensile test (see 8.3)

t actual thickness of the test specimen, in mm (see Figure 7)

NOTE For cryoformed and cold formed cylinders, the minimum value guaranteed by the manufacturer refers only to the cylindrical part of the finished cylinder.

4 Materials and heat treatment

4.1 General

4.1.1 Materials of shells and end pressings shall be stainless steels in a condition suitable for pressing or drawing and welding, and shall conform to ISO 9328-7.

4.1.2 Grades of steel used for the cylinder manufacture shall be compatible with the intended gas service (e.g. corrosive gases, embrittling gases), in accordance with ISO 11114-1.

4.1.3 There is a risk of sensitization to intergranular corrosion resulting from the hot processing of austenitic and duplex stainless steels. If any heat treatment was done during manufacturing, an intergranular corrosion test in accordance with 7.3.3 shall be carried out.

4.1.4 The manufacturer shall be able to guarantee cylinder steel casting traceability for each pressure-retaining part of the cylinder.

4.1.5 All parts welded to the cylinder shall be made of compatible material with respect to the weldability.

4.1.6 The cylinder manufacturer shall obtain and provide material certificates of the ladle analysis from the steel manufacture of the steel supplied for the construction of the pressure-retaining parts of the cylinder and for the welding consumables.

4.1.7 Some grades of stainless steel may be susceptible to environmental stress corrosion cracking (SCC). A check shall be made of the material standard to ensure that the selection of material is compatible with the intended service. Special precautions shall be taken, e.g. by carrying out a post-processing SCC test or by using a grade of material more resistant to SCC. No special precautions shall compromise any other requirements in this part of ISO 18172.

4.1.8 The welding consumables shall be such that they are capable of giving consistent welds. The strength characteristics of the welds shall not be less than those considered in the design and/or calculations.

4.1.9 Cylinders for acetylene service shall be manufactured with materials compatible with the manufacturing process of the porous mass, or an internal coating shall be applied.

4.2 Categories

The following three broad categories of stainless steels are recognised:

— ferritic;

— austenitic;

— ferritic/austenitic (duplex).

The steels used shall be in accordance with ISO 9328-7.

4.3 Heat treatment

4.3.1 For cylinders subjected to cold forming or cryoforming processes, heat treatment of the preform component part is not required. Cryoformed cylinders shall not be subjected to any subsequent heat treatment or to additional heat application, such as welding.

4.3.2 Raw materials used for the manufacture of pressure-retaining parts of the cylinders shall be annealed for ferritic steels, or solution annealed for austenitic and duplex steels (see ISO 9328-7:2004, Annex C).

4.3.3 The cylinder manufacturer shall obtain and provide certificates for the heat treatment of all parts covered by 4.3.2 that are used for the construction of the gas cylinders.

4.3.4 The cylinder manufacturer shall maintain records of any heat treatment carried out.

4.4 Test requirements

The material of the finished cylinders shall satisfy the requirements of Clause 7.

5 Design

5.1 General requirements

5.1.1 The calculation of the wall thickness of the pressure containing parts shall be related to the yield stress of the parent material.

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

5.1.3 The internal pressure upon which the calculation of gas cylinders is based shall be the test pressure p_h.

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

5.1.5 Cylinders for acetylene service shall be designed to allow for a test pressure of 6 MPa (60 bar).

5.1.6 Cylinders for acetylene service shall be designed and manufactured to ensure that conditions are safe for the eventual filling of the porous mass, e.g. ensuring that there are no sharp edges and voids.

5.2 Calculation of cylindrical shell wall thickness

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

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

where

F = 0,77

J = 1 for circumferential welds

J = 0,9 for longitudinal welds

The minimum wall thickness shall also satisfy the requirements of 5.4.

5.3 Design of convex ends

5.3.1 The shape of ends of gas cylinders shall be such that the following conditions are fulfilled:

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

— for ellipsoidal shaped ends [see Figure 1 b)]: $H \geqslant 0{,}192\ D$; $h \geqslant 4\ b$

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

$$b = a_1 \times C \quad (2)$$

where

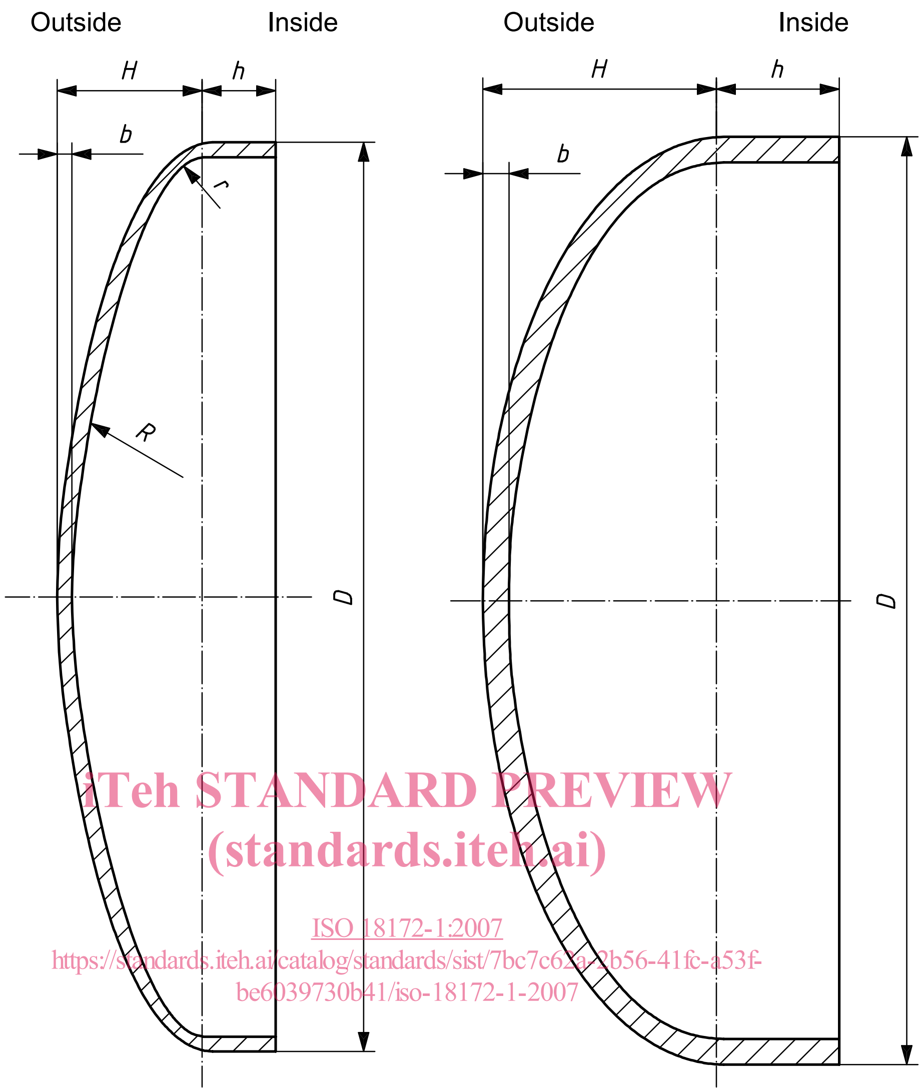
a_1 is the value of a calculated in accordance with 5.2, using J = 1,0

C is a shape factor, whose value shall be obtained from the graph given in Figure 2 or Figure 3.

5.3.3 For cryoformed cylinders, convex ends shall be hemispherically shaped. The shape factor C shall be equal to 1.

The minimum 1,0 % proof stress to be achieved in the hemispherical ends shall be equal to

$$R_p = R_{p1,0} \times (a \div 2b) \quad (3)$$



a) Torispherical shaped end **b) Ellipsoidal shaped end**

NOTE For torispherical shaped ends, the height H can be calculated using

$$H = (R+b) - \sqrt{\left[(R+b) - \frac{D}{2}\right] \cdot \left[(R+b) + \frac{D}{2} - 2(r+b)\right]} \quad (4)$$

Figure 1 — Illustration of cylinder ends