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Gas cylinders — Refillable welded steel cylinders containing materials for sub-atmospheric gas packaging (excluding acetylene) — Design, construction, testing, use and periodic inspection

Bouteilles à gaz — Bouteilles en acier soudées rechargeables contenant des matériaux pour le stockage des gaz à une pression sub-atmosphérique (à l'exclusion de l'acétylène) — Conception, fabrication, essais, utilisation et contrôle périodique

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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 11513 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

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Introduction

This International Standard provides a specification for the design, manufacture, use and periodic inspection and testing of a welded steel cylinder necessary to facilitate sub-atmospheric pressure gas packaging technology on a worldwide basis. The specifications given are based on knowledge of, and experience with, materials, design requirements, manufacturing processes and control at manufacture of cylinders in common use in the countries of the ISO member bodies. With respect to those aspects concerning construction materials, approval of design rules and inspection during manufacture which are subject to national or international regulations, it is necessary for interested parties to ensure that, in the practical application of this International Standard, the requirements of the relevant authority are also satisfied.

The pressure shell of the cylinder is fabricated by manufacturing a cylindrical shape with a base and welding a machined plug (boss) or semi-ellipsoidal or torispherical shape onto the open end of the shell to form the cylinder. This method of fabrication allows for insertion of material prior to sealing the cylinder.

A further objective of this International Standard is to balance design and economic efficiency against international acceptance and universal utility. It aims to eliminate the concerns about climate, duplicate inspections and restrictions currently existing because of lack of definitive International Standards. It should not be construed as reflecting on the suitability of the practices of any nation or region.

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Gas cylinders — Refillable welded steel cylinders containing materials for sub-atmospheric gas packaging (excluding acetylene) — Design, construction, testing, use and periodic inspection

WARNING — This International Standard requires 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.

1 Scope

This International Standard specifies minimum requirements for the material, design, construction, workmanship, examination and testing at manufacture of refillable welded steel cylinders for the sub-atmospheric pressure storage of liquefied and compressed gases. It only applies to the cylinders themselves, irrespective of the materials contained therein (e.g. adsorbents, media, materials and/or gases) and other related applications. The cylinders have a test pressure not greater than 42 bar and a water capacity from 0,5 l up to and including 12 l exposed to ambient temperatures for the purpose of facilitating the sub-atmospheric pressure storage of liquefied and compressed gases. Inspection at the time of fill is specified in Annex A and periodic inspection and testing is specified in Annex B.

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High-pressure and low-pressure liquefied gases as specified in Annex C can be suitably filled into these cylinders. The filling pressure will be less than one bar gauge at 21 °C.

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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 the recommended patterns of image quality indications (I.Q.I.)*

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

ISO 6892-1:2009, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 7438, *Metallic materials — Bend test*

ISO 9809-3:2010, *Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 3: Normalised steel cylinders*

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

ISO 13769, *Gas cylinders — Stamp marking*

ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*

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*

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UN Recommendations on the Transport of Dangerous Goods — Model Regulations, sixteenth edition, Packaging Note P200

3 Terms, definitions and symbols

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

3.1 Terms and definitions

3.1.1
yield strength
value corresponding to the lower yield strength, R_{eL}, or 0,92 × the upper yield strength, R_{eH}, or for steels that do not exhibit a defined yield, the 0,2 % proof strength, $R_p0{,}2$

3.1.2
stress relieving
heat treatment given to the drawn pressure shell by heating to a uniform temperature below the lower critical point, AC_1, of the steel and cooling in a still atmosphere

NOTE The object is to reduce the residual stresses without altering the metallurgical structure of the steel.

3.1.3
batch
quantity of finished cylinders made consecutively during the same or consecutive days to the same design, size and material specifications and cast for each pressure-containing part on the same equipment and subjected to the same heat-treatment conditions

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NOTE Different suppliers can be used for the different pressure-containing parts within a batch, e.g. one supplier for shells, another for plugs.

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3.1.4
design stress factor
F
ratio of equivalent wall stress at test pressure, p_h, to guaranteed minimum yield strength, R_{eg}

3.1.5
sub-atmospheric gas packaging
gas source package that stores and delivers gas at sub-atmospheric pressure, which includes a container (e.g. gas cylinder and outlet valve) that stores and delivers gas at a pressure of less than 1 bar at normal conditions of temperature and pressure

NOTE The container can incorporate a medium in order to reduce the pressure of the gas to sub-atmospheric levels.

3.2 Symbols

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

a' Guaranteed minimum thickness, in millimetres, of the cylindrical shell (including any corrosion allowance, see 8.1)

a_1 Guaranteed minimum thickness, in millimeters, of a concave base at the knuckle. See Figure 1 a).

a_2 Guaranteed minimum thickness, in millimetres, at the centre of a concave base. See Figure 1 a).

b Calculated minimum thickness, in millimetres, of the cylinder end

A Percentage elongation after fracture

D Outside diameter of the cylinder, in millimetres

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d Internal diameter of the cylinder, in millimetres

F Design stress factor

h Outside height, in millimetres, of domed part (convex base end). See Figure 1 a).

L Length of the cylinder, in millimetres

P_b Measured burst pressure, in bars, above atmospheric pressure, in the burst test

p_h Test pressure above atmospheric pressure, in bars

P_y The observed pressure when cylinder starts yielding during hydraulic bursting tests, in bars, above atmospheric pressure

r Inside knuckle radius, in millimetres. See Figures 1 and 2.

R_{eg} Guaranteed minimum yield strength in megapascals (yield strength as defined in 3.1.1), for the finished cylinder and used for design calculation

R_{ea} Value of the actual yield strength in megapascals (yield strength as defined in 3.1.1), determined by the tensile test. See 9.4.2.2.

R_{ma} Value of the actual tensile strength in megapascals as determined by the tensile test. See 9.4.2.2.

R_{mg} Guaranteed minimum tensile strength in megapascals, for the finished cylinder and used for design calculations

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4 Inspection and testing

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Evaluation of conformity shall be performed in accordance with the relevant regulations of the country or countries where the cylinders are used.

To ensure that the cylinders conform to this International Standard, they should be subject to inspection and testing by an authorized inspection body recognized in the country or countries of manufacture.

Equipment used for measurement, testing and examination during production shall be maintained and calibrated within a documented quality management system.

5 Materials and stress relieving

5.1 Materials for shells and end pressings shall conform to either ISO 4978 or ISO 9809-3.

NOTE “Materials” refers to materials in the state before transformation with regard to the manufacturing process.

To conform to the state of the art for modern steel manufacturing and steel grades used for pressure purposes, the same limits on sulphur and phosphorous contents as noted in 5.9.1 of ISO 4706:2008 for refillable welded steel cylinders and Table 3 of ISO 9809-3:2010 shall apply in this International Standard. The following limits are noted:

— carbon: 0,25 % max.;

— silicon: 0,45 % max.;

— manganese: 1,60 % max.;

— phosphorous: 0,040 % max.;

— sulphur: 0,040 % max.

5.2 All parts welded to the cylinder shall be made of compatible materials with respect to their weldability.

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5.3 The welding consumables selected by the manufacturer shall be compatible with the base materials and shall produce welds which meet the minimum strength values used in the design of the cylinder and guaranteed by the manufacturer of 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 so that all materials for pressure parts in the completed cylinder are traceable to their origin.

5.6 Grades of steel used for cylinder manufacture shall be compatible with the intended gas service, e.g. corrosive gases, embrittling gases. See ISO 11114-1.

5.7 The drawn pressure shell and plug shall be delivered in the stress-relieved condition. Localized stress relief of the drawn pressure shell and plug shall not be undertaken.

The quality of the welds shall be checked by non-destructive examination (NDE) or other equivalent means to demonstrate that the cylinder is fit for the intended service. See 9.7.4.

The actual temperature of stress relief 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 manufacturer for the cylinder type.

5.8 The material properties of the finished cylinders shall be suitable to meet the requirements of Clause 8 and Clause 9.

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Only steel pressure receptacles resistant to hydrogen embrittlement can be used for gases assigned the special packing provision “d” as per Table 2 of P200 of the UN Model Regulations. See Annex C.

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6 Design

6.1 General

6.1.1 The calculation of the wall thickness of the pressure-containing parts shall be related to the guaranteed minimum yield strength, R_{eg}, for the parent material in the finished cylinder.

For certain gases, additional corrosion allowances may be applicable.

6.1.2 For calculation purposes, the value of the yield strength, R_{eg}, shall be limited to a maximum of 0,85 R_{mg}.

6.1.3 The internal pressure upon which the minimum sidewall thickness calculation of gas cylinders is based shall be the test pressure, p_h.

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

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6.2 Calculation of cylindrical wall thickness

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

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

where F is the lesser of $\frac{0,65}{\frac{R_{eg}}{R_{mg}}}$ or 0,77.

$\frac{R_{eg}}{R_{mg}}$ shall not exceed 0,85.

The guaranteed minimum thickness of the cylinder shell shall also conform to 6.4.

6.3 Design of cylinder ends

NOTE Examples of typical cylinder ends are shown in Figure 1. Figure 1 a) is a typical base end concave to pressure and Figure 1 b) is a typical end plug used to seal the top of the cylinder.

6.3.1 General

The thickness in the base of a cylinder with a convex base end shall not be less than the guaranteed minimum wall thickness of the cylindrical shell specified in 6.2.

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6.3.2 Design of base concave to pressure

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When concave base ends [see Figure 1 a)] are used, the following design values are recommended:

$a_1 \geq 2a$

$a_2 \geq 2a$

$h \geq 0,12\ D$

$r \geq 0,075\ D$

The design drawing shall at least show values for a_1, a_2, h and r.

The cylinder manufacturer shall in all cases prove by the pressure cycling test given in 8.3.2 that the design is satisfactory.

NOTE 1 An example of a typical end is shown in Figure 1 a).

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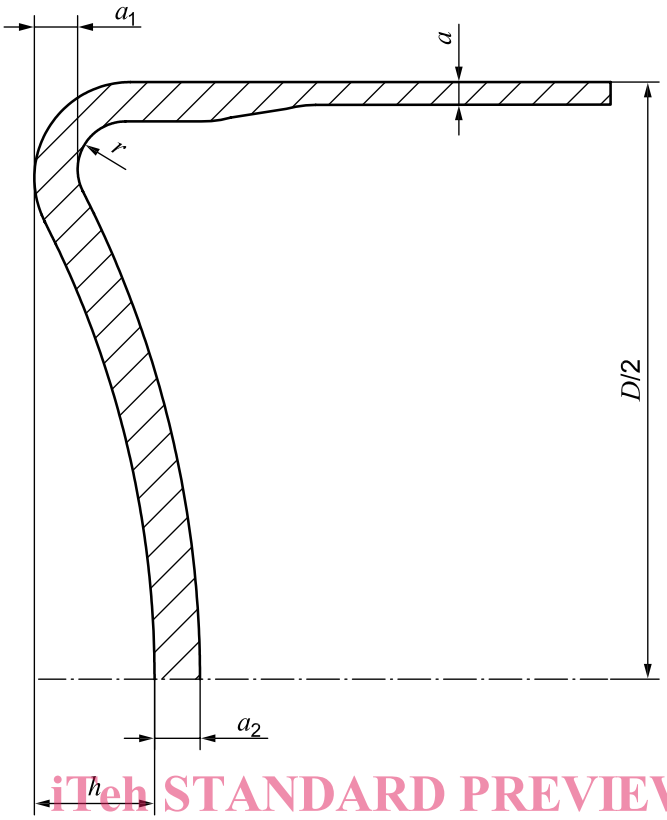

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a) Illustration of cylinder base end concave to pressure

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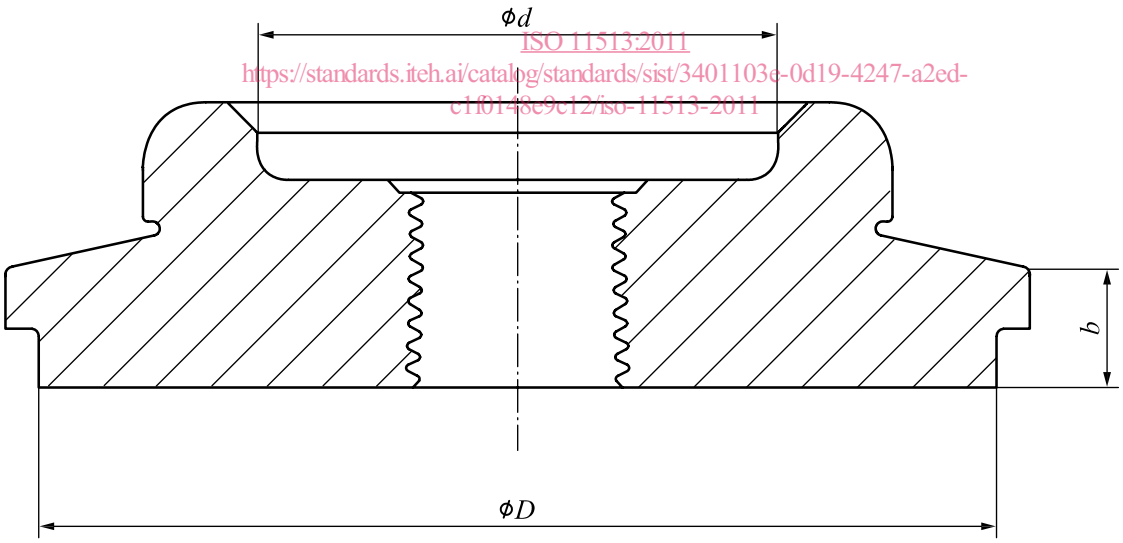

b) Boss style end plug with inlet threads

Figure 1 — Typical cylinder ends

6.4 Minimum wall thickness

6.4.1 The minimum wall thickness of the cylindrical shell including the base, a, shall be not less than the value derived from the appropriate formula listed hereafter:

for $D \leq 100$ mm, $a = 1{,}1$ mm;

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