International Standard

ISO 11118

Gas cylinders — Non-refillable metallic gas cylinders — Specification and test methods

Bouteilles à gaz — Bouteilles à gaz métalliques non rechargeables — Spécifications et méthodes d'essai

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 23, *Transportable gas cylinders,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 11118:2015), which has been technically revised. It also incorporates the Amendment ISO 11118:2015/Amd 1:2019.

The main changes are as follows:

— the normative references have been updated;

— verification of minimum cylinder shell wall thickness has been added;

— the calculation of determination of minimum wall thickness has been simplified by fixing the “F” factor;

— welding qualification, including defining process and operator, has been modified;

— testing of nonrefillable valve sampling has been clarified;

— marking requirements based on UN Model Regulation requirements have been clarified.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The purpose of this document is to facilitate agreement on the design and manufacture of non-refillable metallic gas cylinders and their sealing devices in all countries. The requirements are based on knowledge of, and experience with, materials, design requirements, manufacturing processes and controls in common use for the manufacture of gas cylinders.

This document has been written so that it is suitable to be referenced in the UN Model Regulations[10].

In this document, the unit bar is used, due to its universal use in the field of technical gases. It should, however, be noted that bar is not an SI unit, and that the corresponding SI unit for pressure is Pa (1 bar = 10^5 Pa = 10^5 N/m^2).

Pressure values given in this document are given as gauge pressure (pressure exceeding atmospheric pressure) unless noted otherwise.

Any tolerances given in this document include measurement uncertainties.

Gas cylinders — Non-refillable metallic gas cylinders — Specification and test methods

1 Scope

This document specifies requirements for the material, design, inspections, construction and workmanship, manufacturing processes, and tests at manufacture of non-refillable metallic gas cylinders of welded, brazed, or seamless construction. This document also specifies the requirements for the non-refillable sealing devices and their methods of testing. It is applicable to non-refillable metallic gas cylinders for compressed and liquefied gases.

NOTE The specific gases permitted in cylinders constructed to this document can be limited by national or international requirements.

This document is applicable to cylinders where:

a) the test pressure does not exceed 250 bar[1)] (i.e. $p_h \leq 250$ bar) for liquefied gases and 450 bar for compressed gases; or

b) the product of the test pressure and the water capacity does not exceed 1 000 bar·litres (i.e. $p_h V \leq 1\,000$ bar l); or

c) the test pressure exceeds 45 bar and the water capacity does not exceed 5 l (i.e. for $p_h > 45$ bar, then $V \leq 5$ l).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 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 4706:2023, *Gas cylinders — Refillable welded steel cylinders — Test pressure 60 bar and below*

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

ISO 7866:2012, *Gas cylinders — Refillable seamless aluminium alloy gas cylinders — Design, construction and testing*

ISO 9329-1, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 1: Unalloyed steels with specified room temperature properties*

ISO 9809-1:2019, *Gas cylinders — Design, construction and testing of refillable seamless steel gas cylinders and tubes — Part 1: Quenched and tempered steel cylinders and tubes with tensile strength less than 1 100 MPa*

ISO 9809-4:2021, *Gas cylinders — Design, construction and testing of refillable seamless steel gas cylinders and tubes — Part 4: Stainless steel cylinders with an R_m value of less than 1 100 MPa*

ISO 10156, *Gas cylinders — Gases and gas mixtures — Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets*

ISO 10286, *Gas cylinders — Vocabulary*

1) 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2

ISO 10297, *Gas cylinders — Cylinder valves — Specification and type testing*

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

ISO 11114-2, *Gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 2: Non-metallic materials*

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 15614-12, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 12: Spot, seam and projection welding*

ISO 20703:2006, *Gas cylinders — Refillable welded aluminium-alloy cylinders — Design, construction and testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10286 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
batch
<non-refillable metallic gas cylinders> quantity of completed and pressure tested cylinders made consecutively by the same manufacturer using the same manufacturing techniques to the same design, size, and material specifications using the same type of welding machines (when applicable), welding procedures (when applicable), and to the same heat treatment conditions (when applicable)

Note 1 to entry: See Clause 10 for details.

3.2
cylindrical shell
portion of the cylinder shell excluding the cylinder ends which is parallel to the centreline axis of the cylinder

3.3
cylinder shell
empty cylinder before affixing the *non-refillable sealing device* (3.12), but including all other permanent attachments

3.4
material certificate
document issued by the material manufacturer which certifies the chemical analysis, mechanical properties, heat treatment, processing techniques, or other properties/features if required

3.5
burst pressure
highest pressure reached in a cylinder during the burst test

3.6
test pressure
required pressure applied during the pressure test

3.7
working pressure
settled pressure of compressed gas at a uniform reference temperature of 15 °C (288 K) in a full gas cylinder

3.8
minimum operating temperature
minimum temperature to which the cylinder contents can be exposed

Note 1 to entry: See 5.1.6.

3.9
non-refillable cylinder
cylinder including a *non-refillable sealing device* (3.12) that permits the cylinder to be filled only once

Note 1 to entry: Where there is no risk of ambiguity, the short abbreviated form "cylinder" is used in this document.

3.10
water capacity
volume of water required to completely fill an empty cylinder

3.11
processor
facility that anneals, rolls, slits, or otherwise, changes the material from the form received from the location where the steel was melted

3.12
non-refillable sealing device
device permanently attached to the cylinder which, once activated, prevents the cylinder from being refilled

4 Symbols

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

D nominal outside diameter of the cylinder, in millimetres

F design stress factor

P_b burst pressure of the cylinder, in bar

p_h test pressure, in bar above atmospheric pressure

p_w working pressure, in bar above atmospheric pressure

p_{vt} non-refillable sealing device test pressure, in bar above atmospheric pressure

R_{ea} actual value of the yield strength, in megapascals, of the cylinder when tested

R_{eg} minimum guaranteed value of the yield strength, in megapascals, for the finished cylinder

R_{ma} actual value of the tensile strength, in megapascals, of the cylinder when tested

R_{mg} minimum guaranteed value of the tensile strength, in megapascals, for the finished cylinder

V water capacity of the cylinder, in litres

5 Materials

5.1 General requirements

5.1.1 Cylinder shells shall be made of carbon or low alloy steels, austenitic stainless steel, aluminium, or aluminium alloys. The materials used shall be specified by type (see 5.2) and chemical composition (see 5.3). Materials shall not contain seams, cracks, laminations, or other injurious defects. For material requirements of non-refillable sealing devices, see Annex A.

5.1.2 The cylinder manufacturer shall specify the chemical and mechanical requirements to the material supplier.

5.1.3 The cylinder manufacturer shall obtain a material certificate from the manufacturer/processor of the material certifying the chemical analysis of the cast. The certificate shall be issued by the manufacturer of the material and shall confirm compliance to the material specification.

5.1.4 The cylinder manufacturer shall verify that the materials are in accordance with the cylinder manufacturer specifications.

5.1.5 All materials used in the construction of the pressure containing parts of the cylinder shall be traceable.

5.1.6 All materials shall be suitable for use at the minimum operating temperature or at –20 °C, whichever is the lower.

5.1.7 The materials used for manufacture of the cylinder shell shall be compatible with the intended gas service as specified in ISO 11114-1 or ISO 11114-2.

5.1.8 Contact between dissimilar metals resulting in damage by galvanic corrosion shall be avoided.

5.2 Material types

5.2.1 Carbon and low-alloy steels

5.2.1.1 The steel used for the fabrication of gas cylinder shells shall be made in an electric furnace or, by the basic oxygen process, shall have non-ageing properties and shall be fully killed (de-oxidized) by aluminium and/or silicon.

5.2.1.2 Carbon steel for cold deep drawn seamless, welded, or brazed cylinder shells shall have non-ageing properties, processed free of stretcher strain, and shall be fully killed with aluminium and/or silicon. The chemical composition shall meet the requirements of 5.3.1.1.

5.2.1.3 Carbon steel for other welded cylinder shells shall have a chemical composition which meets the requirements of 5.3.1.2. The maximum tensile strength shall not exceed 700 MPa.

5.2.1.4 Carbon steel for cylinder shells made from seamless steel tubing with integrally formed ends, hot drawn, and finished shall have a chemical composition which meets the requirements of 5.3.1.3.

5.2.1.5 Low alloy steels shall conform to ISO 4706:2023, 5.2.1 or ISO 9809-1:2019, 6.1, 6.2, and 6.3.

5.2.2 Aluminium and aluminium alloy

5.2.2.1 Aluminium alloys with a tensile strength greater than 500 MPa shall not be used.

5.2.2.2 Aluminium alloys used for cylinders shall conform to the material requirements of ISO 7866:2012, 6.1 and 6.2 or ISO 20703:2006, 4.1 and 4.2, as appropriate.

5.2.2.3 Pure aluminium is permitted and shall have a minimum aluminium content of 99,0 %.

5.2.3 Austenitic stainless steels

5.2.3.1 For austenitic stainless steels, the maximum tensile strength shall not exceed 800 MPa.

5.2.3.2 The cylinder manufacturer shall take into consideration the loss of material strength within the heat affected zone of any weld.

5.2.3.3 Austenitic stainless steels for all types of cylinder shells shall conform to ISO 9809-4:2021, 6.1 and 6.2.

5.2.3.4 Due to the risk of sensitization to inter-granular corrosion resulting from hot working/welding for each material specification and heat-treatment method, a corrosion test shall be carried out in accordance with ISO 3651-2 on a specimen taken from a finished cylinder.

Some grades of stainless steels can be susceptible to environmental stress corrosion cracking. Special precautions should be taken in such cases.

5.3 Chemical compositions

5.3.1 Carbon and low-alloy steels

5.3.1.1 Carbon steels having non-aging properties for cold deep drawn welded or brazed cylinder shells shall have the following chemical composition limits in % mass fraction given in Table 1.

Table 1 — Cylinder shell and ends non-aging properties for cold deep drawn chemistry allowable limits

Element	Maximum content % (mass fraction)
Carbon	≤ 0,12
Manganese	≤ 0,50
Phosphorus	≤ 0,025
Sulfur	≤ 0,025

5.3.1.2 Carbon steels for welded cylinder shells other than cold deep drawn shall have the following chemical composition limits in % mass fraction given in Table 2.

Table 2 — Cylinder shell and ends other than cold deep drawn chemistry allowable limits

Element	Maximum content % (mass fraction)
Carbon	≤ 0,25
Manganese	≤ 0,50
Phosphorus	≤ 0,025
Sulfur	≤ 0,025

5.3.1.3 Carbon steels for cylinder shells made of seamless steel with integrally formed ends, hot drawn, and finished shall have the following chemical composition limits in % mass fraction given in Table 3.

Table 3 — Seamless steel with integrally formed ends, hot drawn cylinder shell chemistry allowable limits

Element	Maximum content % (mass fraction)
Carbon	≤ 0,55
Manganese	≤ 1,70
Phosphorus	≤ 0,025
Sulfur	≤ 0,025

5.3.2 Aluminium and aluminium alloys

Aluminium and aluminium alloys shall have a maximum lead and bismuth contents not exceeding 0,003 % each.

6 Inspection and testing

To ensure that the cylinders conform to this document, they shall be subject to inspection and testing in accordance with Clauses 9 to 11 and Annex A by an inspection body (hereinafter referred to as "the inspector").

Tests and examinations performed to demonstrate compliance with this document shall be conducted using instruments calibrated before being put into service and thereafter according to an established program.

7 Design

7.1 General requirements

7.1.1 The calculation of the cylindrical wall thickness of the pressure containing parts shall be related to the guaranteed minimum yield strength of the finished cylinder (R_{eg}).

7.1.2 The design of the cylinder shell shall be such that the pressure containing parts, when subjected to the test pressure (p_h), shall not show any permanent visible deformation.

7.1.3 Welded aluminium and welded aluminium alloy cylinders are limited to a maximum of 60 bar test pressure.

7.2 Calculation of pressure containing parts

The minimum thickness of the cylindrical shell of the pressure containing parts shall not be less than any of the three values determined in 7.2 a), b), and c).

a) The minimum thickness of the cylindrical shell shall be not less than that necessary for the minimum burst pressure to be greater than 1,6 times the test pressure (p_h) and such that the requirements of 9.2.4.5 and Clause 11 are met.

b) The minimum thickness of the cylindrical shell shall not be less than that calculated by the Lamé - von Mises formula as given in Formula (1).

$$a = \frac{D}{2}\left[1 - \sqrt{\left(\frac{10FR_{eg} - \sqrt{3}\ p_h}{10FR_{eg}}\right)}\right] \quad (1)$$

with $F = 0{,}85$

c) The minimum thickness of the cylindrical shell shall not be less than that calculated by using Formula (2) or Formula (3) as appropriate.

Formula (2) (for steel):

$$a = D/650 + 0{,}4 \quad (2)$$

Formula (3) (for aluminium alloys):

$$a = D/300 + 0{,}5 \quad (3)$$

NOTE It is generally assumed that p_h is equal to 1,5 times working pressure for compressed gases.